NICE National Institute for Health and Care Excellence

Medical technologies advisory committee (MTAC)

21st July 2023

Information pack for draft guidance considerations on

GID-HTE10006 Virtual Ward Platform Technologies for acute respiratory infections

This product was selected for early value assessment in 2022. Clinical and economic evidence has been submitted to NICE by the company, and an external assessment centre report has been completed.

This pack presents the information required for the MTAC to make draft recommendations on this topic. The consultation period on these draft recommendations is scheduled to take place between 09 August 2023 and 23 August 2023.

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Papers included in pack:

1. Front sheet
2. Scope
3. EAG assessment report (AR)
4. Assessment Report Overview (ARO)
5. Register of interest

NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

Medical Technologies Evaluation Programme

Virtual Ward Platform Technologies for acute respiratory infections

Final scope

May 2023

1 Introduction

NICE has been asked to produce a number of related products to support and inform the expansion of virtual ward provision and other intermediate care areas. This Health technology evaluation will focus on the use of virtual ward platforms to enable the provision of virtual wards for people with acute respiratory infections. The aim is to outline key considerations and characteristics of the digital platforms, create an early economic model and identify outcomes to prioritise for future data collection. This could help support the adoption of virtual ward platforms for acute respiratory infections in the NHS. This assessment will take place as a bespoke project as part of the Health Technology Assessment Innovation Laboratory (HTA Lab) programme at NICE.

A list of abbreviations is provided in appendix A.

2 Description of Virtual Wards

This section describes the properties of virtual wards based on information provided to NICE by manufacturers and experts and information available in the public domain. NICE has not carried out an independent evaluation of this description.

2.1 Definition of a virtual ward

According to the definition provided by NHS England and NHS Improvement, a virtual ward allows people who would otherwise be in hospital to receive acute care, monitoring and treatment to receive the same level of care at home.

Purpose of virtual wards

A NHS England Transformation Directorate programme aims to develop and expand the use of virtual wards in the NHS. The ambition for virtual wards is to expand the capacity of the acute care sector by managing patients, who would otherwise be in hospital, remotely in their homes, creating potential staffing efficiencies and providing more convenient care for patients. Virtual wards could also reduce the pressure on other aspects of the care system, including primary care appointments and emergency hospital attendance.

Virtual wards are designed to provide an alternative to admission into hospital or support early discharge out of hospital. A virtual ward is not intended to be a mechanism for enhanced primary care programmes; chronic disease management; home intravenous or infusion services; intermediate or day care; safety netting; or proactive deterioration prevention.

The NHS Operational Planning guidance has sets a target to deliver 40 to 50 virtual ward beds per 100,000 population (equivalent to the delivery of up to 24,000 virtual ward beds nationally) by December 2023. Additional funding of up to £450 million over two years has been made available to systems to support this transformation.

The ambition was set following national development of acute respiratory infection and frailty pathways, which included defining the approach and resource required to support the scale of virtual wards. There is an expectation that the system will support these two pathways and there is a two-year transformation programme being initiated nationally, which will support and guide local and regional development. The acute respiratory and

frailty pathways are expected to deliver 50% of the overall bed target for virtual wards nationally.

2.2 Virtual Wards properties

Virtual wards should be technology-enabled to maximise the opportunity they offer for patients, carers and staff. A technology-enabled virtual ward platform comprises of a patient facing app or website, medical devices for measuring vital signs and a digital platform for healthcare providers to monitor patients. Here patients or their carers measure agreed vital signs using medical devices such as pulse oximeters and enter data into an app or website (manually or automatically if using a connected device). In some cases, they wear a device that continuously monitors and reports vital signs.

Clinical teams see measurements for the patients they are responsible for displayed on a digital dashboard. The platforms or technology software ensures they are alerted when any patient moves outside agreed parameters, allowing them to take appropriate action. Patients should be considered for a technology-enabled service where one exists. However, it is important that alternatives are available to avoid digital exclusion and take account of personal choice. It is also important consideration is given to other opportunities technology may offer such as the use of point of care testing or remote diagnostics to support virtual wards.

Automatic data collection

The RSET Rapid evaluation of remote home monitoring models during COVID-19 pandemic in England highlighted that the use of apps for patient monitoring allowed the follow up of more patients. It did also highlight that this method is not appropriate for everyone, with some people needing paper recording or telephone follow ups. NHS England guidance on setting up virtual wards requests the platforms to minimise the burden on providers by capturing data items that enable reporting of patient attributes, throughput, length of stay, referral and discharge routes, clinical activity and patient

outcomes by the platforms in a consistent format and linked closely to clinical data capture.

Accessibility and interoperability

NHS England guidance on virtual wards for integrated care system (ICS) leads states that virtual ward services are likely to be delivered by teams from different organisations across the ICS and relevant patient information will need to be available to all those involved. Interoperability has also been highlighted as a key feature to enable effective data sharing, aligned to the ICS's digital, data and technology strategy.

For this assessment, NICE will consider virtual wards platforms that:

- are intended for use by adults in their usual place of residence (where appropriate)
- have been developed to support a step-up or step-down pathway for adults with acute respiratory infections and have the following key features:
    - record all the necessary clinical measurements needed to remotely manage people with acute respiratory infections
    - enable the clinical team to monitor patients at home using software equipment, including an online dashboard of the vital signs
    - the technologies should be device agnostic or integrate with medical devices that have CE or UKCA mark, if required. Data can be entered manually by the user or automatically using connected devices
    - enable case management functionality (the platform ensures the clinical team is alerted when any patient moves outside agreed parameters, allowing them to take appropriate action).
    - are accessible across all staff that need to provide input (such as secondary care and community health)
    - offer direct interoperability with appropriate clinical systems (including data sharing)

- meet the standards within the digital technology assessment criteria (DTAC), including the criteria to have a CE or UKCA mark where required. Products may also be considered if they are actively working towards required CE or UKCA mark and meet all other standards within the DTAC.
- are available for use in the NHS.

In total, 20 virtual ward platforms are considered in the scope. These are listed in appendix A. The final list of included technologies may be subject to change.

3 Target conditions

The target population for this assessment is people (aged 16 and over) with a suspected or confirmed acute respiratory infection (ARI; including COVID-19) who are stable or improving but require ongoing monitoring that can be safely provided in their home or usual place of residence.

NHS England's guidance on ARI virtual wards recommends the following criteria when considering virtual ward care for people with an ARI:

- suspected or confirmed ARI including COVID-19
- oxygen saturations of 95 to 100%, NEWS2 less than 3, clinically stable or improving
- no significant respiratory co-morbidities.

People with the following clinical features may also be considered, where clinically appropriate:

- saturations of 93 to 94% or NEWS2 3 or 4, or both, with improving clinical trajectories (in people being discharged from hospital-based acute care)

- saturations of 88 to 94% (or baseline) if known chronic hypoxia, such as chronic obstructive pulmonary disease (COPD)

- frailer people should not be excluded but dedicated frailty services, such as frailty virtual wards, may be more appropriate where these exist locally

- pregnant people with saturations greater than 94% should not be excluded and early maternity involvement should be sought for specific advice around management of suspected ARI including COVID-19 in pregnancy.

People with the following clinical criteria should be excluded:

- unstable or worsening clinical trajectory, such as saturations less than 93% (unless confirmed baseline) or NEWS2 greater than or equal to 5, or both

- severe or life-threatening presentations of pneumonia, asthma or COPD

- suspected sepsis

- chest pain that is concerning for a serious cause requiring immediate hospital transfer, such as acute coronary syndrome

- pregnant people with saturations of less than or equal to 94%.

It also recommends that clinical judgement is key for all assessments, particularly for people at higher risk of serious illness, people with a learning disability or people with serious mental illness.

3.1 Care pathway

Virtual ward services for ARI are intended for people who need acute level care and would otherwise be in hospital. It is not intended for chronic disease management. The ARI virtual ward supports both an admission alternative to hospital and early supported discharge from hospital.

Clinical assessment to assess suitability for admission to a virtual ward should be carried out in person by a clinician. It should include a review of symptoms,

function, clinical observations, appropriate diagnostics, clinical severity scoring, overall clinical trajectory and a shared decision-making discussion about any support requirements for the patient or their carers. Suitability of the patient's usual place of residence also needs to be considered, such as access to a fixed or mobile telephone line, running water and electricity. Patient's or their carers would also need the motivation and skills to be able to use a virtual ward platform and the associated medical devices.

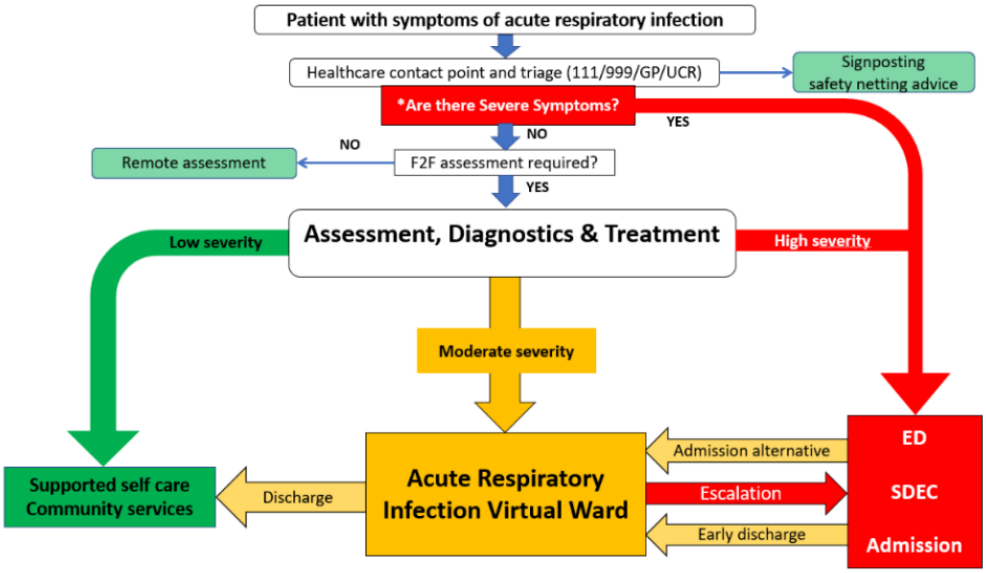
Virtual wards should be delivered by a multidisciplinary team, if clinically appropriate, led by a named consultant practitioner (including a nurse or consultant allied health professional) or suitably trained GP with relevant experience and training, with clear lines of clinical responsibility and governance.

Services may need to develop their own admission and discharge criteria for acute level care in line with their population needs, available workforce and competencies. Healthcare practitioners need a clear pathway for recognising deterioration and escalating care, including the use of clinical acuity scoring such as NEWS2. Patients and their carers need clear information on who to contact if their symptoms worsen, including out of hours.

Potential place of virtual wards in the care pathway

NHS England's ARI virtual ward guidance proposes the pathway shown in figure 1. This pathway includes clinical assessment to assess suitability for admission to a virtual ward from either a hospital setting as an early discharge or alternative to admission or via direct patient NHS contact. The assessment includes a review of the patient's symptoms, function, clinical observations, appropriate diagnostics, clinical severity scoring, overall clinical trajectory and a shared decision-making discussion about any support requirements for the patient or their carers. On admission to a virtual ward, plans relating to monitoring, escalation of care and discharge are made. The expected length of an admission is up to 14 days, subject to clinical judgement.

Figure 1: Proposed pathway for the use of virtual wards in people with acute respiratory infection



Source: [NHS England's acute respiratory infection virtual ward guidance]

Related NICE Guidance

- Acute Respiratory Infection in over 16s: Initial assessment and management (in development) NICE guideline GID-NG10376
- COVID-19 rapid guideline: managing COVID-19 (2021, updated 2022) NICE guideline NG191
- Pneumonia (community-acquired): antimicrobial prescribing (2019) NICE guideline NG138
- Cough (acute): antimicrobial prescribing (2019) NICE guideline NG120
- Emergency and acute medical care in over 16s: service delivery and organisation (2018) NICE guideline NG94
- Sepsis: recognition, diagnosis and early management (2017) NICE guideline NG51

3.2 Patient issues and preferences

Virtual wards platforms are delivered via smart digital devices along with the associated monitoring devices, allowing for monitoring from a patient's place of residence. This may be particularly appealing to people who do not want to be treated in hospital.

Suitability of the patient's usual place of residence needs to be considered, such as access to a fixed or mobile telephone line, running water and electricity. Additionally, some people may not to want to be monitored from their place of residence using a virtual ward platform and prefer monitoring in hospital. There may be concerns about the level of support provided and the safety of being monitored remotely. The risks and benefits of virtual ward use needs to be communicated to patients prior to use. Consideration is also needed on to the ability of patients to consent to using a virtual ward, including those with dementia or receiving end of life care. People have the right to make informed decisions about their care, including the use of virtual ward platforms.

The Ofcom Adults' Media Use and Attitudes report states that 6% of households (around 1.7 million) did not have access to the internet at home in December 2021 (Ofcom report, 2022). The groups more likely not to have internet access at home are those aged 75 and over (26%), those in a lower socioeconomic household classification (DE social grade; 14%) and those who are most financially vulnerable (10%). Digital exclusion would need to be considered when offering the use of a virtual ward platform. Support in the form of internet access, access to a smart device, and training on using the virtual ward platform would be needed for those who do not have access to these technologies or who may not be confident in using digital technologies. Patient facing aspects of virtual ward technologies need to be easy to use, to ensure accessibility to people who may have limited digital literacy skills.

Relevant monitoring devices will need to be loaned in order to use a virtual ward. Patients and carers will need training on how to use the devices and when they need to submit readings as well as any additional questionnaires. Clear information would need to be provided on when and how a patient or carer can self-escalate if symptoms are getting worse.

4 Comparator

Technology-enabled virtual wards would be used as an alternative to inpatient secondary care, for those who are eligible for treatment from home.

5 Scope of the assessment

Table 1: Scope of the assessment

Populations	• Adults (aged 16 or over) referred for hospital admission with acute respiratory infection. • Adults (aged 16 or over) admitted to the hospital with acute respiratory infection who are stable or improving but require ongoing monitoring. Treatment using virtual wards should also be based on the criteria listed under target conditions. Subgroups could be considered for health inequalities and those with co-morbidities.
Interventions (proposed technologies)	• Technology-enabled virtual ward platforms for treating adults with acute respiratory infections, as an alternative to inpatient hospital care • Technologies would need to meet the eligibility criteria listed in section 2.3. A list of technologies provisionally identified are listed in appendix A. This list of technologies is not exhaustive and may be subject to change.
Comparator	Inpatient hospital care or care in the community or a patient's usual place of residence without the use of a virtual ward platform
Healthcare setting	Care from the patient's usual place of residence
Outcomes	Intermediate measures for consideration may include: • Number of people in treatment and their respective demographics • Number of people in which treatment is escalated
	Clinical outcomes for consideration may include: • Length of hospital or virtual ward stay • Rate of hospital- acquired infections • Mortality Operational and service level clinical outcomes: • Number of admissions to a hospital or virtual ward • Number of hospital readmissions • Emergency attendance or unplanned hospital admissions • Number of contacts with other care providers such as GP visits, 111 calls • Release of staff time for other caring responsibilities • Ease of use and acceptability of virtual ward by healthcare professionals • Patient adherence to scheduled reporting of clinical outcomes or use of wearable technologies • Waiting time for admission to or discharge from a virtual ward

	• Antimicrobial use • Interoperability with electronic health records • Adverse events
	Patient-reported outcomes for consideration may include: • Health-related quality of life • Patient and carer experience (including preferable place of care and carer strain) • Patient and carer acceptability
	Costs will be considered from an NHS and Personal Social Services perspective. Costs for consideration may include: • Costs of the technologies • Cost of other resource use
Time horizon	The time horizon for estimating clinical and cost effectiveness should be sufficiently long to reflect any differences in costs or outcomes between the technologies being compared. For people with acute respiratory infection a time horizon of 30 days is considered long enough to capture all outcomes related to the intervention and the condition. Sensitivity analysis will be undertaken to address uncertainties in the model parameters.

6 Other issues for consideration

Characteristics of virtual ward platforms

- There are a wide range of platforms which can deliver virtual wards. The technologies listed in this scope are those identified as being used for acute respiratory infections in the NHS. This list is not definitive and can be subject to change throughout the evaluation period.
- There are common features between virtual wards, with all technologies offering a patient app and clinician platform. Some technologies are device agnostic and some provide set monitoring devices. There is also variation in interoperability of the platforms and different NHS patient record systems. Interoperability with electronic health records in primary and secondary care was highlighted as a key functional aspect of virtual ward platforms.

Patient population

- There are a wide range of people that could be offered a virtual ward for acute respiratory infections. Additional considerations are needed for people with co-morbidities or those who might be stepped down from hospital care but who still require oxygen.

Although a length of stay of up to 14 days may be expected for most, some people may be on a virtual ward for longer.

Evidence

- This assessment will look across a range of evidence types including randomised controlled trials, real world evidence and grey literature. Evidence considered will include evidence of clinical effectiveness and comparative outcomes to inpatient care, where available.

- This evaluation is focused on the overall quantity and quality of evidence for virtual ward platforms for acute respiratory infections. If there is insufficient evidence in this area, the scope of the literature review may be expanded to other virtual wards populations, where appropriate.

7 Potential equality issues

NICE is committed to promoting equality of opportunity, eliminating unlawful discrimination and fostering good relations between people with particular protected characteristics and others.

- Technology-enabled virtual wards are often delivered through a smart device. People need regular access to a device with internet access to use the technologies. Additional support and resources may be needed for people who are unfamiliar with digital technologies or do not have access to smart devices or the internet.
- People with cognitive impairment, problems with manual dexterity, learning disabilities or who have difficulty reading or understanding health-related information may need additional support to use technology-enabled virtual wards. This should be considered when selecting and delivering these interventions.
- Technology-enabled virtual wards should be accessible to people with visual impairments using screen readers, and people with hearing impairments.
- People with English as a second language may have difficulties navigating technology-enabled virtual wards provided in English. Technology-enabled virtual wards providers should consider how to translate these interventions or provide additional support as needed.
- Acute respiratory infections are more common in people who are 65 and Over. This population also has a higher risk of serious illness and worse outcomes.

- People with learning disabilities have higher rates of asthma, COPD and upper respiratory tract infections and poorer measured lung function.
- Pregnant people are at greater risk of developing complications due to acute respiratory tract infections.
- Some pulse oximetry devices have been reported to overestimate oxygen saturation levels in people with darker skin, which may lead to them not being treated when treatment is needed.
- There is evidence to suggest that there is a higher incidence of mortality from respiratory disease in England for men than women. There are differences in help seeking behaviour between men and women, which may increase a man's risk for pneumonia hospitalisation.

Age, sex, disability, race, and pregnancy are protected characteristics under the Equality Act 2010.

8 Potential implementation issues

Training

Training and appropriate staffing is required to facilitate virtual wards. Patients and carers will need training on how to take the required measurements and report them on the virtual ward platforms. Training on escalation processes should also be provided to carers, staff, the multidisciplinary team as necessary.

Cost

Costs may differ between technologies. Smaller service areas may have higher costs per user due to not needing as many licences for the technology. Some technologies may be used for other conditions within the virtual ward service, which may reduce the overall implementation cost. As multidisciplinary teams are needed to deliver virtual wards, the cost of the staffing models would form a key part of the cost. Consideration is needed as to whether a virtual ward company or an NHS provider provides some logistical functions such as maintaining and supplying monitoring equipment as well as providing reminders for patients to submit recordings.

Digital exclusion would need to be considered as part of implementation. This includes the provision of necessary equipment, support and training and

mobile data or WiFi access to those who want to use a virtual ward but do not have the resources to do so.

Risk of harm

Patients should be screened based on the eligibility criteria outlined by NHS England's guidance on acute respiratory infection virtual wards. Patients should be given clear information on who to contact if their symptoms worsen, including out of hours. Staff should have clearly defined roles within the multidisciplinary team. There should be clear pathways to support early recognition of deterioration and appropriate escalation processes in place to maintain patient safety. For out of hours care, a clear support plan is needed. This may require a specially commissioned primary care service, if the virtual ward is run by a secondary care service. All teams responsible for patient care would need access the virtual ward platform. In addition to this, consideration of connectivity and safety plans if contact is lost with a patient is needed.

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Appendix A

Table 1: Technologies considered in the scope
To note, this information has been provided by a company or through review of publicly available information. As a result, the level of detailed information varies. This list is not exhaustive and may be subject to change following provision of additional information.

Accurx (Accurx)	Accurx offers a virtual ward platform. The technology can integrate with EMIS, TPP and Vision.
Andersen (Andersen)	Andersen is a software development company with remote patient monitoring software to continuously track patient health.
Baywater Healthcare (Baywater Healthcare)	Baywater Healthcare provides patient monitoring services for a range of conditions including offering a COVID-19 virtual ward.
Camascope (Camascope)	The Camascope platforms supports the use of virtual wards. The technology has wearable devices and custom forms can be created for individual patients or entire patient groups to periodically provide further information on their health. Patients receive custom alert messages when vital signs go outside of pre-defined parameters. Video calls can be held between patient and a clinical team to ensure full support is available during remote monitoring. The company provide continual support if there are any questions. Camascope integrates with GP Systems, such as EMIS.
Clinitouch (Spirit Health)	CliniTouch is a digitally connected health care platform that provides remote monitoring. It is designed to prioritise patients by clinical need, allowing the clinician to see when a patient's condition is likely to deteriorate, prompting them to take pre-emptive measures. The platform enables the digitisation of multiple care pathways. It has a patient app where patients answer predefined questions and submit health data, at intervals set by their clinician. This app is currently accessed via a supplied tablet. The clinician dashboard has a smart algorithm which converts question sets and health data into a red, amber or green rating to make it easier to spot deterioration. Clinitouch can integrate with any peripheral measurement device using Bluetooth or manual data entry. This includes those which measure oxygen levels, temperature and heart rate. The technology is not currently interoperable with core clinical systems. The company provide virtual training sessions to clinicians and service

	administrators to on the use of the system. Supplementary user guides are also provided.
Current Health (Current Health)	The Current Health system is a remote patient monitoring platform. It works alongside the Current Health wearable device which provides continuous and intermittent vital sign measurements including oxygen saturation, respiratory rate, mobility and step count, pulse rate, blood pressure and skin temperature. Devices come pre-configured for easy patient set up. The company can provide a tablet with data access or a patient can use the Current Health app on their own device. The platform provides physiological alarm notifications, triage, escalation and video visiting. The alarms are tailored to clinical pathways and specific patient populations and are based on sustained changes to vital signs over time. The company provides a quick start guide for patients, which is translated into 30 languages. The company also provides continuous support for patients using the technology, in addition to a clinician training programme. Interoperability with electronic patient records is primarily done through the public API of the electronic patient record.
Doccla Virtual Ward solution (Doccla)	Doccla Virtual Ward solution is a remote monitoring platform which can be adapted to any care pathway. Patients have access to an app to submit vital signs (such as temperature, blood oxygen and blood pressure) and other information about their condition. The platform is device agnostic so patients can enter vital signs manually or using Bluetooth connected devices. The app also gives the patient automatic nudges and reminders to submit information. Patients are supplied with a smartphone or tablet, with 4G data plans, to ensure connectivity if the patient cannot connect to WiFi. A clinician dashboard allows real time access to the information submitted by their patients. The clinical dashboard also shows the text of the last outbound or inbound message from a patient, and whether or not it has been read. The technology allows content, timing and logic of patient questionnaires to be adaptable, and can be set by default for all the patients on a pathway or customised to suit individual patients. The technology can integrate with SystmOne, EMIS, Cerner, EPIC and through TIE's Sunrise and RIO. The company provide patient support and a helpline for clinicians.

	The company also uses NHS-approved translation services for those who do not speak English well.
DOC@HOME (Docobo)	DOC@HOME is a remote patient monitoring platform for a range of conditions. Patients can record data via a CAREPORTAL device, DocoboAPP, DocoboWeb, or via SMS for simple vitals (such as blood pressure or oxygen saturation). The technology is compatible with a range of connect devices which will automatically submit readings as well as allowing manual data entry. There is a library of template questionnaires or the ability to create new questionnaires to capture soft sign data from patients. There is also a secure two-way messaging between patient and healthcare professionals. DOC@HOME can be configured to generate alerts based off vital sign parameters, soft signs, and scores. Alerts are coded by risk and can be standardised across an entire patient cohort or tailored to a patient's normal parameters. DOC@HOME integrates into other core clinical or care systems such as EMIS, Care Centric and Nourish. Self-help educational content can also be sent to patients and there is a technical support desk for all service users during normal business operating hours. The company offers training for healthcare professionals and patients can receive training from either a healthcare professional or by a company field technician.
Doctaly Assist (BDM Medical)	Doctaly Assist is a remote patient monitoring platform. The technology allows patients to provide their symptoms and vital signs for a clinical to review remotely. A prioritisation system is used to make sure care is escalated where needed.
Dignio (Dignio)	The Dignio platform can be used for a wide range of applications. It has 3 aspects the platforms, a patient application called MyDignio, a web-based patient monitoring portal called Dignio Prevent, and a tool for caregivers on the go called Dignio Care. The platform is device agnostic and so data can be inputted manually by the patient or by using Bluetooth-integrated medical devices. The platform integrates with the core clinical system EMIS.
Feebris (Feebris)	Feebris is a cloud based, device agnostic, virtual ward platform. Vital signs and symptoms can be entered manually or by using Bluetooth-integrated medical devices. The technology uses AI-review to provide immediate feedback to the user if measurements need to be retaken or any other

	changes in the use of the sensors need to be made. Customisable questionnaires can also be used to capture soft signs. The app operates entirely offline so that patient data can be captured regardless of connectivity. A mobile device with data is provided to patients. There are accessibility functions including the patient facing app being picture based, voice access and spoken feedback, and adjustments to display and font size can be done. The clinical portal provides a top-level summary of patients on the ward including RAG-rated vitals, stratification to allow prioritisation and configurable alerts. The technology has a FHIR API to integrate with primary care systems (EMIS and SystmOne) and secondary care systems (EPIC and Cerner). The company provide training for clinical staff and a virtual learning hub. Onboarding of patients can be done by clinical staff or the company.
Health Call (Health Call)	Health Call offer a virtual ward platform for a range of acute and chronic health conditions including respiratory and COVID-19. Patients are sent reminders to submit a range of core observations including heart rate, blood oxygen levels and respiratory rate. A clinician dashboard shows patients who are breaching parameters and require urgent attention. The technology integrates with all electronic patient record systems.
Huma (Huma)	Huma virtual ward platform comprises of a patient facing app and web-based clinician platform. A patient can input core clinical parameters into the app including, oxygen saturations, temperature, heart rate and blood pressure manually or using Bluetooth-integrated medical devices. They can also respond to questionnaires. Additionally, there is a helper feature to enable a carer or proxy to enter data for a patient. The clinician platform can provide alerts if patients measures move outside of agreed parameters, with threshold-based flagging systems. The technology allows video conferencing or messaging between healthcare professionals and the patient. Huma can integrate with TPP SystmOne and EMIS The company provide technical support for healthcare professionals and patients.
Inhealthcare Digital Health Platform (Inhealthcare)	The Inhealthcare Digital Health Platform is a single platform which allows the management of multiple patient monitoring services. Patients can provide vital sign measurements and respond to questionnaires

	for clinicians to review. The platform is device agnostic and so data can be inputted manually by the patient or by using continuous monitoring devices, Bluetooth-integrated medical devices, responding via SMS or automated phone calls. The platform integrates with core clinical systems SystmOne and EMIS Web and can share data to GP practices that do not have Inhealthcare applications installed via the MESH. The platform is operated as a Software as a Service Platform and therefore can be accessed by any staff that need it. There is access to a service desk, learning management system and knowledgebase as well as user guides to support use of this platform.
Lenus COPD Support Service (Lenus Health)	The Lenus COPD Support Service provides a remote monitoring and virtual ward platform to support people with a range of respiratory conditions, including acute respiratory infections. The platform allows patients to submit structured questionnaires as well as data from medical devices. A clinical dashboard allows healthcare professionals to assess the patient's wellbeing remotely. Alert lists highlight patients who have messaged, or whose measurements are outside of expected parameters. The technology can integrate with existing electronic health record systems. Clinicians using the system are given training (virtual and in-person) on how to use the technology, in addition to ongoing support.
Luscii (Luscii Healthtech)	Luscii supports virtual wards for a range of conditions including acute respiratory infections. Patients can provide vital sign measurements and respond to questionnaires for clinicians to review using an app on a smart phone or tablet. Luscii is device agnostic and so vital sign data (such as blood oxygen and temperature) can be inputted manually by the patient or by using Bluetooth-integrated medical devices. If needed, the company can loan tablets with WiFi or data to patients. Clinicians access Luscii via a web-based dashboard. Thresholds can be set at a cohort and individual level if required, so that any measurement outside of a specific threshold or combination of thresholds will trigger an automatic alert to the clinical team. Direct contact can then be made if required via in-app secure messaging or in-app video calling. The company works with either third party partner providers who create dedicated clinical monitoring teams or with existing staff within

	the care provider's teams, or a combination. Specific educational content can also be provided to encourage and support self-management. A support desk is available, via phone or in-app chat, for both patients and clinicians. The technology can integrate with existing electronic health record systems including Epic, Cerner and SystmOne.
RespiraSense Hub (PMD Solutions)	Respirasense Hub is a remote monitoring service. It comprises of a web based and mobile app platform, a continuous respiratory rate monitor (RespiraSense), and the use of additional medical devices to measure other vital signs. The RespiraSense respiratory rate monitor is a rechargeable motion-tolerant device for continuously monitoring respiratory rate. The company additionally loans the use of vital sign monitors for pulse rate, peripheral blood oxygen saturation, blood pressure and temperature. The company can also loan a mobile device, if required. Data can be collected using Bluetooth-enabled medical devices or manually entered. Data collected is displayed on the clinician dashboard. The dashboard also allows the creation of patient questionnaires, two-way communication to the patient via text or video call, and interoperability with GP services. The company provides nursing staff to onboard patients and provide both patient and provider with continual phone support, 2 home visits per patient, and 6 hours of one-to-one support outside of phone support.
Virtual Ward Technologies (Virtual Ward Technologies)	Virtual Ward Technologies offers a virtual ward platform which involves risk stratification and remote monitoring. The technology uses a smart watch to collect vital sign measures automatically. Patients can also manually input data such as blood pressure and symptom reporting. The company state that no patient training is needed. Healthcare professionals using the platform would need training.
VitalPatch remote patient monitoring solution (MediBioSense Ltd)	VitalPatch is a 7-day wearable disposal patch. It measures electrocardiogram (ECG), heart rate, RR interval, respiratory rate, body temperature, posture, fall detection, and activity including steps. Blood pressure and oxygen saturation can also be collected using additional devices. The data from the VitalPatch and additional devices is collected via Bluetooth using a mobile device or via the MediBioSense internet of things box called Infinity. The data is sent to the HealthStream cloud platform

	or integration into electronic health record systems for review. Patient alerts are configurable on an individual patient basis with the default alert levels based on NEWS2 guidelines. Training is provided and technical support is available.
Whzan Blue Box (Solcom)	The Whzan is a cloud based triaging dashboard that delivers remote monitoring of patients. Vital sign and assessment data is collected from patients via the Blue Box. The Blue Box is a portable telehealth kit comprising of a tablet or smartphone connected to Bluetooth enabled thermometer, pulse oximeter and blood pressure monitor for automated data collection. Assessments can also be completed on the smart device to record other parameters such as a NEWS2 score or a condition specific questionnaire. The data collected is then transferred to the Whzan dashboard. Whzan is interoperable with EMIS, SystmOne, PDS, Adastra, NRL, PARIS and some NHS local record systems. There is access face-to-face training for NHS staff, in addition to a support desk, user guides and help documents for patients and clinicians to support use of this platform.

Abbreviations

ARI	Acute respiratory infection
COPD	Chronic obstructive pulmonary disease
DTAC	Digital technology assessment criteria
EVA	Early value assessment
ICS	Integrated care system
MTEP	Medical technologies evaluation programme
NEWS2	National Early Warning Score 2

NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

Early Value Assessment
[MTG 10006]: Virtual Ward Platform Technologies for Acute Respiratory Infections
External Assessment Group Report

Produced by: York Health Economics Consortium

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Contains confidential information: yes

Number of attached appendices: 6

Purpose of the assessment report

The purpose of this External assessment group (EAG) report is to review the evidence currently available for included technologies and advise what further evidence should be collected to help inform decisions on whether the technologies should be widely adopted in the NHS. The report may also include additional analysis of the submitted evidence or new clinical and/or economic evidence. NICE has commissioned this work and provided the template for the report. The report forms part of the papers considered by the Medical Technologies Advisory Committee when it is making decisions about the early value assessment.

Declared interests of the authors

Description of any declared interests with related companies, and the matter under consideration. See NICE's Policy on managing interests for board members and employees.

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Jim Swift, Spirit Health, provided clarifications on an identified study evaluating this product.

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Responsibility for report

The views expressed in this report are those of the authors and not those of NICE. Any errors are the responsibility of the authors.

Contents

Abbreviations

Term	Definition
AI	Artificial intelligence
ARI	Acute respiratory infection
CI	Confidence interval
DES	Discrete event simulation
DHSC	Department of Health and Social Care
DSA	Deterministic sernsitivity analysis
EAG	External assessment group
EJP	Economically justifiable price
GP	General practice/practitioner
HRQoL	Health-related quality of life
IQR	Interquartile range
MAUDE	Manufacturer and User Facility Device Experience
MHRA	Medicines & Healthcare products Regulatory Agency
MCR	Medical Research Council
MTAC	Medical technologies advisory committee
MTEP	Medical Technologies Evaluation Programme
NHS	National Health Service
NIHR	National Institute for Health and Care Research
NICE	National Institute for Health and Care Excellence
NICE CG	NICE clinical guideline
NICE MTG	NICE medical technology guidance
NICE QS	NICE quality standard
OPAT	Outpatient parenteral antimicrobial therapy
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSA	Probabilistic sensitivity analysis
PSSRU	Personal Social Services Research Unit
QUORUM	Quality of Reporting of Meta-analyses
RCT	Randomised controlled trial
SD	Standard deviation
UK	United Kingdom
VAS	Visual analogue scale
VOI	Value of information
Vs	Versus
VW	Virtual ward

Executive summary

Quality and relevance of the clinical evidence

The EAG considered evidence from 2 randomised controlled trials (RCT), 1 cohort study and 16 case series studies that met or almost met the scope criteria. Overall, the evidence base was limited to identify a treatment effect due to the small quantity of reliable comparative evidence. The evidence that was identified (although limited) did not indicate VWs are likely to be unsafe for patients. The EAG had concerns regarding the generalisability of the identified evidence to the use of virtual ward platform technologies (VWs) for treating ARI in the UK NHS. This is due to heterogeneity in recruited patient populations, healthcare settings and countries of evaluation.

Quality and relevance of the economic evidence

The economic analyses conducted by the EAG was a simple-cost comparison model to indicate the potential benefit of VW platforms. The analysis suggests that the incorporation of VWs into the NHS has the potential to be cost saving, assuming there are no major safety concerns. However, the results are based on naïve and limited data with a high level of uncertainty, particularly due to the heterogeneity of different VW platforms and clinical pathways. Model inputs were primarily sourced though clinical elicitation, company provided detail and two previous economic studies.

Evidence gap analysis

Future evidence generation should focus on addressing the key components of the value proposition of VWs: reduction of resources and cost for comparable or improved patient safety. While RCTs are the gold standard for answering these research questions, VWs have already been implemented by the NHS and so RCTs are unlikely to be feasible, both for methodological and resource reasons. Comparative data would therefore best be obtained through prospective collection of relevant outcomes in controlled cohort studies or non-randomised controlled trials.

The EAG suggests that future evaluations should not look to treat all VW platforms as homogenous healthcare technologies. The evidence summarised throughout the

report details variations in VW components. It may not be feasible to evaluate all VWs individually. However, it may be worthwhile subgrouping platforms based on key components that may drive differences in resource and health outcomes, as determined by healthcare providers working with VWs in the NHS setting. Any future economic modelling should be designed to be flexible enough to be adapted to all VW platforms.

1 Decision problem

Table 1.1: Summary of decision problem

Decision problem	Scope	EAG comment
Population	• Adults (aged 16 or over) referred for hospital admission with ARI • Adults (age 16 or over) admitted to the hospital with ARI who are stable or improving but require ongoing monitoring • Treatment using VW based on the criteria listed under target conditions Subgroups: health inequalities, co-morbidities	No evidence found for subgroups
Intervention	• Technology-enabled VW platforms for treating adults with ARI, as an alternative to inpatient hospital care • Technologies would need to meet the eligibility criteria listed in section 2.3. A list of technologies provisionally identified are listed in the scope	No change
Comparator(s)	Inpatient hospital care, care in the community, or care in patient's usual place of residence without the use of a VW platform.	No evidence found for these comparators: care in the community, or care in patient's usual place of residence without the use of a VW platform.
Healthcare setting	Care from the patient's usual place of residence	No change
Outcomes	Intermediate measures: • Number of people in treatment and their respective demographics • Number of people in which treatment is escalated Clinical outcomes: • Length of hospital or VW stay • Rate of hospital- acquired infections • Mortality Operational and service level outcomes: • Number of admissions to a hospital or VW • Number of hospital readmissions • Emergency attendance or unplanned hospital admissions • Number of contacts with other care providers such as GP visits, 111 calls • Release of staff time for other caring responsibilities • Ease of use and acceptability of VW by healthcare professionals	All outcomes included. No evidence found for: time to ARI resolution, rate of hospital-acquired infections, antimicrobial use, and carer burden.

	• Patient adherence to scheduled reporting of clinical outcomes or use of wearable technologies • Waiting time for admission to or discharge from a VW • Antimicrobial use • Interoperability with electronic health records • Adverse events	
	Patient-reported outcomes: • Health-related quality of life • Patient and carer experience (including preferable place of care and carer strain) • Patient and carer acceptability	
	Costs will be considered from an NHS and Personal Social Services perspective. Costs for consideration may include: • Costs of the technologies • Cost of other resource use	No change
Time horizon	The time horizon for estimating clinical and cost effectiveness should be sufficiently long to reflect any differences in costs or outcomes between the technologies being compared. For people with acute respiratory infection a time horizon of 30 days is considered long enough to capture all outcomes related to the intervention and the condition. Sensitivity analysis will be undertaken to address uncertainties in the model parameters.	No change
Cost analysis	Costs will be considered from an NHS and Personal Social Services perspective. Costs for consideration may include: • Cost of technologies including device, subscription, and training/implementation costs • Hospital admission/readmission costs Cost of other resource use associated with managing patients with an ARI (e.g., staff time, GP/emergency attendance, home visits, 111 contacts).	No change
Subgroups	N/A	No subgroup analysis will be considered in the economic model. Although, identified potential subgroups for future evidence generation will be detailed as part of this EVA.

Abbreviations: ARI – acute respiratory infections, EVA – early value assessment, GP – general practitioner, NHS – National Health Service, VW – virtual ward.

2 Overview of the technology

Included in this early value assessment (EVA) are technology-enabled VW platforms for the treatment and monitoring of adults (16+) with acute respiratory infection (ARI). Moderate ARI is defined in Section 3. The VW platform can be for either people referred for hospital admission with an ARI, or admitted to the hospital with an ARI who are stable or improving but require ongoing monitoring. The objective of technology-enabled VWs is to allow people with moderate ARI who would otherwise be admitted to hospital to receive the same level of care at home (NHS, 2022b).

VWs should be technology-enabled to maximise the opportunity they offer for patients, carers and staff. Technology enablement means the management of patients via a digital platform. VW platforms considered as part of this EVA:

- Are intended for use by adults in their usual place of residence (where appropriate).
- Have been developed to support a step-up or step-down pathway for adults with acute respiratory infections.
- Should be device agnostic or integrate with medical devices that have CE or UKCA mark, if required.
- Should offer direct interoperability with core clinical systems (including data sharing).
- Are accessible across all staff that need to provide input (such as secondary care and community health).

Any technologies included must have regulatory approval or be actively working towards regulatory approval, specifically DTAC and CE or UKCA mark where required, and be available for use in the NHS.

2.1 *Included technologies*

In total, 20 technology-enabled VW platforms were identified as relevant to the assessment (**Error! Reference source not found.**). A common theme across company submissions is that they have stated their technology can be applied beyond just an ARI population, with many technologies used across

chronic obstructive pulmonary disease (COPD), heart failure, or other VW settings. Further details on each technology are detailed in the NICE Scope.

Table 2.1 Included Technologies

Technology (Company)	EAG summary
Accurx (Accurx)	This company did not provide information to NICE.
Andersen (Andersen)	This company did not provide information to NICE.
Baywater Healthcare (Baywater Healthcare)	This company did not provide information to NICE.
Camascope (Camascope)	This company did not provide information to NICE.
Clinitouch (Spirit Health)	**Clinician-facing features:** risk stratification, alarms based on sustained changes in patient vitals over time. **Patient-facing features:** currently used via a tablet provided, app released June 2023 that allows the patient to use Clinitouch on their personal mobile. Can text or video call through the app. **Additional & advanced features:** N/A. **Devices supported:** peripheral medical devices (e.g. pulse oximeter) and specified medical devices with Bluetooth automation can both be used. **Current NHS use:** [redacted]
Current Health (Current Health)	**Clinician-facing features:** clinical pathway specific alerts, risk stratification, alarms based on sustained changes in patient vitals over time. **Patient-facing features:** can use phone app or be loaned a tablet, information available in multiple languages, patient reminders, video calling. **Additional & advanced features:** team of nurses and allied health professionals are available to assist patient monitoring. **Devices supported:** company-provided and 3rd party wearable continuous monitor, peripheral, or intermittent medical devices.

Technology (Company)	EAG summary
	Current NHS use: [redacted]
Doccla Virtual Ward solution (Doccla)	**Clinician-facing features:** risk stratification, alarms based on sustained changes in patient vitals over time, detailed patient questionnaires and qualitative feedback. **Patient-facing features:** can use phone app or be loaned a tablet or smartphone, it is compliant with WCAG and will work with a wide range of accessibility aids, patient reminders, picture uploads, video calling. **Additional & advanced features:** CQC registered in-house clinicians to support implementation and operation of platform and patient support staff. **Devices supported:** peripheral medical devices (e.g. pulse oximeter) and specified medical devices with Bluetooth automation can both be used. **Current NHS use:** [redacted]
DOC@HOME (Docobo)	**Clinician-facing features**: alarms based on sustained changes in patient vitals over time, patient questionnaires and qualitative feedback, ability to push self-guided educational content, risk stratification. **Patient-facing features:** can use phone app or any web browser, patient reminders, text and video calls available through the app. **Additional & advanced features**: ECG trace capabilities **Devices supported:** peripheral medical devices (e.g. pulse oximeter) and specified medical devices with Bluetooth automation can both be used. **Current NHS use:** [redacted]
Doctaly Assist (BDM Medical)	This company did not provide information to NICE.

Technology (Company)	EAG summary
Dignio (Dignio)	This company did not provide information to NICE.
Feebris (Feebris)	**Clinician-facing features**: alarms based on clinically defined set of rules or requirements, patient questionnaires and qualitative feedback, risk stratification. **Patient-facing features:** can use phone app, patient reminders and prompts, text and video calls available through the app, multi-language support, adjustable display, offline functionality. **Additional & advanced features**: Machine learning algorithms to inform both patients or clinicians of potential issues with data quality and reliability (particularly to support with patient adherence of the technology).Wearable ECG with automated arrhythmia reports. **Devices supported:** peripheral medical devices (e.g. pulse oximeter) and specified medical devices with Bluetooth automation can both be used. Continuous monitoring devices also supported. **Current NHS use:** [redacted]
Health Call (Health Call Solutions)	This company did not provide information to NICE.
Huma (Huma Therapeutics)	**Clinician-facing features**: alarms based on sustained changes in patient vitals over time, patient questionnaires and qualitative feedback, risk stratification, adherence monitoring. **Patient-facing features:** app available on the patients personal or company-provided phone, patient reminders and prompts, photo and video calls available through the app, ability to push self-guided educational content, multi-language support and other digital accessibility features, **Additional & advanced features**: Mirror image technology so clinician can see the patient-facing side of the app if needed. **Devices supported:** peripheral medical devices (e.g. pulse oximeter) and specified medical devices with Bluetooth automation can both be used. **Current NHS use:** [redacted]
Inhealthcare Digital Health Platform (Inhealthcare)	**Clinician-facing features**: alarm-based alerts, patient questionnaires and qualitative feedback, risk stratification. **Patient-facing features:** access through a phone app, online portal or text and automated calls. Text and video calls available through the app to clinician, request for physical follow up. **Additional & advanced features**: N/A.

Technology (Company)	EAG summary
	Devices supported: peripheral medical devices (e.g. pulse oximeter) and specified medical devices with Bluetooth automation can both be used. **Current NHS use:** [redacted]
Lenus Health Platform (Lenus Health)	**Clinician-facing features**: No mention of current alarms or risk stratification, patient questionnaires and qualitative feedback included as well as general monitoring of patient vitals. **Patient-facing features:** access through a phone app. Text service available. **Additional & advanced features**: AI currently in development to stratify risk before acute event to identify patients for admission avoidance VW, and risk stratification based on physiology while in VW should a patient be at further risk of decline.. **Devices supported:** peripheral medical devices (e.g. pulse oximeter) and specified medical devices with Bluetooth automation can both be used. **Current NHS use:** [redacted]
Luscii (Luscii Healthtech)	**Clinician-facing features**: alarms and risk stratification included, patient questionnaires and qualitative feedback included as well as general monitoring of patient vitals, connect multi-team support across primary and secondary care. **Patient-facing features:** access through a phone app, text and video call service available. **Additional & advanced features**: currently in development of "virtual A&E waiting room" to more effectively triage and prioritise patient care. **Devices supported:** peripheral medical devices (e.g. pulse oximeter) and specified medical devices with Bluetooth automation can both be used. Also supports manual entries from devices. **Current NHS use:** [redacted]
MediBioSense (MediBioSense Ltd)	**Clinician-facing features:** alarms and risk stratification included, remote continuous monitoring, web-based data system. **Patient-facing features:** access through a phone app (4G sim can be provided), IoT (internet of things) "Infinity" box can be provided, wearable patch to monitor vitals. Some digital accessibility features such as IoT box or 4g sim provided, although limited description of other features. Video call service due to go live July 2023 **Additional & advanced features:** can detect heart arrhythmias and produce AI-driven ECG reports as part of monitoring. 24/7 non-clinical monitoring service. Data can be stored offline is connectivity is lost.

Technology (Company)	EAG summary
	NDevices supported: MediBioSense IoT “Infinity” box. VitalPatch. 3rd party . peripheral medical devices (e.g. pulse oximeter) and specified medical devices with Bluetooth automation can both be used. Also supports manual entries from devices. **Current NHS use:** currently [redacted]
PMD (PMD Solutions)	**Clinician-facing features:** Web-based data system, patient questionnaires, connect multi-team support across primary and secondary care, risk stratification. **Patient-facing features:** can use mobile phone app (can be provided on loan) or website from other device to access technology. text and video call available, Google translate used for multi-language purposes. **Additional & advanced features:** 24-hour phone support and additional nurse capacity provided by the company. **Devices supported:** vital signs monitor (pulse blood oxygen monitor, blood pressure cuff, infra-red thermometer), wearable RespiraSense respiratory rate monitor. [redacted]
Virtual Ward Technologies (Virtual Ward Technologies)	**Clinician-facing features**: track patient vitals and qualitative feedback, no mention of risk stratification or alerts. **Patient-facing features:** use phone app and smart watch (company can provide phone and smart watch if needed), support available via text. Highlight features of digital accessibility such as multi-language features. **Additional & advanced features**: [redacted] **Devices supported:** Smart watch, peripheral medical devices (e.g. pulse oximeter) and specified medical devices with Bluetooth automation can both be used. **Current NHS use** [redacted]

Technology (Company)	EAG summary
Whzan Blue Box (Solcom)	**Clinician-facing features:** alarms based on sustained changes in patient vitals over time, patient questionnaires and qualitative feedback, risk stratification, adherence monitoring. **Patient-facing features:** Can use mobile phone app, or through tablet or PC. Can use text or video calls. Digital accessibility is considered and Wzhan is WCAG 2.1 compliant. **Additional & advanced features:** Optional additional Bluetooth-enabled devices can be provided to support other VW pathways (1-12 lead ECG, stethoscope, POC blood testing etc.) Informal carer app to share patient data and receive alerts. **Devices supported:** Blue Box portable telehealth kit for manual intermittent monitoring (Bluetooth enabled thermometer, pulse oximeter and blood pressure monitor). Continuous monitoring also supported. [redacted]

Abbreviations: AI – artificial intelligence, API – Application Programming Interface, ARI – acute respiratory infections, ChoC – Cumbria Health on Call, COPD – chronic obstructive pulmonary disease, EMIS – Egton Medical Information Systems, GP – general practitioner, HUTH – Hull University Teaching Hospital NHS Trust, ICB– Integrated care board, NHS – National Health Service, TIE – Thematic Innovation Ecosystems, VW – virtual ward, WCAG - web content accessibility guidelines.

3 Clinical context

ARI VWs can support an alternative to hospital admission, early supported discharge from hospital, and a method of greater supported self-care. ARI VWs are not intended for chronic disease management. Patients with moderate severity ARI can be admitted to these platform technologies by three potential routes which are determined through clinical assessment and suitability. These potential routes include:

- Triage directly to a technology-enabled VW system.
- De-escalation from inpatient care (step-down care).
- Escalation from supported self-care (step-up care).

Severity of ARI is determined by a clinical review of the patient's symptoms, function, clinical observations, appropriate diagnostics, any severity scoring (such as CURB-65), and the overall clinical trajectory of the patient (NHS, 2022a). Hence, there is no neat definition of what is classified as a moderate ARI, but rather a combination of different factors and characteristics. Moderate ARI patients on a VW are supplied with necessary equipment and training to enable their care. Patients will receive this care until they become healthy enough to be discharged, or until they are escalated to hospital if required. VWs should be delivered by a multidisciplinary team. VWs are likely to be led by a named consultant practitioner or suitably trained general practitioner (GP) with relevant experience and training. VWs are likely to be subject to different constraints to that of inpatient care. For example, the number of telehealth appointments is likely to increase which will require more staff with relevant training in the clinical team. It is important for the operation of VWs to have clear lines of clinical responsibility and governance.

There is likely to be heterogeneity between each of the 3 methods of VW care delivery detailed above. For example, it may be the case that step-up care or direct triage would lead to a higher proportion of clinic check-ups than step-down care. This may be due to the fact that patients are entering the

”recovery” phase of their the infection in step-down care. Different types of monitoring may also impact the resource use. For instance, those on continuous monitoring may have less check-ups, but may generate more alerts when compared to those on intermittent monitoring. These uncertainties were corroborated with clinical experts.

As detailed in Section 1, there are two comparators for VW platforms:

- Inpatient hospital care.
- Care in the community or a patient’s usual place of residence without the use of a VW platform.

For the inpatient hospital care comparator, patients who need care are admitted to hospital either through a referral to the emergency department (ED) or same day emergency care (SDEC). The community care comparator involves patients being managed in the community in their usual place of residence. Exactly how community care is managed is likely to be heterogenous across different healthcare providers. However, the key aspect for this evaluation is the lack of a VW platform to support this community management. Patients may also be stepped up or stepped down from either one of these comparators to a VW platform during care.

When considering the introduction of VW platforms, it may be the case that a proportion of patients who are assessed as “mild severity” may also receive VW care. This is due to the platform’s availability to clinicians. Given VWs are likely not subject to the same capacity constraints as inpatient care, clinicians may be more clinically cautious and refer more people to VW care, even if they do not meet the defined population. Hence, despite the EVA of VWs being focused on patients with moderate ARI, the EAG notes there may be a spill over effect to milder populations. Potential implications of this may include inefficient care delivery, or delivering care to those who would otherwise not require it. Although not explicit to the population considered in this EVA, the EAG believes it is important clinical context to consider as part

of the evaluation. Further detail on the clinical context, as well as relevant NICE guidelines are outlined in the NICE Scope.

Special considerations, including issues related to equality

No further equality issues have been identified since the publishing of the Scope.

4 Clinical evidence selection

4.1 *Evidence search strategy and study selection*

Searches were conducted to identify studies of VW platform technologies for managing adults with acute respiratory infections. A single set of searches was conducted to identify both clinical and economic evidence. The searches were conducted in a range of resources including research published in the journal literature, conference abstracts and ongoing research. The searches were conducted in May 2023.

The EAG searches retrieved a total of 2,636 records after elimination of 856 duplicates. Titles and abstracts were sifted by one reviewer (the first 10% assessed by two reviewers independently) based on the intervention and population; due to the volume of COVID-19 literature, studies in broad groups of patients with COVID-19 that had not been selected based on severity of disease were excluded. A total of 201 full papers were retrieved and examined by one reviewer (the first 20% assessed by two reviewers) to select those meeting the scope definition of a VW platform, and meeting or almost meeting the population criteria. Company submissions were received for 13 of the 20 scoped technologies (Clinitouch (Spirit Health), Current Health (Current Health), Doccla Virtual Ward solution (Doccla), DOC@Home (Docobo), Feebris (Feebris), Huma remote patient moitoring / virtual ward software platform (Huma), Inhealthcare Digital Health Platform (Inhealthcare), Lenus COPD Support Service (Lenus), Luscii (Luscii Healthtech BV), RespiraSense HubTM (PMD), Virtual Ward Technologies (Virtual Ward Technologies), VitalPatch (MediBioSense) and Whzan Blue Box (Solcolm)). 100 documents

provided by company submissions were examined and 2 relevant published and 4 unpublished studies not identified by the EAG searches were added to full text screening. An additional 50 documents sent by 3 companies (Huma Therapeutics, Lenus, Luscii Healthtech, PMD and Virtual Ward Technologies) were received late and so were examined more briefly to identify essential information. From these, the EAG identified 3 studies in relevant populations that did not contain enough data to contribute substantively to the review, and so these studies were not included. Four additional relevant studies with substantial data were identified and included in the review.

Full details of the search methods are provided in Appendix A.

4.2 *Included and excluded studies*

A total of 29 studies (reported in 34 papers) were identified in the clinical review and are summarised in Table 4.1, of which 19 were considered to have best met the scope or were of highest relevance to the UK NHS setting and were prioritised for data extraction. The remaining 10 studies were not extracted further; they were deprioritised due to uncertainty about whether patients using the VW would otherwise have been hospitalised. This was either because the VW recruited symptomatic patients presenting to clinical care for diagnosis (all instances were in studies of COVID-19 patients), or because studies reported patients with milder disease in whom it was unclear whether patients were being discharged to facilitate step-down care, rather than discharged as normal with additional monitoring. One of the key value propositions of digital health technologies is that they facilitate care and increase accessibility of care. A consequence of this can be that they are used in populations with less acute need, and in the EAG's opinion including such data would be likely to give a more optimistic view of the evidence than might be the case for the scoped population.

A list of 173 studies excluded at full text is provided in (Appendix B).

Seven companies provided some additional, unpublished evidence for their technologies and this has been included and discussed where appropriate.

Table 4.1: Studies selected by the EAG as the evidence base

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
Step-up care				
Akhtaruzzaman 2022 (Akhtaruzzaman et al., 2022) **Location:** Bangladesh	**Design:** Case-series **Intervention:** Virtual Ward Technologies platform at home and during hospital stay using online apps/telephone. Access to pulse oximeter and virtual platform was given to enrolled patients. Record continually updated with flow of data from patient or healthcare professional to the medical team. **Comparator:** None AMBER	**Participants:** 20 confirmed COVID-19 cases presenting to a fever clinic. Median age 45 years, male to female ratio 1.8:1. 9 (45%) patients had co-morbidities like hypertension, DM, IHD, COPD/BA, CKD. **Setting:** Step-up – patients initially managed at home and HDU level beds were kept ready for admission, if and when necessary. AMBER	Duration of monitoring Escalation: Hospitalization or ICU admission Duration of hospital stay Mortality Patient satisfaction GREEN	Single arm study with a small sample size. Patients admitted following positive COVID test with no indication of severity of symptoms at recruitment.
Jakobsen 2015 (Jakobsen et al., 2015) **Location:** Denmark	**Design:** Randomised controlled trial **Intervention:** Unnamed telehealth monitoring platform using a videoconference system, webcam and touchscreen interface. Enrolled patients	**Participants:** 646 patients with severe to very severe COPD, who had an acute exacerbation and expected duration of hospitalisation of >2 days, were screened. 57 were randomised to telehealth or hospital treatment. Telehealth patients were	Waiting time for admission (time from hospital admission to study recruitment) Mortality Adverse events	Randomised controlled trial with small study population. Study was underpowered and type 2 statistical errors cannot be ruled out. No report that the VW platform included automated

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	given monitoring equipment and data transmitted by wireless broadband. Communication with hospital staff through videoconferencing or telephone AMBER **Comparator:** Standard hospital treatment GREEN	discharged home within 24 hours of hospital admission. Telehealth (n=29): age range <60 to >80 years, 18 (62.1%) female, 28 (96.6%) long-term oxygen user. 16 (55.2%) of patients were current smokers and 12 (41.4%) former smokers Hospital (n=28): age range <60 to >80 years, 17 (60.7%) female, 26 (92.9%) long-term oxygen user. 14 (50.0%) of patients were current smokers and 14 (50.0%) former smokers. **Setting:** Step-up - home monitoring instead of inpatient care (onboarding within 24 hours of hospital admission). AMBER	Escalation: treatment, hospitalisation Duration of stay Contacts with other care providers Health-related quality of life User satisfaction (health professional and patient) GREEN	alerts/warning system should vital signs deteriorate. Unclear whether it is available in the NHS setting but this study was included as it is the only RCT evidence in a fully relevant population.
Gordon 2020 (Gordon et al., 2020) **Location:** USA	**Design:** Case series **Intervention:** MyChart Care Companion app embedded in patient portal software (Epic Systems Inc., Verona, Wisconsin, US). Daily monitoring of symptoms, pulse oximetry (Masimo MightSat or the Sensogram Sensoscan) and temperature (Care Line Inc., oral) using app or	**Participants:** 225 enrolled on day 1 following hospital discharge for COVID-19 or an ambulatory virtual clinical assessment. 181 patients completed the programme (30 LTFU, 5 opted out, 9 other). Median age 54 (IQR 41-65). Females 114 (51%). Comorbidities NR. **Setting:** Step-up AMBER	Duration of stay Escalation: to ICU, to ED, hospitalization GREEN	Single arm audit data. Unclear if all patients would have required continued hospitalisation without the VW. Unclear if the technology met all specified VW criteria and whether it is available in the NHS setting. **Study not extracted due to intervention, population and NHS availability.**

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	telephone. Responses monitored by clinical team for escalation. **Comparator**: None **AMBER**			
Medina 2020 (Medina et al., 2020) **Location:** USA	**Design:** Case series **Intervention:** MyChart Care Companion app (patient-engagement platform available on smartphone and web-based platforms). Daily monitoring of symptoms, pulse oximetry and temperature using app or telephone. Responses monitored by clinical team for escalation. **Comparator**: None **AMBER**	**Participants:** 878 enrolled after hospital discharge for COVID-19 or an ambulatory virtual clinical assessment. 302 patients (34%) aged over 60, 8 (1%) aged under 18. Male:female ratio 1:1. 487 (55%) patients with >1 risk factor. **Setting:** Step-up **AMBER**	Duration of stay Escalation: to virtual provider, hospitalisation Time to escalation Mortality **GREEN**	Single arm audit data. Unclear if all patients would have required hospitalisation without the VW. Unclear if the technology met all specified VW criteria and whether it is available in the NHS setting. **Study not extracted due to intervention, population and NHS availability.**

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
Steimer 2021 (Steimer et al., 2021) **Location: USA** **Associated publication:** Steimer 2022 (Steimer et al., 2022)	**Design:** Case series **Intervention**: Locus Health platform (Locus Health, Charlottesville, USA) **Comparator**: None AMBER	**Participants:** 29 cancer outpatients tested for COVID-19 because of symptom onset, but were clinically stable, were offered the remote monitoring program. 26 were enrolled. Mean age 57 (range 30-88) years, 14 women. 22 (85%) patients were on active anticancer therapy. Primary disease was lung cancer in 3 patients **Setting:** Step-up AMBER	Duration of stay Compliance/engagement Escalation: hospitalisation, emergency department admission GREEN	Single arm pilot study. Patients were clinically stable and did not require hospitalisation. At baseline, only 12/26 patients were confirmed COVID-positive. Unclear if the technology met all specified VW criteria and whether it is available in the NHS setting. **Study not extracted due to population and NHS availability.**
Moes 2022. (Moes et al., 2022) **Location:** The Netherlands	**Design:** Prospective case series **Intervention:** SAFE@home Corona (including the Luscii platform) and automatic pulse oximeter (iHealth Air, iHealthlabs Wurope, Paris). Patients asked to monitor their oxygen saturation, temperature, heart rate and other symptoms. If a predefined threshold was reached, a notification was sent to the web-portal of	**Participants:** 28 pregnant women with PCR positive COVID-19 identified during hospital admission or public health test (November 2020 - November 2021). Median age 32 years, IQR (29-36). 20 (71.4%) patients Caucasian and 8 (28.6%) Middle-Eastern or North African background. **Setting:** Step-up AMBER	Duration of monitoring Admissions Adverse events Adherence Patient satisfaction, acceptability and experience Discontinuations GREEN	The population was for any pregnant patients with a positive COVID-19 diagnosis regardless or severity. Includes patients who otherwise would not need to be admitted to hospital.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	the hospital and incoming alarms were checked by clinical team. **Comparator:** None GREEN			
Step-down care				
Grutters 2021 (Grutters et al., 2021) Grutters 2020 (Grutters et al., 2020) **Location:** The Netherlands	**Design:** Retrospective Case series **Intervention:** Luscii (Amsterdam) healthcare monitoring platform using mobile app / telephone. Enrolled patients given pulse oximeter and asked to use thermometer and sent data on oximetry, respiratory symptoms and temperature via an app. Record continuously updated with data from patient or medical team **Comparator:** None GREEN	**Participants**: 320 severe COVID-19 patients discharged early to VW from hospital between April 2020 and May 2021 (includes pilot of 33 patients treated from April 8 and May 20, 2020). Mean age 56 (SD 12), 206 (64%) male. 196 (61%) patients discharged with oxygen therapy. **Setting:** Step-down – home monitoring after discharge GREEN	Mortality Duration of VW stay Reduction in hospital length of stay Treatment escalation Escalation: hospitalisation Contact with hospital or emergency services Patient satisfaction GREEN	Study reported in 2 published journal letters. Single arm pilot study with a small sample size and short term duration (between 8 April and 20 May 2020). Retrospective inclusion of patients.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
Kodama 2021 (Kodama et al., 2021) **Location:** USA	**Design:** Prospective Case series **Intervention:** Unnamed remote patient monitoring system from a 3rd party vendor, using a smartphone app and dashboard. Enrolled patients given a pulse oximeter and vital signs were monitored by the software, which a nurse accessed via a dashboard. Triggers for escalation based on biometric data. Communication with the medical team by telephone. **Comparator:** None AMBER	**Participants:** 50 adult COVID-19 patients discharged from hospital to home were enrolled. **Setting:** Step-down - home monitoring following discharge from hospital. GREEN	Escalation: emergency department admission; hospital admission Compliance Patient satisfaction GREEN	Single arm study with small sample size. Commercial system not named. Unclear if it met all specified VW criteria and was available to the NHS but the population aligns with the scope.
O'Malley 2022 (O'Malley et al., 2022) **Location:** UK	**Design:** Retrospective Case series **Intervention:** DOCCLA (DOCCLA, Sweden) VW. Patients provided with equipment to monitor temperature, heart rate, oxygen saturation, blood pressure using a mobile monitoring device. Medical	**Participants:** 50 COVID-19 patients of mixed severity discharged from hospital were referred to the VW and 43 admitted, of which 39 were from the respiratory ward. Suitable patients selected based the NHS standard operating procedure for a VW. Average age 58.7 (±12.9; range 27-89) years, 67.5% male. 31 (72%)	Waiting time for VW admission Duration of stay Hospital readmission GREEN	Preliminary retrospective study with small sample size COVID-19 patients of mixed severity, with separate treatment pathways and criteria accordingly for mild, moderate, severe and palliative.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	team monitored vital signs on a dashboard meeting twice a day to discuss. **Comparator:** None GREEN	were discharged with an ongoing oxygen requirement. **Setting:** Step-down - home monitoring following discharge from hospital GREEN		
Swift 2022 (Swift et al., 2022b) **Location:** UK **Associated records:** Swift 2021 pre-print Swift unpublished economic analysis	**Design:** Retrospective Case series **Intervention:** CliniTouch Vie (Spirit Digital, Spirit Health Group, Leicester, UK). Patients provided with a thermometer and pulse oximeter and entered vital signs using a smartphone, tablet or computer. Medical team monitored on a clinical dashboard with colours assigned according to daily risk and health status. **Comparator (economic analysis):** NHS data for patients discharged without VW immediately prior (no oxygen) or patients discharged routinely (oxygen)	**Participants (clinical study):** patients admitted with COVID-19 respiratory disease and discharged home into a VW. Data reported for the first 65 patients discharged to the VW. This is a subgroup of the economic analysis study. Mean age 56 (range 21.5-87.4) years, 39% female. **Participants (economic analysis):** 310 patients admitted with COVID-19 respiratory disease and discharged home into a VW to support oxygen weaning (n=31, 10%) or had not required oxygen and needed additional support to fully recover (n=279, 90%). Mean age 55.0 (median 56). 3.2% aged 80 or older. 40.6% female. No ethnicity, co-morbidity or socio-economic status information collected.	Mortality Adverse events Duration of stay Escalation: hospital readmission GREEN	Single arm study evaluating a digital service in terms of deployment and early clinical and economic outcomes. Admission criteria for VW excluded patients discharged on oxygen. For this study, if patients did not have access to a suitable device Spirit Digital provided a smartphone. Reports resource use and costs associated with the VW. Conflict of interest: 3 authors are employed by Spirit Health Group, who holds intellectual property rights for CliniTouch Vie.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	GREEN	**Setting:** Step-down - home monitoring following discharge from hospital GREEN		
van Goor 2021. (van Goor et al., 2021) **Location:** The Netherlands	**Design:** Randomised controlled trial **Intervention**: Luscii app (Luscii Healthtech BV) Smartphone application with an integrated questionnaire. Patients are given pulse oximeter and input data into the app for clinical team review at scheduled points. **Comparator:** Usual hospital care GREEN	**Participants:** 62 hospitalised COVID-19 patients randomised 1:1 to VW intervention group or control (hospital care as usual) group. Intervention (n=31): Mean age: 55.1: (SD: 13.2), 14 (45.1%) female, mean clinical frailty scale (CFS) score: 2.0 (SD: 0.6), median Charlson comorbidity index (CCI): 1 (IQR: 1-2). Control (n=31): Mean age: 55.4 (SD, 13.2), 13 (41.9%) female, CFS score 2.1 (SD, 1.3), median CCI 2 (IQR 0-3). **Setting:** Step-down GREEN	Hospital readmissions Mortality GREEN	Baseline patient characteristics of participants were relatively young with few comorbidities.
Walter 2023a (Walter et al., 2023)	**Design:** Retrospective case series (clinical data); Cohort study (econometric data)	**Participants:** All Tricare beneficiaries admitted to a military treatment facility with COVID-19 (7 December 2020-6 December 2021), either directly by their physician or via ED, and then	Mortality Duration of stay Treatment escalation	Retrospective differences-in-differences analysis comparing military treatment facilities with/without a virtual care program. Clinical

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
Location: USA	**Intervention:** Current Care Virtual Care platform (Current Health Inc.). FDA 510(k) cleared wearable device collected continous monitoring data (pulse rate, respiratory rate, oxygen saturation, temperature, motion, blood pressure, weight), and patients also provided with a tablet. Medical team monitored a web dashboard, receiving automated alerts when vital signs fell outside range. **Comparator (for econometric analysis only):** No virtual care GREEN	discharged home. 237 admitted to the VW (of 1838 patients admitted to a treatment facility with a VW program). Mean age 53 (SD 15.3) years, 100 (42%) female **Setting:** Step-down – home monitoring following discharge from military treatment facility. AMBER	Hospital readmission Patient adherence GREEN	outcomes only reported for patients in the virtual program. Mixed population with some recruited not requiring hospitalisation (deemed high risk of COVID exposure with risk of developing severe disease). No indication of severity of COVID-19. Patients were serving miltary personnel who are likely to have a different spectrum of treatment effect modifiers than the general population for ARI, and so this study has limited generalisability. Conflict of interest: 5 authors were paid employees of Current Health.
Wells 2022 **Location:** UK	**Design:** Prospective case series **Intervention:** VW platform (Current Health) used by Norfolk and Norwich University Hospitals Foundation Trust. Consisting of a kit given to patients (tablet plus	**Participants:** 852 patients admitted to the VW who would otherwise have been hospitalised. Patients admitted from 9 different specialties, of which 583 (68.4%) were COVID-19 patients and an additional 57 (6.7%) were respiratory patients. Median age 44 years (IQR 31-39). **Setting:** Step-down	Patient satisfaction Barriers to implementation GREEN	Mixed patients with approximately one third of the study population not ARI.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	wearable armband providing continuous, clinical grade measures of oxygen saturation, respiratory rate, pulse, motion and skin temperature) and a web dashboard. **Comparator:** None GREEN	AMBER		
Tan 2023 (Tan et al., 2023) **Location:** Singapore	**Design:** Prospective comparative study with unclear design (extracted as a case series) **Intervention:** DrCovid+, a digital enhancement of a COVID VW programme developed for Singapore General Hospital. Contains a remote monitoring app (Telegram Messenger) and dashboard. App collects body temperature, heart rate, oxygen level, and blood pressure. Enrolled patients given monitoring equipment and data transmitted by wireless broadband. Communication with hospital staff through	**Participants:** 400 COVID-19 patients referred to the VW who would otherwise be treated as hospital inpatients. Mean age of 51.45 (SD 15.1) years, 184 (46%) male (no other characteristics reported). **Setting**: Unclear if step-down only or mixed. GREEN	Escalation of care Mortality LOS Hospital bed-days saved Routine home visits (staff productivity and person days saved) GREEN	Unclear selection of comparison group (COVID VW without digital enhancement). VW platform and assisting technology developed for the local context (Singapore) so unlikely to be available to the NHS and results of limited generalisability in findings to the NHS. No comparison to standard care so effectively a single arm study, with a context that does not provide data useful for decision-making in the UK.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	videoconferencing (Zoom) or telephone. **Comparator:** COVID VW only (without DrCovid+) **AMBER**			
Marquez-Algaba 2022 (Marquez-Algaba et al., 2022) **Location:** Spain	**Design:** Randomised controlled trial **Intervention**: Farmalarm app **Comparator:** Standard follow-up in primary care **AMBER**	**Participants:** 150 COVID-19 patients discharged from hospital were randomised to follow-up using the Farmalarm app or regular primary care. Farmalarm (n=74): Median age 53.5 (IQR 46-59) years, 42 (56.8%) male. 72 (97.3%) had viral pneumonia, 45 (60.8%) had required oxygen in hospital, 9 (12.2%) required ICU admission. Primary care (n=76): Median age 53.5 (IQR 43.2-63) years, 43 (56.6%) male. 74 (97.4%) had viral pneumonia, 46 (60.5%) had required oxygen in hospital, 7 (9.2%) required ICU admission. **Setting:** Step-down - home monitoring following discharge from hospital. **AMBER**	Escalation: emergency department visits Patient satisfaction Health related quality of life **GREEN**	Excluded patients who had been discharged to health care facilities or medicalised hotels to complete the isolation period. Unclear whether patients being discharged early from hospital. Unclear if the technology met all specified VW criteria and whether it is available in the NHS setting. **Study not extracted due to population and NHS availability.**

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
Patel 2023 (Patel et al., 2023) **Location:** USA	**Design:** Prospective cohort study **Intervention:** Unnamed remote monitoring program based on a smartphone app and 'cloud'-based system. Patients given a wearable monitoring device and vital signs data were transmitted via the app to a 'cloud' for the virtual health centre to review. Communication with medical staff by telephone. AMBER **Comparator:** No remote monitoring RED	**Participants**: COVID-19 patients discharged from hospital with/without remote patient monitoring. Overall, 88.4-93.6% were inpatients and 6.4-11.6% were observation patients. Remote monitoring (n=203): Phase 1 (n=78), mean age 49 (SD 15) years, 38 (48.7%) female, 53 (67.9%) discharged on home oxygen; Phase 2 (n=125), mean age 55 (SD 14) years, 56 (44.8%) female, 89 (71.2%) discharged on home oxygen. No remote monitoring: Patient characteristics at baseline were not reported for the population analysed but for all patients discharged without remote monitoring. **Setting:** Step-down - home monitoring following discharge from hospital, unclear whether this was an early discharge. AMBER	Duration of stay Hospital readmission within 7, 14 and 30 days Escalation: return to the emergency department within 30 days GREEN	The focus of the feasibility study was to create infrastructure to enable the deployment of remote patient monitoring. Unclear whether the population was discharged early. Unclear if the technology met all specified VW criteria and whether it is available in the NHS setting. **Study not extracted due to population, comparator and NHS availability.**
Mixed				
Bircher 2022a (Bircher et al., 2022)	**Design:** Prospective case series	**Participants:** 228 pregnant women with confirmed COVID-19 from 3 settings: discharged from hospital (n NR), direct contact from patient in	Length of stay Escalation: hospitalisation or critical care Mortality	Single arm study in pregnant women only. Patients recruited from 3 avenues, of which only the

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
Location: UK	**Intervention:** Maternity VW (Current Health Ltd, Edinburgh, UK). Vital signs monitored using a finger pulse oximeter (intermittent) or the Current Health wearable (collecting continuous oxygen saturation, respiratory rate, pulse, motion, skin temperature) and could integrate with a blood pressure cuff, axillary temperature patch and spirometer. Vital signs monitored continuously by medical team. **Comparator:** None **GREEN**	community (n NR), positive swab from patient in community (n NR). Mean age of 30.6 (SD 5.6, range 16–44) years, and all stages of gestation. **Setting:** Mixed - home monitoring after discharge or as main care setting. **GREEN (subgroup)**	Patient satisfaction **GREEN**	discharged from hospital group (step-down care, number not reported) met the decision problem. The 3 groups are not reported separately.
Health Innovation Network 2021 a (Health Innovation Network, 2021) **Location**: UK	**Design:** Retrospective cohort study (control group not eligible so this evidence has been extracted as a case series) **Intervention:** Current Health hub (Current Health Ltd). Vital signs collected continuously using Current Health wearable (collecting continuous oxygen	**Participants:** adult patients residing in the Croydon area, or registered with a Croydon GP. Age ranged from 20-80+ years VW: 250 patient episodes treated in the VW for COVID-19 (161, 64%), long term conditions (65, 26%, not ARI) or emergency episode (24, 10%, including 19 for 'infection' not further specified).	Duration of stay on VW Post-discharge hospital readmission Escalation: hospitalisation, critical care admission Patient adherence Patient satisfaction Mortality	Mixed methods analysis of pre-existing quantitative data, three qualitative patient interviews, and three survey responses from health care staff. Mixed patient group, at least 26% not relevant to the scope. COVID patients also possibly mixed, some admitted with symptoms and not clarified if these would

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	saturation, respiratory rate, pulse, motion, skin temperature). and could integrate with a blood pressure cuff, axillary temperature patch and spirometer. Vital signs monitored continuously by medical team on a web dashboard, which sent automated alerts when vital signs fell outside range. GREEN **Comparator:** See, treat and discharge service provided by Rapid Response team (to patients with long term conditions) RED	Control: 33 patients with long term conditions seen by the Rapid Response team prior to the VW being implemented (July 2020) who could have been managed by telehealth. **Setting:** Mixed – home monitoring of patients recruited from various settings (in particular 31% Rapid Response, 26% hospital, 23% emergency department) AMBER	GREEN	otherwise have been hospitalised. Patient episodes analysed, not patients – 5 patients experienced more than 1 episode; this may affect the reliability of results. Ineligible comparator group (long term conditions, not ARI), so data treated as single arm.
Fox 2022 (Fox et al., 2022) **Location:** UK	**Design**: Prospective cohort study (extracted as a case series) **Intervention:** Covid VW comprising Huma remote patient monitoring solutions (Huma Therapeutics) and a pulse oximeter. Patient	**Participants:** 142 patients managed on the ward. 97 (67.8%) input data into the app and were considered "app users". Data available for 65 app users (2 declined to take part and 29 unreachable). Mean age 50.1 years (range not reported)	Readmission rates Adverse outcomes Mortality Patient satisfaction Barriers to use GREEN	All eligible patients were referred to the COVID VW by a doctor from the discharge team. Some patients used the app while others didn't. Study focuses on digital exclusion. Scoped intervention, company confirmed VW comprises a central platform

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	observations (heart rate, oxygen saturations, core temperature and self-reported symptoms) monitored via app. GREEN **Comparator (extracted as intervention**): Patients given the same VW information but did not use the app AMBER	45 (31.5%) did not input data or download the app and were considered non-app users. Data available for 23 non-app users (2 declined to take part, 14 unreachable, 1 did not receive oximeter, 1 not contactable). Mean age 55.8 (range 26–87) years. **Setting:** Mixed, patients monitored after discharge from ward (step-down) or emergency department (step-up). GREEN		and dashboard available to all relevant teams (Huma Therapeutics pers. comm.).
Kent Surrey Sussex Academic Health Science Network 2020. **Location:** UK	**Design:** Prospective cohort study **Intervention:** Medopad VW (Huma Therapeutics) comprising a mobile smartphone application where patients can upload their vital signs and metrics, and a web-based dashboard that enables clinicians to view patient metrics alongside their electronic patient records and set threshold ranges for each patient. GREEN	**Participants:** 318 patients with suspected or confirmed COVID-19 (recruited between 24th April 2020 and 31st July 2020) who are deemed appropriate for remote care, and offered remote monitoring via telephone calls or the Medopad application, depending on the patient's choice and clinical suitability. **Setting:** Step-down GREEN	Mortality Clinical capacity Cost Escalation: Hospital admissions User satisfaction (patient and clinicians) GREEN	Unclear how many patients in the VW would have required hospital admission without the VW. Data was not collected consistently across the 3 study sites or between the VW intervention group and the control group.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	Comparator: Telephone-based VW or historical hospital controls (early COVID pandemic) GREEN			
Inhealthcare 2022 (inhealthcare, 2022) **Location:** UK	**Design:** Prospective case-series **Intervention:** CovidOximetry@Home / COVID VW (Inhealthcare) used at Sussex Health and Care. GREEN	**Participants:** 2088 referrs to CO@Home. 27 referrals to the COVID VW. High-risk and clinically vulnerable patients, including those at risk of health inequalities through disability or deprivation, were prioritised for referral to CO@Home. Patient characteristics NR **Setting:** Possibly Mixed –step-down clearly reported (early and safe discharge), possibly step-up. GREEN	Duration of stay Escalation: hospitalisation Patient experience Mortality GREEN	The company clarified that Covid Oximetry@Home and COVID VW both provide the same service as full VWs (InHealthcare pers.comm). Limited data reported.
Ko 2023 (Ko et al., 2023) **Location:** Singapore	**Design:** Retrospective case series **Intervention**: COVID VW serving 3 acute hospitals (National University Hospital, Ng Teng Fong General Hospital, Alexandra Hospital). Patients provided with monitoring equipment	**Participants:** 238 COVID-19 patients referred to the VW: stable patients discharged from hospital COVID wards (58%) and patients admitted directly from primary care, outpatient clinics and emergency departments (42%). Mean age 62.5 (SD 19.1) years, 101 (42.4%) male, 67.9% (n NR) Chinese, 99 (41.6%) no comorbidity, 16 (6%)	Mortality Waiting time at admission Duration of stay Escalation: Hospitalisation Contacts with other care providers Release of staff time for other caring responsibilities Patient compliance	Single arm study with subgroup analysis according to reason for VW referral (early discharge or admission avoidance). Patients living in Singapore of predominantly Asian family background (Chinese, Malay, Indian), thus likely to impact generalisability to the UK.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	(thermometer, blood pressure machine, oximeter). Vital signs entered into an app form, and monitored by medical team via an online dashboard. Automated alerts when signs fell outside range. **Comparator:** None AMBER	pregnant, 86 (36.6%) not fully vaccinated. **Setting:** Mixed – home monitoring after discharge or for admission avoidance GREEN	Patient satisfaction GREEN	Unclear if the technology met all specified VW criteria. Unlikely to be available in the NHS setting as it was run by an integrated healthcare system through their existing Hospital-at-Home Programme.
Mid and South Essex ICS 2022 (Mid and South Essex ICS, 2022) **Location:** UK	**Design:** Prospective case series using mixed methods (quantitative, survey and meetings) **Intervention**: Whzan Blue Box (Solcolm) implemented by the NHS. 4 VWs, using the Blue Box kit. GREEN	**Participants:** 201 patients admitted to respiratory VW (April to June 2022). 114 (56.7%) aged 75 or older. 107 (53%) female. **Setting:** Mixed – step-up (n=75) and step-down care (n=100) reported. GREEN	Bed days saved Duration of stay (respiratory VW) Hospital acquired infection (all patients) Readmission at 30 days Decline in function GREEN	Single arm data from NHS setting. Scoped intervention with limited details on VW characteristics. Company submission verified that the product meets scope criteria.
Agarwal 2021 (Agarwal et al., 2021) **Location**: Canada	**Design:** Case series **Intervention:** COVIDCare@home (Women's College Hospital, University of Toronto,	**Participants:** 98 patients diagnosed with COVID-19 referred from COVID-19 assessment centres, an emergency department, acute care, or inpatient rehabilitation during the study period (08 April - 11 May 2020); 97 included.	COVIDCare@home program uptake Duration of stay Escalation: hospitalisations or emergency department visits	Preliminary analysis of feasibility and safety (first 5 weeks of program enrolment) Diagnosed patients had confirmed COVD-19 (positive test) or probable COVID-19 (Ontario Ministry of Health

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
	Mount Sinai Hospital, Toronto, Canada) **Comparator**: None AMBER	Median age 41 years (IQR 31-58), 65 (67%) female. 49 (51%) patients had ≥1 co-morbidity such as asthma, COPD, diabetes, hypertension; 5 (5%) were current smokers; and 4 (4%) were pregnant. 55 (57%) patients worked in health care settings and were at high risk for COVID infection. **Setting:** Mixed: home monitoring was main care setting AMBER	Mortality Consultations with other care services GREEN	definition); analysis included 5 with negative test result. Unclear if the technology met all specified VW criteria. Unlikely to be available in the NHS setting as it was developed by an ambulatory academic centre in Canada. **Study not extracted due to intervention and NHS availability.**
Ferrua 2022 (Ferrua et al., 2021) **Location:** France	**Design:** Case series **Intervention:** Monitoring by CAPRI-COVID platform using CAPRI App or telemonitoring **Comparator:** None AMBER	**Participants:** 130 cancer patients diagnosed with COVID-19 enrolled from outpatient department (including pre-surgery/treatment) or following hospitalisation for COVID-19; 129 included. CAPRI app (n=50): mean age 55 (SD 16) years, 29 (58.0%) female. Various tumour sites, 3 (6.0%) lung cancer. 5 (10.0%) patients did not have cancer. 25 (50.0%) patients were being treated. Telemonitoring (n=79): mean age 60 (SD 14) years, 47 (59.5%) female. Various tumour sites, 4 (5.1%) lung cancer. 3 (3.8%) patients did not have cancer. 36 (45.6%) patients were being treated.	Mortality Waiting time for admission Duration of stay Hospital readmission Escalation: hospitalisation, emergency department or ICU admission. Contact with emergency physician Patient adherence Patient satisfaction GREEN	Severity of symptoms likely mixed at enrolment given where testing conducted (outpatients and on hospitalisation). Unclear whether CAPRI-COVID was used for all patients with access either via CAPRI App or by mobile phone. Some outcomes reported for overall sample population; others specifically for CAPRI App only. Unclear if the technology met all specified VW criteria and whether it is available in the NHS setting.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
		Setting: Mixed: home monitoring after discharge or as main care setting **AMBER (subgroup)**		**Study not extracted due to intervention, population and NHS availability.**
Gios 2021 (Gios et al., 2021) **Location:** Italy	**Design:** Case series **Intervention:** TreCovid19 app (non-proprietary; Competence Centre on Digital Health of PAT initiative TS4.0, Italy) **Comparator**: None **AMBER**	**Participants:** 170 home-quarantined individuals were recruited: 107 (62.9%) patients with confirmed COVID-19 and 63 (37.1%) cohabitants/family members living with them volunteered for the study. COVID 19-positive patients: mean age 38.95 (SD14.98) years, 52 (48.6%) female **Setting:** Home monitoring of quarantined patients and individuals living with them. **AMBER**	Escalation: Hospitalisation **GREEN**	Participants were a limited and convenient sample of patients with relatively stable medical conditions. Unclear whether recruited patients would have been eligible for hospitalisation in the absence of VW. Unlikely to be available in the NHS setting as it was developed through an Italian initiative that involved multiple academic organisations and institutions. **Study not extracted due to population and NHS availability.**
Pecchioli 2022 (Pecchioli et al., 2022) **Location:** Italy	**Design:** Case series **Intervention:** BioBeat platform **Comparator**: None **AMBER**	**Participants:** 18 COVID-19 infected patients being treated at home or in hospital discharge. 10 patients discharged from hospital. Mean age 66.4 (SD 12.58, range 51-86) years.	Mortality **GREEN**	Conference abstract only reporting small study. Patients analysed according to whether treated at home or being discharged from hospital to home monitoring.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
		Setting: Mixed – monitoring of patients both at home and after hospital discharge. AMBER		Unclear if the technology met all specified VW criteria and whether it is available in the NHS setting. **Study not extracted due to unclear population and intervention and very limited reporting.**
van der Berg 2022 (van de Berg et al., 2022) **Location:** The Netherlands	**Design:** Prospective case series **Intervention:** Luscii platform (Luscii Healthtech BV) was installed on patients smartphone or tablet. Devices were programmed to monitor vital signs (oxygen saturation and respiratory rate) 4 times a day and if individual thresholds were reached this triggered an alert to the clinical team via the dashboard. GREEN	**Participants:** 278 patients with COVID-19 positive PCR recruited (November 2020 to February 2022) from the emergency department (ED, n=65) or following hospital admission (n=213). ED group: 65 patients. Mean age: 57.1 (SD: 12.4), 28 (43.1%) female. Admission group: 213 patients. Mean age: 59.9 (SD: 11.4), 82 (38.5%) female. **Setting:** Mixed - home monitoring after discharge or admission avoidance following ED assessment. GREEN	Duration of stay Patient satisfaction Physician contact Escalation: hospitalisation or rehospitalisation Mortality GREEN	Mixed care group, with step-up care and step-down care also reported separately. Unclear of COVID-19 severity amongst the VW patients.

Study name and location	Design and intervention(s)	Participants and setting	Outcomes	EAG comments
Yordanov 2020 (Yordanov et al., 2020b) **Location:** France	Design: Case series **Intervention**: Covidom. A patient web app (health status questionnaire) with regional control center that monitors and manages alerts. **Comparator**: None AMBER	**Participants:** 57,182 enrolled after hospital discharge for COVID-19 admission (n=5,493) or an ambulatory virtual clinical assessment (n=42,797). Post-discharge: mean age 48.5 (SD 17.2) years. 2818 (51.3%) female. 3315 (60.3%) 'high risk profile'. Following initial diagnosis: mean age 42.3 (SD 14.9) years. 26,488 (61.9%) female. 17,082 (39.9%) 'high risk profile'. **Setting:** Mixed – after an ED, GP or other clinical consultation COVID diagnosis, or at hospital discharge. Outcomes reported separately. AMBER	Duration of stay Escalation: hospitalisation or rehospitalisation Time to escalation Mortality GREEN	Single arm audit data. Unclear if all patients would have required hospitalisation without the VW. Unclear if the technology is available in the NHS setting. **Study not extracted due to population and NHS availability.**

Abbreviations: ARI – acute respiratory infection; BA – bronchial asthma; CKD – chronic kidney disease; COPD – chronic obstructive pulmonary disease; DM – diabetes mellitus; EAG – external assessment group; ED – emergency department; GP – general practitioner; HDU – high dependency unit; ICU – intensive care unit; IQR – inter-quartile range; LTFU – loss to follow-up; NHS – National Health Service; NR – not reported; PAT - autonomous province of Trento; RCT – randomised controlled trial; SD – standard deviation; UK – United Kingdom; USA – United States of America; VW – virtual ward.

Intervention, study participants and outcomes rated according to whether they met the scope fully (green), partially (amber) or not at all (red).

5 Clinical evidence review

5.1 *Overview of methodologies of all included studies*

Of all 29 included studies, 4 were comparative. Three were RCTs comparing VW to standard hospital treatment (Jakobsen 2015, van Goor 2021) or standard follow-up in primary care (Marquez-Algaba 2022). The fourth was a prospective cohort study comparing VW care with telephone-based VW care, and with historical in-patients (early COVID pandemic)(Kent Surrey Sussex Academic Health Science Network, 2020). The remaining 25 studies were observational in design and provided non-comparative data. One was a prospective cohort study comparing patients who used the VW to patients who chose not to access a VW (Fox 2022), so was extracted as a case series due to lack of a non-VW comparator. Two prospective cohort studies were extracted as case series due to ineligible comparators. The Health Innovation Network (2021) compared the Current Health platform (Current Health) to a preceding rapid response service used to treat patients with long-term conditions. A second prospective study compared a digital enhancement of COVID VW (DrCovid+) to outcomes produced by the VW alone. The remainder were case series, 5 of which were retrospective (Grutters 2020, Ko 2023, O'Malley 2022, Swift 2022, Walter 2023).

Ten case series and 1 RCT were not extracted further. The most common reasons for deprioritising studies were insufficient reporting of patient populations to determine if all identified study populations were fully aligned with the scope. In the step-down context there was a lack of clarity on whether recruited patients were being discharged **early** as per the scope, or being discharged **as usual** with the VW monitoring constituting additional care. This was the EAG's reason for not extracting a second RCT (Marquez-Algaba 2022) comparing VW ('Farmalarm') to standard primary care follow-up. In the step-up context the uncertainty was whether COVID patients being provided with monitoring would have ordinarily been hospitalised, or if monitoring was being provided as additional care for patients with milder disease.

Two RCTs (Jakobsen 2015, van Goor 2021), one prospective cohort study (Kent Surrey Sussex Academic Health Science Network, 2020) and 16 case series (5

retrospective) were prioritised for further extraction. The remainder of this report summarises these 19 prioritised studies.

Patients and settings

The evidence-base evaluated VWs to facilitate step-up care (1 RCT and 2 case series), step-down care (1 RCT and 7 case series) or both step-up and step-down care (1 cohort study and 7 case series), of which 1 study reported some outcomes for step-up and step-down subgroups (van der Berg 2022).

The EAG considered the population to partly meet the scope in 6 studies; 4 due to the inclusion of some patients who would not have been hospitalised, and were monitored due to a risk of deterioration rather than existing or recent risk (Health Innovation Network 2022, InHealthcare unpublished, Moes 2022, Walter 2023). A fourth because patients with various conditions were recruited (68.5% COVID) (Wells 2022). And a fifth because COVID patients were recruited from a fever clinic with no indication of severity (Akhtaruzzaman et al., 2022). All 6 were included because they evaluated a technology listed in the NICE Scope.

In 16 studies recruited patients were COVID admissions and/or people with COVID being provided with home monitoring. Two of these studies specifically recruited pregnant patients with COVID (Bircher 2022, Moes 2022). Two further studies evaluated different patient groups; Jakobsen et al. (2015) randomised severe to very severe COPD patients hospitalised for an acute exacerbation to step-up VW care (within the first 24 hours) or standard inpatient care. An evaluation of Whzan Blue Box (Solcom) by the Mid and South Essex ICS recruited patients with any acute respiratory condition to the respiratory VW for step-up or step-down care. An evaluation of Current Health by the Norfolk and Norwich University Hospitals recruited patients from 10 specialties, with two thirds admitted due to COVID or respiratory conditions (Wells 2022).

Data on patient comorbidities was poorly reported and often absent.

Interventions

Fifteen identified studies assessed 8 named technologies identified in the NICE Scope. The EAG considered all to fully meet the scope

Five were each evaluated by one case series (4 in the UK):

- CliniTouch Vie (Spirit Digital) (Swift et al., 2021, Swift et al., 2022b, Swift et al., 2022a)).
- CovidOximetry@Home/Covid VW (InHealthCare) (Inhealthcare 2022).
- DOCCLA Virtual Ward Solution (Doccla) (O'Malley 2022).
-
- Virtual Ward Technologies (Virtual Ward Technologies) evaluated in Bangladesh (Akhtaruzzaman 2022).
- Whzan Blue Box (Solcolm) (Mid and South Essex ICS 2022).

Three technologies were evaluated by multiple studies.

The Huma platform was evaluated in 2 studies, including a comparative UK study of mixed model care for COVID patients in 3 NHS sites using the Medopad platform, an early version of the technology (Kent Surrey Sussex Academic Health Science Network, 2020), and a UK cohort study comparing patients using Huma (Huma Therapeutics) as a COVID VW to those who chose not to use the technology (Fox 2022).

The Luscii platform (Luscii Healthtech) was evaluated in 4 studies conducted the Netherlands including 1 case series evaluating step-up care in pregnant women with COVID (Moes 2022), 1 RCT comparing step-down VW care to in-hospital care in COVID patients van Goor 2021) and 1 case series in step-down care (Grutters 2020); and 1 case series in both step-up and step-down care (van der Berg 2022).

The Current Health platform (Current Health) was evaluated in 4 studies in COVID patients or a mixture of patients: 2 UK studies positioning the technology for step-up and step-down care comprising a case series of pregnant women (Bircher 2022) and a cohort study comparing VW to rapid response care in a population of mixed relevance (Health Innovation Network 2022); 1 further UK study evaluating step-down care in a cohort of patients with various indications (Wells 2022); and 1 case series in the USA using the technology for step-down care (Walter 2023).

A further 4 studies reported on non-scoped technologies, 2 constituting unnamed and localised adaptations to the COVID crisis (Jakobsen 2015, Ko 2023), 1 reporting on the use of DrCovid+, also a localised non-UK adaptation (Tan 2023), and 1 citing

purchase of the platform from an unnamed third-party vendor (Kodama 2021). Since these localised adaptations were conducted abroad, the EAG suggests these technologies are unlikely to be available to the NHS. However, they were kept in the review in recognition that some scoped interventions are produced by international companies. Key characteristics of these interventions are provided in Table C 2.

All 19 studies evaluated technology enabled remote monitoring that allowed patients to input data or capture data automatically, allowed medical staff to monitor patients at home, and 14 included an alert system (Jakobsen 2015 did not report one). Company evidence submissions from all 8 named technologies reported direct interoperability with core clinical systems and capability to record multiple clinical measurements needed to remotely manage people with ARIs. By comparison none of the remaining 4 studies evaluating a non-scoped intervention reported on interoperability. It was often unclear whether these interventions aligned with the remaining scope criteria, particularly availability to the UK NHS and DTAC status.

5.2 *Critical appraisal of studies*

As specified by the NICE EVA interim guidance no formal risk of bias assessment was conducted.

Two included studies reported comparative data and both studies were limited by small patient numbers. The single RCT evaluated step-up care, and although comparative and randomised, this study under-recruited and did not achieve the sample size needed in the power calculation, raising the possibility of type 2 error in its findings (Jakobsen 2015). While comparative, the UK cohort study (Fox 2022) focused on evaluating digital exclusion and so in terms of the impact of VWs this study should be considered a case series, without comparison to an alternative treatment type or setting. The EAG therefore notes that this evidence base cannot provide a direct measure of the extent to which VW care impacts on patient health and operational outcomes, when used to replace standard inpatient care.

The EAG had several concerns regarding the generalisability of the 19 prioritised studies to the use of VWs to treat acute ARI in the UK NHS setting:

- VW admission criteria were not always clear, and affected studies may have relaxed access to remote monitoring to patients with milder disease than that required by the scope of this EVA.
- 16 studies were limited to patients with one type of ARI (COVID), which may not be fully generalisable to the likely future situation faced by the NHS in which multiple ARIs will need to be treated. Only one study (evaluating Whzan Blue Box) was performed in a respiratory VW (Mid and South Essex ICS 2022).
- 3 studies evaluated unnamed interventions in different countries, and a fourth a named intervention developed locally in Singapore and so availability of these interventions to the UK NHS setting is unclear.
- Insufficient reporting of patient comorbidities means it is difficult to fully establish the applicability of the evidence base to the decision problem.

5.3 *Results from the evidence base*

All clinical outcome data are presented in **Error! Reference source not found.** to Table C 6: Patient Reported Outcomes. Although company submissions provided some statements relating to the scope outcomes, none provided adequate information on the context of the data to enable extraction and/or incorporation into the results.

Clinical outcomes (Table C 1: Clinical Outcomes**Table C 1)**

Only 1 study (Whzan Blue Box, MSE ICS 2022) commented on hospital-acquired infections, noting that across both frailty and respiratory VWs patients were up to 5 times less likely to acquire an infection than acute inpatients. This data was based on a series of 1,258 patients receiving mixed care in the UK (of which 201 respiratory). Source or further description of the comparison data were not provided.

Operational outcomes (Table C 3, Table C 4, Table C 5)

The RCT reporting step-up care admitted 29 patients to the VW and 28 as inpatients (Jakobsen 2015), and 2 small case series reported on 20 (Akhtaruzzaman 2022) and 28 VW patients (Moes 2022).

The RCT reporting step-down care admitted 31 patients to the VW and 31 as inpatients (van Goor 2021), and step-down case series studies admitted between 33 and 852 patients. Mixed case series studies admitted between 27 (Inhealthcare 2022 (inhealthcare, 2022)) and [redacted] to VWs.

Interoperability with core clinical systems

All of the 8 scoped interventions with published evidence, were reported as being interoperable with a variety of record systems (Table C 3).

Waiting time for admission to or discharge from VW

Three studies reported time to VW admission, all giving disparate definitions preventing comparability: day of COVID illness at admission (Ko 2023), mean time from hospital admission to study recruitment (Jakobsen 2015) and average time from a COVID positive test result to VW admission (O'Malley 2022).

Length of stay

Data for this outcome were reported by the step-up RCT (Jakobsen 2015) and one step-up case series (Moes 2022), 6 step-down studies including 1 RCT (van Goor 2021) and 5 case series (Grutters 2021, O'Malley 2022, Swift 2022, Tan 2023, Walters 2023), and 6 mixed studies (Bircher 2022, Fox 2022, Health Innovation Network 2022, Inhealthcare 2022, Ko 2023, MSE ICS 2022. A final mixed study (van der Berg 2022) also reported data on some outcomes for step-up and step-down subgroups.

- For step-up care, the RCT reported shorter length of stay in patients admitted to VW step-up care which was not statistically significant when compared to inpatient length of stay (% patients staying >5 days: 17.2% vs 28.6%, p=0.48). The two small case series reported a mean of 10 (range 8-12) days (Akhtaruzzaman 2022) and a median of 6 (IQR 4 to 7) days (Moes 2022). Finally, van der Berg (N = 65 for the step-up subgroup) reported a median of 6.5 days (IQR 1-8) (range 1 to 27).
- For step-down care, the RCT reported a significant reduction of 1.6 days mean hospital stay following randomisation (VW = 0.7 (0.9) days; hospital = 2.3 (2.3) days, difference -1.6 days (95%CI -2.4 to -0.8), p<0.001). However, duration of total hospital stay (VW stay plus hospital stay) was

significantly greater in VW patients (mean 14.1 (SD 7.6) days vs. 10.0 (SD 7.0) days in hospital inpatients; difference 4.1 (95%CI 0.5 to 7.7), p = 0.028); while no difference was found in the number of hospital-free days in the 30 days following randomisation. Across the case series studies, mean length of VW stay varied from 3.9 days (IQR 2.4-6.7), Wells 2022) to 11.7 days (SD 5.4, Grutters 2021) across 4 studies (**parameter from Health Innovation Network, mean 9 days (range <1 to 49 days) was used to inform the model**). Van der Berg (N = 213 for the step-down subgroup) reported a median of 5 days (IQR 2-8), (range 0 to 81). One of the case series (Grutters 2021) reported a reduction in mean length of stay in the VW of 5.1 (SD 3.4) days (reported as "the sum of days receiving oxygen therapy at home plus one day, comparable to the hospitals ward protocol in which patients were discharged one day after the oxygen was tapered down"). This was compared to hospital ward patients, although the source of data and number of patients the comparison was based on was not reported. The reduction was greater in the subgroup requiring oxygen (196 patients: reduction 6.4 (SD 3.2) days). Swift et al. [redacted] Reporting for mixed care was also variable. Length of stay ranged from an average of 6 days to 12 days across 5 studies, while van der Berg did not report an overall value for the whole mixed population.

There is uncertain and conflicting evidence of a comparable difference in length of stay on a VW by comparison to a hospital ward.

Escalations and readmissions

- Escalations and readmissions were reported at varying timepoints, to varying locations (ED, hospital ward, critical care) and using interchangeable terminology making comparisons across studies difficult. This outcome was reported by the step-up RCT (Jakobsen 2015) and 2 case series (Akhtaruzzaman 2022 and Moes 2022), the step-down RCT and 7 case series (Grutters 2021, InHealthcare 2022, Kodama 2021, O'Malley 2022, Swift 2022, Tan 2023, Walters 2023), and 5 mixed studies (Bircher 2022, Fox 2022, Health Innovation Network 2022, Ko 2023, MSE ICS 2022). Van der Berg 2022 reported data on readmissions for the whole mixed population, as well as for the step-up and step-down subgroups.
- Testing the incidence of re-admission within 30, 90, and 180 days after discharge could not confirm noninferiority between patients treated for step-up VW care and inpatients (1 RCT, Jakobsen 2015). One small case series reported 10% of patients (3/20) were escalated and hospitalised (Akhtaruzzaman 2022), while the second (Moes 2022) reported that 14.8% (4/28) were treated with anticoagulant, oxygen and corticosteroid therapy, and 55.6% (15/28) had ≥1 time(s) contact with medical management centre, while 22.2% (6/28) of patients were readmitted to hospital. For the step-up subgroup of van der Berg 2022, 10/65 (reported as 15.9%) VW patients were readmitted to hospital.
- The step-down RCT reported 6.5% (2/31) patients readmitted to hospital in the virtual ward group, and 1/31 (3.2%) in the inpatient group. Of the case series studies, between 2% (InHealthcare 2022) and 11.4% (Walters 2023) of patients were readmitted to hospital from a VW for step-down care, across 5 studies. [redacted] (**this parameter was used to inform the model**). Grutters et al. (2021) found 12% (39/320) were escalated to ED assessment, and 7% (23/320) hospitalised. These figures vary substantially from those of the first 33 patients reported in a pilot study (Grutters 2020) which found 18.2% (6/33) were escalated to hospital assessment (none of which to the ED), of which 9.1% (3/33) were admitted. Kodama et al. (2021) reported a much higher rate of 26% of patients being escalated 29 times, although these led to 6% being admitted to the ED, of which 2% (1 patient) were admitted to a ward. For the step-down subgroup of van der Berg 2022, 14/213 (reported as 6.5%) VW patients were readmitted to hospital.
- Between 17.2% (Ko 2023) and 18.3% (Fox 2022) of patients were escalated whilst on a mixed VW (escalation reported only by these 2 studies). Between 6.6% (Bircher 2022) and 22% (Health Innovation

Network 2022) of VW patients were hospitalised during VW care; and between 0.4% (Bircher 2022) and 3.6% (van der Berg 2022) admitted to critical care. Within 28 to 30 days of discharge readmissions were between 7% (Health Innovation Network 2022) and 30% (MSE ICS 2022); although for the latter study it was not clear whether these were readmissions to hospital or to the VW.

- Fox et al. (2022) found no significant difference in the combined rate of readmission or death for non-app users compared to app users in a mixed care VW (26.7% vs. 18.5%, p=0.2).
- An NHSX report provided by Huma Therapeutics (Kent Surrey Sussex Academic Health Science Network, 2020) describing a service evaluation of Medopad (early version of Huma Platform, Huma Therapeutics) found lower rates of hospital admissions in VW users: at a Central London primary care NHS site 15% (10/67) of Medopad patients were admitted, compared to 26% (16/61) of patients receiving mixed model care using a telephone-based VW. In another London NHS site 16% (8/49) of Medopad patients were admitted, though no data were collected for the telephone-based VW group. In a Hertfordshire NHS secondary care site 28 day readmission rates were 5% (4/75) for patients cared by Medopad, compared to 8.4% (76/900) who used standard care in the baseline period of March to May 2020. Differences were not tested for statistical significance.

There is limited evidence of unknown significance and reliability suggesting possible differences in readmissions from VWs by comparison to care on a hospital ward or telephone-based VW.

Contacts with other care providers

Evidence was limited, some of which was unlikely to be generalisable to the UK NHS setting due to locations outside of the UK. Five studies reported on the types of additional contacts required by VW patients. The step-up RCT conducted in Denmark found that 25% (4/20) of respondents to the user satisfaction questionnaire had made an acute call outside of planned contacts (Jakobsen 2015), while one of the step-up case series (Moes 2022) reported that 25.9% (7/28) of patients made contact one or more times with a gynaecologist-in-training / supervisor (the population of this study comprised pregnant women). For the step-up subgroup of

van der Berg 2022 (N=65), a median of 9 (IQR 7 to 12, range 0 to 27) telephone contacts with a HCP were made.

The step-down RCT (van Goor 2021) found that 38.7% (12/31) of VW patients made a GP visit, compared with 64.5% (20/31) of hospital patients (a non-significant difference; p=0.035). 80.6% (25/31) VW patients made telephone contact with a GP, compared with 71% (22/31) of hospital patients (also a non-significant difference; p=0.371). For the step-down subgroup of van der Berg 2022 (N=213), a median of 9 (IQR 7 to 12, range 0 to 38) telephone contacts with a HCP were made.

One mixed study, Ko et al (2023) reported high rates of other contacts (after hours, pharmacist consults, or courier services: between 24.4% and 58.4% of patients) in a Singapore healthcare context.

The NHSX report (Kent Surrey Sussex Academic Health Science Network, 2020) found GP appointments from one site were an average of 0.23 per Medopad patient compared to 0.37 per telephone-based VW patient. Data for the same site reported fewer numbers of contacts per patient in Medopad patients (average 16.3 per patient, n=67) than telephone-based VW patients (average 21.5, n=61). Differences were not tested for significance.

Release of staff time for other caring responsibilities

Evidence was very limited, not comparative and unlikely to be generalisable to the UK NHS setting. Two studies provided some information for this outcome. One mixed study (Ko 2023) and one step-down study (Tan 2023), both conducted in Singapore, reported staff:patient ratios to be lower on a VW than required in an inpatient setting, Tan et al. estimating the same group of staff to be able to care for over 100 VW patients compared to 20 to 30 patients on a hospital ward.

Patient adherence

Evidence was very limited. Seven studies reported different aspects of patient adherence to the VW. Overall adherence in published evidence was at least 84% (Inhealthcare 2022, Ko 2023, Kodama 2021, Moes 2022, van der Berg 2022, Walter 2023) with the exception of a UK study focusing on evaluating digital exclusion,

which found 68.5% used the full digital capabilities of the Huma app, while 31.5% (45 patients) did not input data to the app or did not download it (Fox 2022). The NHSX report provided by Huma Therapeutics (Kent Surrey Sussex Academic Health Science Network, 2020) describing a service evaluation of Medopad (an early version of the Huma platform) found that between 42% and 74% of patients from two NHS sites in Northwest London did not download the app, with a further 5% (7 patients) from one site not using the app after download. The reasons were not captured in the report.

Five of the 6 studies reporting higher rates of adherence required study patients to be able to self-monitor and/or use digital equipment (Ko 2023, Kodama 2021, Moes 2022, van der Berg 2022, Walter 2023; not reported by InHealthcare 2022), suggesting this finding is likely to reflect the patient selection processes of those studies for patient admission to VWs. In total, 9 studies (Bircher 2022, Fox 2022, Grutters 2021, Moes 2022, O'Malley 2022, Swift 2022b, van der Berg 2022, Walter 2023, Wells 2022) evaluating 4 scoped interventions (Doccla VW, Clinitouch, Current Health, Luscii) excluded patients from studies who did not have access to digital equipment and/or could not use it correctly, of which two studies provided study patients with access to a suitable device (Swift 2022b, Wells 2022).Walter et al. (2023) further noted that patients less adherent to the wearable device (used for continuous monitoring) were more likely to require escalation to physical care.

Healthcare provider usability and acceptability

Evidence was limited with no evaluations of staff acceptability in non-tech enabled monitoring including inhospital care. The NHSX report of Medopad (Kent Surrey Sussex Academic Health Science Network, 2020) surveyed 10 staff members, with 56% finding patient data on the dashboard easy to review and an average acceptability score of 6.9/10. A second study measuring the healthcare provider's acceptability of VW care in a very small sample (8 nurses), and reported high staff confidence in using the VW (6/8, 75%) to monitor COPD patients with acute exacerbations (Jakobsen 2015). Two UK studies reported staff perceptions of the barriers and facilitators of VWs, citing knowledge of the impacts of VWs, coordination with other services and training staff as key factors for the success of VWs (Bircher

2022, Health Innovation Network 2021). One other UK study reported that staff acceptability was impaired due to the perception that VWs would create additional workload, with adequate training being another barrier (Wells 2022). In addition to improving the ability to work while shielding or isolating, staff also reported that it was easier to cover staff who were absent due to illness at short notice.

Patient reported outcomes (Table C6)

The evidence base was very limited in its reporting of patient reported outcomes and not comparative, with no quantitative data from a UK setting.

Health related quality of life (HRQoL)

One study measured HRQoL using standardised tools, finding that although CCG, SGRQ and EQ-5D scores improved over the first 30 days after discharge, there was no difference in improvement between patients randomised to the VW or hospital ward (Jakobsen 2015).

One UK study provided qualitative descriptions of functional decline, finding that VW patients demonstrated comparable decline (22%) or less decline (11%) than expected in an acute setting (MSE ICS 2022).

Patient and carer experience and acceptability

Four studies measuring patient acceptability in small subgroups (between 24 and 37 patients) all found user satisfaction to be high with patients giving largely positive feedback and finding the VW service to be user friendly (Bircher 2022, Grutters 2020, Health Innovation Network 2021, Moes 2022). Moes 2022 found that although patients stated a median of 4 (IQR 1 to 13) times that they wanted additional physician consult, the overall score for “recommending the platform” was 10/10.

Of the overall mixed population of van den Berg 2022 (58/65 VW patients completed the experience and satisfaction questionnaire), the majority were satisfied with home tele-monitoring, regarding the information (71%), and the instructions they had received (62-84%). Overall, the platform had a median score of 9/10 (IQR: 8 to 10), and 94% of patients agreed or largely agreed that they felt safe at home instead of in

the hospital. However a lower number (62.2%) reported receiving sufficient time and attention from the clinical team.

A larger case series surveyed 290 of 852 patients receiving step-down care and summarised responses qualitatively, without providing numbers or proportions. Many participants mentioned that being part of the VW increased their confidence with leaving hospital. Some patients expressed anxiety about being discharged from hospital, and a handful of patients expressed frustration with technical issues with the remote monitoring equipment (Wells 2022).

The digital exclusion evaluation of Huma (Fox 2022) reported several barriers to patients using the COVID VW, including IT skills (patients were not able to use the app themselves or had difficulties), language barriers (having the app available in languages other than English would have been helpful), inadequate demonstration or explanation of the pulse oximeter and/or the app in the hospital setting prior to discharge, and digital exclusion (some patients did not have a smartphone or internet connection to use the app).

No studies provided data to quantify carer burden or experience. The digital exclusion evaluation of Huma (Fox 2022) reported that a family member completed all app inputs for 11 of 97 app users, finding that for 71% of these patients this affected the decision to reattend hospital or not. Van der Berg 2022 reported that 67.5% of patients agreed or largely agreed that “Healthcare providers paid attention to my caregiver”.

6 Adverse events and clinical risk

Limited adverse event (AE) or patient safety data were reported in eligible studies identified by the EAG. In order to identify more information on patient safety, the EAG performed an additional targeted extraction of 4 studies that were deprioritised due to a concern that patients with mild ARI were recruited, who may have been less likely to have required hospital care ((Ferrua et al., 2021), (Marquez-Algaba et al., 2022), (Steimer et al., 2021), (Yordanov et al., 2020a). These studies were case series of 26 patients receiving step-up VW care (Stemier 2021), 150 patients receiving step-down care (Marquez-Algaba 2022) and 2 studies of 130 patients

(Ferrua 2021) and 57,182 patients (Yordanov 2020) in mixed care VWs; 3 were conducted in Europe and 1 in the US (Steimer 2021). The EAG cautions that because these populations are likely to reflect a milder disease spectrum, patient characteristics are also likely to differ from the target ARI population as set out in the scope. Consequently, any safety data could provide a more optimistic impression of safety than when used in patients who would require hospital assessment and/or care.

Three studies reported specific adverse events, none providing comparison to patients treated in any other settings than VW.

The RCT of step-up care reported 2 discontinuations of VW care (due to hyponatremia and severe dyspnea with nebuliser failure) compared to 1 discontinuation of inpatient care (difference not reported) (Jakobsen 2015). The RCT of step-down care reported no discontinuations, and 1 withdrawal from the intervention group following the patient learning they had been randomised to the VW (van Goor 2021).

Small numbers of discontinuations were reported by 3 case series as due to telehealth not being appropriate for the patient or hospital admission required within a day of VW admission (Health Innovation Network 2021), due to the patient experiencing few COVID-19 related complaints (Moes 2022) or at the patient's discretion (Swift 2022). Three deprioritised studies reported discontinuations: the large case series (mixed care) reported 8304 (17.2%) of 48,290 patients ended the VW early at their request (no more symptoms, no longer willing to answer questionnaires, or any other reason at the patient's discretion) (Yordanov 2020). This higher rate could reflect the milder disease severity of study patients assessed within the context of this large case series. The RCT comparing VW to standard follow-up in primary care for step-down care reported 6 of 74 VW patients discontinued due to loss of usual residence, language barrier and inability to answer the surveys, or technical issues related to the patient's smartphone or app usage (loss of password, inability to answer surveys, lack of mobile coverage) (Marquez-Algaba 2022). The small case series reported 1 withdrawal of patient consent after enrollment.

Adverse events in hospital were not reported, although it was noted that all comparator patients received inpatient care as planned. Clotting events affected 6% of the series of 65 COVID patients being treated with step-down care using CliniTouch Vie VW (Swift 2022a). A case series in pregnant women with COVID-19 reported 1 birth induced on maternal indication due to COVID-19 symptoms, and 1 emergency premature Caesarean Section performed due to the need to ventilate the mother in prone position because of severe COVID-19 pneumonia (Moes 2022). One deprioritised study reported adverse events, finding 5 of 26 patients developed worsened respiratory status with no consequence or hospitalisation (Steimer 2021).

Fifteen studies reported mortality, occurring either during VW care (Bircher 2022, Health Innovation Network 2021, Fox 2022, Grutters 2020, InHealthcare 2022, Jakobsen 2015, Kent Surrey Sussex Academic Health Science Network 2020, Ko 2023, Moes 2022, MSE ICS 2022, O'Malley 2022, Swift 2022, van der Berg 2022, Walter 2023) or following discharge (Health Innovation Network 2021, Jakobson 2015, Kent Surrey Sussex Academic Health Science Network 2020, van Goor 2021). Two of the 4 deprioritised studies reported mortality at unclear timepoints (Ferrua 2021, Yordanov 2020).

Mortality during VW care was generally low, although there was inconsistent evidence to determine whether there was a difference when compared to inpatient care or remote monitoring without a tech-enabled platform.

- The step-up RCT reported no deaths within 30 days of VW discharge in either arm (Jakobson 2015). Overall probability of survival at 2 years was also not statistically different (Kaplan-Meier method, 82.8% (95%CI: 69.0 to 6.5%) in the VW group vs. 59.2% (95%CI: 40.2 to 78.1%) in the control group; log-rank test, p=0.053. The 3 step-up case series reported mortality rates of 0% (Akhtaruzzaman 2022 and Moes 2022) and 3.1% (2/65 of which 1/65 was ARI related, van der Berg 2022) The company-provided NHSX report of the Medopad (Kent Surrey Sussex Academic Health Science Network, 2020) reported no mortality for 1 site in Hertfordshire in 75 patients using the Medopad VW or in 387 patients taking part in a telephone-based VW. This compared with a crude incidence of 2% (18/900) mortality in the same site during a baseline period of March to May 2020. For a primary care site in central london, none of the 67 patients using Medopad died compared to 13% (8/61

patients) using the telephone-based VW. Differences were not tested for statistical significance.

- Three step-down case series reported mortality rates of 0% (Grutters 2021, Walter 2023) and 3.8% (8/213, of which 6/213 were ARI related, van der Berg 2022). Swift et al. (2022) reported 1 death (1.5%) that was not considered related to the ARI (COVID). A UK study of 2,088 VW patients reported a mortality rate of less than 1%, noting that no reports had been associated with the safety or effectiveness of the service. O'Malley et al. (2022) reported no deaths occurring in the 4 patients readmitted to hospital.
- Six studies of mixed care reported mortality rates of between 0% (Bircher 2022) and 3.6% (van der Berg 2022). The highest rate was reported by a study measuring all-cause mortality in the Netherlands that also reported mortality for step-up and step-down subgroups (summarised above). The 2 deprioritised case series of mixed care reported mortality of 0.1% (39/48,290) by the end of the 1 year data capture period in a population of suspected or confirmed people with COVID receiving care as part of outpatient management after diagnosis, or at discharge from a COVID admission (Yordanov 2020); and 0 deaths attributable to COVID at an unknown timepoint (Ferrua 2021).
- Mortality during the 6 months following discharge from the step-up RCT occurred at similar rates for both the telehealth group (3/29, 10%) and the hospital group (4/28, 15%; statistical difference not reported) (Jakubson 2015). The step-down RCT reported no difference in deaths between the VW (0/31) and hospital care (1/31) groups within 30 days of discharge (van Goor 2021). The Health Innovation Network (2021) reported slightly lower rates within 7 days of discharge (7, 2%) and within a month of discharge (4%).

7 Evidence synthesis

Findings across studies are discussed narratively. It was not feasible to undertake meta-analysis within the constraints of this EVA.

This review included 29 studies, of which 19 were prioritised for extraction because they best met the scope or were of highest relevance to the UK NHS setting. The EAG did not identify any published evidence comparing VWs to care in the community or a patient's usual place of residence without the use of a VW platform. Two RCTs compared VWs to in-patient hospital care, and some additional comparative data from in hospital and telephone-based VWs were provided in the

NHSX service evaluation of Medopad, an earlier version of the Huma platform (Huma Therapeutics).

The current evidence base is limited by consisting of mainly single-arm data, with only 2 small RCTs of which one was powered adequately for the primary outcome, but likely underpowered for mortality. The other RCT was underpowered and recruited a population the EAG considered not fully relevant to the decision problem (COPD exacerbations). It found no significant differences. However, due to the underpowered analyses it is not possible to determine whether these findings are due to type 2 error or reflect genuine noninferiority. The NHSX report listed in a company submission provided comparison to both hospital care (historical cohort of early pandemic COVID patients) and telephone-based remote monitoring. Although more patients were included, numbers were small and no differences were examined using statistical significance tests so it remains unclear whether differences found could be explained by chance. In addition, the comparison to early pandemic hospital care may not be reliable since mortality and readmissions are likely to have been greater in this cohort who were infected with the then novel coronavirus. The remaining 16 included studies were case series, 3 conducted in less relevant patient populations, and of which 2 were conducted in the UK. The EAG therefore considers this evidence provides uncertain indications of the comparative performance of VWs.

Evidence that care provided through VWs is comparably safe to in-hospital care or remote monitoring was particularly limited. It is important to note that no evidence was identified which suggested VWs were not safe. Mortality on VWs was low, with very uncertain evidence that it might not differ to mortality in relevant comparator groups. However, this was based on 2 small RCTs that were likely to be underpowered to detect a clinically meaningful difference in mortality; and on the NHSX report, which found possible but uninvestigated similar mortality to telephone-based remote monitoring in a secondary care based VW, and lower mortality to telephone-based remote monitoring in a primary care based VW. Single arm evidence found mortality during admission varied between 0% and 3.6%, and at one month following discharge between 4% and 10%.

Evidence for difference in length of stay was reported in 3 studies and was uncertain and conflicting with no data from the UK. The underpowered step-up RCT found no difference, which cannot be interpreted. The step-down RCT (possibly adequately powered for length of stay) reported a significantly shorter index admission with VW patients able to go home on average 1.6 days earlier; however the total duration of care (VW plus hospital stay) was significantly greater for VW patients (mean 14.1 days (SD 7.6) vs mean 10.0 days (SD 7.0) for hospital comparators, p=0.028), and ultimately the initial reduction did not translate to any increase in the number of hospital-free days 1 month after admission between groups (28.4 vs. 26.7, p=0.112). A case series of 320 patients reported a mean reduction of 5.1 days stay for VW patients, although the source of comparator data was not provided. Single arm evidence provides average ranges of stay of 6 to 10 days for step-up care, 4 to 11.7 days for step-down care and 6 to 12 days for mixed care.

Evidence for differences in admission or readmission rates was reported in 3 studies and was limited and of unknown significance and reliability. In addition to the underpowered RCT that could not confirm noninferiority, the step-down RCT found a numeric reduction in readmissions to hospital (6.5% VW vs. 3.2% in-patients) but did not test this difference for significance. The NHSX report also suggested readmission rates from VW care could be lower than telephone-based remote monitoring (15% vs 26%) or standard in-hospital care delivered during the early pandemic (5% vs 8.4%); however, the reliability of the comparison to the early pandemic setting is uncertain and differences due to chance were not ruled out. Single arm evidence provides wide ranges for step-down care (2%-11.4%) and mixed care (6.6%-22%). Admissions to critical care were more poorly reported and varied between 0.4% and 7.7%.

Differences in hospital-acquired infection were almost absent from the evidence record. One single arm study claimed a considerable reduction (5 fold) in VW patients, but did not provide the source of nature of comparator data.

No evidence was identified for time to ARI resolution.

Evidence for the impact of VWs on patient contacts with other healthcare services was limited, of uncertain reliability and significance and based on small numbers.

The step-down RCT found no significant differences in the proportion of patients visiting a GP or telephoning a GP (VW vs hospitalised care). One study (NHSX report) reported comparative rates of patient contacts, finding a lower frequency of contact in VW patients. However, this difference was not investigated and could be due to chance.

Patients were reported to find VWs acceptable and gave positive feedback on their experience of care, with some evidence that patients would prefer receiving additional time and attention from clinical staff. However, these data were based on small subgroups of patients selected by unknown criteria, so it remains unknown how representative they are of all VW patients. Common barriers to using VWs include IT skills and digital accessibility, inadequate demonstration at onboarding and language barriers. Patient adherence to VWs was variable, with higher rates in studies selecting patients for their ability to use a digital interface (≥84% adhered) than the two studies that did not pre-select these patients (68.5% in one study and 26%-58% in a second).

Healthcare staff acceptability was variable, and again based on small numbers. Key barriers were inadequate training and perceptions that VWs would impact negatively on workload.

8 Economic evidence

8.1 *Economic evidence*

A single set of searches was conducted to identify both clinical and economic evidence (see Section 4.1). Search methods are reported in Appendix A and study selection criteria and excluded studies are summarised in Appendix D.

A total of 4 studies were included and summarised below and in Table 8.1.

No relevant economic evaluations assessing cost-effectiveness were identified. Two studies (including one UK study) were in step-down settings (1 retrospective difference in difference analysis and 1 cost minimisation analysis) and 2 UK studies (both self-published rapid evaluations) were in a setting providing a mix of step-up

and step-down care. All 4 studies report data indicating that implementing VW provides cost savings. The studies also report data on the impact of VW on resource utilisation and staffing, and were examined for usefulness to the conceptual model. Two of the studies identified contained data that was used to populate the model. Data from Health Innovation Network (2021) was used to inform some resource use parameters as well as the average length of stay on a VW. Some population characteristics, the hospital admission/readmission rate, and other resource use was sourced from Swift et al (2022). The integrity of the evidence from the 3 studies set within NHS settings is limited due to those studies being not peer reviewed so their findings should be considered with that caveat. The generalisability of evidence from the non-UK study should be carefully considered.

Table 8.1: Narrative summary of economic studies

Study ID and location	Title	Study type	Narrative summary
Mixed – step-up and step-down care			
Health Innovation Network 2021. UK (Health Innovation Network, 2021)	Rapid Evaluation of Croydon Virtual Ward	Rapid evaluation, published independently by the Health Innovation Network on behalf of NHSX.	A rapid evaluation of Current Health hub, a VW service provided by Croydon Health Services within the Rapid Response team managing up to 30 acutely unwell patients at one time using a small team of clinicians. The evaluation was for care between July 2020 and June 2021. It takes a mixed methods approach: quantitative data from 250 patients admitted to the ward; plus three interviews with patients; plus 3 survey responses from staff. Data from 33 control patients (that received care by the Rapid Response team prior to the implementation of the VW) were not considered within the NICE scope.. The evaluation claimed the ward delivered care appropriately in patients' homes for 65% of VW patients. More data collection and evaluation was recommended. Economic outcome data for VW patients around service impact on healthcare utilisation included: • The mean number of daily telephone contacts per patient was 1.27. • The mean number of daily home visits per patient was 0.32 Data were similar across all reasons for admission. The median number of daily physiological alarms per patient was 2.5, with the majority (80%) of patients having 4 or fewer. 4% of patients had an average of 10 or more alarms per day. The study has some limitations. It has not been peer reviewed, the control group was small and the interview and survey responses were captured in three people each. Patients had a broad range of conditions and comorbidities and were referred from multiple sources within the healthcare service and from the community.
Mid and South Essex Integrated Care System. UK (Mid and South Essex ICS, 2022)	Rapid Evaluation of Mid & South Essex ICS Virtual Hospital	Rapid evaluation, published independently by the Mid and South Essex	A rapid evaluation of two VWs (respiratory and frailty) using Whzan Blue Box (Solcolm) at Mid and South Essex Integrated Care System. The evaluation was for care between April and June 2022. It takes a mixed methods: quantitative data from 1,258 patients (across both wards), survey and meetings with staff. The evaluation claimed the technology enabled the VWs to deliver improved outcomes compared to traditional pathways.

		Integrated Care System.	Economic outcome data around service impact included: • The average saving per month for the respiratory ward was £100,347 (based on 1,612 bed days saved across the four months). Economic outcome data around staffing included: • The respiratory ward required 29.5 whole time equivalents (WTEs) of staff. The study is limited by not being peer reviewed. 84% of respiratory patients were aged 75 or older and the majority were female.
Step-down care			
Swift 2022. UK (Swift et al., 2022b)	An Economic Evaluation of a virtual Covid-19 Respiratory Ward in Leicester, Leicestershire, and Rutland	Economic evaluation, based on observational data (available as a pre-print).	A cost minimisation analysis evaluated the impact on NHS resource of a virtual Covid-19 respiratory ward using the Clinitouch digital tool (Spirit Health). For the analysis, it was assumed the VW would not result in different health outcomes or long-term health-related quality of life for patients. Observational data of 310 patients discharged from University Hospitals Leicester NHS Trust between November 2020 and November 2021 into the ward were analysed. Data are reported in 2020/2021 UK pounds. Economic outcome data around cost savings delivered by the service included: • In the base case, the VW delivered estimated net health care system savings across two key groups of patients (both P<.001): those who required oxygen weaning while within the VW and those not requiring oxygen therapy with less severe acute Covid disease. • The intervention was cost saving in all scenarios. The costs were between 9.7% and 15.2% of the estimated gross savings. • The mean gross savings per patient were £1,426 (net: £1,251) in the base case. This does not include savings associated with a potential reduction in re-admissions. The study approach is appropriate though has some limitations. The authors self-report two limitations of the analysis: the observational nature of the data and associated use of imputed indirect comparators for 90% of patients

			resulting in some uncertainty around the findings. Furthermore, at this time the publication is only available as a pre-print so is not peer reviewed.
Walter 2023. US (Walter et al., 2023)	Financial and Clinical Impact of Virtual Care During the COVID-19 Pandemic: Difference-in-Differences Analysis	Retrospective difference-in-difference analysis (published as an original journal paper).	A journal published financial and clinical evaluation of a virtual care platform (Current Care Virtual Care platform (Current Health Inc.)) using a wearable device monitored daily or twice daily. Patients were enrolled at 39 US military treatment facilities who were symptomatic for COVID-19 or at risk for severe disease from December 2020 to December 2021. The analysis was a retrospective differences-in-differences analysis of 237 patients. Economic outcome data around cost savings delivered by the service included: • An average saving of US $2,047 per patient for every COVID-19 patient admitted to a virtual care centre, due to a 12% lower length of stay. • The total cost of equipping, establishing, and staffing the virtual care program was estimated at US $3,816 per day. Economic outcome data around service impact on healthcare utilisation included: • Patients triggered a median of 1.6 (IQR: 0.7 to 5.2) physiological alarms per patient per day. The study has limitations. The setting is not in the UK, and is serving military patients. Also, there is no indication of severity of COVID-19. The authors noted the VW program was hampered by the inability to coordinate community services, to make home visits, and the lack of an integrated in-/outpatient electronic medical record system. A potential conflict of interest is that five authors were paid employees of Current Health.

Abbreviations: ICS – integrate care service; NHS – National Health Service; UK – United Kingdom; US – United States; WTE – whole time equivalents.

8.2 *Economic modelling*

The primary purpose of this analysis was to assess whether there is a plausible case for technology-enabled VW platforms to be a cost-saving intervention for adults with moderate ARI. The secondary aim of the analysis was to identify the value of future research, understand the likely key drivers of the results, and highlight the current evidence gaps.

A simple cost-comparison model was designed to capture the potential benefit that could be provided from these platforms. There is a wide heterogeneity in the clinical practice and operation of technology-enabled VW platforms. Hence, there is no expectation that one particular base case will perfectly represent each type of technology-enabled VW platform. However, the simple and flexible model can be used to highlight the potential impact or value, given the current limitations of the evidence. The EAG considers that the simple cost-comparison model can provide a good indication of the direction of the results, given the base case assumptions. Therefore, this should be useful for decision-makers to evaluate the potential of VW platforms. Section 9.1 describes a potential future model structure, once future evidence is collected, that would take steps to address the simple model's limitations.

8.2.1 Population

We consider adults (aged 16 or over) referred for hospital admission with ARI, or admitted to hospital with ARI who are stable or improving but require ongoing monitoring. This is in line with the NICE final scope. No specific subgroups were considered for the simple model, given the limited evidence currently available. Studies which may not explicitly capture only moderate ARIs were considered as potential evidence to populate the model, due to limited evidence. This included people with a range of COVID-19 (Covid) outcomes, or ARIs with no specific severity recorded (Swift et al., 2022b, Croydon Health Services, 2020).

8.2.2 Model structure

The model used by the EAG was a 30-day cost-comparison model which estimated resource use across the different treatment arms, and then applied costs to the different resource use. The 30-day time horizon was consistent with the NICE scope, which was considered by NICE to be sufficiently long to reflect any differences in costs and outcomes between the technologies compared. The logic and accuracy of this time horizon for capturing all outcomes is discussed in Sections 9 and 9.1. Utilities values were not captured within the model, given the short time horizon of 30 days and NICE's most common approach to evaluating medical devices. The model structure was limited by the amount and type of data available, and assumptions have been made in order to populate it. The model should therefore be seen as an initial exploration of the economic impact of technology-enabled VW platforms, and caution should be taken in interpreting the results.

The model compares technology-enabled VW platforms with:

- Inpatient hospital care (hospital inpatient).
- Care in the community or a patient's usual place of residence without the use of a VW platform (at home care).

The model captured different resource use that can be attributed to the three different treatment pathways. The modelling approach took the perspective of the NHS and personal social services perspective. The key aspects of the model was to capture the setup, staff time, appointments, and healthcare visits associated with technology-enabled VW platforms or at home care. Hospital costs were approximated using representative ARI costs from NHS cost collection data (NHS, 2023). This is because NHS cost collection codes are supposed to represent one episode of care (encompassing all potential resource use). Resource use captured were based on outcomes captured in existing clinical and economic evidence of VWs, as well as advice from clinical experts. This resource use may not be exhaustive, especially given the heterogeneity and variations in models of care associated with

technology-enabled VW platforms. The model diagram highlights the resource use captured and is presented in Figure 8.1.

Outcomes from the model included incremental cost between treatment arms, as well as a breakdown of the costs by type of resource use. Deterministic sensitivity analysis (DSA) was conducted using a tornado diagram, which highlights the key drivers of the model results. Economically justifiable price (EJP) was also calculated as part of deterministic sensitivity analysis. EJP should be interpreted with extreme caution, given that the results of the analysis are designed to be indicative. Therefore, the true value is likely to be very uncertain and heterogenous across VW platforms.

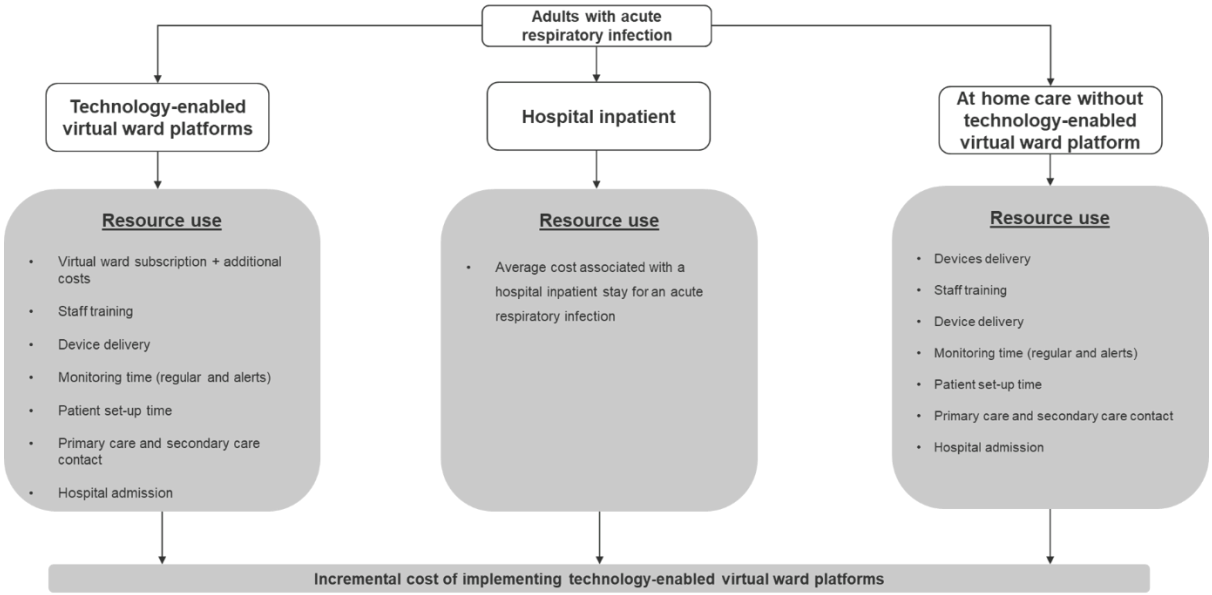
Other DSA included two-way sensitivity analysis on readmissions and home visits when comparing technology-enabled VW platforms with at home care. Probabilistic sensitivity analysis (PSA) was also conducted, with 1,000 simulations of the model run (enough for the results to stabilise) and the results averaged. Where possible, confidence intervals or appropriate ranges (based on clinical experts or ranges from company evidence) were used to inform parameter uncertainty. Where no appropriate ranges could be determined, a standard error of 20% of the mean was assumed to inform parameter uncertainty, providing this appeared to capture appropriate ranges. Although this is an arbitrary variation, the EAG notes this still allows for greater understanding of the key drivers. Future modelling should look to determine appropriate confidence intervals for these inputs.

Although a probabilistic base case is preferred for health technology assessment, given this is a very early and simple model, a deterministic base case is used. The results of the deterministic and probabilistic base case are very similar, so the EAG does not expect this to impact any outcomes of the analysis.

Value of information (VOI) analysis was not conducted as part of this analysis due to the very limited data associated with VWs. VOI would be most useful when better data has been collected at the point of decision making. Currently, many inputs are based on assumptions, while the model is

simplified into a less detailed structure. Therefore, it would not be useful to conduct VOI, given we do not have a clear idea of confidence interval ranges for specific parameters.

Figure 8.1: EAG simple cost-comparison model



8.2.3 Assumptions and limitations

A number of assumptions were required to produce a simple-cost comparison model using the available data. These assumptions may not completely reflect the actual patient pathway, especially given the heterogeneity across technology-enabled VW platforms. These assumptions are discussed in Table 8.2.

Table 8.2: Assumptions and limitations of the simple model

Assumption	Discussion
The model does not fully capture differences in safety between technology-enabled VW platforms, hospital inpatients and at home care.	There is currently insufficient evidence to determine if care will be improved or made worse by introducing technology-enabled VWs. Therefore, the model does not fully capture if adverse events increase or decrease, or the impact of this on costs and resource use. It is likely if adverse events increased with VWs, so would readmissions. Currently, there is a lack of comparative evidence for this outcome. Some safety evidence in milder populations was identified, although this is not applicable to the scope of this population. As a result, sensitivity analysis was conducted around relative differences on readmissions and the potential impact this may have on the results. Some other resource use such as home visits or outpatient appointments may overlap with adverse events, although there is a lack of clarity if these are driven by adverse events.
Medical devices associated with monitoring (either at home or in hospital) are not captured, other than continuous monitoring devices associated with technology-enabled VWs.	The exact makeup of the devices of patients with a moderate ARI is likely to be heterogenous. Currently, there is no published evidence which suggests the average make up of devices required to monitor a patient. Therefore, the exact make up of devices would have to be provided by estimations from clinical experts. Correspondence with clinical experts suggested the make-up of monitoring devices between at home care and technology-enabled VWs is likely to be the similar. Devices may differ while in hospital, although the cost per patient of these is expected to be very marginal, given the re-usability associated with these devices. Hence, we have assumed these are broadly equal across all three treatment pathways, except for continuous monitoring patches as part of VW platforms, which would be more costly. Similarly, over half of potential companies offer devices as part of their service. This provides an additional level of uncertainty to the true impact of VWs. If the company provided devices cost more than current supplies of monitoring devices, this will have a negative incremental impact on the results for technology-enabled VWs. Similarly, if the devices offered by VW platforms are cheaper than current supplies, this will make the incremental impact less costly than the model estimates. Appendix provides NHS supply chain (NHS) costs for common medical devices to add context to this caveat.
Implementation costs (and other VW platform costs) can be scaled down to a per person cost based on average VW sizes.	As part of the model, implementation and training costs are captured in the model. The range charged by respective companies for implementation varies between providers. This implementation cost will depend on the hospital characteristics of where the technology-enabled VW platform is being implemented. The modelling approach assumes this can be scaled using the annual number of people expected to be treated based on the average VW size. Similarly, respective companies and clinical experts report a large variation in ward sizes. Hence, there is likely to be large uncertainty surrounding the potential implementation costs (such as continuous monitoring). These upfront costs will be an important consideration

Assumption	Discussion
	for clinical commissioners, even if there are potential cost savings from implementing VW platforms.
The cost of managing ARIs in hospital can be adequately captured through a weighted average of NHS cost collection codes. Readmissions are also assumed to the same cost as the initial hospital stay (or episode of care).	NHS cost collection codes are supposed to be representative of an episode of care associated with a particular disease or intervention (NHS, 2023). Cost codes for unspecified ARIs are used as a weighted average for the expected hospital resource use for an ARI. This may vary depending on the type of ARI, while the cost codes may not accurately capture all aspects of a hospital inpatient stay. Readmissions may indicate that the severity of someone condition has worsened, so may incur greater costs than the first admission. The true resource use impact of readmissions is unknown and likely to be very heterogenous. Hence, the EAG assumed that this cost would be similar to the initial hospital stay.
Monitoring and checks for people using VW platforms or at home care are homogenous based on the available evidence.	As highlighted in correspondence with clinical experts, the level of engagement on a VW is very heterogenous, so will differ between different healthcare providers. The number of monitoring checks are based on a mixture of assumptions from clinical experts and published data. It is unlikely that this will fairly represent the practices of all VW platform providers and pathways, where very different approaches may be used. Similarly, the intensity of monitoring performed by clinicians or the ability of platforms to notify for at risk patients may be linked to other resource use. For example, greater frequency of monitoring may prevent more serious adverse events, although, this is not necessarily the case. Just because someone is reviewed more often, this may not lead to better results if the trajectory of the patient is not altered. .The need for further evidence generation around this assumption is detailed in Section 9.1.
The modelling approach assumes perfect scalability, meaning that the cost per patient is the very similar regardless of the size, infrastructure or clinical practice of each VW.	This is a simplifying assumption. In reality, a larger VW may result in differences in clinical practice and resource use or higher implementation costs. These would impact the overall results of the model, however, the bias of this assumption is unknown. This is because although larger VWs may differ in clinical practice and require higher implementation costs, they may lead to greater economies of scale for managing larger groups of patients.
The model does not fully capture the potential de-escalation that may occur from introducing VWs.	In some cases, VWs may offer a quicker route out of hospital, rather than a direct alternative to being in hospital. There is likely heterogeneity for when this de-escalation occurs, how long the VW monitoring platform lasts, or how long the patient would have remained in hospital in this case. Similarly, how monitoring practices differ for those de-escalated compared to those introduced straight onto a VW is unknown. The expectation is that this would be less than what is currently modelled. The impact of de-escalation for the simple model is discussed in **Error! Reference source not found.**.4, and is evaluated based on the estimated cost of the VW. This evidence gap and the impact for future modelling is detailed further in Section 9.1.

Abbreviations: ARI - acute respiratory infections, EVA – early value assessment, NHS-National Health Service VW – virtual ward.

8.2.4 Model inputs

Model inputs were primarily sourced via clinical correspondence and company evidence submissions. Inputs from a variety of VW providers have been used to populate the model. Where multiple companies had submitted data which could be used for the same input, an average was used between all company submissions. The range of these values were used as uncertainty intervals for sensitivity analyses.

Set-up inputs

Set-up parameters are detailed in Table 8.3. In the base case, the model compared hospital inpatient care with VW care. A population modifier input was included to account for patient who are escalated to a VW who would not otherwise have received hospital inpatient care. The modifier adjusts the cohort size to account for the expected growth in population. This input is set at 1 in the base case and is only applicable when comparing with hospital inpatient care. The impact of varying this parameter is highlighted in Section 8.3.

Resource use

Resource use inputs were predominantly sourced through clinical elicitation or via company submission documents submitted to NICE in May 2023. Where values reported by different companies varied, an average was used. VW resource use values are detailed in Table 8.4. The readmission rate was found to be [redacted]% and is detailed in Table 8.5. Only one previous study looked at comparative evidence of readmissions and found no difference across treatment arms. Due to a lack of other comparative data, it was assumed that the hospital readmission rate was the same for all arms of the model. No further resource use for hospital inpatients were captured as it was assumed that this would be included in the cost collection code. One study by Swift J

(Swift et al., 2022b). (unpublished) and one conducted by the Health Innovation Network (Health Innovation Network, 2021) compared the use of VWs to a control group who were treated in the community. The control groups in these studies were assumed to represent those receiving at home care. Other at home care inputs were assumed the same as VW values, based on clinical correspondence. Any other inputs were sourced by clinical correspondence via email, based on assumptions. At home care resource use inputs are detailed in Table 8.6.

Costs

Where possible, costs were sourced from the National Cost Collection for the NHS 2021/2022 (NHS, 2023) and the Personal Social Services Research Unit (PSSRU) Unit Costs of Health and Social Care 2021/2022 (Jones, 2023). Costs specific to providing VWs were sourced from company evidence submissions where available or based on assumptions. VW costs are detailed in Table 8.7. Other NHS costs are detailed in

Table 8.8.

Set-up parameters

Table 8.3: Model population inputs

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Population modifier	1.00	Assumption	This assumes that only those who would otherwise be in hospital with moderate ARI are admitted to VW.

Resource use parameters

Table 8.4: Virtual ward resource use inputs

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Average capacity of a VW	90 patients	Company provided – unpublished data	Multiple company data sources used to derive the average. Variation between 30 and 150 identified across company submissions.
Proportion of time that VW devices are in maintenance	31.0%	Clinical correspondence with virtual ward provider via email. May 2023	VW devices expected to be with the patient 21 days a month. Proportion derived from this.
Average length of stay on a VW	8.89 days	Health Innovation Network South London. 2021 (Health Innovation Network, 2021)	Rapid evaluation based on 250 patients admitted to a VW and 33 people in a control group receiving care from a rapid response group (assumed a proxy for at home care). Assumption that those who are admitted to a VW for 29+ days are discharged on day 29.
Nurse training time per VW	120 minutes	Company provided – unpublished data	

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Respiratory consultant training time per VW	120 minutes	Company provided – unpublished data	Training time provided as the total time for one session of training. It has been assumed that this will be attended by one nurse and one respiratory consultant.
Nurse time taken to train and set-up a patient	22.5 minutes	Company provided – unpublished data	Range of 15-30 minutes reported.
Proportion of patients on oxygen	10.0%	Swift, J. et al. 2022. (Unpublished version) (Swift et al., 2022b)	Study investigating the impact of VW on patients who are de-escalated from inpatient care. 31 of the 310 patients were discharged home for oxygen weaning.
Online dashboard checks by nurse per day	Patients on oxygen: 3.00 Patients not on oxygen: 1.00	Clinical correspondence with VW provider via email. May 2023	Nurse will check in on a patient 1-3 times a day. Assumption that this variation will reflect whether the patient is on oxygen or not.
Time taken to check by nurse	2 minutes	Assumption	Uncertain in the absence of evidence. Likely very heterogenous across different VW.
Online dashboard checks by respiratory consultant	Patients on oxygen: 1.00 Patients not on oxygen: 0.50	Assumption	Uncertain in the absence of evidence. Likely very heterogenous across different VW.
Time taken to check by respiratory consultant	1 minute	Assumption	Uncertain in the absence of evidence. Likely very heterogenous across different VW.
Number of alert-related notifications per stay	Patients on oxygen: 10.03 Patients not on oxygen: 3.37	Swift, J. et al. 2022. (Unpublished version) (Swift et al., 2022b)	Study investigating the impact of VW on patients who are de-escalated from inpatient care. 31 patients on oxygen - total number of alerts = 311 279 patients not on oxygen - total number of alerts = 1041

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Nurse time spent dealing with alerts	27.50 minutes	Swift, J. et al. 2022. (Unpublished version) (Swift et al., 2022b)	Study investigating the impact of VW on patients who are de-escalated from inpatient care.
Proportion of alerts requiring respiratory consultant input	50.0%	Assumption	Uncertain in the absence of evidence. Likely very heterogenous across different VW. Likely not 100% from clinical feedback as some scenarios could be dealt with by other staff members (for example, an equipment issue which logs an alert). A range of 25% to 75% used in sensitivity analysis.
Time taken to check by respiratory consultant	10.00 minutes	Assumption	Uncertain in the absence of evidence. Likely very heterogenous across different VW.
Reduction in NHS staff monitoring	Regular monitoring: 50.0%	Assumption	Uncertain in the absence of evidence. Likely very heterogenous across different VW.
	Alarm monitoring: 10.0%		
Home visits	1.62	Health Innovation Network South London. 2021 (Health Innovation Network, 2021)	Rapid evaluation based on 250 patients admitted to a VW and 33 people in a control group receiving care from a rapid response group (assumed a proxy for at home care).
Outpatient appointments	0.08		
Emergency attendances	0.24		
Hospital admissions	0.18		
111 contacts	0.49	Assumption	Assumed double the amount of 111 calls than emergency attendances.

Table 8.5: Hospital inpatient care inputs

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Proportion readmitted to hospital	[redacted]	Swift, J. et al. 2022. (Unpublished version) (Swift et al., 2022b)	Proportion of readmissions for patients with Covid-19. Assumption that this is applicable for all ARI re-admissions.

Table 8.6: At home care resource use inputs

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Length of stay	11.09 days	Swift, J. et al. 2022. (Unpublished version) (Swift et al., 2022b)	2.2 days reduction in length of stay with VW. Added to the length of stay on a VW. Value for the first 64 patients not on oxygen who were discharged from VW.
Number of calls by nurse per day	0.35	Health Innovation Network South London. 2021 (Health Innovation Network, 2021)	0.47 phone calls per day to the control group Assumption that 75% of these will be carried out by a nurse.
Time taken to call by nurse	27.5 minutes	Swift, J. et al. 2022. (Unpublished version) (Swift et al., 2022b)	Staff time per consultation assumed equal for at home and VW care and does not vary between nurse and consultant.
Number of calls by respiratory consultant per day	0.12	Health Innovation Network South London. 2021 (Health Innovation Network, 2021)	0.47 phone calls per day to the control group. Assumption that 25% of these will be carried out by a respiratory consultant.
Time taken to call by respiratory consultant	27.5 minutes	Swift, J. et al. 2022. (Unpublished version) (Swift et al., 2022b)	Staff time per consultation assumed equal for at home and VW care and does not vary between nurse and consultant.
Manual vital checks by nurse per day	Patent on oxygen: 3.00	Clinical correspondence with VW provider via email. May 2023	Nurse will check in on a patient 1-3 times a day. Assumption that this variation will reflect whether the patient is on oxygen or not.

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
	Patients not on oxygen: 1.00		Values reported for VW patients but assumed the same for at home care.
Time taken to check by nurse	5 minutes	Assumption	Assumed higher than VW platforms due to lack of interoperability.
Manual vital checks by respiratory consultant per day	Patients on oxygen: 1.00	Assumption	Assumed higher than VW platforms due to lack of interoperability.
	Patients not on oxygen: 0.50		
Time taken to check by respiratory consultant	1 minute	Assumption	Assumed higher than VW platforms due to lack of interoperability.
Home visits	2.55	Health Innovation Network South London. 2021 (Health Innovation Network, 2021)	Control group being cared for by a rapid response group used as a proxy for at home care.
Outpatient appointments	0.21		
Emergency attendances	0.24		
Hospital admissions	0.18		
111 contacts	0.48	Assumption	Assumed double the number of 111 calls as emergency attendances.

Cost input parameters

Table 8.7: Virtual ward company cost inputs

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Annual subscription/license cost per person	[redacted]	Company provided – unpublished data	[redacted] Average value calculated from reported data provided by three VW providers. Input included in base case.
Tablet/continuous monitoring device cost	[redacted]	Company provided – unpublished data	[redacted]Conservative assumption that a new device will need to be purchased every year for each VW bed This is then scaled to how many people could use this device in a year. Assuming 28.34, this cost is then calculated at £42.02 per person. Continuous monitoring devices captured due to the higher cost compared to other devices (the highest cost option of devices). Continuous monitoring often comes with a patch which is provided as part of the device. Cleaning and maintenance of this device is not included in this cost and included separately. Often, maintenance and cleaning will be done in bulk for many devices at once, so is included as a separate cost. Input included in base case.
Regular monitoring cost (if supported out by VW company)	[redacted]	Company provided – unpublished data	"View ECG basic" service cost used as a proxy for regular monitoring of a patient from one company provider. Input not included in base case
Alarm monitoring cost (if supported out by VW company)	[redacted]	Company provided – unpublished data	"View ECG alert" service cost used as a proxy for regular monitoring of a patient from one company provider. Input not included in base case
Patient set up cost (if supported by VW company)	[redacted]	Company provided – unpublished data	[redacted]maintaining patient set up across the whole ward. This input was provided by one company.

			This is then divided by the average capacity to calculate a cost per person (£9.44). Input included in base case.
Device/equipment delivery cost	[redacted]	Company provided – unpublished data	[redacted] Assumed 25% accounts for delivery cost, and 75% accounts for maintenance. Costs scaled to per bed in the VW. Cost per patient can then be calculated based on the cost per bed provided. Inputs not included in base case.
Device cleaning and maintenance	[redacted]	Company provided – unpublished data	
VW platform training and implementation cost	[redacted]	Company provided – unpublished data	[redacted] Cost provided by one company. This can then be scaled to a cost per patient based on the number of patients on a VW over the course of a year. Input included in base case.

Table 8.8: NHS cost inputs

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Band 8a nurse cost per working hour	£72.00	PSSRU Unit Costs of Health and Social Care. (Jones, 2023)	Based on a band 8 hospital nurse. Band 8 selected based on clinical feedback.
Respiratory consultant cost per working hour	£143.00	PSSRU Unit Costs of Health and Social Care. (Jones, 2023)	Based on a hospital consultant.
Device collection and delivery	[redacted]	Company provided – unpublished data	Assumption that this is the same as if a VW company was to provide it. Converted to per patient cost
Device cleaning and maintenance	[redacted]	Company provided – unpublished data	Assumption that this is the same as if a VW company was to provide it. Converted to per patient cost
Home visit	£110.07	National Cost Collection for the NHS 2021/2022. (NHS, 2023)	Community health services. Specialist Nursing, Asthma and Respiratory Nursing/Liaison, Adult, Face to face. Currency code N08AF.

Variable	Value	Source	EAG commentary on availability, quality, reliability and relevance of the source/s
Outpatient appointment	£185.07	National Cost Collection for the NHS 2021/2022. (NHS, 2023)	Outpatient appointments. Respiratory Medicine Service. Consultant and non-consultant led. Service code 340
Emergency attendance	£157.62	National Cost Collection for the NHS 2021/2022. (NHS, 2023)	Outpatient care. Service code 180.Weighted average of all consultant-led emergency medicines services
111 contact	£11.40	Turner, J. et al. (Turner et al., 2021)	Unit cost of a call to NHS 111. Original source marked confidential. Inflated to current prices using PSSRU (Jones and J., 2022).
Hospital admission for acute respiratory infection	£1733.77	National Cost Collection for the NHS 2021/2022. (NHS, 2023)	Unspecified Acute Respiratory Infection. Weighted average of currency codes DZ22N, DZ2NNP, DZ22L for non-elective, long stay and short stay only.
Hospital excess bed day cost for acute respiratory infection	£315.80	National Cost Collection for the NHS 2017/2018	Used older National Cost Collection due to newer versions not reporting excess bed day costs. Costs inflated to current prices using PSSRU (Jones and J., 2022). This cost is only used as part of scenario analysis.

8.3 *Results from the economic modelling*

Exploratory results are presented from the simple cost-comparison model in Sections 8.3.1 and 8.3.2. Due to the heterogeneity in clinical practices and types of VW platforms, the base case is designed to represent an indicative average, rather than a definitive representation of every VW platform.

8.3.1 Hospital inpatient care

Under the base case assumptions, the deterministic base case model results suggest that VWs are potentially cost saving compared with hospital inpatient care. The cost breakdown in Table 8.10 suggests that despite the various costs potentially associated with setting up and delivering a VW, it is unlikely to cost more than hospital inpatient care.

Table 8.9: Deterministic base case results - hospital inpatient

	Virtual wards	Hospital inpatient	Incremental
Cost per patient	£912	£1,784	-£872

Table 8.10: Cost breakdown per patient

	Virtual wards	Hospital inpatient	Incremental
VW platform costs*	£91	£0	£91
Home delivery and maintenance (provided by NHS)	£19	£0	£19
Home monitoring costs	£233	£0	£233
Home visits	£178	£0	£178
Outpatient appointments	£16	£0	£16
Emergency attendance	£38	£0	£38
Hospital admission or readmission	£305	£1,784	-£1,479
111 contact	£6	£0	£6
Home set up costs	£27	£0	£27
Total	**£912**	**£1,784**	**-£872**

*Includes license, continuous monitoring, patient and set up and implementation costs.

8.3.1.1 Scenario analyses

Given the wide range of potential variation in VWs, a range of scenarios were run. These are described and reported in Table 8.11. When comparing VWs with hospital inpatient care, no scenario changed the direction of the results.

Table 8.11: Scenario analyses for hospital inpatient comparator

Scenario analyses description	EAG base case description	Incremental cost
EAG base case.		-£872
All potential VW costs included and no impact on NHS staff time for monitoring.	Only the subscription/license costs, tablet and continuous monitoring and set up costs are included.	-£794
Population modifier applied to VW of 1.5, meaning a 50% increase in patients that are using VW, that would not otherwise be hospitalised. This is due to the availability of VW, meaning patients are triage beyond the scoped population.	No adjustment in the VW population.	-£415
Only subscription costs are included for the VW.	Only the subscription/license costs, tablet and continuous monitoring and set up costs are included.	-£923
Implementation costs are increased to £500,000 for the VW to reflect heterogeneity of implementation resource use.	Implementation costs are set at £15,000, only reflecting the company charges.	-£740

In order for there to be no estimated incremental cost reduction from implementing VW, the population modifier would have to be 1.96. Hence, this indicates that if for every 1 person that would be admitted to hospital, 2 people would be admitted to VW due to population creep (admitting milder patients who don't require monitoring), VW may no longer be cost saving.

Similarly, in order for there to be no estimated incremental cost reduction from implementing VW, readmissions would have to be an average difference of 0.65 per person when compared with hospital admissions.

The same scenarios are conducted in Table 8.12: Scenario analyses (equivalent cost in hospital bed days)Table 8.12, however, expressing the results in terms of the equivalent hospital bed day costs saved. For example, in the base case, the cost saving of a VW with an average length of stay of

8.89 days is equivalent to 2.89 hospital bed days. This would indicate that if a person were to leave hospital 3 days earlier and stay in the VW for just under 9 days, this would result in cost-savings. The scenario with the largest impact on the results is the population modifier. This indicates that if for every person that would have been admitted to hospital, 1.5 people are admitted to a VW (admitting milder patients), then 8.89 days on a VW would be equivalent to 4.33 hospital bed days, in terms of cost.

Table 8.12: Scenario analyses (equivalent cost in hospital bed days)

Scenario analyses description	EAG base case description	Equivalence number of hospital bed days for cost neutrality
EAG base case.	A VW with an average length of stay of 8.89 days	2.89
All potential VW costs included and no impact on NHS staff time for monitoring.	Only the subscription/license costs, tablet and continuous monitoring and set up costs are included.	3.13
Population modifier applied to VW of 1.5, meaning a 50% increase in patients that are using VW, that would not otherwise be hospitalised. This is due to the availability of VW, meaning patients are triage beyond the scoped population.	No adjustment in the VW population.	4.33
Only subscription costs are included for the VW.	Only the subscription/license costs, tablet and continuous monitoring and set up costs are included.	2.73
Implementation costs are increased to £500,000 for the VW to reflect heterogeneity of implementation resource use.	Implementation costs are set at £15,000, only reflecting the company charges.	3.30

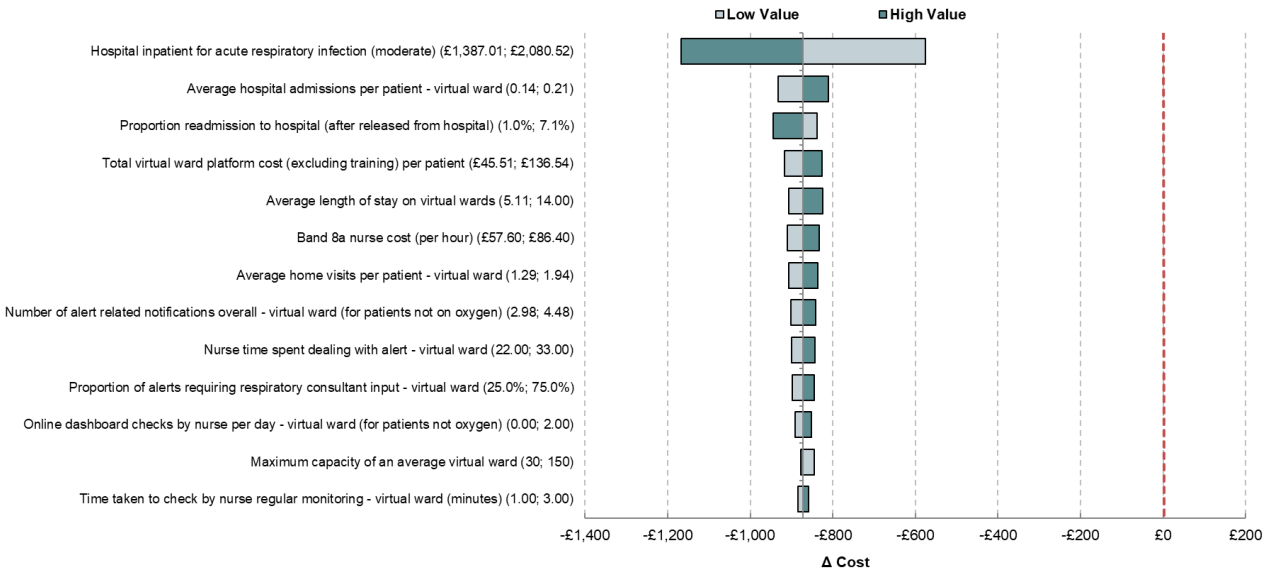
8.3.1.2 Deterministic sensitivity analysis

One-way sensitivity analysis was conducted on all model parameters. The results of this analysis are presented in a tornado diagram in Figure 8.2. The results of the analysis suggest the key drivers are the:

- Expected costs/resource use of people in hospital with a moderate ARI.
- Length of stay in VWs.

- Readmission rates associated with VWs.
- The platform costs for the VW.

Figure 8.2: Tornado diagram for hospital inpatient comparator



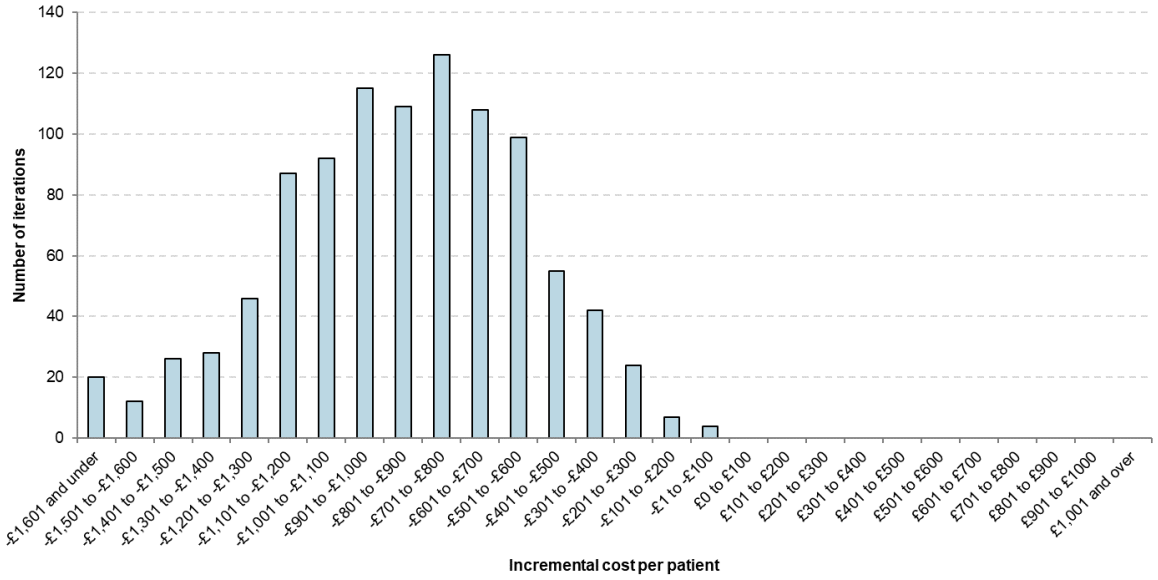
Additional DSA included EJP analysis. The highest price of providing a VW platform per patient, while still leading to cost savings to the NHS, is estimated at £950 when compared with hospital inpatients. This must be interpreted with extreme caution, as this does not account for the scenarios conducted in 8.3.1.1, while the results are currently very uncertain due to the limited evidence. If VW were only to be used solely in step-down care, the relative price would be substantially lower (approximately £275, using base case assumptions). Additionally, if there is population creep, higher readmissions than base case data with VW, or other factors, the EJP will be even lower.

This price is estimated based on the EAG base case, so will likely vary depending on the services provided by the company for the VW platform and clinical practice locally.

8.3.1.3 *Probabilistic sensitivity analysis*

PSA indicated similar results to the deterministic base case. The probabilistic incremental cost per patient was calculated as -£851, based on 1,000 model iterations. A graphical distribution of the results is presented in Figure 8.3.

Figure 8.3: PSA results showing cost difference on histogram



8.3.2 *At home care*

Under the base case assumptions, the deterministic base case model results suggest that VWs are potentially cost saving compared with at home care. The cost breakdown in Table 8.14 suggests that the key cost savings from a VW compared with at home care are potentially:

- Reduction in home visits.
- Reduction home monitoring resources.
- Reduction in outpatient appointments.

Table 8.13: Deterministic base case results – at home care

	Virtual wards	At home care	Incremental
Cost per patient	£912	£1,027	-£115

Table 8.14: Cost breakdown per patient

	Virtual wards	At home care	Incremental
VW platform*	£91	£0	£91
Home delivery and maintenance (provided by NHS)	£14	£19	£0
Home monitoring	£233	£303	-£70
Home visits	£178	£280	-£102
Outpatient appointments	£16	£39	-£24
Emergency attendance	£38	£38	£0
Hospital admission or readmission	£305	£316	-£10
111 contact	£6	£6	£0
Home set up	£27	£27	£0
Total	**£912**	**£1,027**	**-£115**

*Includes license, continuous monitoring, patient and set up and implementation costs.

8.3.2.1 Scenario analyses

Given the wide range of potential variation in VWs, a range of scenarios were run. These are described and reported in Table 8.15. When comparing VWs with at home care, only the increased implementation costs changed the direction of the results.

Table 8.15: Scenario analyses for at home care comparator

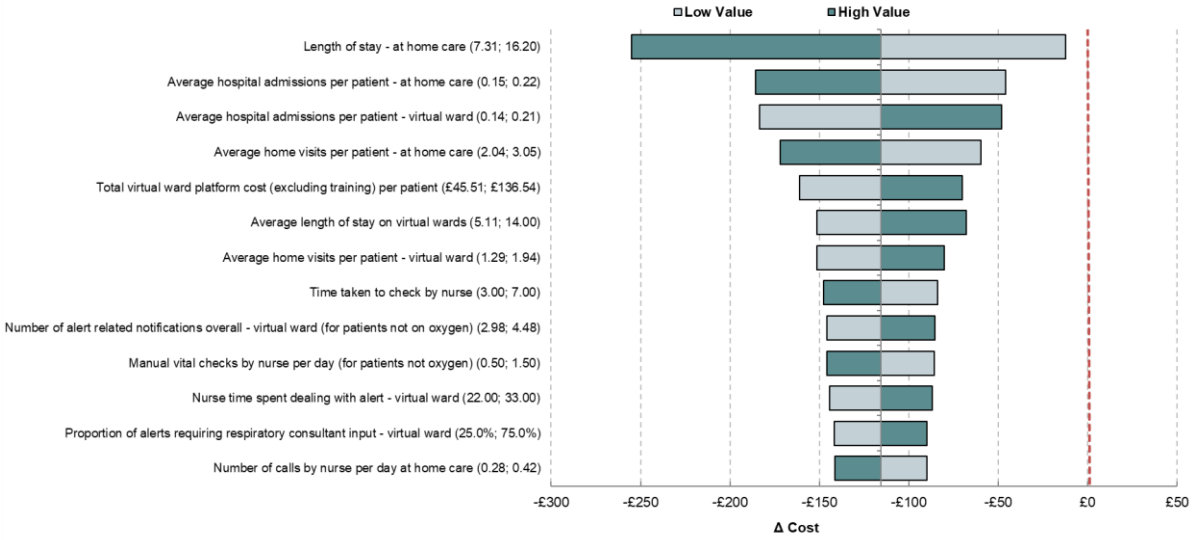
Scenario analyses description	EAG base case description	Incremental cost
EAG base case.		-£115
All potential VW costs included and no impact on NHS staff time for monitoring.	Only the subscription/license costs, tablet and continuous monitoring and set up costs are included.	-£37
All potential VW costs included and reduction in staff monitoring due to VW provider support	Only the subscription/license costs, tablet and continuous monitoring and set up costs are included.	-£75
Implementation costs are increased to £500,000 for the VW to reflect heterogeneity of implementation resource use.	Implementation costs are set at £15,000, only reflecting the company charges.	£17
Only subscription costs are included for the VW.	Only the subscription/license costs, tablet and continuous monitoring and set up costs are included.	-£166
Rather that all at home care, the comparator is an equal split between at home care and a hospital inpatient.	At home care or hospital inpatient are considered as separate comparators.	-£493

8.3.2.2 Deterministic sensitivity analysis

One-way sensitivity analysis was conducted on all model parameters. The results of this analysis are presented in a tornado diagram in Figure 8.4. The results of the analysis suggest the key drivers are the:

- Length of stay either in the VW or at home care.
- Number of admissions to hospitals for either the VW or at home care.
- Number of home visits for either the VW or at home care.
- Number of alert notifications associated with being in a VW or at home care.

Figure 8.4: Tornado diagram for at home care comparator



Since readmissions and home visits were key drivers of the results, two-way sensitivity analysis was conducted to highlight how changes in home visits and readmissions across both treatment arms (VWs and at home care) impacted the results of the model. This analysis is presented in Figure 8.5 and Figure 8.6.

Figure 8.5: Two-way sensitivity analysis – readmissions by treatment arm per patient

		Readmissions (at home care)										
	-£114.53	0.00	0.03	0.06	0.09	0.12	0.15	0.18	0.21	0.24	0.27	0.30
	0.00	-£104	-£156	-£208	-£260	-£312	-£364	-£420	-£468	-£520	-£572	-£624
	0.03	-£52	-£104	-£156	-£208	-£260	-£312	-£368	-£416	-£468	-£520	-£572
	0.06	£0	-£52	-£104	-£156	-£208	-£260	-£316	-£364	-£416	-£468	-£520
	0.09	£52	£0	-£52	-£104	-£156	-£208	-£264	-£312	-£364	-£416	-£468
	0.12	£104	£52	£0	-£52	-£104	-£156	-£212	-£260	-£312	-£364	-£416
Readmissions (virtual wards)	0.15	£156	£104	£52	£0	-£52	-£104	-£160	-£208	-£260	-£312	-£364
	0.18	£201	£149	£97	£45	-£7	-£59	**-£115**	-£163	-£215	-£267	-£319
	0.21	£260	£208	£156	£104	£52	£0	-£56	-£104	-£156	-£208	-£260
	0.24	£312	£260	£208	£156	£104	£52	-£4	-£52	-£104	-£156	-£208
	0.27	£364	£312	£260	£208	£156	£104	£48	£0	-£52	-£104	-£156
	0.30	£416	£364	£312	£260	£208	£156	£100	£52	£0	-£52	-£104

Figure 8.6: Two-way sensitivity analysis – home visits by treatment arm per patient

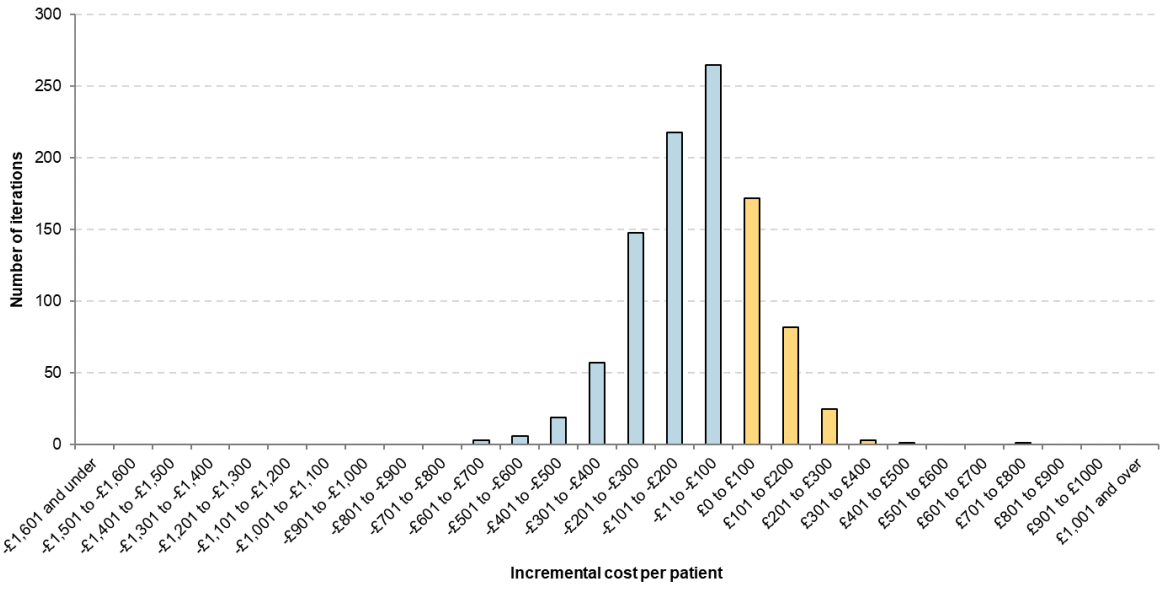
		Home visits (at home care)												
	-£114.53	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.55	2.75	3.00
	0.00	-£12	-£40	-£67	-£95	-£122	-£150	-£177	-£205	-£232	-£260	-£292	-£315	-£342
	0.25	£15	-£12	-£40	-£67	-£95	-£122	-£150	-£177	-£205	-£232	-£265	-£287	-£315
	0.50	£43	£15	-£12	-£40	-£67	-£95	-£122	-£150	-£177	-£205	-£237	-£260	-£287
	0.75	£70	£43	£15	-£12	-£40	-£67	-£95	-£122	-£150	-£177	-£210	-£232	-£260
	1.00	£98	£70	£43	£15	-£12	-£40	-£67	-£95	-£122	-£150	-£182	-£205	-£232
Home visits (virtual wards)	1.25	£125	£98	£70	£43	£15	-£12	-£40	-£67	-£95	-£122	-£155	-£177	-£205
	1.50	£153	£125	£98	£70	£43	£15	-£12	-£40	-£67	-£95	-£127	-£150	-£177
	1.62	£166	£138	£111	£83	£56	£28	£0	-£27	-£55	-£82	**-£115**	-£137	-£165
	2.00	£208	£180	£153	£125	£98	£70	£43	£15	-£12	-£40	-£72	-£95	-£122
	2.25	£235	£208	£180	£153	£125	£98	£70	£43	£15	-£12	-£45	-£67	-£95
	2.50	£263	£235	£208	£180	£153	£125	£98	£70	£43	£15	-£17	-£40	-£67

Additional DSA included EJP analysis. The highest price of providing a VW platform per patient, while still leading to cost savings to the NHS, is estimated at £200 when compared with at home care. This price is estimated based on the EAG base case, so will likely vary depending on the services provided by the company for the VW platform and clinical practice locally.

8.3.2.3 Probabilistic sensitivity analysis

PSA indicated similar results to the deterministic base case. The probabilistic incremental cost per patient was calculated as -£88, based on 1,000 model iterations. A graphical distribution of the results is presented in Figure 8.7.

Figure 8.7: PSA results showing cost difference on histogram



8.4 *Summary and interpretation of the economic modelling*

Using base case assumptions, it is estimated to be plausible that technology-enabled VW platforms are a cost-saving intervention to the NHS for adults with moderate ARIs. The estimated results are not intended to capture every VW platform technology perfectly, but to provide an indication of the potential NHS resource impact of implementing VW platforms. The results suggest that VWs have potential to be a cost-saving intervention when compared with both hospital inpatient care, and at home care (without a VW platform).

However, the results of this analysis should be interpreted with caution due to the naïve and limited data available. One of the key details of the model is

that other than readmissions, no other potential safety outcomes are captured in the model. Simplifying assumptions were made throughout the model to provide a useful tool for an early evaluation of VWs.

8.4.1 Hospital inpatient care

Key drivers of the economic results

When VW platforms are compared with hospital inpatient care, DSA indicates that the key drivers of the model results are:

- The expected resource use associated with a hospital admission.
- The length of stay in a VW.
- Admissions or readmissions associated with either hospital inpatient care or VW care.

Population spill over effects

A cohort of patients receiving VW care are likely to have different population characteristics to those receiving inpatient care. This is because some patients with milder ARIs (who would not otherwise receive inpatient care) may receive VW care. This could be because of the availability of the VW platform or issues with hospital capacity. Hence, this change in population from introducing VW platforms may lead to increased healthcare costs. Scenario analysis that increased the population in the VWs arm of the model elicited the largest difference in cost savings of all scenario analyses conducted. The scenario indicated that if for every 1 patient who would have been admitted to hospital with a moderate ARI, 1.96 patients are admitted to a VW (with milder patients getting admitted), there would be no cost-savings associated with VWs.

Step-down care

The model results do not fully capture differences in step-down care from inpatient care to a VW, as well as the potential impact of when a patient is stepped down. In the base case, a VW admission with an average length of

stay of 8.89 days is estimated to cost £912 per patient. The cost of an excess bed day can be calculated as approximately £316 (using 2017/2018 cost collection and inflating to current prices) (NHS, 2020, Jones, 2023). This indicates that approximately less than 3 excess hospital bed days would cost as much as providing VW care for 8.89 days. If there is a 50% population creep (1 hospital patient for every 1.5 VW patients), then this would increase to 4.3 hospital bed days. It is likely that patients who are stepped down from hospital care later would have a shorter length of stay in a VW than presented in the base case, and so would incur less cost on the VW. This would be driven by a reduction in the levels of monitoring, as well as a reduction in the number of healthcare contacts such as home visits or outpatient appointments. Hence, step-down care onto a VW from hospital has the potential to be cost saving to the NHS, depending on the point at step-down occurs. It was not possible to model this scenario fully, given the lack of data. However, this simple comparison offers an indicative impact for patients who are stepped down onto a VW.

8.4.2 At home care

Key drivers of the economic results

When VW platforms are compared with at home care, the key drivers are the relative differences in:

- Length of stay.
- Monitoring practices.
- Home visits.
- Admissions to hospital.

Uncertainty surrounding at home care

The results for comparing VWs with at home care were associated with greater levels of uncertainty than when compared with inpatient care. Contributing factors may include assumptions that resource use for VW platforms were similar to that of at home care, where there was a lack of

evidence. For instance, if the make-up of devices were different across at home care and VW platforms, this would change the current estimated results. VW care was associated with a lower length of stay compared with at home care. This may indicate that the use of VWs is more effective at monitoring patients than at home care. This is assuming a similar level of monitoring from at home care, albeit without a technology-enabled VW platform.

Clinical practice, populations and step-up care

It is likely there are variations of at home care in clinical practice. Additionally, the population of patients who are stepped up to VW care is potentially different to the population of patients who are stepped down or introduced directly to VW care. Therefore, without further evidence, it is difficult to estimate a fair reflection of outcomes associated with step-up care.

8.4.3 Heterogeneity of virtual wards

Based on current evidence, it is uncertain as to what aspects of VW are driving any differences in effectiveness or resource use savings. Some of the potential resource use benefits stem from monitoring at home, regardless of a technology-enabled VW platform. If at home care was compared with hospital inpatient care, there is potential savings even with 'manual' forms of VWs (represented by at home care). The three key determinants which are likely to impact the effectiveness for different types of technology-enabled VW are:

- Interoperability and ease of use- more interoperable VWs may improve the efficiency of monitoring and associated staff time. Staff time will also be reduced by the effective design of the platform and the ease of use.

- The effectiveness of continuous monitoring – this type of monitoring is associated with higher costs than intermittent methods. However, it may lead to more efficient monitoring, as well as registering concerns at an early period for more effective healthcare responses.

- Additional features- this could include predictive AI models of monitoring, or company provided support teams to assist current monitoring practices. These additional features are likely to come at a greater direct cost from the company, but may lead to improved patient outcomes, efficient monitoring, reduced community care support or other resource use savings. If a VW company provides services that include taking on clinical responsibility for patients (such as monitoring their vital signs), it is key that appropriate regulations are in place to ensure that this is carried out safely.

Currently, the differing features of VW and the potential impact on the outcomes of the patient are unknown. Understanding the different features and the impact they may have on efficiency or costs should be one of the priorities for future evidence generation. This is because from the current evidence, the impact of different features cannot be elicited on the overall impact of VW. Therefore, it cannot be determined which features are necessarily driving potential economic results. This is detailed further in Section 10.2.

9 Interpretation of the evidence

9.1 *Interpretation of the clinical and economic evidence*

Currently there is some limited evidence to judge the clinical effectiveness and comparative safety of VW platforms. In the context of this EVA, some included safety and clinical effectiveness data is based on studies which are likely to examine milder populations and do not necessarily represent the patient population. As a group, the included studies suggest VW platforms have the potential to be safe and may be effective as an alternative to hospital care. This evidence may still be subject to major biases. In light of the early nature of the evidence, a pragmatic view should be taken about the risk associated with VWs. Clinical interpretation will be important for the generalisability of this evidence to the patient population of this EVA. As expected with the early nature of the evidence, the outcomes are uncertain. It

is important to note that there was no evidence identified that suggested safety concerns with VWs.

The EAG identified 29 relevant or partially relevant studies, of which 19 were prioritised for data extraction because they were considered to be the most relevant to the decision problem and/or the NHS setting. Two RCTs were identified; 1 of limited reliability in a partially relevant population (COPD exacerbations) (comparator: inpatient care), and a second in a relevant population that was probably underpowered for mortality differences. A third comparative observational study compared small numbers of VW patients with telephone-based VW care and a recent historical cohort of early pandemic in-hospital COVID patients. 16 case series provided non-comparative data. No evidence was identified comparing VWs to care in the community.

The step-up RCT did not report any significant differences in measured outcomes, but this is likely due to being underpowered to detect these differences. The step-down RCT reported some significant but conflicting differences in length of stay, and no differences in mortality which could be due to chance. The comparative observational study reported some numeric reductions in length of stay, readmission rates and patient contacts, but did not investigate whether these were due to chance.

Given these caveats, there is weak evidence that across all models of care length of stay on a VW is between 3.9 and 12 days, between 2% and 22% of patients are admitted to hospital and 0.4% to 3.6% are admitted to critical care.

Hospitalisation rates varied widely, which is likely due to multiple differences between the included studies and potentially, the range of severity of ARI within the study populations. Step-down studies had a lower range of hospitalisation rates (2% to 11.4%) than step-up care studies (10% to 22.2%) or mixed model studies (6.6% to 22%). This may indicate patients receiving step-down care were less likely to require escalated care due to recovery from the infection, but equally could also indicate different case mixes between

studies. Most studies recruited COVID patients at various points during the pandemic, and so underlying prevalence and severity of infection might also explain some differences. Variations in the delivery of care may also contribute, both due to the location of the care setting, and possibly due to the different components included in individual VWs and how they interact with healthcare settings at the local level. The current evidence base is not sufficient to test this hypothesis.

Reported patient adherence rates are likely to overestimate the number of patients able to use the technology in reality because access to and ability to engage with the app was a selection criterion in most of the studies. Two studies that did not pre-select on this basis found between 31.5% and 74% of patients did not use the app to interact with the VW.

All VW companies that submitted evidence have systems in place to support providing technology if the patient does not have access to a device or the internet. Twelve VW companies that submitted evidence referenced additional solutions to enhance digital accessibility including offline functionality, increasing text size and zoom functions, text-to speech functionality, multi-language systems, wearable devices, large buttons, choice of interface and remote administration by carers. These details are listed in Table 2.1 Included Technologies. There is limited information detailing if these systems were in place in existing studies and the outcomes are rarely reported and so it is not possible to measure their impact.

The EAG identified the following concerns regarding the generalisability of findings:

- **Population:** The EAG considered the patient population to only partly meet the scope in 6 studies. This was due to the inclusion of patients who would not otherwise receive hospital care or because patient selection was insufficiently reported to determine whether at home virtual monitoring was being used as an ‘add-on’ to monitor patients who were being discharged as normal, or who were not severe enough to consider hospitalising. A key value proposition of most

digital health technologies is that they facilitate and increase the accessibility of care. A consequence of this can be that they are used in populations with less acute need, hence the EAG considers including such data may provide a more optimistic view of the evidence than might be the case for the scoped population. Only 1 study (conducted in the UK) recruited patients with any ARI into a respiratory VW. Most of the remaining studies (n=12) evaluated COVID patients during pandemic surges, and there is uncertainty as to whether these studies are fully generalisable to the populations who would receive care on ARI VWs in a non-pandemic setting.

- **UK NHS setting:** 3 studies evaluated unnamed VW platforms evaluated in other countries and 1 other a named VW platform developed locally for a hospital in Singapore, for which it was not possible to determine whether they are available in the UK. Only one cited a third party vendor (Kodama 2021).

All but one technology (Current Health) were evaluated in a single non-comparative study, therefore it is not possible to determine whether the evidence is generalisable between different VW platform products.

No economic evaluations were identified. Four unpublished studies and grey literature reports (3 UK and 1 USA) indicated that implementing VWs provides cost savings.

9.2 *Integration into the NHS*

Of the 13 VW technology providers included within the scope of this evaluation and who submitted company evidence, 11 of these are currently used within the NHS as outlined in Section 2.1. Existing VW platforms are used to manage patients with ARI for both step-up and step-down care. Existing platforms are also used for care homes and for long-term conditions such as COPD, outpatient parenteral antimicrobial therapy (OPAT), heart failure and diabetes.

Clinical and management risk

Key criteria that should be considered when determining if a patient should receive VW care include:

- Cognitive impairment, learning disabilities or problems with manual dexterity.
- Accessibility issues, such as visual impairment or inability to understand health-related information.
- Potential co-morbidities and how these are managed on VWs.
- Geography of the patient and any internet connectivity issues.
- Other issues which may impact the ability of a patient to self-monitor. such as access to a fixed or mobile telephone line, running water and electricity. Further details of other issues are detailed in the NICE scope.

To mitigate some of these risks, companies often provide offline functionality, support patient set up and correct usage on behalf of the healthcare provider, and compliance monitoring procedures. Other risks include high professional turnover rates, which may lead to less clinical knowledge within the hospital team. Of the 13 VW companies that submitted evidence, 9 stated and described their risk management procedures for managing VWs. 4 companies [redacted] did not provide any reference to risk management procedures. Regular training and support will be required to further mitigate risks to the delivery of VWs.

Further details on the potential risk of implementing technology-enabled VW platforms are provided in the NICE scope, including equality concerns such as the potential inaccuracy of pulse oximeters. The EAG recommends that the issues listed in the NICE scope, alongside those detailed in this section are important considerations for implementing VWs.

Training & resource use considerations

Healthcare providers are expected to undertake training to enable the delivery of VW care. Some VW companies also offer patient onboarding services; NHS staff would otherwise be expected to deliver this and would require

additional training to do so. Onboarding services vary between provider but generally include the delivery of equipment, patient training, and patient account set-up.

Interoperability requirements are likely to differ substantially across NHS trusts, due to the make-up of current systems. For example, implementation-(fixed) costs would still be incurred in rural areas. These areas tend to treat lower numbers of patients, with potentially less sophisticated operating systems and as such, the cost-per-patient may be increased. Where any VWs cannot be fully interoperable, additional resource use such as staff time will have to be considered in any integration.

The integration of VWs may increase the number of telehealth appointments and so additional staff trained to carry out these appointments would need to be made available. GPs and other members of community care may also need to receive low-level training on VW procedures. This may be required, where VW systems integrate with community care (so community care teams take a more active role in patient management compared with hospital), where patients are contacting community services while on a VW, or where there is any overlap between treatment in primary and secondary. The impact on community resource use such as a potential increase in the number of home visits should be considered, if people are moving out of hospital onto VWs. This would likely impact community teams who support with home visits. Other issues may arise related to the logistics of distributing, managing, storing, and decontaminating devices, particularly for large VWs.

Transferability across patient pathways

No included studies or evidence from company submissions directly addressed the issue of potential transferability of VWs used for non-ARI indications, to the ARI setting (or vice versa). Of the 10 companies providing submissions by the deadline, 4 referred to additional evidence for the performance of VWs conducted in other settings (Spirit Digital (CliniTouch Vie), Feebris, Lenus and Solcom (Whzan Blue Box)). This information is listed in Appendix F. To summarise, indications included COPD (4 evaluations by

Clinitouch and 1 by Lenus), care homes (1 by Spirit Digital, 1 by Feebris and 3 by Solcom) and psychiatric care homes (1 study by Spirit Digital, no data provided). Studies with data suggested reductions in admissions, length of stay and cost savings. However, it is not possible to verify the reliability of this company-produced information from the limited details available.

The EAG recognises that there are key outcomes that indicate that the use of VWs is potentially safe, clinically effective, and cost-saving. However, the EAG is has concerns about the risk of bias from this evidence, and the applicability to this patient population. Given the early nature of this assessment, it is expected that the evidence will have material biases.

Further to this, while these studies demonstrate that one product can be used across pathways, none explicitly evaluated transferability across patient pathways, or trusts. Although other populations may be indicative of the potential impact of VWs, the extent to which outcomes of VWs in other contexts can be achieved in the target context of ARI, and each individual trust, needs to be assessed as the subject of further studies (Schloemer and Schroder-Back, 2018).

9.3 *Ongoing studies*

Studies identified through EAG searches

The EAG searches identified 4 ongoing studies, listed in Table 9.1. One study, a single arm trial, was considered of direct relevance to the scope (NCT05087082), and reports it is collecting multiple relevant outcomes, including many of use for economic modelling. However, this study does not complete until June 2024 and is being conducted in Denmark using an unnamed app and case management system.

The remaining 3 studies are all of partial relevance, with an Australian study completing in June of 2023. The only UK study was due to complete in March 2021 but the trials record has not been updated since January 2021.

Table 9.1: Ongoing studies list from EAG searches

Ongoing study (EAG searches)	Alignment with scope	Outcome data for economic model	Indicated trial end date
NCT05087082 (Hospital, 2022) **Study design:** Single arm trial Part of a larger, 'virtual hospital-at-home' (vHaH) project called Influenz-er. **Company:** Nordsjaellands Hospital (2022) **Country**: Denmark	Intervention: Hospital at home model including telemedicine and specifically developed app and case management system **GREEN** Participants: ARI **GREEN** Setting: step-down **GREEN** Outcomes: Patient adherence, handling time, red/yellow alarm rate, drop out rate, compound of clinical events (incl mortality, healthcare associated infections, readmissions), self-perceived quality of care **GREEN**	EQ-5D-5L SF-36 Patient productivity loss Carer burden and productivity loss Costs of hospital resource use Number contacts to GP and costs Total per patient cost Number outpatient visits Productivity loss	December 2024
ACTRN12623000018617 (Limited, 2023) **Study design:** RCT (3 arms) **Company:** Silver Chain Group Limited (2023) **Country:** Australia	Intervention: 'Hospital at home' using Biobeat Wrist Monitor or Biobeat Chest Monitor to constantly monitor respiratory rate, oxygen saturation, heart rate and blood pressure including dashboard **GREEN** Comparator: Standard care (not further specified) **AMBER** Participants: 30 patients enrolled in hospital at home (multiple conditions likely, not further specified) **AMBER** Setting: "This project will advance understanding and use of remote patient monitoring devices on top of standard care." **AMBER** Outcomes: Patient experience, patient acceptability and feasibility of wearables **GREEN**	None	June 2023
NCT04695821 (Ltd, 2021) **Study design:**	Intervention: Wearable device to measure breath sounds and heart sounds, in future will be accompanied by cloud-based software **AMBER**	Adverse events	March 2021

Ongoing study (EAG searches)	Alignment with scope	Outcome data for economic model	Indicated trial end date
Single arm trial (feasibility study) **Company:** Senti Tech Ltd (2021) **Country**: UK	Participants: 10 patients attending A&E with or suspected to have Covid-19, who are being discharged into the community **AMBER** Setting: Unclear, possibly step-down **AMBER** Outcomes: patient acceptablity, comfort, ease of use, data quality, adverse events **GREEN**		
NCT04330378 (National University Health System, 2020) **Study design:** Prospective cohort **Company**: Unnamed (National University Health System) **Country**: Singapore	Intervention: Hospital at home clinical service. The clinical service that is tech-enabled, by remote monitoring and telecommunication technologies **AMBER** Comparator: usual care in hospital **GREEN** Participants: 441 patients – mixed conditions, including those admitted to acute units. **AMBER** Setting: Step-up **GREEN** Outcomes: Readmissions, ED attendance, Mortality, iatrogenic events, QoL, HRQoL, patient satisfaction, carer burden, care transition experience **GREEN**	Cost of care (consumables, labour, additional) bed days in hospital Length of stay ICU transfers EQ-5D-5L	Not stated (still recruiting as of January 2023)

Abbreviations: A&E – accident and emergency, ARI – acute respiratory infections, ED – emergency department, EQ-5D-5L – European Quality of Life Dimensions 5 Level Version, GP – general practitioner, HRQoL – Health Related Quality of Life, ICU – intensive care unit, QoL – Quality of Life, RCT – randomised controlled trial, SF-36 – 36-item short form survey, UK – United Kingdom.

Studies identified through company submissions

Company submission documents listed 10 ongoing studies evaluating products by 5 companies (Current Health, Feebris, Docobo, Lenus, PMD) for which a summary is provided in Table 9.2. None were considered fully relevant to the scope of this EVA and 4 partly relevant.

Table 9.2: Ongoing studies list from company submissions

Ongoing study (company submissions)	Alignment with scope	Outcome data for economic model	Indicated study end date
Relevant ongoing studies (intervention, population and setting match the scope)			
No entries found	-	-	-
Ongoing studies of partial relevance			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

Ongoing study (company submissions)	Alignment with scope	Outcome data for economic model	Indicated study end date
Irrelevant ongoing studies (at least one PICO element does not meet scoped criteria)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

Ongoing study (company submissions)	Alignment with scope	Outcome data for economic model	Indicated study end date
Unclear relevance (insufficient details provided to assess)			
[redacted]	[redacted]	[redacted]	[redacted]

10 Evidence gap analysis

The primary evidence gap is a lack of reliable comparative evidence from the UK NHS setting for the key scoped outcomes. Although 1 RCT was identified, it was not in a fully relevant population (COPD exacerbations). The RCT evaluated an unnamed VW platform in a European healthcare setting and it was underpowered to detect the relevant outcomes. No RCTs were identified evaluating step-down or step-up care in an eligible (or partially eligible) population. One other comparative study was identified, but was based on low numbers and did not test differences for chance effects.

No evidence was identified comparing VWs to care at home settings.

The EAG has taken the approach of assuming similarity in effectiveness between VW for this EVA. When examined individually, relevant evidence was found for only 8 of the 20 scoped technologies (CliniTouch Vie, Current Health, Doccla VW, CO@Home/Covid VW, Huma, Luscii, Virtual Ward Technologies, Whzan Blue Box), 6 of which were reported in 1 study each. Of the remaining 13 technologies, 5 provided company submissions containing qualitative statements that could not be used for this review because they lacked sufficient context and were anecdotal, and so no relevant published or grey literature clinical evidence is available.

Current evidence is limited, and although an uncertain indication of direction of safety and effect can be deduced, the evidence was of insufficient quality, quantity and consistency or similarity to determine the clinical effectiveness of VWs for all scoped outcomes, across all scoped comparisons, for patients with ARI.

No relevant economic evaluations assessing cost-effectiveness were identified.

Table 10.1 summarises the evidence available, largely from observational single arm studies, for each of the scoped outcomes.

Table 10.1: Evidence gap analysis for scoped outcomes

Outcomes	RCT evidence		Real World Evidence		
	Step-up*	Step-down*	Step-up	Step-down	Mixed
		Clinical outcomes			
% hospital-acquired infections	No data reported **RED**	No data reported **RED**	No data reported **RED**	No data reported **RED**	Very limited data from 1 small case series **RED**
Time to ARI resolution	No data reported **RED**	No data reported **RED**	No data reported **RED**	No data reported **RED**	No data reported **RED**
Mortality	Limited to 1 small underpowered RCT. No UK evidence **RED**	Limited to 1 small underpowered RCT. No UK evidence **RED**	1 small case series **RED**	5 small case series, 2 UK **RED**	1 UK cohort study and 4 small case studies **RED**
Adverse events	Very limited non comparative evidence from 1 small underpowered RCT. No UK evidence. **RED**	No data reported **RED**	No data reported **RED**	1 small case series, UK **RED**	1 small case series, 0 UK **RED**
		Operational outcomes			

Waiting time for admission to or discharge from a VW	Limited to 1 small underpowered RCT. No UK evidence. RED	No data reported RED	No data reported RED	1 small case series, UK RED	1 small case series, 0 UK RED
Length of hospital or VW stay	Limited to 1 small underpowered RCT. No UK evidence. RED	1 RCT, no UK evidence. RED	1 small case series RED	6 small case series, 3 UK RED	6 small case series, 5 UK AMBER
Number with treatment escalation	Limited to 1 small underpowered RCT. No UK evidence. RED	1 RCT, no UK evidence. RED	1 small case series RED	2 small case series, 1 UK RED	2 small case series, 1 UK RED
Admissions or readmissions	Limited to 1 small underpowered RCT. No UK evidence. RED	1 RCT, no UK evidence. RED	1 small case series RED	6 small case series, 4 UK AMBER	1 UK cohort study and 6 small case series, 5 UK AMBER
Contacts with other care providers	Very limited – selected subgroup of 1 small underpowered RCT. No UK evidence. RED	1 RCT, no UK evidence. RED	No data reported RED	1 case series RED	1 UK cohort study and and 1 small case series, 0 UK RED
Release of staff time for other caring responsibilities	No data reported RED	No data reported RED	No data reported RED	1 small case series, 0 UK RED	1 small case series, 0 UK RED
Patient adherence	No data reported RED	1 RCT, no UK evidence. RED	No data reported RED	2 small case series, 0 UK RED	1 UK cohort study and and 3 small case series, 2 UK RED

Healthcare provider usability or acceptability	Very limited non comparative evidence from 1 small underpowered RCT. No UK evidence. RED	1 RCT, no UK evidence. RED	No data reported RED	1 case series, UK RED	1 UK cohort study and 2 small case series, 2 UK RED
		Patient reported outcomes			
Health related quality of life	Limited to 1 small underpowered RCT. No UK evidence. **RED**	No data reported RED	No data reported **RED**	No data reported **RED**	1 small case series (qualitative only), UK
Patient and carer experience and acceptability	No data reported **RED**	1 RCT, no UK evidence. RED	1 small case series **RED**	1 small case series, 0 UK **RED**	1 UK cohort study and 2 small case series, 2 UK **RED**
Carer burden or strain	No data reported **RED**	No data reported RED	No data reported **RED**	No data reported **RED**	No data reported **RED**
Ongoing studies 3 comparative studies identified: 1 RCT (ACTRN12623000018617, Australia) focussing on feasibility, acceptability and patient experience (no outcomes for model) 1 prospective cohort study (NCT04330378, Singapore) collecting multiple outcomes for clinical effectiveness and the model: Readmissions, ED attendance, Mortality, iatrogenic events, QoL, HRQoL, patient satisfaction, carer burden, care transition experience, Cost of care (consumables, labour, additional), bed days in hospital, length of stay, ICU transfers, EQ-5D-5L. [redacted]					

* no RCT evidence found for mixed models of care.

Table 10.2: Evidence gap analysis for economic outcomes

Outcomes	Gap in current evidence
Effectiveness evidence: long-term outcomes	Are there any long-term impacts from monitoring on a VW in comparison with hospital inpatients or care in the community? **RED**
Effectiveness evidence: Step-care initiation	The point in the care pathway where step-down or step-up care becomes cost-effective is unknown. Clearer definitions are required at the optimal use for step-care in order to appropriately capture and model the outcomes. **RED**
Effectiveness evidence: Effect of variations in VW platforms	Many providers offer additional services as part of the VW platform. This includes parts such as AI driven monitoring to provide alerts to clinical staff. There is little to assess the impact more or less functionality has on clinical or economic outcomes. **RED**
Effectiveness evidence: Readmissions	Some evidence has been captured on readmissions. However, there is not enough evidence to conclude if there are statistically significant differences in readmissions in a VW care, compared with hospital inpatient care or care in the community. **AMBER**
Resource use: Monitoring practices on VWs or care in the community	Clinical practice is likely to differ for managing VWs. Little is documented on how different these practices are, and what this means for the level of monitoring required. **RED**
Resource use: Impact of subgroups	Evidence is currently unknown for how VW resource use differs between subgroups. For instance, for people monitored at home, how does this differ between patients at home, patients in a community care home, or patients in a nursing care home? Other subgroups include solely managed in VW, step-up care, or step-down care. **RED**
Resource use: Population spill over	The scope of this EVA is to consider moderate ARI. However, once VWs are implemented, there is likely to be spill over effects, where milder patients are triaged through VW care. This may result in people receiving treatment who would not require the same level of resource use. This has the potential to augment the results of VW platforms. **RED**
Resource use: Make up of the clinical teams	Clinical practice is likely to differ for managing VWs. Little is documented on how different these practices are. Different practices are likely to result in different care teams, and a range of different economic costs for managing VWs. **AMBER**

Outcomes	Gap in current evidence
Costs: Set up and implementation costs	Although companies provide the costs associated with implementation, there is no indication of the NHS time and resource use to implement VWs. This is likely to differ by hospital type and location. **RED**
Costs: Method of provision of access	The method to be used to provided patients who do not have the required hardware and internet connection at home with access is currently unclear. This impacts upon costs and also equality of access. AMBER

10.1 *Summary and conclusions of evidence gap analysis*

Under the assumption of similarity, the evidence gap is a lack of comparative data demonstrating the clinical efficacy and safety of VWs as an alternative to inpatient care or care in the home for patients with ARI. Although evidence was found for several scoped outcomes, the evidence was limited by being observational and largely non-comparative, while comparative evidence has generated differences and similarities that have not been established to be due to chance or genuine differences. This is expected given the early nature of the assessment, and data from alternative and milder populations appeared to suggest there are some economic benefits associated with the use of VWs, although was subject to biases.

Five small UK case series provided evidence for length of stay and 1 UK cohort study also provided evidence of (re)admissions and so these have been rated as amber due to quantity since they may be more useful to inform a model. Although the cohort study was comparative, numbers were small and numeric differences were not tested for chance effects.

The evidence was particularly scarce for patient safety outcomes, and where evidence was available it was reported inconsistently and mainly addressed mortality during the admission period.

There was insufficient evidence to consider whether the variation in components used across VWs, such as automated monitoring, machine learning assistance, or continuous monitoring devices impacted on outcomes.

Key data gaps for economic analysis include:

- Long-term impacts of delivering VW care for future cost or health-related quality of life outcomes. This could include the development of chronic respiratory illnesses if conditions are managed at different qualities between VWs, hospital and at home care.
- Analysis of the use of the technology for specific subgroups. For example, differences may occur in patients monitored at home or in a nursing home, as well as step-up or step-down care or triage directly to a VW.

- Different factors or additions with VW platforms and their economic impact, such as the impact of using artificial intelligence (AI) predictive monitoring.
- The size of the implementation costs, and how this will vary across different hospitals.

10.2 *Key areas for evidence generation*

Suggestions for future evidence generation are summarised in Table 10.3. Evidence generation should focus on addressing the key components of the value proposition of VWs: reduction of resources and cost for comparable or improved patient safety.

While RCTs are the gold standard for answering comparative effectiveness questions, VWs have already been implemented by the NHS and so are unlikely to be feasible, both for methodological and resource reasons. Comparative data would therefore best be obtained through prospective collection of relevant outcomes in controlled cohort studies or non-randomised controlled trials. Interrupted time series designs, involving the comparison of data collected before and after introduction of a VW, would be feasible in trusts that have not yet implemented VWs for ARI. Such designs would be more susceptible to confounding factors and other issues associated with a lack of randomisation, although still provide useful insight into VWs.

Alternatively, large registry-based studies contributing substantial datasets would provide more precise estimates of impact, and are of relative value when compared to national benchmarking statistics. These findings would require close examination by clinical experts to ensure that patient safety and operational outcomes are within acceptable limits for current UK NHS practice.

The EAG notes that VWs can be described as complex interventions, in which multiple active components (which may be simple individual components) combine to create impact to health and resource use outcomes. Complex intervention research, as defined by the National Institute for Health and Care Research (NIHR) and Medical Research Council (MRC) (Skivington K, 2021),

transcends asking whether an intervention impacts on outcomes to address broader questions. In addition to establishing the value of VWs relative to the resources required to deliver VWs, this interrogation could entail establishing which components are the main drivers of effect and how they contribute to system change.

Decisions on which technologies will provide the most effective solutions to the NHS require comparative evidence. New evidence should detail outcomes according to the components that are suspected to be the main drivers to health and cost effectiveness improvement. Under advice from NICE, the EAG has used a 4-component categorisation of VW features outlined by the Health Innovation Network (Health Innovation Network, 2023) for this EVA (see Table 2.1 Included Technologies). Table 2.1 Included TechnologiesThe face validity of this categorisation has not been established, and NHS healthcare providers with experience of working with or for active VWs are likely to provide valuable insights into which VW components are most or least useful.

Due to the scarcity of comparative evidence, a key uncertainty is whether the potential benefits provided by VW platform technologies that have been identified by this EVA are caused by the technology enablement itself, by the routine monitoring of patients in their usual place of residence, or a combination of both. Establishing the added cost and safety benefit of VW platform technologies is therefore likely to be key information for future decision-making.

Since the added value of different VW components (including technology enablement) is unknown, the EAG suggests that future evaluations should not look to treat all VW platform technologies as homogenous healthcare technologies. This is the case particularly if future procurement decisions will require decision-makers to select between competitor products. It may not be feasible to evaluate all VW platform technologies individually, however, future reviews or primary studies would produce more useful information for decision-makers by categorising platforms based on the services provided.

Any future economic modelling should be designed to be flexible enough to be adapted to all VW platform technologies.

Finally, in order for potential benefits to be fully realised, VWs need to be implemented successfully. This will require optimal staff acceptability and patient access to ensure that benefits are realised across as large a proportion of eligible ARI patients as possible. Further evidence is required to establish which implementation strategies will maximise both factors.

Table 10.3: Evidence generation recommendations

Research question	Recommended study design	Outcomes
What are the comparative resource and outcome consequences of using VWs to treat ARIs	Prospective controlled cohort studies or non randomised controlled trials, comparing to inpatient care (priority), care in the community or home monitoring without a VW platform. Large scale interrupted time series or registry based studies comparing to national benchmarking data. Conducted in the UK.	Time to ARI resolution Adverse events Mortality Admissions to ED, hospital wards, ICU Length of stay in hospital Number of care episodes Staff time Costs Patients ineligible for VW care and discontinuations due to adherence and digital barriers Carer burden HRQoL and QoL
Which components of VWs are likely to drive differences in relevant outcomes	Qualitative studies investigating clinical perspectives on which are the most resource saving features of VWs.	Components of VWs to interrogate further
	Prospective studies comparing different VW platforms used during the same period of care. Ideally conducted in the UK	Identified from the qualitative studies
What is the cost-effectiveness of VWs?	Detailed in Section 9.1.3	Quality of life Resource use Cost
How does VW platforms interact with other community care services, such as people already living in community or nursing residences?	No specific study design recommended	Resource use Cost

What is the scale of implementation costs, and how might this differ across hospitals?	No specific study design required. However, reporting from NHS trusts on the scale of the implementation would need to be provided.	Costs Resource use
Staff acceptability and facilitators to maximise implementation	Qualitative or semi-qualitative studies exploring the barriers and facilitators to implementing VWs in a UK NHS setting	Usability Acceptability Other aspects of staff experience Implementation characteristics Barriers Facilitators
Patient uptake of VWs and facilitators of adherence	Mixed methods studies assessing patient adherence to VWs using different solutions to maximise uptake and adherence	Patient adherence Categorisation of solutions for digital exclusion and acceptability Impact and cost of enhanced support features Facilitators of uptake

10.3 *Potential future conceptual model*

When evidence is collected to bridge current evidence gaps on VW platforms, a future model design could provide a more robust evaluation of the technologies. The EAG recommends that either a patient simulation or Markov model may be suitable. The decision between the two structures is likely to be determined by:

- The detail of the evidence collected as part of future evidence generation.
- If there is significant heterogeneity in characteristics of the patient population which may impact the results.

In either model structure, the short-term health states of the model should be able to capture where the patient care begins in any of the treatment arms. For instance, some people who receive VW care may initially be receiving inpatient care, and then de-escalated to a VW, rather than being triaged straight to the VW. This could be captured in daily cycles for the first 30 days, with patients gradually transitioning out of care over time with recovery. It is

likely that a range of adaptations to the early model structure would have to be made given that:

- There is a heterogeneity in clinical practice for managing VWs.
- VW platform technologies offer a range of different services, which result in varying degrees of healthcare resource use and outcomes.

Therefore, it is likely that the assumption of similarity cannot be taken between VWs, but it may be possible to group these technologies into smaller sub-categories for evaluation.

The EAG also suggests building a long-term aspect into the model. This would be to capture any potential differences between VWs when compared with other care pathways. If the quality of care differs between treatment pathways, there is a higher likelihood that longer-term impacts would not be the same. This may lead to differences in future cost or HRQoL outcomes that should be included. If this is the case, a full cost-utility model should be developed, rather than a cost-comparison model. The exact health states and design of the long-term structure will depend on the exact longer-term outcomes that occur, so should be guided by clinical experts and the data collection. In either model structure, relevant subgroups as discussed in Section 9.1 could be included.

Another aspect to consider for any future model is the incorporation of system capacity and waiting time. This may be particularly important when comparing VW platform technologies with hospital inpatient care. A potential benefit of VWs is to extend patient capacity of hospitals treating ARIs. Discrete event simulation (DES) modelling could be considered for investigating system capacity. DES models can be used to investigate patient scheduling challenges, waiting time bottlenecks, overall system capacity and bed requirements in various healthcare settings (Vazquez-Serrano et al., 2021). However, such studies depend on robust modelling of the distribution of capacity and wait times, which should be informed by robustly collected real world data. The EAG suggests that a DES model would not be required to develop a fair evaluation of VW platform technologies, as capacity

implications could be evaluated qualitatively through discussion with committee members. Nonetheless, this has been detailed as a useful reference for any discussions of future evidence collection.

11 Conclusions

11.1 *Conclusions from the clinical evidence*

The current evidence base as identified within this EVA is characterised mainly by non-comparative data, with little comparative data, which is not sufficiently robust to conclude if relative differences in care are due to chance. There was no evidence of direct harms and no comparable evidence found numeric increases in mortality, which may begin to suggest that VWs are plausibly safe. Further evidence generation is needed to verify this hypothesis, but there is an absence of evidence to suggest they are unsafe. The EAG has identified weak evidence for the operational performance of VWs, of which length of stay and admission or readmission data has the most evidence. Estimates vary widely reflecting the likely heterogeneity in patient populations recruited, VW components and modes of monitoring, healthcare settings and countries of evaluation.

These estimates may not be generalisable to all VW platform technologies available to the NHS.

11.2 *Conclusions from the economic evidence*

Previous economic evidence

A total of 4 economic studies were identified. Two studies were in step-down care settings, and 2 UK studies were in a setting providing a mix of step-up and step-down care. All of the studies suggested that VWs could potentially be a cost-saving intervention. None of these specific studies aligned with the scope of this evaluation. However, the studies report data on the impact of VWs on resource utilisation and staffing. Data from 2 studies were used as part of the EAG modelling.

Base case economic model results

The economic analyses conducted by the EAG was a simple-cost comparison model to indicate the potential benefit of VW platform technologies. The analysis suggests that the incorporation of VW platform technologies into the

NHS has the potential to be cost saving, based on the limited evidence available. The results of the analysis suggest that there is a potential cost saving of £872 per patient treated on a VW, when compared with those receiving inpatient care. Similarly, the cost of a running a VW per patient with an average length of stay of 8.89 days, is a similar cost to less than 3 excess bed days in hospital. This result can be used as a proxy for the potential impact of step-down care. The results suggest when compared with at home care, VWs could lead to a cost-saving of £115 per person. However, the results are based on naïve and limited data with a high level of uncertainty. Key areas of uncertainty are population creep, implementation costs, variations in different VW features which may or may not impact effectiveness, variations in clinical practice, and the point at which step-down care is initiated. Further to this, the simple cost-comparison model does not fully capture any potential differences in safety baring readmissions. Model inputs were primarily sourced though clinical elicitation and company provided detail.

Key drivers of the model results

The sensitivity analysis indicated the likely key drivers of the economic results were:

- Expected resource use of people in hospital with a moderate ARI.
- Length of stay in VW care and at home care.
- Readmissions and home visits in VW care and at home care.
- Level of monitoring time with VW care or at home care.
- Implementation costs required for VW platform technologies, which could vary significantly by geography or trust capabilities.
- Population spill over effects, treating milder patients due to VW platform technology availability.

Future conceptual model

Limited evidence was available to fully model the potential impact on step-up and step-down care. A future model could be developed to support decision-makers with:

- Capturing step-up and step-down care in greater detail.
- Understanding the impact of variations in clinical practice and different types of VW platform technologies, and the effectiveness impact (if any) of specific features of VWs.
- Capturing long-term impacts associated with VW care compared with hospital inpatient care or at home care.

11.3 *Conclusions on the gap analysis*

The primary evidence gap is a lack of reliable comparative evidence from a UK NHS setting for comparing VWs to standard inpatient care or any other relevant comparator, and for all 3 models of care (step-up, step-down and mixed) in this patient population. The EAG identified several ideas for further evidence generation but consider the priority to be prospective comparative studies producing evidence of patient safety and cost effectiveness. These studies should also attempt to capture how different VW features (which is heterogenous across providers) may impact patient safety, effectiveness, and cost effectiveness.

In summary, this EVA concludes that there is currently limited existing evidence to understand the impact VWs have on patient safety and other health outcomes. However, no evidence was identified which suggested that VW care reduces patient safety or worsen health outcomes. Existing economic evidence is also scarce, though the 4 included studies (not economic evaluations, 1 UK study) all found the use of VW platform technologies to be cost saving. Future evidence generation, in particular for any economic evaluation, would need to evaluate long-term outcomes, consider subgroups different usual places of residence, provide an understanding of the potential population creep or spillover, and determine the true difference (if any) in adverse events from implementing VWs.

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13 Appendices

Appendix A - Search methods (clinical and economic reviews)

A MEDLINE (OvidSP) search strategy was designed to identify studies of VW platform technologies for managing adults with acute respiratory infections. The final MEDLINE strategy is presented below (Search strategies

The main structure of the strategy comprised three concepts:

- virtual wards (search lines 2 to 11)

- digital technologies (search lines 12 to 29)
- respiratory tract infections (search lines 30 to 36).

The concepts were combined as follows: virtual wards AND digital technologies AND respiratory tract infections.

In addition to the above approach, the strategy included three supplementary search strands designed to identify:

- Records referring to virtual wards in the title, abstract or keyword heading word field AND respiratory tract infections (search line 46).
- Records referring to virtual wards AND known named technology providers/platforms (except Inhealthcare) (search line 44).
- Records referring to virtual wards AND Inhealthcare AND respiratory tract infections (search line 45).

The strategy was devised using a combination of subject indexing terms and free text search terms in the Title, Abstract and Keyword Heading Word fields. The search terms were identified through discussion within the research team, scanning background literature and browsing database thesauri. Searches were not restricted by study design or outcome so were appropriate to retrieve both clinical and economic evidence.

The strategy excluded animal studies from MEDLINE using a standard algorithm (search line 48). The strategy also excluded some ineligible publication types which are unlikely to yield relevant study reports (editorials, news items and case reports) and records with the phrase 'case report' in the title (search lines 49).

Reflecting the eligibility criteria, the strategy was restricted to studies published in English. The strategy was not limited by publication date.

The final Ovid MEDLINE strategy was peer-reviewed before execution by a second Information Specialist. Peer review considered the appropriateness of the strategy for the review scope and eligibility criteria, inclusion of key search terms, errors in spelling, syntax and line combinations, and application of exclusions.

Search limitations

The search approach was designed to enable search strategy development and result assessment to be conducted within project resources and timelines. The search methods aimed to strike an appropriate balance of sensitivity and precision. This balanced approach used a number of techniques to focus the search strategy. These included for example:

- Using a relatively limited range of terms for the digital technologies concepts and focusing on their monitoring use.
- Using a relatively limited range of terms for the respiratory infections concept and only including a limited number of specific infections.

Although the focused search methods may have increased the risk of not retrieving relevant studies, the balance of sensitivity and precision was judged to be appropriate to the review.

Resources searched

We conducted the literature search in the databases and information resources shown in Table 13.1.

Table 13.1: Databases and information sources searched

Resource	Interface / URL
Databases	
MEDLINE(R) ALL	OvidSP
Embase	OvidSP
Cochrane Database of Systematic Reviews(CDSR)	Cochrane Library/Wiley
Cochrane Central Register of Controlled Trials (CENTRAL)	Cochrane Library/Wiley
Conference Proceedings Citation Index - Science (CPCI-S)	Web of Science
NHS Economic Evaluation Database (NHS EED)	https://www.crd.york.ac.uk/CRDWeb/HomePage.asp
EconLit	OvidSP
Trials Registers	
ClinicalTrials.gov	https://clinicaltrials.gov/
WHO International Clinical Trials Registry Platform (ICTRP)	https://trialsearch.who.int/
Other	
Future NHS virtual wards network	https://future.nhs.uk/NationalVirtualWards
Reference list checking	n/a

The trials register sources listed above (ClinicalTrials.gov and ICTRP) were searched to identify information on studies in progress.

Reflecting the eligibility criteria, records indexed as preprints were excluded from Embase search results.

We also checked included studies lists of any industry submissions to NICE as well as retrieved relevant systematic reviews published in the last five years, for additional eligible studies.

Running the search strategies and downloading results

We conducted searches using each database or resource listed above, translating the agreed Ovid MEDLINE strategy appropriately. Translation included consideration of differences in database interfaces and functionality, in addition to variation in indexing languages and thesauri. The final translated database strategies were peer-reviewed by a second Information Specialist.

Peer review considered the appropriateness of the translation for the database being searched, errors in syntax and line combinations, and application of exclusions.

Where possible, we downloaded the results of searches in a tagged format and loaded them into bibliographic software (EndNote) (Clarivate, 2021). The results were deduplicated using several algorithms and the duplicate references held in a separate EndNote database for checking if required. Results from resources that did not allow export in a format compatible with EndNote were saved in Word or Excel documents as appropriate and manually deduplicated.

Literature search results

The searches were conducted between 23 and 30 May 2023 and identified 3,497 records (Table 13.2). Following deduplication, 2,636 records were assessed for relevance.

Table 13.2: Literature search results

Resource	Number of records identified
Databases	
MEDLINE	909
Embase	1475
Cochrane Database of Systematic Reviews (CDSR)	4
Cochrane Central Register of Controlled Trials (CENTRAL)	191
Conference Proceedings Citation Index - Science (CPCI-S)	38
NHS Economic Evaluation Database (NHS EED)	79
EconLit	12
Total records identified through database searching	**2708**
Trials Registers	
ClinicalTrials.gov.	580
WHO International Clinical Trials Registry Portal (ICTRP)	137
Total records identified through trials register searching	**717**
Other sources	
Future NHS virtual wards network	44
Reference list checking	22
Company evidence	6
Total additional records identified through other sources	**72**
Total number of records retrieved	**3,497**
Total number of records after deduplication	**2,636**

Search strategies

A.1: Source: MEDLINE ALL

Interface / URL: OvidSP

Database coverage dates: 1946 to 22 May 2023

Search date: 23 May 2023

Retrieved records: 909

Search strategy:

1 (virtual* and ward*).ti. or (virtual* adj6 ward*).ab,kf. 129

2 home care services, hospital-based/ 1978

3 (hospital adj3 home).ti,ab,kf. 8586

4 (virtual* adj3 (ward or wards or unit or units or facility or facilities or hospital* or triage* or inpatient* or in-patient* or care or healthcare or pathway*)).ti,ab,kf. 3497

5 ((early or earlier or supported or assisted) adj3 discharge?).ti,ab,kf. 7607

6 ((admission* or readmission*) adj3 (avoid* or alternative*)).ti,ab,kf. 1895

7 ((step down or step up) adj3 (care or healthcare or service* or ward* or approach* or manag*)).ti,ab,kf. 912

8 vward*.ti,ab,kf. 2

9 (healthcare adj3 home).ti,ab,kf. 2199

10 (home adj3 (monitor* or manag*)).ti,ab,kf. 10536

11 or/2-10 35287

12 telemedicine/ 37059

13 telenursing/ 248

14 monitoring, physiologic/ 58660

15 exp telemetry/ 15100

16 mobile applications/ 11344

17 exp computers, handheld/ 12876

18 medical informatics applications/ 2550

19 ((remote* or digital* or smart) adj3 (monitor* or manag*)).ti,ab,kf. 11127

20 ((telemetry or telemetric*) adj3 (monitor* or manag*)).ti,ab,kf. 1263

21 (telemonitor* or tele-monitor*).ti,ab,kf. 2569

22 ((platform* or portal or portals or dashboard* or dash board* or software or tech or technolog*) adj3 (monitor* or manag*)).ti,ab,kf. 17491

23 (telemanag* or tele-manag*).ti,ab,kf. 90

24 (app or apps).ti,ab,kf. 43305

25 ((wireless or wifi or wi-fi or bluetooth or blue-tooth or mobile or cellular or telephone* or smartphone* or cellphone* or phone* or smartwatch*) adj3 (monitor* or manag*)).ti,ab,kf. 7602

26 ((mhealth or m-health or ehealth or e-health or online or web or internet or digital* or application* or wearable) adj3 (monitor* or manag*)).ti,ab,kf. 20541

27 ((automat* or continuous) adj3 monitor*).ti,ab,kf. 31873

28 remote patient.ti,ab,kf. 989

29 or/12-28 230323

30 exp respiratory tract infections/ 606893

31 (aspergillosis or blastomycosis or bronchiolitis or bronchitis or bronchopneumonia* or common cold* or covid or coronavirus* or echinococcosis or empyema* or epiglottitis or influenza* or flu or laryngitis or legionellosis or legionnaires or nasopharyngitis or pasteurellosis or pharyngitis or pleurisy or pleuropneumonia* or pneumonia* or rhinitis or rhinoscleroma* or severe acute respiratory syndrome* or silicotuberculosis or sinusitis or supraglottitis or tonsillitis or tracheitis or tuberculosis or whooping cough).ti,ab,kf. 1033453

32 (laryngotracheobronchitis or tracheobronchitis or laryngotracheitis or parainfluenza*).ti,ab,kf. 9093

33 (pertussis or parapertussis or tuberculous or lobitis or peripneumonia or pleuropneumonitis or pneumonic or pneumonitis).ti,ab,kf. 81658

34 ((respiratory or lung? or pulmonary or chest or airway* or bronchopulmonary or thoracic or thorax) adj5 (infection* or inflamm* or illness* or abscess*)).ti,ab,kf. 188945

35 ((bronch* or pneumon* or epiglott* or laryng* or larynx or legionell* or pharyng* or pharynx or sinus* or tonsil* or trachea*) adj5 infection*).ti,ab,kf. 38827

36 or/30-35 1315562

37 11 and 29 and 36 838

38 (andersen* or doccla* or docobo* or "doc@home" or "doc@hometm" or "doc@homer" or careportal* or dignio* or mydignio* or healum* or spirit digital or spirit digitalr or spirit digitaltm or spirit health or spirit healthr or spirit healthtm or clinitouch* or whzan* or whzapp* or huma or humatm or humar).ti,ab,kf,ot. 3579

39 (accurx* or bt health* or feebris* or baywater healthcare* or doctaly* or bdm medical* or luscii* or camascope* or vcare* or "blue box" or "blue boxr" or "blue boxtm" or solcom* or lenus* or medibiosense* or vitalpatch* or healthstream* or biobeat* or earswitch* or isla or islar or islatm).ti,ab,kf,ot. 635

40 ("health call" or "health callr" or "health calltm").ti,ab,kf,ot. 59

41 (currenthealth* or "current health" or "current healthtm" or "current healthr").ti,ab,kf,ot. 5171

42 (inhealthcare* or "in health care" or "in health carer" or "in health caretm").ti,ab,kf,ot. 39887

43 or/38-41 9439

44 11 and 43 54

45 11 and 36 and 42 57

46 1 and 36 53

47 37 or 44 or 45 or 46 953

48 exp animals/ not humans/ 5123728

49 (news or editorial or case reports).pt. or case report.ti. 3249128

50 or/48-49 8308541

51 47 not 50 922

52 limit 51 to english language 909

A.2: Source: Embase

Interface / URL: OvidSP

Database coverage dates: 1974 to 22 May 2023

Search date: 23 May 2023

Retrieved records: 1475

Search strategy:

1 (virtual* and ward*).ti. or (virtual* adj6 ward*).ab,kf,dq. 250

2 home monitoring/ 5692

3 telecare/ 1005

4 (hospital adj3 home).ti,ab,kf,dq. 12794

5 (virtual* adj3 (ward or wards or unit or units or facility or facilities or hospital* or triage* or inpatient* or in-patient* or care or healthcare or pathway*)).ti,ab,kf,dq. 4979

6 ((early or earlier or supported or assisted) adj3 discharge?).ti,ab,kf,dq. 12611

7 ((admission* or readmission*) adj3 (avoid* or alternative*)).ti,ab,kf,dq. 3650

8 ((step down or step up) adj3 (care or healthcare or service* or ward* or approach* or manag*)).ti,ab,kf,dq. 1686

9 vward*.ti,ab,kf,dq. 1

10 (healthcare adj3 home).ti,ab,kf,dq. 2741

11 (home adj3 (monitor* or manag*)).ti,ab,kf,dq. 16230

12 or/2-11 55445

13 telemedicine/ 44032

14 telemonitoring/ 5539

15 telenursing/ 378

16 telemetry/ 20826

17 exp mobile application/ 24727

18 personal digital assistant/ 1785

19 ((remote* or digital* or smart) adj3 (monitor* or manag*)).ti,ab,kf,dq. 16755

20 ((telemetry or telemetric*) adj3 (monitor* or manag*)).ti,ab,kf,dq. 2323

21 (telemonitor* or tele-monitor*).ti,ab,kf,dq. 3932

22 ((platform* or portal or portals or dashboard* or dash board* or software or tech or technolog*) adj3 (monitor* or manag*)).ti,ab,kf,dq. 24539

23 (telemanag* or tele-manag*).ti,ab,kf,dq. 147

24 (app or apps).ti,ab,kf,dq. 60274

25 ((wireless or wifi or wi-fi or bluetooth or blue-tooth or mobile or cellular or telephone* or smartphone* or cellphone* or phone* or smartwatch*) adj3 (monitor* or manag*)).ti,ab,kf,dq. 10595

26 ((mhealth or m-health or ehealth or e-health or online or web or internet or digital* or application* or wearable) adj3 (monitor* or manag*)).ti,ab,kf,dq. 26199

27 ((automat* or continuous) adj3 monitor*).ti,ab,kf,dq. 48527

28 remote patient.ti,ab,kf,dq. 1473

29 or/13-28 244974

30 exp respiratory tract infection/ 487640

31 (aspergillosis or blastomycosis or bronchiolitis or bronchitis or bronchopneumonia* or common cold* or covid or coronavirus* or echinococcosis or empyema* or epiglottitis or influenza* or flu or laryngitis or legionellosis or legionnaires or nasopharyngitis or pasteurellosis or pharyngitis or pleurisy or pleuropneumonia* or pneumonia* or rhinitis or rhinoscleroma* or severe acute respiratory syndrome* or silicotuberculosis or sinusitis or supraglottitis or tonsillitis or tracheitis or tuberculosis or whooping cough).ti,ab,kf,dq. 1222725

32 (laryngotracheobronchitis or tracheobronchitis or laryngotracheitis or parainfluenza*).ti,ab,kf,dq. 10905

33 (pertussis or parapertussis or tuberculous or lobitis or peripneumonia or pleuropneumonitis or pneumonic or pneumonitis).ti,ab,kf,dq. 94243

34 ((respiratory or lung? or pulmonary or chest or airway* or bronchopulmonary or thoracic or thorax) adj5 (infection* or inflamm* or illness* or abscess*)).ti,ab,kf,dq. 275923

35 ((bronch* or pneumon* or epiglott* or laryng* or larynx or legionell* or pharyng* or pharynx or sinus* or tonsil* or trachea*) adj5 infection*).ti,ab,kf,dq. 57082

36 or/30-35 1610719

37 12 and 29 and 36 1351

38 (andersen* or doccla* or docobo* or "doc@home" or "doc@hometm" or "doc@homer" or careportal* or dignio* or mydignio* or healum* or spirit digital or spirit digitalr or spirit digitaltm or spirit health or spirit healthr or spirit healthtm or clinitouch* or whzan* or whzapp* or huma or humatm or humar).ti,ab,kf,dq,dv,my,ot,dm. 4975

39 (accurx* or bt health* or feebris* or baywater healthcare* or doctaly* or bdm medical* or luscii* or camascope* or vcare* or "blue box" or "blue boxr" or "blue boxtm" or solcom* or lenus* or medibiosense* or vitalpatch* or healthstream* or biobeat* or earswitch* or isla or islar or islatm).ti,ab,kf,dq,dv,my,ot,dm. 783

40 ("health call" or "health callr" or "health calltm").ti,ab,kf,dq,dv,my,ot,dm. 81

41 (currenthealth* or "current health" or "current healthtm" or "current healthr").ti,ab,kf,dq,dv,my,ot,dm. 6693

42 (inhealthcare* or "in health care" or "in health carer" or "in health caretm").ti,ab,kf,dq,dv,my,ot,dm. 48165

43 or/38-41 12524

44 12 and 43 85

45 12 and 36 and 42 75

46 1 and 36 104

47 37 or 44 or 45 or 46 1538

48 (animal/ or animal experiment/ or animal model/ or animal tissue/ or nonhuman/) not exp human/ 6806136

49 editorial.pt. or case report.ti. 1155029

50 preprint.pt. 65307

51 or/48-50 7983473

52 47 not 51 1490

53 limit 52 to english language 1475

A.3: Source: Cochrane Database of Systematic Reviews (CDSR)

Interface / URL: Cochrane Library / Wiley

Database coverage dates: Information not found. Issue searched: Issue 5 of 12, May 2023

Search date: 23 May 2023

Retrieved records: 4

Search strategy:

#1 (virtual* and ward*):ti or (virtual* NEAR/6 ward*):ab,kw 14

#2 [mh ^"home care services, hospital-based"] 268

#3 (hospital NEAR/3 home):ti,ab,kw 2592

#4 (virtual* NEAR/3 (ward or wards or unit or units or facility or facilities or hospital* or triage* or inpatient* or in-patient* or care or healthcare or pathway*)):ti,ab,kw 532

#5 ((early or earlier or supported or assisted) NEAR/3 discharge?):ti,ab,kw 2242

#6 ((admission* or readmission*) NEAR/3 (avoid* or alternative*)):ti,ab,kw 207

#7 (("step down" or "step up") NEAR/3 (care or healthcare or service* or ward* or approach* or manag*)):ti,ab,kw 195

#8 vward*:ti,ab,kw 0

#9 (healthcare NEAR/3 home):ti,ab,kw 184

#10 (home NEAR/3 (monitor* or manag*)):ti,ab,kw 3179

#11 #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 8595

#12 [mh ^"telemedicine"] 3522

#13 [mh ^"telenursing"] 46

#14 [mh ^"monitoring, physiologic"] 2519

#15 [mh "telemetry"] 377

#16 [mh ^"mobile applications"] 1538

#17 [mh "computers, handheld"] 1351

#18 [mh ^"medical informatics applications"] 38

#19 ((remote* or digital* or smart) NEAR/3 (monitor* or manag*)):ti,ab,kw 2326

#20 ((telemetry or telemetric*) NEAR/3 (monitor* or manag*)):ti,ab,kw 182

#21 (telemonitor* or tele-monitor*):ti,ab,kw 1332

#22 ((platform* or portal or portals or dashboard* or dash NEXT board* or software or tech or technolog*) NEAR/3 (monitor* or manag*)):ti,ab,kw 1720

#23 (telemanag* or tele-manag*):ti,ab,kw 46

#24 (app or apps):ti,ab,kw 9032

#25 ((wireless or wifi or wi-fi or bluetooth or blue-tooth or mobile or cellular or telephone* or smartphone* or cellphone* or phone* or smartwatch*) NEAR/3 (monitor* or manag*)):ti,ab,kw 2365

#26 ((mhealth or m-health or ehealth or e-health or online or web or internet or digital* or application* or wearable) NEAR/3 (monitor* or manag*)):ti,ab,kw 3361

#27 ((automat* or continuous) NEAR/3 monitor*):ti,ab,kw 6091

#28 "remote patient":ti,ab,kw 195

#29 #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 28499

#30 [mh "respiratory tract infections"] 23846

#31 (aspergillosis or blastomycosis or bronchiolitis or bronchitis or bronchopneumonia* or common NEXT cold* or covid or coronavirus* or echinococcosis or empyema* or epiglottitis or influenza* or flu or laryngitis or legionellosis or legionnaires or nasopharyngitis or pasteurellosis or pharyngitis or pleurisy or pleuropneumonia* or pneumonia* or rhinitis or rhinoscleroma* or "severe acute respiratory" NEXT syndrome* or silicotuberculosis or sinusitis or supraglottitis or tonsillitis or tracheitis or tuberculosis or "whooping cough"):ti,ab,kw 77239

#32 (laryngotracheobronchitis or tracheobronchitis or laryngotracheitis or parainfluenza*):ti,ab,kw 384

#33 (pertussis or parapertussis or tuberculous or lobitis or peripneumonia or pleuropneumonitis or pneumonic or pneumonitis):ti,ab,kw 4268

#34 ((respiratory or lung? or pulmonary or chest or airway* or bronchopulmonary or thoracic or thorax) NEAR/5 (infection* or inflamm* or illness* or abscess*)):ti,ab,kw 24150

#35 ((bronch* or pneumon* or epiglott* or laryng* or larynx or legionell* or pharyng* or pharynx or sinus* or tonsil* or trachea*) NEAR/5 infection*):ti,ab,kw 3770

#36 #30 or #31 or #32 or #33 or #34 or #35 93760

#37 #11 and #29 and #36 86

#38 (andersen* or doccla* or docobo* or "doc@home" or "doc@hometm" or "doc@homer" or careportal* or dignio* or mydignio* or healum* or "spirit digital" or "spirit digitalr" or "spirit digitaltm" or "spirit health" or "spirit healthr" or "spirit healthtm" or clinitouch* or whzan* or whzapp* or huma or humatm or humar):ti,ab,kw 261

#39 (accurx* or bt NEXT health* or feebris* or baywater NEXT healthcare* or doctaly* or bdm NEXT medical* or luscii* or camascope* or vcare* or "blue box" or "blue boxr" or "blue boxtm" or solcom* or lenus* or medibiosense* or vitalpatch* or healthstream* or biobeat* or earswitch* or isla or islar or islatm):ti,ab,kw 26

#40 ("health call" or "health callr" or "health calltm"):ti,ab,kw 31

#41 (currenthealth* or "current health" or "current healthtm" or "current healthr"):ti,ab,kw 381

#42 (inhealthcare* or "in health care" or "in health carer" or "in health caretm"):ti,ab,kw 1621

#43 #38 or #39 or #40 or #41 699

#44 #11 and #43 18

#45 #11 and #36 and #42 7

#46 #1 and #36 1

#47 #37 or #44 or #45 or #46 in Cochrane Reviews, Cochrane Protocols 4

A.4: Source: Cochrane Central Register of Controlled Trials (CENTRAL)

Interface / URL: Cochrane Library / Wiley

Database coverage dates: Information not found. Issue searched: Issue 5 of 12, May 2023

Search date: 23 May 2023

Retrieved records: 191

Search strategy:

#1 virtual* and ward* 671

#2 [mh ^"home care services, hospital-based"] 268

#3 (hospital NEAR/3 home) 3024

#4 (virtual* NEAR/3 (ward or wards or unit or units or facility or facilities or hospital* or triage* or inpatient* or in-patient* or care or healthcare or pathway*)) 737

#5 ((early or earlier or supported or assisted) NEAR/3 discharge?) 2438

#6 ((admission* or readmission*) NEAR/3 (avoid* or alternative*)) 266

#7 (("step down" or "step up") NEAR/3 (care or healthcare or service* or ward* or approach* or manag*)) 229

#8 vward* 0

#9 (healthcare NEAR/3 home) 270

#10 (home NEAR/3 (monitor* or manag*)) 3418

#11 #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 9652

#12 [mh ^"telemedicine"] 3522

#13 [mh ^"telenursing"] 46

#14 [mh ^"monitoring, physiologic"] 2519

#15 [mh "telemetry"] 377

#16 [mh ^"mobile applications"] 1538

#17 [mh "computers, handheld"] 1351

#18 [mh ^"medical informatics applications"] 38

#19 ((remote* or digital* or smart) NEAR/3 (monitor* or manag*)) 2450

#20 ((telemetry or telemetric*) NEAR/3 (monitor* or manag*)) 201

#21 (telemonitor* or tele-monitor*) 1414

#22 ((platform* or portal or portals or dashboard* or dash NEXT board* or software or tech or technolog*) NEAR/3 (monitor* or manag*)) 4722

#23 (telemanag* or tele-manag*) 58

#24 (app or apps) 11464

#25 ((wireless or wifi or wi-fi or bluetooth or blue-tooth or mobile or cellular or telephone* or smartphone* or cellphone* or phone* or smartwatch*) NEAR/3 (monitor* or manag*)) 2626

#26 ((mhealth or m-health or ehealth or e-health or online or web or internet or digital* or application* or wearable) NEAR/3 (monitor* or manag*)) 4033

#27 ((automat* or continuous) NEAR/3 monitor*) 6309

#28 "remote patient" 208

#29 #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 33662

#30 [mh "respiratory tract infections"] 23846

#31 (aspergillosis or blastomycosis or bronchiolitis or bronchitis or bronchopneumonia* or common NEXT cold* or covid or coronavirus* or echinococcosis or empyema* or epiglottitis or influenza* or flu or laryngitis or legionellosis or legionnaires or nasopharyngitis or pasteurellosis or pharyngitis or pleurisy or pleuropneumonia* or pneumonia* or rhinitis or rhinoscleroma* or "severe acute respiratory" NEXT syndrome* or silicotuberculosis or sinusitis or supraglottitis or tonsillitis or tracheitis or tuberculosis or "whooping cough") 79879

#32 (laryngotracheobronchitis or tracheobronchitis or laryngotracheitis or parainfluenza*) 452

#33 (pertussis or parapertussis or tuberculous or lobitis or peripneumonia or pleuropneumonitis or pneumonic or pneumonitis) 4551

#34 ((respiratory or lung? or pulmonary or chest or airway* or bronchopulmonary or thoracic or thorax) NEAR/5 (infection* or inflamm* or illness* or abscess*)) 27022

#35 ((bronch* or pneumon* or epiglott* or laryng* or larynx or legionell* or pharyng* or pharynx or sinus* or tonsil* or trachea*) NEAR/5 infection*) 6012

#36 #30 or #31 or #32 or #33 or #34 or #35 97842

#37 #11 and #29 and #36 277

#38 (andersen* or doccla* or docobo* or "doc@home" or "doc@hometm" or "doc@homer" or careportal* or dignio* or mydignio* or healum* or "spirit digital" or "spirit digitalr" or "spirit digitaltm" or "spirit health" or "spirit healthr" or "spirit healthtm" or clinitouch* or whzan* or whzapp* or huma or humatm or humar) 5110

#39 (accurx* or bt NEXT health* or feebris* or baywater NEXT healthcare* or doctaly* or bdm NEXT medical* or luscii* or camascope* or vcare* or "blue box" or "blue boxr" or "blue boxtm" or solcom* or lenus* or medibiosense* or vitalpatch* or healthstream* or biobeat* or earswitch* or isla or islar or islatm) 152

#40 ("health call" or "health callr" or "health calltm") 34

#41 (currenthealth* or "current health" or "current healthtm" or "current healthr") 419

#42 (inhealthcare* or "in health care" or "in health carer" or "in health caretm") 3167

#43 #38 or #39 or #40 or #41 5714

#44 #11 and #43 67

#45 #11 and #36 and #42 91

#46 #1 and #36 110

#47 #37 or #44 or #45 or #46 in Trials 191

A.5: Source: Conference Proceedings Citation Index - Science (CPCI-S)

Interface / URL: Web of Science

Database coverage dates: 1990 to present

Search date: 23 May 2023

Retrieved records: 38

Search strategy:

Searches were conducted in the advanced search interface with the "exact search" option selected for all search lines.

1 TS=(virtual* AND ward*) 88

2 TS=(hospital NEAR/3 home) 775

3 TS=(virtual* NEAR/3 (ward OR wards OR unit OR units OR facility OR facilities OR hospital* OR triage* OR inpatient* OR in-patient* OR care OR healthcare OR pathway*)) 1,207

4 TS=((early OR earlier OR supported OR assisted) NEAR/3 discharge$) 989

5 TS=((admission* OR readmission*) NEAR/3 (avoid* OR alternative*)) 125

6 TS=(("step down" OR "step up") NEAR/3 (care OR healthcare OR service* OR ward* OR approach* OR manag*))111

7 TS=vward* 0

8 TS=(healthcare NEAR/3 home) 620

9 TS=(home NEAR/3 (monitor* OR manag*)) 4,440

10 #9 OR #8 OR #7 OR #6 OR #5 OR #4 OR #3 OR #2 8,042

11 TS=((remote* OR digital* OR smart) NEAR/3 (monitor* OR manag*)) 23,462

12 TS=((telemetry OR telemetric*) NEAR/3 (monitor* OR manag*)) 492

13 TS=(telemonitor* OR tele-monitor*) 994

14 TS=((platform* OR portal OR portals OR dashboard* OR "dash board*" OR software OR tech OR technolog*) NEAR/3 (monitor* OR manag*)) 35,935

15 TS=(telemanag* OR tele-manag*) 90

16 TS=(app OR apps) 18,294

17 TS=((wireless OR wifi OR wi-fi OR bluetooth OR blue-tooth OR mobile OR cellular OR telephone* OR smartphone* OR cellphone* OR phone* OR smartwatch*) NEAR/3 (monitor* OR manag*)) 14,404

18 TS=((mhealth OR m-health OR ehealth OR e-health OR online OR web OR internet OR digital* OR application* OR wearable) NEAR/3 (monitor* OR manag*))44,217

19 TS=((automat* OR continuous) NEAR/3 monitor*) 15,984

20 TS=remote patient 2,896

21 #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 134,135

22 TS=(aspergillosis OR blastomycosis OR bronchiolitis OR bronchitis OR bronchopneumonia* OR "common cold*" OR covid OR coronavirus* OR echinococcosis OR empyema* OR epiglottitis OR influenza* OR flu OR laryngitis OR legionellosis OR legionnaires OR nasopharyngitis OR pasteurellosis OR pharyngitis OR pleurisy OR pleuropneumonia* OR pneumonia* OR rhinitis OR rhinoscleroma* OR "severe acute respiratory syndrome*" OR silicotuberculosis OR sinusitis OR supraglottitis OR tonsillitis OR tracheitis OR tuberculosis OR "whooping cough") 60,855

23 TS=(laryngotracheobronchitis OR tracheobronchitis OR laryngotracheitis OR parainfluenza*) 316

24 TS=(pertussis OR parapertussis OR tuberculous OR lobitis OR peripneumonia OR pleuropneumonitis OR pneumonic OR pneumonitis) 4,033

25 TS=((respiratory OR lung$ OR pulmonary OR chest OR airway* OR bronchopulmonary OR thoracic OR thorax) NEAR/5 (infection* OR inflamm* OR illness* OR abscess*)) 12,154

26 TS=((bronch* OR pneumon* OR epiglott* OR laryng* OR larynx OR legionell* OR pharyng* OR pharynx OR sinus* OR tonsil* OR trachea*) NEAR/5 infection*) 2,138

27 #22 OR #23 OR #24 OR #25 OR #26 73,887

28 #10 AND #21 AND #27 25

29 TS=(andersen* OR doccla* OR docobo* OR "doc@home" OR "doc@hometm" OR "doc@homer" OR careportal* OR dignio* OR mydignio* OR healum* OR "spirit digital" OR "spirit digitalr" OR "spirit digitaltm" OR "spirit health" OR "spirit healthr" OR "spirit healthtm" OR clinitouch* OR whzan* OR whzapp* OR huma OR humatm OR humar) 454

30 TS=(accurx* OR "bt health*" OR feebris* OR "baywater healthcare*" OR doctaly* OR "bdm medical*" OR luscii* OR camascope* OR vcare* OR "blue box" OR "blue boxr" OR "blue boxtm" OR solcom* OR lenus* OR medibiosense* OR vitalpatch* OR healthstream* OR biobeat* OR earswitch* OR isla OR islar OR islatm) 127

31 TS=("health call" OR "health callr" OR "health calltm") 5

32 TS=(currenthealth* OR "current health" OR "current healthtm" OR "current healthr") 425

33 TS=(inhealthcare* OR "in health care" OR "in health carer" OR "in health caretm") 2,498

34 #29 OR #30 OR #31 OR #32 1,011

35 #10 AND #34 8

36 #10 AND #27 AND #33 2

37 #1 AND #27 5

38 #28 OR #35 OR #36 OR #37 38

A.6: Source: NHS Economic Evaluation Database (NHS EED)

Interface / URL: https://www.crd.york.ac.uk/CRDWeb

Database coverage dates: Information not found. Bibliographic records were published on NHS EED until 31st March 2015. Searches of MEDLINE, Embase, CINAHL, PsycINFO and PubMed were continued until the end of the 2014.

Search date: 23 May 2023

Retrieved records: 79

Search strategy:

1 (virtual* AND ward*)7

2 MeSH DESCRIPTOR Home Care Services, Hospital-Based 66

3 (hospital AND home) 1377

4 (virtual* AND (ward OR wards OR unit OR units OR facility OR facilities OR hospital* OR triage* OR inpatient* OR in-patient* OR care OR healthcare OR pathway*)) 164

5 ((early OR earlier OR supported OR assisted) AND discharge*) 1020

6 ((admission* OR readmission*) AND (avoid* OR alternative*)) 793

7 ((step down OR step up) AND (care OR healthcare OR service* OR ward* OR approach* OR manag*)) 54

8 (vward*) 0

9 (healthcare AND home) 281

10 (home AND (monitor* OR manag*)) 1115

11 #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 3399

12 MeSH DESCRIPTOR Telemedicine 372

13 MeSH DESCRIPTOR Telenursing 5

14 MeSH DESCRIPTOR Monitoring, Physiologic 223

15 MeSH DESCRIPTOR Telemetry EXPLODE ALL TREES 44

16 MeSH DESCRIPTOR Mobile Applications 5

17 MeSH DESCRIPTOR Computers, Handheld EXPLODE ALL TREES 13

18 MeSH DESCRIPTOR Medical Informatics Applications 8

19 ((remote* OR digital* OR smart) AND (monitor* OR manag*)) 265

20 ((telemetry OR telemetric*) AND (monitor* OR manag*)) 52

21 (telemonitor* OR tele-monitor*) 58

22 ((platform* OR portal OR portals OR dashboard* OR dash board* OR software OR tech OR technolog*) AND (monitor* OR manag*)) 4553

23 (telemanag* OR tele-manag*) 6

24 (app OR apps) 133

25 ((wireless OR wifi OR wi-fi OR bluetooth OR blue-tooth OR mobile OR cellular OR telephone* OR smartphone* OR cellphone* OR phone* OR smartwatch*) AND (monitor* OR manag*)) 671

26 ((mhealth OR m-health OR ehealth OR e-health OR online OR web OR internet OR digital* OR application* OR wearable) AND (monitor* OR manag*)) 1687

27 ((automat* OR continuous) AND monitor*) 415

28 (remote patient) 6

29 #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 6565

30 MeSH DESCRIPTOR Respiratory Tract Infections EXPLODE ALL TREES 1432

31 (aspergillosis OR blastomycosis OR bronchiolitis OR bronchitis OR bronchopneumonia* OR common cold* OR covid OR coronavirus* OR echinococcosis OR empyema* OR epiglottitis OR influenza* OR flu OR laryngitis OR legionellosis OR legionnaires OR nasopharyngitis OR pasteurellosis OR pharyngitis OR pleurisy OR pleuropneumonia* OR pneumonia* OR rhinitis OR rhinoscleroma* OR severe acute respiratory syndrome* OR silicotuberculosis OR sinusitis OR supraglottitis OR tonsillitis OR tracheitis OR tuberculosis OR whooping cough) 2953

32 (laryngotracheobronchitis OR tracheobronchitis OR laryngotracheitis OR parainfluenza*) 10

33 (pertussis OR parapertussis OR tuberculous OR lobitis OR peripneumonia OR pleuropneumonitis OR pneumonic OR pneumonitis) 156

34 ((respiratory OR lung* OR pulmonary OR chest OR airway* OR bronchopulmonary OR thoracic OR thorax) AND (infection* OR inflamm* OR illness* OR abscess*)) 1957

35 ((bronch* OR pneumon* OR epiglott* OR laryng* OR larynx OR legionell* OR pharyng* OR pharynx OR sinus* OR tonsil* OR trachea*) AND infection*) 994

36 #30 OR #31 OR #32 OR #33 OR #34 OR #35 4364

37 #11 AND #29 AND #36 89

38 (andersen* OR doccla* OR docobo* OR "doc@home" OR "doc@hometm" OR "doc@homer" OR careportal* OR dignio* OR mydignio* OR healum* OR spirit digital OR spirit digitalr OR spirit digitaltm OR spirit health OR spirit healthr OR spirit healthtm OR clinitouch* OR whzan* OR whzapp* OR huma OR humatm OR humar) 84

39 (accurx* OR bt health* OR feebris* OR baywater healthcare* OR doctaly* OR bdm medical* OR luscii* OR camascope* OR vcare* OR "blue box" OR "blue boxr" OR "blue boxtm" OR solcom* OR lenus* OR medibiosense* OR vitalpatch* OR healthstream* OR biobeat* OR earswitch* OR isla OR islar OR islatm) 2

40 ("health call" OR "health callr" OR "health calltm") 0

41 (currenthealth* OR "current health" OR "current healthtm" OR "current healthr") 40

42 (inhealthcare* OR "in health care" OR "in health carer" OR "in health caretm") 991

43 #38 OR #39 OR #40 OR #41 125

44 #11 AND #43 21

45 #11 AND #36 AND #42 7

46 #1 OR #37 OR #44 OR #45 122

47 (#46) IN NHSEED 79

A.7: Source: Econlit

Interface / URL: OvidSP

Database coverage dates: 1886 to 11 May 2023

Search date: 23 May 2023

Retrieved records: 12

Search strategy:

Given the small numbers retrieved in this database it was decided to simplify the translation from MEDLINE to Econlit by removing the digital technologies concept.

1 (virtual* and ward*).af. 8

2 (hospital adj3 home).af. 46

3 (virtual* adj3 (ward or wards or unit or units or facility or facilities or hospital* or triage* or inpatient* or in-patient* or care or healthcare or pathway*)).af. 31

4 ((early or earlier or supported or assisted) adj3 discharge?).af. 23

5 ((admission* or readmission*) adj3 (avoid* or alternative*)).af. 33

6 ((step down or step up) adj3 (care or healthcare or service* or ward* or approach* or manag*)).af. 7

7 vward*.af. 0

8 (healthcare adj3 home).af. 34

9 (home adj3 (monitor* or manag*)).af. 136

10 or/2-9 307

11 (aspergillosis or blastomycosis or bronchiolitis or bronchitis or bronchopneumonia* or common cold* or covid or coronavirus* or echinococcosis or empyema* or epiglottitis or influenza* or flu or laryngitis or legionellosis or legionnaires or nasopharyngitis or pasteurellosis or pharyngitis or pleurisy or pleuropneumonia* or pneumonia* or rhinitis or rhinoscleroma* or severe acute respiratory syndrome* or silicotuberculosis or sinusitis or supraglottitis or tonsillitis or tracheitis or tuberculosis or whooping cough).af. 12492

12 (laryngotracheobronchitis or tracheobronchitis or laryngotracheitis or parainfluenza*).af. 1

13 (pertussis or parapertussis or tuberculous or lobitis or peripneumonia or pleuropneumonitis or pneumonic or pneumonitis).af. 35

14 ((respiratory or lung? or pulmonary or chest or airway* or bronchopulmonary or thoracic or thorax) adj5 (infection* or inflamm* or illness* or abscess*)).af. 158

15 ((bronch* or pneumon* or epiglott* or laryng* or larynx or legionell* or pharyng* or pharynx or sinus* or tonsil* or trachea*) adj5 infection*).af. 17

16 or/11-15 12624

17 10 and 16 12

18 (andersen* or doccla* or docobo* or "doc@home" or "doc@hometm" or "doc@homer" or careportal* or dignio* or mydignio* or healum* or spirit digital or spirit digitalr or spirit digitaltm or spirit health or spirit healthr or spirit

healthtm or clinitouch* or whzan* or whzapp* or huma or humatm or humar).af. 1635

19 (accurx* or bt health* or feebris* or baywater healthcare* or doctaly* or bdm medical* or luscii* or camascope* or vcare* or "blue box" or "blue boxr" or "blue boxtm" or solcom* or lenus* or medibiosense* or vitalpatch* or healthstream* or biobeat* or earswitch* or isla or islar or islatm).af. 66

20 ("health call" or "health callr" or "health calltm").af. 1

21 (currenthealth* or "current health" or "current healthtm" or "current healthr").af. 209

22 (inhealthcare* or "in health care" or "in health carer" or "in health caretm").af. 2132

23 or/18-21 1911

24 10 and 23 0

25 10 and 16 and 22 0

26 1 and 17 0

27 17 or 24 or 25 or 26 12

28 limit 27 to english 12

A.8: Source: ClinicalTrials.gov

Interface / URL: https://clinicaltrials.gov/ct2/home

Database coverage dates: Information not found. ClinicalTrials.gov was created as a result of the Food and Drug Administration Modernization Act of 1997 (FDAMA). The site was made available to the public in February 2000.

Search date: 23 May 2023

Retrieved records: 580

Search strategy:

The following four searches were conducted separately. All search terms were entered using the Expert search interface: https://clinicaltrials.gov/ct2/results/refine?show_xprt=Y

The results from each search were downloaded as an individual set. The total number of records retrieved represents the sum of all searches, and includes duplicates caused by the same record being retrieved in each search.

Field searching was used where noted in square brackets below to ensure retrieved numbers remained manageable within the project context.

1. Search for virtual wards only:

(virtual ward OR virtual wards)

= 32 studies

2. Search for virtual wards AND digital monitoring[INTERVENTION] AND respiratory infections[CONDITION]

((hospital AND home) OR ((virtual OR virtually) AND (ward OR wards OR unit OR units OR facility OR facilities OR hospital OR hospitals OR hospitalisation OR hospitalisations OR hospitalised OR hospitalization OR hospitalizations OR hospitalized OR triage OR triaged OR triages OR inpatient OR inpatients OR in-patient OR in-patients OR care OR healthcare OR pathway OR pathways)) OR ((early OR earlier OR supported OR assisted) AND (discharge OR discharged OR discharges OR discharging)) OR ((admission OR admissions OR readmission OR readmissions) AND (avoid OR avoided OR avoiding OR avoids OR avoidance OR avoidances OR alternative OR alternatives)) OR (("step down" OR "step up") AND (care OR healthcare OR service OR services OR ward OR wards OR approach OR approaches OR manage OR manages OR managed OR management OR managing)) OR (vward OR vwards) OR (healthcare AND home) OR (home AND (monitor OR

monitors OR monitored OR monitoring OR manage OR manages OR managed OR management OR managing))) AND AREA[InterventionSearch](((remote OR remotely OR digital OR digitally OR smart OR telemetry OR telemetric OR telemetrics OR platform OR platforms OR portal OR portals OR dashboard OR dashboards OR "dash board" OR "dash boards" OR software OR tech OR technology OR technologies OR wireless OR wifi OR wi-fi OR bluetooth OR blue-tooth OR mobile OR cellular OR telephone OR telephones OR smartphone OR smartphones OR cellphone OR cellphones OR phone OR phones OR smartwatch OR smartwatches OR mhealth OR m-health OR ehealth OR e-health OR online OR web OR internet OR digital OR digitally OR application OR applications OR wearable) AND (monitor OR monitors OR monitored OR monitoring OR manage OR manages OR managed OR management OR managing)) OR (telemonitor OR telemonitors OR telemonitored OR telemonitoring OR tele-monitor OR tele-monitors OR tele-monitored OR tele-monitoring OR telemanage OR telemanages OR telemanaged OR telemanagement OR telemanaging OR tele-manage OR tele-manages OR tele-managed OR tele-management OR tele-managing OR app OR apps) OR ((automatic OR automated OR automatically OR continuous) AND monitor OR monitors OR monitored OR monitoring) OR ("remote patient")) AND AREA[ConditionSearch]((aspergillosis OR blastomycosis OR bronchiolitis OR bronchitis OR bronchopneumonia OR bronchopneumonias OR "common cold" OR "common colds" OR covid OR coronavirus OR coronaviruses OR echinococcosis OR empyema OR empyemas OR epiglottitis OR influenza OR influenzas OR flu OR laryngitis OR legionellosis OR legionnaires OR nasopharyngitis OR pasteurellosis OR pharyngitis OR pleurisy OR pleuropneumonia OR pleuropneumonias OR pneumonia OR pneumonias OR rhinitis OR rhinoscleroma OR rhinoscleromas OR "severe acute respiratory syndrome" OR "severe acute respiratory syndromes" OR silicotuberculosis OR sinusitis OR supraglottitis OR tonsillitis OR tracheitis OR tuberculosis OR "whooping cough" OR laryngotracheobronchitis OR tracheobronchitis OR laryngotracheitis OR parainfluenza OR parainfluenzas OR pertussis OR parapertussis OR tuberculous OR lobitis OR peripneumonia OR

pleuropneumonitis OR pneumonic OR pneumonitis) OR ((respiratory OR lung OR lungs OR pulmonary OR chest OR airway OR airways OR bronchopulmonary OR thoracic OR thorax) AND (infection OR infections OR inflammation OR inflammatory OR inflammations OR illness OR illnesses OR abscess OR abscesses)) OR ((bronchus OR bronchi OR bronchiole OR bronchioles OR bronchial OR pneumonic OR pneumonitis OR epiglottis OR epiglottal OR epiglottic OR laryngeal OR laryngeum OR larynx OR legionella OR legionellas OR legionellosis OR pharyngeal OR pharyngotonsillitis OR pharyngeum OR pharynx OR sinus OR sinuses OR tonsil OR tonsils OR trachea OR tracheal OR tracheas) AND (infection OR infections)))

= 347 studies

3. Search for named products/platforms/manufacturers[INTERVENTION] AND respiratory infections[CONDITION]:

AREA[InterventionSearch](andersen OR andersenr OR andersentm OR doccla OR docclar OR docclatm OR docobo OR doccobor OR doccobotm OR "doc@home" OR "doc@hometm" OR "doc@homer" OR careportal OR careportalr OR careportaltm OR dignio OR dignior OR digniotm OR mydignio OR mydignior OR mydigniotm OR healum OR healumr OR healumtm OR "spirit digital" OR "spirit digitalr" OR "spirit digitaltm" OR "spirit health" OR "spirit healthr" OR "spirit healthtm" OR clinitouch OR clinitouchr OR clinitouchtm OR whzan OR whzanr OR whzantm OR whzapp OR whzappr OR whzapptm OR huma OR humatm OR humar OR accurx OR accurxr OR accurxtm OR "bt health" OR "bt healthr" OR "bt healthtm" OR feebris OR feebrisr OR feebristm OR "baywater healthcare" OR "baywater healthcarer" OR "baywater healthcaretm" OR doctaly OR doctalyr OR doctalytm OR "bdm medical" OR "bdm medicalr" OR "bdm medicaltm" OR luscii OR lusciir OR lusciitm OR camascope OR camascoper OR camascopetm OR vcare OR vcarer OR vcaretm OR "blue box" OR "blue boxr" OR "blue boxtm" OR solcom OR solcomr OR solcomtm OR lenus OR lenusr OR lenustm OR medibiosense OR medibiosenser OR medibiosensetm OR vitalpatch OR vitalpatchr OR vitalpatchtm OR healthstream OR healthstreamr OR

healthstreamtm OR biobeat OR biobeatr OR biobeattm OR earswitch OR earswitchr OR earswitchtm OR isla OR islar OR islatm OR "health call" OR "health callr" OR "health calltm" OR currenthealth OR currenthealthr OR currenthealthtm OR "current health" OR "current healthtm" OR "current healthr" OR inhealthcare OR inhealthcarer OR inhealthcaretm OR "in health care" OR "in health carer" OR "in health caretm") AND AREA[ConditionSearch]((aspergillosis OR blastomycosis OR bronchiolitis OR bronchitis OR bronchopneumonia OR bronchopneumonias OR "common cold" OR "common colds" OR covid OR coronavirus OR coronaviruses OR echinococcosis OR empyema OR empyemas OR epiglottitis OR influenza OR influenzas OR flu OR laryngitis OR legionellosis OR legionnaires OR nasopharyngitis OR pasteurellosis OR pharyngitis OR pleurisy OR pleuropneumonia OR pleuropneumonias OR pneumonia OR pneumonias OR rhinitis OR rhinoscleroma OR rhinoscleromas OR "severe acute respiratory syndrome" OR "severe acute respiratory syndromes" OR silicotuberculosis OR sinusitis OR supraglottitis OR tonsillitis OR tracheitis OR tuberculosis OR "whooping cough" OR laryngotracheobronchitis OR tracheobronchitis OR laryngotracheitis OR parainfluenza OR parainfluenzas OR pertussis OR parapertussis OR tuberculous OR lobitis OR peripneumonia OR pleuropneumonitis OR pneumonic OR pneumonitis) OR ((respiratory OR lung OR lungs OR pulmonary OR chest OR airway OR airways OR bronchopulmonary OR thoracic OR thorax) AND (infection OR infections OR inflammation OR inflammatory OR inflammations OR illness OR illnesses OR abscess OR abscesses)) OR ((bronchus OR bronchi OR bronchiole OR bronchioles OR bronchial OR pneumonic OR pneumonitis OR epiglottis OR epiglottal OR epiglottic OR laryngeal OR laryngeum OR larynx OR legionella OR legionellas OR legionellosis OR pharyngeal OR pharyngotonsillitis OR pharyngeum OR pharynx OR sinus OR sinuses OR tonsil OR tonsils OR trachea OR tracheal OR tracheas) AND (infection OR infections)))

= 133 studies

4. Search for named products/platforms/manufacturers[INTERVENTION] AND virtual wards:

AREA[InterventionSearch](andersen OR andersenr OR andersentm OR doccla OR docclar OR docclatm OR docobo OR doccobor OR doccobotm OR "doc@home" OR "doc@hometm" OR "doc@homer" OR careportal OR careportalr OR careportaltm OR dignio OR dignior OR digniotm OR mydignio OR mydignior OR mydigniotm OR healum OR healumr OR healumtm OR "spirit digital" OR "spirit digitalr" OR "spirit digitaltm" OR "spirit health" OR "spirit healthr" OR "spirit healthtm" OR clinitouch OR clinitouchr OR clinitouchtm OR whzan OR whzanr OR whzantm OR whzapp OR whzappr OR whzapptm OR huma OR humatm OR humar OR accurx OR accurxr OR accurxtm OR "bt health" OR "bt healthr" OR "bt healthtm" OR feebris OR feebrisr OR feebristm OR "baywater healthcare" OR "baywater healthcarer" OR "baywater healthcaretm" OR doctaly OR doctalyr OR doctalytm OR "bdm medical" OR "bdm medicalr" OR "bdm medicaltm" OR luscii OR lusciir OR lusciitm OR camascope OR camascoper OR camascopetm OR vcare OR vcarer OR vcaretm OR "blue box" OR "blue boxr" OR "blue boxtm" OR solcom OR solcomr OR solcomtm OR lenus OR lenusr OR lenustm OR medibiosense OR medibiosenser OR medibiosensetm OR vitalpatch OR vitalpatchr OR vitalpatchtm OR healthstream OR healthstreamr OR healthstreamtm OR biobeat OR biobeatr OR biobeattm OR earswitch OR earswitchr OR earswitchtm OR isla OR islar OR islatm OR "health call" OR "health callr" OR "health calltm" OR currenthealth OR currenthealthr OR currenthealthtm OR "current health" OR "current healthtm" OR "current healthr" OR inhealthcare OR inhealthcarer OR inhealthcaretm OR "in health care" OR "in health carer" OR "in health caretm") AND ((hospital AND home) OR ((virtual OR virtually) AND (ward OR wards OR unit OR units OR facility OR facilities OR hospital OR hospitals OR hospitalisation OR hospitalisations OR hospitalised OR hospitalization OR hospitalizations OR hospitalized OR triage OR triaged OR triages OR inpatient OR inpatients OR in-patient OR in-patients OR care OR healthcare OR pathway OR pathways)) OR ((early OR earlier OR supported OR assisted) AND (discharge OR discharged OR discharges OR discharging)) OR ((admission OR admissions OR readmission OR readmissions) AND (avoid OR avoided OR avoiding OR avoids OR avoidance OR avoidances OR alternative OR alternatives)) OR (("step down"

OR "step up") AND (care OR healthcare OR service OR services OR ward OR wards OR approach OR approaches OR manage OR manages OR managed OR management OR managing)) OR (vward OR vwards) OR (healthcare AND home) OR (home AND (monitor OR monitors OR monitored OR monitoring OR manage OR manages OR managed OR management OR managing)))

= 68 studies

A.9: Source: WHO International Clinical Trials Registry Portal (ICTRP)

Interface / URL: https://trialsearch.who.int/

Database coverage dates: Information not found. On the date of search, files had been imported from data providers between November 2022 and May 2023

Search date: 23 May 2023

Retrieved records: 137

Search strategy:

The following three searches were conducted separately using the search interface at the above URL. 'Without Synonyms' was selected for all searches.

The results from each search were downloaded as an individual set. The total number of records retrieved represents the sum of all searches, and includes duplicates caused by the same record being retrieved in each search.

1.

(virtual* and ward*)

= 41 results

2.

((hospital AND home) OR (virtual* AND (ward OR wards OR unit OR units OR facility OR facilities OR hospital* OR triage* OR inpatient* OR in-patient* OR care OR healthcare OR pathway*)) OR ((early OR earlier OR supported OR assisted) AND discharge*) OR ((admission* OR readmission*) AND (avoid* OR alternative*)) OR (("step down" OR "step up") AND (care OR healthcare OR service* OR ward* OR approach* OR manag*)) OR vward* OR (healthcare AND home) OR (home AND (monitor* OR manag*))) AND (((remote* OR digital* OR smart OR telemetry OR telemetric* OR platform* OR portal OR portals OR dashboard* OR dash board* OR software OR tech OR technolog* OR wireless OR wifi OR wi-fi OR bluetooth OR blue-tooth OR mobile OR cellular OR telephone* OR smartphone* OR cellphone* OR phone* OR smartwatch* OR mhealth OR m-health OR ehealth OR e-health OR online OR web OR internet OR digital* OR application* OR wearable) AND (monitor* OR manag*)) OR (telemonitor* OR tele-monitor* OR telemanag* OR tele-manag* OR app OR apps) OR ((automat* OR continuous) AND monitor*) OR "remote patient") AND ((aspergillosis OR blastomycosis OR bronchiolitis OR bronchitis OR bronchopneumonia* OR "common cold*" OR covid OR coronavirus* OR echinococcosis OR empyema* OR epiglottitis OR influenza* OR flu OR laryngitis OR legionellosis OR legionnaires OR nasopharyngitis OR pasteurellosis OR pharyngitis OR pleurisy OR pleuropneumonia* OR pneumonia* OR rhinitis OR rhinoscleroma* OR "severe acute respiratory syndrome*" OR silicotuberculosis OR sinusitis OR supraglottitis OR tonsillitis OR tracheitis OR tuberculosis OR whooping cough OR laryngotracheobronchitis OR tracheobronchitis OR laryngotracheitis OR parainfluenza* OR pertussis OR parapertussis OR tuberculous OR lobitis OR peripneumonia OR pleuropneumonitis OR pneumonic OR pneumonitis) OR ((respiratory OR lung* OR pulmonary OR chest OR airway* OR bronchopulmonary OR thoracic OR thorax) AND (infection* OR inflamm* OR illness* OR abscess*)) OR ((bronch* OR pneumon* OR epiglott* OR laryng* OR larynx OR legionell* OR pharyng* OR pharynx OR sinus* OR tonsil* OR trachea*) AND infection*))

= 83 results

3.

(andersen* OR doccla* OR docobo* OR "doc@home" OR "doc@hometm" OR "doc@homer" OR careportal* OR dignio* OR mydignio* OR healum* OR "spirit digital" OR "spirit digitalr" OR "spirit digitaltm" OR "spirit health" OR "spirit healthr" OR "spirit healthtm" OR clinitouch* OR whzan* OR whzapp* OR huma OR humatm OR humar OR accurx* OR "bt health*" OR feebris* OR "baywater healthcare*" OR doctaly* OR "bdm medical*" OR luscii* OR camascope* OR vcare* OR "blue box" OR "blue boxr" OR "blue boxtm" OR solcom* OR lenus* OR medibiosense* OR vitalpatch* OR healthstream* OR biobeat* OR earswitch* OR isla OR islar OR islatm OR "health call" OR "health callr" OR "health calltm" OR currenthealth* OR "current health" OR "current healthtm" OR "current healthr" OR inhealthcare* OR "in health care" OR "in health carer" OR "in health caretm") AND ((hospital AND home) OR (virtual* AND (ward OR wards OR unit OR units OR facility OR facilities OR hospital* OR triage* OR inpatient* OR in-patient* OR care OR healthcare OR pathway*)) OR ((early OR earlier OR supported OR assisted) AND discharge*) OR ((admission* OR readmission*) AND (avoid* OR alternative*)) OR (("step down" OR "step up") AND (care OR healthcare OR service* OR ward* OR approach* OR manag*)) OR vward* OR (healthcare AND home) OR (home AND (monitor* OR manag*)))

= 13 results

A.10: Source: Future NHS Virtual ward network

Interface / URL: https://future.nhs.uk/NationalVirtualWards

Search date: 30 May 2023

Retrieved records: 44

Search approach: 44 records were retrieved from the "Data, reporting and evidence" section of the site.

Appendix B - List of studies excluded at full text assessment (n=173)

Table B.1: List of excluded studies

Study	EAG comment
Beaney T, Clarke J, Alboksmaty A, Flott K, Fowler A, Benger J, et al. Evaluating the impact of a pulse oximetry remote monitoring programme on mortality and healthcare utilisation in patients with COVID-19 assessed in emergency departments in England: a retrospective matched cohort study. Emerg Med J. 2023.28:28. doi: https://dx.doi.org/10.1136/emermed-2022-212377	Ineligible intervention
(CTRG) CTaRGt. Retrospective analysis of vital signs data from patients with COVID-19 using the 'virtual high dependency unit' monitoring system. Identifier: ISRCTN85624923. In: ISRCTN Registry [internet]. London: University of Tokyo Hospital: 2022. Available from https://www.isrctn.com/ISRCTN85624923.	Ineligible population
(UK) IH. A new model for continuous care of chronic patients - eCare and eLearning for patients with chronic obstructive pulmonary disease (COPD). Identifier: ISRCTN. In: ISRCTN Registry [internet]. London: BioMed Central Limited: 2008. Available from https://www.cochranelibrary.com/central/doi/10.1002/central/CN-01864173/full.	Ineligible population
Aachen UHR. COVID-19@Home Aachen. Identifier: DRKS00025123. In: German Clinical Trials Register [internet]. Freiburg: Institute for Medical Biometry and Statistics - University of Freiburg: 2021. Available from http://www.drks.de/DRKS00025123.	Ineligible intervention
Adly MS, Adly AS. Tele-management of home isolated COVID-19 patients via oxygen therapy with non-invasive positive pressure ventilation and physical therapy techniques: a randomized clinical trial. J Med Internet Res. 2021.23(4):e23446. doi: https://dx.doi.org/10.2196/23446	Virtual ward- Respiratory but not ARI
Ali Akhtar M, Alzarnougi E, Alraddadi A, Afifi A, Saeedi M, Amanullah K, et al. To admit or discharge? Outcome of high-risk patients with COVID-19 presenting with moderate disease to the hospital. Chest. 2021.160(Suppl 4):A1960-A61. doi: https://dx.doi.org/10.1016/j.chest.2021.07.1739	Ineligible intervention
Annis T, Pleasants S, Hultman G, Lindemann E, Thompson JA, Billecke S, et al. Rapid implementation of a COVID-19 remote patient monitoring program. J Am Med Inform Assoc. 2020.27(8):1326-30. doi: 10.1093/jamia/ocaa097	Ineligible intervention
Annunziata A, Coppola A, Carannante N, Simioli F, Lanza M, Di Micco P, et al. Home management of patients with moderate or severe respiratory failure secondary to COVID-19, using remote monitoring and oxygen with or without HFNC. Pathogens. 2021.10(4):01. doi: https://dx.doi.org/10.3390/pathogens10040413	Ineligible intervention

Ansari FN, Khan AS, Ansari SS, Ishtiaque ZB, Inam-Ul-haq M. Role of virtual ward in COVID-19 pandemic in a developing country: our experience of first 100 patients. Rawal Medical Journal. 2022.47(3):519-22. doi: https://www.rmj.org.pk/fulltext/27-1620286554.pdf?1686158668	Ineligible intervention
Bell LC, Norris-Grey C, Luintel A, Bidwell G, Lanham D, Marks M, et al. Implementation and evaluation of a COVID-19 rapid follow-up service for patients discharged from the emergency department. Clin Med (Lond). 2021.21(1):e57-e62. doi: 10.7861/clinmed.2020-0816	Ineligible intervention
Bella S, Murgia F, Alghisi F, Lucidi V. Is telemedicine useful in home management of Cystic Fibrosis patients? J Cyst Fibros. 2010.9(Suppl 1):S61. doi: https://dx.doi.org/10.1016/S1569-1993%2810%2960239-1	Abstract - insufficient info
Ben Hassen H, Ayari N, Hamdi B. A home hospitalization system based on the Internet of things, fog computing and cloud computing. Inform Med Unlocked. 2020.20:100368. doi: https://dx.doi.org/10.1016/j.imu.2020.100368	Ineligible intervention
Beurnier A, Yordanov Y, Dechartres A, Dinh A, Debuc E, Lescure FX, et al. Characteristics and outcomes of asthmatic outpatients with COVID-19 who receive home telesurveillance. ERJ open res. 2022.8(4):00012-2022. doi: https://dx.doi.org/10.1183/23120541.00012-2022	Ineligible intervention
Biancuzzi H, Dal Mas F, Bidoli C, Pegoraro V, Zantedeschi M, Negro PA, et al. Economic and perfomance evaluation of e-health before and after the pandemic era: a literature review and future perspectives. Int J Environ Res&Public Health [Electronic Resource]. 2023.20(5):24. doi: https://dx.doi.org/10.3390/ijerph20054038	SR for reference checking
Blazey-Martin D, Barnhart E, Gillis J, Jr., Vazquez GA. Primary care population management for COVID-19 patients. J Gen Intern Med. 2020.35(10):3077-80. doi: https://dx.doi.org/10.1007/s11606-020-05981-1	SR for reference checking
Bokolo Anthony J. Use of telemedicine and virtual care for remote treatment in response to COVID-19 pandemic. J Med Syst. 2020.44(7):132. doi: https://dx.doi.org/10.1007/s10916-020-01596-5	Ineligible intervention
Boniface M, Burns D, Duckworth C, Ahmed M, Duruiheoma F, Armitage H, et al. COVID-19 Oximetry @home: evaluation of patient outcomes. BMJ open qual. 2022.11(1):03. doi: https://dx.doi.org/10.1136/bmjoq-2021-001584	Ineligible SR
Boreland S, Parrott H, Madge S. 116 Implementing a digital clinic review service in a national lockdown. J Cyst Fibros. 2021.20(Suppl 2):S58-S59. doi: https://dx.doi.org/10.1016/S1569-1993%2821%2901541-1	Abstract - insufficient info
Borgen I, Romney MC, Redwood N, Delgado B, Alea P, George BH, et al. From hospital to home: an intensive transitional care management intervention for patients with COVID-	Ineligible study design

19. Popul Health Management. 2021.24(1):27-34. doi: https://dx.doi.org/10.1089/pop.2020.0178	
Brennan KA, Kang H, Kraus S, Kang J, Malkawi D. Harnessing remote patient monitoring technology to improve transitions of care. J Am Geriatr Soc. 2021.69(Suppl 1):S63. doi: https://dx.doi.org/10.1111/jgs.17115	Abstract - insufficient info
Carty I, Shah R. The use of virtual reality simulation to facilitate surgical ward-based learning in medical students during the COVID-19 Pandemic. Pak J Med Sci. 2021.37(2):609. doi: https://dx.doi.org/10.12669/pjms.37.2.4118	Ineligible intervention
Catalan Agency for Health Information AaQ. ADAPT (After DischArge Pulmonary Telehealth): home telemonitoring follow-up for chronic obstructive pulmonary disease (COPD) patients post hospital discharge. Identifier: NCT01512992. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2013. Available from http://isrctn.com/ISRCTN34235668.	CT record- no results
Chatwin M, Hawkins G, Panicchia L, Woods A, Hanak A, Lucas R, et al. Randomised crossover trial of telemonitoring in chronic respiratory patients (TeleCRAFT trial). Thorax. 2016.71(4):305-11. doi: 10.1136/thoraxjnl-2015-207045	Ineligible population
Chau JP, Lee DT, Yu DS, Chow AY, Yu WC, Chair SY, et al. A feasibility study to investigate the acceptability and potential effectiveness of a telecare service for older people with chronic obstructive pulmonary disease. Int J Med Inform. 2012.81(10):674-82. doi: 10.1016/j.ijmedinf.2012.06.003	Ineligible population
Chauhan U, McAlister FA. Comparison of mortality and hospital readmissions among patients receiving virtual ward transitional care vs usual postdischarge care: a systematic review and meta-analysis. JAMA Netw Open. 2022.5(6):e2219113. doi: doi:10.1001/jamanetworkopen.2022.19113	SR for reference checking
Chow JSF, D'Souza A, Ford M, Marshall S, San Miguel S, Parameswaran A, et al. A descriptive study of the clinical impacts on COVID-19 survivors using telemonitoring (the TeleCOVID study). Front. 2023.5:1126258. doi: https://dx.doi.org/10.3389/fmedt.2023.1126258	Ineligible population
Clyde NGGa. RECEIVER: Digital service model for Chronic Obstructive Pulmonary Disease (COPD). Identifier: NCT04240353. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2018. Available from https://ClinicalTrials.gov/show/NCT04240353.	Ineligible population
Connolly SP, Katolo HW, Cronin C, Creed M, Lambert JS, Cotter AG, et al. Home spo2 monitoring of patients with covid-19: The mater cvc project. Top Antivir Med. 2021.29(1):289-90.	Abstract - insufficient info

Copeland D, Eisenberg E, Edwards C, Shah NA, Powell CA. Post COVID-19 remote patient monitoring following discharge from nyc hospital. Am J Respir Crit Care Med. 2021.203(9)doi: https://dx.doi.org/10.1164/ajrccm-conference.2021.203.1_MeetingAbstracts.A1727	Abstract - insufficient info
Covic PA. Integrated distance management strategy for patients with cardiovascular diseases in the context of COVID-19. Identifier: NCT04325867. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2020. Available from https://ClinicalTrials.gov/show/NCT04325867.	Ineligible population
Craig C, Min DSH, Mason S, Keegan A, Dahanayake N, Nazir B, et al. Early symptom outcomes in hospitalised covid-19 patients. Thorax. 2021.76(Suppl 1):A180. doi: https://dx.doi.org/10.1136/thorax-2020-BTSabstracts.312	Ineligible intervention
Creavin ST, Garg M, Hay AD. Impact of remote vital sign monitoring on health outcomes in acute respiratory infection and exacerbation of chronic respiratory conditions: systematic review and meta-analysis. ERJ open res. 2023.9(2)doi: https://dx.doi.org/10.1183/23120541.00393-2022	SR for reference checking
Cvietusa PJ, Goodrich GK, Steiner JF, Shoup JA, King DK, Ritzwoller DP, et al. Transition to virtual asthma care during the COVID-19 pandemic: an observational study. J Allergy Clin Immunol Pract. 2022.10(6):1569-76. doi: https://dx.doi.org/10.1016/j.jaip.2022.02.027	Ineligible intervention
Dinh A, Mercier J-C, Jaulmes L, Artigou J-Y, Juilliere Y, Yordanov Y, et al. Safe discharge home with telemedicine of patients requiring nasal oxygen therapy after COVID-19. Front Med (Lausanne). 2021.8:703017. doi: https://dx.doi.org/10.3389/fmed.2021.703017	Ineligible intervention
District SWSLH. Open label, prospective study for the Biofourmis Everion armband telemonitoring solution for patients during COVID-19 home isolation within South Western Sydney. Identifier: ACTRN12620000635965. In: Australian New Zealand Clinical Trials Registry [internet]. Sydney: National Health and Medical Research Council (NHMRC) Clinical Trials Centre - University of Sydney: 2020. Available from https://anzctr.org.au/ACTRN12620000635965.aspx.	CT record- no results
Duffy M, Finlayson E, Griffiths K, Hamilton S, Macleod C, Swanson M, et al. Scottish Patients Living Remotely and Rurally, With Acute Exacerbations of Chronic Obstructive Pulmonary Disease, Can Have Safe, Effective, Person-Centred Care in Their Own Home Through Innovative Use of Technology. In: C15. EMERGING COPD DIAGNOSTICS AND TREATMENTS. p. A4498-A98.	Ineligible study design
Echevarria C, Gray J, Hartley T, Steer J, Miller J, Simpson AJ, et al. Home treatment of COPD exacerbation selected by DECAF score: a non-inferiority, randomised controlled	Ineligible intervention

trial and economic evaluation. Thorax. 2018.73(8):713-22. doi: https://doi.org/10.1136/thoraxjnl-2017-211197	
Edwards C, Costello E, Curley M, Smyth L, O'Seaghdha C, Costello RW, et al. Patient-reported symptom severity and pulse oximetry in the COVID-19 remote monitoring programme in ireland. Am J Respir Crit Care Med. 2021.203(9)doi: https://dx.doi.org/10.1164/ajrccm-conference.2021.203.1_MeetingAbstracts.A1728	Abstract - insufficient info
Ferry OR, Moloney EC, Spratt OT, Whiting GFM, Bennett CJ. A virtual ward model of care for patients with COVID-19: retrospective single-center clinical study. J Med Internet Res. 2021.23(2):e25518. doi: https://dx.doi.org/10.2196/25518	Ineligible study design
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Pathak K, Marwaha JS, Tsai TC. The role of digital technology in surgical home hospital programs. npj digit. 2023.6(1):22. doi: https://dx.doi.org/10.1038/s41746-023-00750-w	Ineligible outcomes
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Shaji S, Pathinarupothi RK, Rangan ES, Menon KAU, Ramesh MV. Heart lung health monitor: remote at-home patient surveillance for pandemic management. In: Ieee Global Humanitarian Technology Conference (Ghtc), 2021. 127-30	Ineligible intervention
Shanbehzadeh M, Kazemi-Arpanahi H, Kalkhajeh SG, Basati G. Systematic review on telemedicine platforms in lockdown periods: lessons learned from the COVID-19 pandemic. J. 2021.10:211. doi: https://dx.doi.org/10.4103/jehp.jehp_1419_20	SR for reference checking
Shen MY, DeMuth KE, Osman K, Liu YX, Sherman J, Priscal D. H2C2 (Home hospital and critical care) - A 2.5 year experience using a new model of hospital at home: development and implementation. J Am Coll Cardiol. 2022.79(Suppl 9):2049. doi: https://dx.doi.org/10.1016/S0735-1097%2822%2903040-6	Abstract - insufficient info
Sherwin J, Lawrence K, Gragnano V, Testa PA. Scaling virtual health at the epicentre of coronavirus disease 2019: a case study from NYU Langone Health. J Telemed Telecare. 2022.28(3):224-29. doi: https://dx.doi.org/10.1177/1357633X20941395	Ineligible intervention
Shrestha BM. Telemedicine and virtual health care during coronavirus disease pandemic. JNMA & J Nepal Med Assoc. 2020.58(228):547-49. doi: https://dx.doi.org/10.31729/jnma.5204	Ineligible intervention
Siegal J, Steel P, Zhang Y, Cato K, Park JC, Melville LD, et al. Exertional hypoxia and virtual follow-up in emergency department patients discharged with COVID-19- like	Abstract - insufficient info

illness. Acad Emerg Med. 2021.28(Suppl 1):S243. doi: https://dx.doi.org/10.1111/acem.14249	
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Silven AV, Petrus AHJ, Villalobos-Quesada M, Dirikgil E, Oerlemans CR, Landstra CP, et al. Telemonitoring for patients with COVID-19: recommendations for design and implementation. J Med Internet Res. 2020.22(9):e20953. doi: https://dx.doi.org/10.2196/20953	Ineligible intervention
Sim SS, Yip MY, Wang Z, Tan ACS, Tan GSW, Cheung CMG, et al. Digital technology for AMD management in the post-COVID-19 new normal. Asia Pac J Ophthalmol (Phila). 2021.10(1):39-48. doi: https://dx.doi.org/10.1097/APO.0000000000000363	Ineligible intervention
Sitammagari K, Murphy S, Kowalkowski M, Chou S-H, Sullivan M, Taylor S, et al. Insights from rapid deployment of a "Virtual Hospital" as standard care during the COVID-19 pandemic. Ann Intern Med. 2021.174(2):192-99. doi: https://dx.doi.org/10.7326/M20-4076	Abstract - insufficient info
Sorknaes AD, Bech M, Madsen H, Titlestad IL, Hounsgaard L, Hansen-Nord M, et al. The effect of real-time teleconsultations between hospital-based nurses and patients with severe COPD discharged after an exacerbation. J Telemed Telecare. 2013.19(8):466-74. doi: 10.1177/1357633X13512067	Ineligible intervention
SpA ICSM. Support for COVID19 patients at home. Identifier: NCT04898179. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2020. Available from https://ClinicalTrials.gov/show/NCT04898179.	CT record- no results
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Stolldorf DP, Barton M. Healthcare professionals' perspectives on benefits and disadvantages of hospital at home. Epidemiology. 2022.70(Suppl 1):S31. doi: https://dx.doi.org/10.1111/jgs.17755	Ineligible population
Sufian A, You CS, Dong MX. A deep transfer learning-based edge computing method for home health monitoring. In: 55th Annual Conference on Information Sciences and Systems (Ciss), 2021. 1-6	Ineligible intervention
Swarnkar V, Abeyratne UR, Chang AB, Amrulloh YA, Setyati A, Triasih R. Automatic identification of wet and dry cough in pediatric patients with respiratory diseases. Ann Biomed Eng. 2013.41(5):1016-28. doi: https://dx.doi.org/10.1007/s10439-013-0741-6	Ineligible population

Taiwo O, Ezugwu AE. Smart healthcare support for remote patient monitoring during covid-19 quarantine. Inform Med Unlocked. 2020.20:100428. doi: https://dx.doi.org/10.1016/j.imu.2020.100428	Ineligible intervention
Technology DIo. Evaluation of the effectiveness and transferability of the digital health platform (ProACT) to support home-based multimorbidity self-management in Europe. Identifier: ISRCTN34134007. In: ISRCTN Registry [internet]. London: BioMed Central Limited: 2023. Available from https://www.isrctn.com/ISRCTN34134007.	Ineligible population
Thornton J. The "virtual wards" supporting patients with covid-19 in the community. BMJ. 2020.369:m2119. doi: https://dx.doi.org/10.1136/bmj.m2119	Ineligible intervention
Toronto UH. A virtual ward to reduce readmissions after hospital discharge. Identifier: NCT01108172. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2010. Available from https://ClinicalTrials.gov/show/NCT01108172.	Ineligible intervention
Trust LUHNF. HOME FIRST pilot: a study of early supported discharge in patients with lower respiratory tract infections. Identifier: NCT02454114. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2013. Available from https://ClinicalTrials.gov/show/NCT02454114.	Ineligible intervention
Tudorache O, Kenemer JB, Pruiett J, Valero M, Hedenstrom ML, Shahriar H, et al. Implementing virtual nursing in health care: an evaluation of effectiveness and sustainability. In: 2022 Ieee International Conference on Digital Health (Ieee Icdh 2022), 2022. 129-31	Ineligible population
University Health Network T. At home monitoring for patients with Covid19. Identifier: NCT04453774. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2020. Available from https://ClinicalTrials.gov/show/NCT04453774.	Ineligible intervention
University Hospital A. HOME-CoV: hospitalization or outpatient management of patients with a SARS-CoV-2 infection. Identifier: NCT04338841. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2020. Available from https://ClinicalTrials.gov/show/NCT04338841.	Ineligible intervention
University of California LA. eRT remote health monitoring. Identifier: NCT01495780. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2012. Available from https://ClinicalTrials.gov/show/NCT01495780.	CT record- no results
University of North Carolina CH. Assessing adherence to home telemedicine in individuals with chronic obstructive pulmonary disease (COPD). Identifier: NCT04369885. In: ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2020. Available from https://ClinicalTrials.gov/show/NCT04369885.	Ineligible population
University Y. Self-verification and support via mobile phones drastically improves tuberculosis treatment success in LMIC settings. Identifier: NCT03135366. In:	Ineligible intervention

ClinicalTrials.gov [internet]. Bethesda: US National Library of Medicine: 2016. Available from https://ClinicalTrials.gov/show/NCT03135366.	
Uno M, O'Connor A, Farrell S, Hassan T. COVID-19 remote monitoring programme in our lady of lourdes hospital drogheda. Ir J Med Sci. 2022.191(Suppl 5):S181. doi: https://dx.doi.org/10.1007/s11845-022-03209-1	Abstract - insufficient info
Vianello A, Fusello M, Gubian L, Rinaldo C, Dario C, Concas A, et al. Home telemonitoring for patients with acute exacerbation of chronic obstructive pulmonary disease: a randomised controlled trial. BMC Pulm Med. 2016.16(1):157. doi: 10.1186/s12890-016-0321-2	Ineligible population
Vianello A, Savoia F, Pipitone E, Nordio B, Gallina G, Paladini L, et al. "Hospital at home" for neuromuscular disease patients with respiratory tract infection: a pilot study. Respir Care. 2013.58(12):2061-8. doi: https://doi.org/10.4187/respcare.02501	Ineligible intervention
Vindrola-Padros C, Singh KE, Sidhu MS, Georghiou T, Sherlaw-Johnson C, Tomini SM, et al. Remote home monitoring (virtual wards) for confirmed or suspected COVID-19 patients: a rapid systematic review. EClinicalMedicine. 2021.37:100965. doi: https://dx.doi.org/10.1016/j.eclinm.2021.100965	SR for reference checking
Vinton D, Thomson N. 51interactive home monitoring of ED patients with suspected or confirmed COVID-19. Ann Emerg Med. 2020.76(Suppl 1):S21. doi: https://dx.doi.org/10.1016/j.annemergmed.2020.09.061	Ineligible population
Vitacca M, Bianchi L, Guerra A, Fracchia C, Spanevello A, Balbi B, et al. Tele-assistance in chronic respiratory failure patients: a randomised clinical trial. Eur Respir J. 2009.33(2):411-8. doi: 10.1183/09031936.00005608	Ineligible intervention
Walton H, Vindrola-Padros C, Crellin NE, Sidhu MS, Herlitz L, Litchfield I, et al. Patients' experiences of, and engagement with, remote home monitoring services for COVID-19 patients: a rapid mixed-methods study. Health Expect. 2022.25(5):2386-404. doi: https://dx.doi.org/10.1111/hex.13548	Ineligible study design
West NE, Goss CH, Lechtzin N. Design and planning of the early intervention in cystic fibrosis exacerbation randomized trial. Pediatr Pulmonol. 2011.46(Suppl 34):345. doi: https://dx.doi.org/10.1002/ppul.21583	Abstract - insufficient info
While A. Digital health and technologies. Br J Community Nurs. 2023.28(3):120-26. doi: https://dx.doi.org/10.12968/bjcn.2023.28.3.120	Ineligible study design
Wijsenbeek MS, Moor CC, Johannson KA, Jackson PD, Khor YH, Kondoh Y, et al. Home monitoring in interstitial lung diseases. Lancet Respir Med. 2023.11(1):97-110. doi: https://dx.doi.org/10.1016/S2213-2600(22)00228-4	Ineligible study design

Wright RC, Partovi N, Levy RD. Necessity is the mother of invention: Rapid implementation of virtual health care in response to the COVID-19 pandemic in a lung transplant clinic. Clin Transplant. 2020.34(11):e14062. doi: https://dx.doi.org/10.1111/ctr.14062	Ineligible outcomes
Wu X, Huang Y, Liu Z, Lai W, Long E, Zhang K, et al. A universal artificial intelligence platform for collaborative management of cataracts. The Lancet. 2019.394(Suppl 1):S22. doi: https://dx.doi.org/10.1016/S0140-6736%2819%2932358-X	Abstract - insufficient info
Wu Y, Ye Q, Shen F, Zhang Z, Jiang CL. Country- and app-level factors affecting the adoption and evaluation of COVID-19 mobile apps. BMC Public Health. 2022.22(1):2457. doi: https://dx.doi.org/10.1186/s12889-022-14918-8	Ineligible intervention
Xu H, Huang S, Qiu C, Liu S, Deng J, Jiao B, et al. Monitoring and Management of Home-Quarantined Patients With COVID-19 Using a WeChat-Based Telemedicine System: Retrospective Cohort Study. J Med Internet Res. 2020.22(7):e19514. doi: 10.2196/19514	Ineligible population
Ye S, Hiura G, Fleck E, Garcia A, Geleris J, Lee P, et al. Hospital Readmissions After Implementation of a Discharge Care Program for Patients with COVID-19 Illness. J Gen Intern Med. 2021.36(3):722-29. doi: 10.1007/s11606-020-06340-w	Ineligible intervention
Yettapu D, Marcinkowski N, Salo A, Domas AJ, Brey E, Innocenti S, et al. Indications for inpatient glucose telemetry. J Diabetes Sci Technol. 2023.17(2):A590. doi: https://dx.doi.org/10.1177/19322968221150148	Ineligible population
Zhou K, Al-Jaghbeer MJ, Lansang MC. Hyperglycemia management in hospitalized patients with COVID-19. Cleve Clin J Med. 2020.17:17. doi: https://dx.doi.org/10.3949/ccjm.87a.ccc012	Ineligible population
Ziacchi M, Calo L, D'Onofrio A, Manzo M, Dello Russo A, Santini L, et al. Implantable cardioverter defibrillator multisensor monitoring caused by the COVID-19 pandemic. Biol. 2022.11(1):12. doi: https://dx.doi.org/10.3390/biology11010120	Ineligible intervention
Zouari FEDI, Touboul AA, Cao PENG, Lee WEINING, Tam TC, Wong EC, et al. Close-to-effortless breathing paradigm maps global and regional lung function using electrical impedance tomography cross sectionally and longitudinal Chest. 2022.162(Suppl 4):A2671-A72. doi: https://dx.doi.org/10.1016/j.chest.2022.08.2179	Ineligible intervention

Appendix C – Clinical review outcome data

Table C 1: Clinical Outcomes

Study name and location	VW Name (company)	% hospital-acquired infections	Time to ARI resolution	Mortality	Adverse events
Step-up care					
Akhtaruzzaman 2022 Location: Bangladesh	Virtual Ward Technologies (Virtual Ward Technologies)	NR	NR	0/20	NR Withdrawals/discontinuations: NR
Moes 2022 (Moes et al., 2022) **Location:** The Netherlands	SAFE@home corona including Luscii platform (Luscii Healthtech BV)	NR	NR	All recovered without noteworthy remaining symptoms.	1 birth was induced on maternal indication due to COVID-19 symptoms. 1 emergency premature Caesarean Section performed due to the need to ventilate the mother in prone position because of severe COVID-19 pneumonia. 1 discontinuation due to few COVID-19 related complaints.

Study name and location	VW Name (company)	% hospital-acquired infections	Time to ARI resolution	Mortality	Adverse events
Jakobsen 2015 (Jakobsen et al., 2015) **Location:** Denmark	Not specified (VW used for data transmission and storage)	NR	NR	No patients died within 30 days after discharge in either group 3 patients (Teleheatlh) and 4 patients (Hospital) died during 6 months of follow-up Overall survival based on registry data (2013); survival probability (Kaplan-Meier) 2 years after randomisation: 82.8% (95%CI: 69.0 to 6.5%) in the VW group vs. 59.2% (95%CI: 40.2 to 78.1%) in the control group (log-rank test, p=0.053).	Telehealth: 3 returned to hospital (1 technology failure, 1 hyponatremia, 1 severe dyspnea and nebulizer failure) Hospital: NR Withdrawals/discontinuations: Telehealth: 10 (1 did not receive intervention, 2 discontinued intervention, 4 lost to follow up, 3 died) Hospital: 9 (1 discontinued intervention, 4 lost to follow up, 4 died)
Step-down care					
Grutters 2021 (Grutters et al., 2021) **Location:** The Netherlands	Not specified (VW used for data transmission and storage)	NR	NR	0/320	NR Withdrawals/discontinuations: NR

Study name and location	VW Name (company)	% hospital-acquired infections	Time to ARI resolution	Mortality	Adverse events
Kodama 2021 (Kodama et al., 2021) **Location:** USA	Commercial system (3rd party vendor not specified) (VW used for data transmission and storage)	NR	NR	NR	NR Withdrawals/discontinuations: NR
O'Malley 2022 (O'Malley et al., 2022) **Location:** UK	DOCCLA technology (DOCCLA, Sweden)	NR	NR	Deaths on hospital readmission: 0/4	NR Withdrawals/discontinuations: NR
Swift 2022 (Swift et al., 2022b) **Location:** UK	CliniTouch Vie (Spirit Digital, Spirit Health Group, Leicester, UK)	NR	NR	1/65 (considered unrelated to COVID-19)	Clotting event: 4/65 Withdrawals/discontinuations: 1 (none of the 66 patients withdrew from the VW because of system failures or faults; one patient withdrew at their own discretion on day two and had been rated green the previous day)
van Goor 2021 (van Goor et al., 2021) **Location:** The Netherlands	Luscii platform (Luscii Healthtech BV)	NR	NR	Mortality within 30 days of discharge: VW: 0/31 Hospital: 1/31	NR 1 withdrawal from intervention group following patient learning they had been randomised to the VW

Study name and location	VW Name (company)	% hospital-acquired infections	Time to ARI resolution	Mortality	Adverse events
Walter 2023 (Walter et al., 2023) **Location:** USA	Current Care Virtual Care platform (Current Health Inc.)	NR	NR	0/237	NR Withdrawals/discontinuations: NR
Wells 2022 **Location:** UK	VW serving 10 specialties (Current Health Ltd, Edinburgh, UK).	NR	NR	NR	NR
Tan 2023 (Tan et al., 2023) **Location:** Singapore	DrCovid+ (digital enhancement for the COVID VW programme developed at Singapore General Hospital)	NR	NR	NR	NR Withdrawals/discontinuations: NR
Mixed					
Bircher 2022 (Bircher et al., 2022) **Location:** UK	Maternity Virtual Ward (Current Health Ltd, Edinburgh, UK).	NR	NR	0/228	NR Withdrawals/discontinuations: NR

Study name and location	VW Name (company)	% hospital-acquired infections	Time to ARI resolution	Mortality	Adverse events
Health Innovation Network 2021 (Health Innovation Network, 2021)* **Location**: UK	Current Health hub (Current Health Ltd).	NR	NR	VW: 2 (1%) VW COVID-subgroup: 4 (2.5%) Post-discharge: 7 days: 5 (2%) 28 days (cumulative): 8 (4%)	NR Withdrawals/discontinuations: 14 (14 patients (6%) stayed on the ward for less than a day after establishing that telehealth was not appropriate for them (10 patients, 4%) or that they required admission to an in-patient bed (4 patients, 2%))
Fox 2022 (Fox et al., 2022) **Location:** UK	Huma (Huma Therapeutics)	NR	NR	App users: 1/97 Non-app users: 3/45	Defined as rehospitalised or died: App users: 18/97 (18.5%) Non-app users: 12/45 (26.7%) No significant difference p=0.27 Withdrawals/discontinuations: NR

Study name and location	VW Name (company)	% hospital-acquired infections	Time to ARI resolution	Mortality	Adverse events
KSS AHSN 2020 (Kent Surrey Sussex Academic Health Science Network, 2020) **Location:** UK	Medopad (Huma Therapeutics)	NR	NR	**Hertfordshire secondary care site:** Medopad: 0/75 Telephone-based VW: 0/387 Crude mortality March to May 2020: 2% (18/900) **Central London site:** VW: 0/67 Telephone-based VW: 8/61 (13%)	No record of adverse events were observed during deployment.
Inhealthcare 2022 (inhealthcare, 2022) **Location:** UK	CO@Home service (Inhealthcare) used as part of the COVID VW	NR	NR	NR	NR Withdrawals/discontinuations: NR
Ko 2023 (Ko et al., 2023) **Location:** Singapore	COVID Virtual Ward (run by the National University Health System's existing Hospital-at-Home Programme, Singapore)	NR	NR	5 (2.1%); all due to COVID-19 pneumonia Of these patients, 3 died following escalation to hospital.	NR Withdrawals/discontinuations: NR

Study name and location	VW Name (company)	% hospital-acquired infections	Time to ARI resolution	Mortality	Adverse events
Mid and South Essex ICS 2022 (Mid and South Essex ICS, 2022) **Location:** UK	Whzan Blue Box (Solcolm) implemented by the NHS.	Across both frailty and respiratory VWs, patients up to five times less likely to acquire an infection than acute inpatients.	NR	Respiratory VW subgroup: 2/201 (Total population 1034 patients)	NR Withdrawals/discontinuations: NR
van der Berg 2022 (van der Berg et al., 2022) **Location:** The Netherlands	Luscii platform (Luscii Healthtech BV)	NR	NR	**All-cause mortality:** Mixed: 10 (3.6%) Step-up: 2 (3.1%) Step-down: 8 (3.8%) **ARI-related mortality:** Mixed: 7 (2.5%) Step-up: 1 (1.5%) Step-down: 6 (2.8%)	NR Withdrawls/discontinuation: NR

* Patient episodes analysed, not patients – 5 patients experienced more than 1 episode; this may affect the reliability of results.

Abbreviations- CI – confidence intervals, ED – emergency department, NHS – National Health Service, NR – not reported, UK – United Kingdom, USA – United States of America, VW – virtual wards.

Table C 2: Key characteristics of non-scoped interventions

VW technology	Intervention features
DrCovid+ Tan 2023 (Tan et al., 2023)	**Clinician-facing features:** Cloud-based data system with dashboard (rated gree/amber/yellow) **Patient-facing features:** Can use mobile phone app with monitoring form **Additional & advanced features:** Peronalised push messaging **Devices supported:** Vital signs monitoring (temperature, heart rate, oxygen level, blood pressure). Device type or model requirements not reported. **Current NHS use:** None reported, local adaptation (Singapore)
Unnamed telehealth monitoring platform Jakobsen 2015 (Jakobsen et al., 2015)	**Clinician-facing features:** Cloud-based data system (alert system not reported) **Patient-facing features:** Touchscreen and webcam **Additional & advanced features:** None reported **Devices supported:** Vital signs monitoring (pulse oximeter, spirometer, thermometer, nebulizer for aerosolized inhalation, medication, oxygen compressor, and a medicine box containing antibiotics, prednisone, sedative, beta2 agonists, and anticholinergics). **Current NHS use:** None reported
Unnamed COVID Virtual Ward Ko 2023 (Ko et al., 2023)	**Clinician-facing features:** Online clinician dashboard (automated SMS alerts to clinicians) **Patient-facing features:** Ability to engage with teleconsultations and self-monitor vital signs using a mobile app chatbot. **Additional & advanced features:** Care team trained patients **Devices supported:** Vital signs monitoring (temperature, oxygen level, blood pressure). Device type or model requirements not reported. **Current NHS use:** None reported, local adaptation
Unnamed remote patient monitoring system from a 3rd party vendor Kodama 2021 (Kodama et al., 2021)	**Clinician-facing features:** Online dashbaord (automated alert system) and teleconsultations **Patient-facing features:** Ability for patient or family member to use a smartphone app and pulse oximeter **Additional & advanced features:** Vendor contact with patient to introduce and help download, then follow-up call to test equipment. **Devices supported:** Vital signs monitoring (oxygen level and heart rate). Device type or model requirements not reported. **Current NHS use:** None reported, third party vendor.

Table C 3: Interoperability of scoped interventions

Technology Name (company)	***The level of interoperability of the technology and how it integrates with core clinical systems.***
DOCCLA Technology (DOCCLA)	In addition to data submitted by patients, the technology also allows other information to be held and shared against a patient's record. For example, information about a patients typical oxygen levels, whether they are on home oxygen, whether they have any allergies, or special communication needs and so on. The technology has multiple APIs conforming to FHIR, HL7 and SNOMED, with the ability to support proprietary interfaces found in NHS legacy systems, and is currently integrated with NHS Spine and most major EHRs.
CliniTouch Vie (Spirit Digital)	Clinitouch shares observations and questionnaire responses in real time, in FHIR format, with FHIR-capable consumer systems such as EPRs or shared care records.
Current Health (Current Health)	Current Health works with a third-party integration management provider, Lyniate, to power a highly flexible interoperability engine in the UK Market. Through Lyniate, Current Health can support the unique requirements of different EPRs including data transmission, platform availability, and any required data transformations or query requirements necessary to automate workflows on behalf of NHS partners.
CO@home/Covid VW service	The platform provides native integration with SystmOne and EMIS Web, both GP and Community models. Providing the ability to extract patient demographics and existing codes on the record. The platform includes the ability to share data via the MESH to GP practices that may reside outside of the region and therefore not have nay Inhealthcare applications installed to share data with SystemOne and EMIS Web. The platform includes API's making data available in real time and includes the ability to access results stored against the patients record as well as specific data elements that are within the platform.
Luscii (Luscii Healthtech)	The platform supports simple integration with existing clinical record systems and complies with the latest FHIR / HL7 interoperability standards. The company reports completing multiple successful integrations with various different clinical systems including Epic, Cerner, Systmone.
Virtual Ward Technologies (Virtual Ward Technologies)	All the necessary data were collected with sufficient quality and safely transferred to the virtual platform for evaluation and management. The Software is built in secure Appian low code. This can easily integrate with historic or new systems.
Whzan Blue Box (Solcolm)	Each user has a specific access level allowing access to all appropriate patient data. Any member of staff can be a user, including primary, secondary care, emergency and community health teams. Whzan is interoperable with EMIS, SystmOne, PDS, Adastra, NRL, PARIS and NHS local record systems for Lincolnshire and Hertfordshire. Data displayed on the portal is posted to EMIS and SystemOne that GPs can access.
Huma	Huma has existing integrations with TPP SystmOne and EMIS through iPlato and Huma have the capability for bi-directional structured data flow (e.g. flow of data captured

	from devices into electronic health records (EHRs) and flow of patient demographics from EHRs into our platform). Huma are also capable of integrating with other EHR and shared care record systems with structured data flow. Huma have access to the IM1 interface enabling integration of our remote patient monitoring system to SystmOne within the next c 6 months, with a dependency on sufficient engagement and support from client IT and EHR provider teams. Huma are also in the process of directly integrating our remote patient monitoring platform with EMIS through their partner API programme, so Huma anticipate Huma will have integration within the next c 6 months. Huma are already working with a number of NHS Trusts to deliver Cerner integration.

Table C 4: Operational Outcomes

Study name and location	VW Name (company)	Number of admissions to hospital/ VW	Waiting time for admission to or discharge from VW	Length of hospital/VW stay	Number with treatment escalation	Number of hospital readmissions	Emergency attendance or unplanned hospital readmissions	Number of contacts with other care providers (e.g. GP, 111 calls)
Step-up care								
Akhtaruzzaman 2022 Location: Bangladesh	Virtual Ward Technologies (Virtual Ward Technologies)	20 admitted to VW	NR	VW stay: Mean: 10 (range: 8-12) days Hospital stay: Mean 4 (range 3-6) days	3 (10%) escalated to hospital care	3 (10%) hospitalised. 0 (0%)_required ICU admission	NR	NR
Moes 2022 (Moes et al., 2022) **Location**: The Netherlands	SAFE@home corona, including the Luscii platform (Luscii Healthtech BV)	28 admitted to VW	NR	Median 6 days (IQR: 4-7)	4 (14.8%) treated with anticoagulant, oxygen and corticosteroid therapy. 15 (55.6%) had ≥1 time(s) contact with medical management centre.	6 (22.2%) admitted to hospital	NR	7 (25.9%) ≥ 1 time(s) contact with gynaecologist-in-training / supervisor

Jakobsen 2015 (Jakobsen et al., 2015) **Location:** Denmark	Not specified (VW used for data transmission and storage)	Telehealth: 29 Hospital: 28	Mean time from hospital admission to study recruitment Overall: 16.3 (SD 6.6) hours	Patients with duration of stay >5 days Telehealth: 5 (17.2%) Hospital: 8 (28.6%)	Need for noninvasive and/or mechanical ventilation for first 30 days after discharge Telehealth: 3 patients during a hospital re-admission (1 after surgery) Hospital: 1 patient	NR	Hospital admission: 3 telehealth patients due to adverse events. Readmission due to COPD within 30 days after discharge: NR*[1] **Readmission survival probability:** 30 days: 72.4 (VW) vs. 78.6% (inpatient), p=0.35. 90 days: 65.5 vs. 60.7%, p=0.33. 180 days: 55.2 vs 50.0%, p=0.33.	4/20 respondents to user satisfaction questionnaire in telehealth group made an acute call outside of the planned contacts
Step-down care								
Grutters 2021 (Grutters et al., 2021) **Location:** The Netherlands	Not specified (VW used for data transmission and storage)	320 admitted to VW	NR	VW stay: Mean 11.7 (SD 5.4) days. Mean reduced length hospital stay (n=265)*[2] : 5.1 (± 3.4) days Mean reduced length of stay for oxygen subgroup (n=196): 6.4 (± 3.2) days	Reassessed at the emergency department: 39 (12%)	23 (7%)	Reassessed at the emergency department: 39 (12%)	Mean phone contacts per patient: 5.7 (SD 3.0)

Kodama 2021 (Kodama et al., 2021) **Location:** USA	Commercial system (3rd party vendor not specified) (VW used for data transmission and storage)	50 admitted to VW	NR	14 days (fixed length of care)	Escalation based on pre-defined trigger criteria (nurse decision on more frequent monitoring, transfer call to a physician, refer directly to emergency department). 13 patients escalated 29 times	NR	3 (6%) referred to the emergency department, 1 of which required hospital readmission (pulmonary embolism)	NR
O'Malley 2022 (O'Malley et al., 2022) **Location:** UK	DOCCLA technology (DOCCLA, Sweden)	43 admitted to VW	Average time from COVID-positive PCR test and VW admission: 8.1 days	Mean 10.3 (SD 9.7, 95% CI 7.4-13.2) days	NR	Hospital admission due to after deterioration was identified (hypoxia): 4 (9.3%). All occurred within 5 days of discharge 3 were referred back to VW with supplemental oxygen on second discharge	NR	NR

Swift 2022*[3] (Swift et al., 2022a) **Location:** UK	CliniTouch Vie (Spirit Digital, Spirit Health Group, Leicester, UK)	[redacted]	NR	[redacted]	NR	NR	[redacted]	NR

van Goor 2021 (van Goor et al., 2021) **Location:** The Netherlands	Luscii platform (Luscii Healthtech BV)	31 admitted to VW 31 admitted to hospital	NR	Duration hospital stay after randomisation: VW: 0.7 (0.9) Hospital: 2.3 (2.3) **Difference -1.6 days (95%CI -2.4 to -0.8), p<0.001** Duration of hospital responsibility (hospital stay + hospital care at home) : VW: 14.1 (7.6) Hospital: 10.0 (7.0) **Difference 4.1 (95%CI 0.5 to 7.7), p = 0.028** Days in hospital or dead after index stay: VW: 0.9 (3.7) Hospital: 1.0 (3.7) **Difference -0.1 (95%CI -2.1 to 1.8), p=0.906** Hospital-free days in 30 days following randomisation: VW: 28.4 (3.8) Hospital: 26.7 (5.7) **Difference 1.7 (95%CI -0.5 to 4.2), p = 0.112**	NR	VW: 2 (6.5%) readmissions Hospital: 1 (3.2%) readmissions	VW: 2 (5.6%) unplanned hospital visits and 3 (9.7%) emergency department visits Hospital: 2 (6.5%) unplanned hospital visits and 1 (3.2%) emergency department visits	GP visits: VW: 12 (38.7%), of which 8 for COVID-19. Hospital: 20 (64.5%) GP visits - 19 for COVID-19 **Difference p=0.035** Telephone contact with GP by patient VW: 25 (80.6%) Hospital:22 (71.0%) **Difference p=0.371**

Walter 2023 (Walter et al., 2023) **Location:** USA	Current Care Virtual Care platform (Current Health Inc.)	237 admitted to VW	NR	Duration of VW monitoring on VW: total of 3474 (median 7.9, IQR 3.2-16.5, range 1-106) days COVID-19 risk factor subgroup (n=39): total of 684 (median 8.8, IQR 3-12, range 1-45) days	27 (11.4%) patients were escalated to a physical hospital bed while on monitoring COVID-19 risk factor subgroup (n=39): 4 (10.3%) were escalated to physical care during their initial admission	NR	Hospital readmission within 30 days of discharge from VW: 1 (0.4%) COVID-19 risk factor subgroup: 0 (0%)	NR
Wells 2022 **Location:** UK	VW serving 10 specialties (Current Health Ltd, Edinburgh, UK).	852 admitted to VW. 370 (43.4%) were COVID-19 patients and 57 (6.7%) were respiratory patients.	NR	Mean (IQR) length of monitoring: 3.9 (2.4-6.7) days	NR	NR	NR	NR
Tan 2023 (Tan et al., 2023) **Location:** Singapore	DrCovid+ (digital enhancement for the COVID VW programme developed at Singapore General Hospital)	400 admitted to VW	NR	Mean (SD) VW stay: 7.09 (3.53)	22 (5.5%) (require inpatient readmission or died)	NR	NR	NR
Mixed								

Bircher 2022 (Bircher et al., 2022) **Location:** UK	Maternity VW (Current Health Ltd, Edinburgh, UK).	228 admitted to VW	NR	Mean: 6 (SD 2.3, range 1-14) days Total bed days: 1,182	15 (6.6%) escalated to hospital care 1 (0.4%) escalated to critical care	15 (6.6%) escalated to hospital care	NR	NR
Health Innovation Network 2021*[4] (Health Innovation Network, 2021) **Location**: UK	Current Health hub (Current Health Ltd).	250 admitted to VW Subgroup: 161 admitted for COVID-19	NR	Mean: 9 (range <1 - 49) days	NR	**Admissions post-discharge (patients completing pathway)** **7 days post-discharge:** VW, 5/170 (3%). COVID subgroup 3/106 (3%) **8-28 days after (cumulative):** VW 15/170 (9%). COVID subgroup 7/106 (7%)	**Hospitalisation while on VW**: 51/ (20%) 43/51 discharged home, 8 died in hospital COVID subgroup: 36 (22%). **Critical care admission:** VW, 5 (10%); Control, 0/6 (0%). COVID subgroup: 4 (11%).	NR
Fox 2022 (Fox et al., 2022) **Location:** UK	Huma (Huma Therapeutics)	142 admitted to VW 97 app users/45 non app users	NR	NR- authors report that the majority of patients were discharged at day 10	26/142 (18.3%) escalated to hospital care	NR	26/142 (18.3%)	NR

KSS AHSN 2020 (Kent Surrey Sussex Academic Health Science Network, 2020)	Huma (Huma Therapeutics)	2 NWL primary care sites: 116 to Medopad VW and 202 to telephone-based VW Hertfordshire secondary care site: 75 to Medopad VW and 387 to telephone-bsaed VW.	NR	NR	NR	NR	**Central London primary care site:** Medopad VW: 10/67 (15%) Telephone-based VW: 16/61 (26%) **NWL primary care site:** Medopad VW: 8/49 (16%) Telephone-based VW: NR. **28-day admissions Hertfordshire NHS secondary care site:** Medopad VW: 4/75 (5%) Early pandemic in-hospital comparator: 76/900 (8.4%).	**GP appointment (per patient average):** Central London primary care site: Medopad VW: 0.23 Telephone-based VW: 0.37 Number of contacts per patient: Central London primary care site: Medopad VW: 16.3 per patient (n=67) Telephone-based VW: 21.5 per patient (n=61).
Inhealthcare 2022 (inhealthcare, 2022) **Location:** UK	CO@Home service / Covid VW (Inhealthcare)	2,088 to CO@Home 27 to Covid VW	NR	Average stay in CO@Home: 9 days (up to 42 days) Average stay in Covid VW: 9 days	NR	CO@Home: 2% admitted to hospital	NR	NR

Ko 2023 (Ko et al., 2023) **Location:** Singapore	COVID Virtual Ward (run by the National University Health System's existing Hospital-at-Home Programme, Singapore)	238 admitted to VW	Day of COVID illness at admission: median 4 (IQR 2, 7)	Median: 6 (IQR 3, 8) days	NR	NR	Hospitall admission: 41 (17.2%) **Outcome of escalation (n=41):** Returned to VW: 13 (31.7%) Ward admission & recovered: 19 (46.3%) ICU admission & recovered: 4 (9.7%) Death: 3 (7.3%) Unknown: 2 (4.8%)	After hours consults: 58 (24.4%) Pharmacist consults: 116 (48.7%) Courier services: 139 (58.4%)
Mid and South Essex ICS 2022 (Mid and South Essex ICS, 2022) **Location:** UK	Whzan Blue Box (Solcolm) implemented by the NHS.	201 admissions 62% needed VW, 38% could have been discharged	NR	Average 12 days	NR	VW 30-day readmission rate: 30% (unclear if readmitted to VW or hospital)	NR	NR
van der Berg 2022 (van der Berg et al., 2022) **Location:** The Netherlands	Luscii platform (Luscii Healthtech BV)	268 admitted to VW. 65 from ED (step-up). 213 from admission group (step-down).	NR	Step-up: 6.5 days, (IQR 1-8) (range 1-27) *[5] Step-down: 5 days (IQR 2-8), (range 0-81)	NR	Hospital (re)admissions: Mixed: 24 (8.7%) Step-up: 10 (15.9%) Step-down: 14 (6.5%) ICU (re)admissions: Step-up: 5 (7.7%) Step-down: 5 (2.4%)	Number of ED reassessments: Step-up: 15 (23.8%) Step-down: 37 (15.8%)	Number of HCP telephone contacts: Step-up: 9 (IQR 7-12, range 0-27) Step-down: 9 (IQR 7-12, range 0-38)

*[1] Primary outcome of treatment failure defined as this, but only IPD in Fig 2. Paper reports estimated values at 180 days.

*[2] Reduction in length of hospitalisation reported as “the sum of days receiving oxygen therapy at home plus one day, comparable to the hospitals ward protocol in which patients were discharged one day after the oxygen was tapered down”

*[3] Data from Swift unpublished economic analysis.

*[4] Patient episodes analysed, not patients – 5 patients experienced more than 1 episode; this may affect the reliability of results.

*[5] Underestimate of true number as 5/213 patients transferred to another hospital and their length of stay data not available.

Abbreviations: CI – confidence interval, COPD – chronic obstructive pulmonary disease, HCP – healthcare provider, ICU – intensive care unit, IQR – interquartile range, NR – not reported, NWL – Northwest London, SD – standard deviation, UK – United Kingdom, USA – United States of America, VW – virtual wards.

Table C 5: Operational Outcomes (2)

Study name and location	VW Name (company)	Healthcare provider usability or acceptability	Patient adherence	Release of staff time for other caring responsibilities
Step-up care				
Akhtaruzzaman 2022 Location: Bangladesh	Virtual Ward Technologies (Virtual Ward Technologies)	NR	NR	NR
Moes 2022 (Moes et al., 2022) Location: The Netherlands	SAFE@home corona, including the Luscii platform (Luscii Healthtech BV)	NR	Daily home self-monitoring adherence (98.9%). 93.9% recorded and uploaded all intended measurements	NR
Jakobsen 2015 (Jakobsen et al., 2015) **Location:** Denmark	Not specified (VW used for data transmission and storage)	8 nurses who used the telehealth system responded to a user satisfaction questionnaire Easy to see and understand patient's problems and felt patient confident in using the equipment: 7/8 Confident in using the equipment: 6/8 Patient's presence would have enhanced confidence 4/8 System easy to use: 5/8 Easier and less time consuming than conventional treatment/care of COPD patients 4/8	NR	NR
Step-down care				

Study name and location	VW Name (company)	Healthcare provider usability or acceptability	Patient adherence	Release of staff time for other caring responsibilities
Grutters 2021 (Grutters et al., 2021) **Location:** The Netherlands	Not specified (VW technologies used for data transmission and storage)	NR	NR	NR
Kodama 2021 (Kodama et al., 2021) **Location:** USA	Commercial system (3rd party vendor not specified) (VW technologies used for data transmission and storage)	NR	High compliance with numerous daily vital submissions (numerical data not reported)	NR
O'Malley 2022 (O'Malley et al., 2022) **Location:** UK	DOCCLA technology (DOCCLA, Sweden)	NR	NR	NR
Swift 2022 (Swift et al., 2022a) **Location:** UK	CliniTouch Vie (Spirit Digital, Spirit Health Group, Leicester, UK)	NR	NR	NR
van Goor 2021 (van Goor et al., 2021) **Location:** The Netherlands	Luscii platform (Luscii Healthtech BV)	NR	NR	NR

Study name and location	VW Name (company)	Healthcare provider usability or acceptability	Patient adherence	Release of staff time for other caring responsibilities
Walter 2023 (Walter et al., 2023) **Location:** USA	Current Care Virtual Care platform (Current Health Inc.)	NR	Wearable activation: 231/237 (97.5%) Wearable adherence: 85% (IQR 63%-94%) COVID-19 risk factor subgroup: Wearable activation: 38/39 (97.4%) Wearable adherence: 78% (IQR 60%-91%)	NR
Wells 2022 Location: UK	VW serving 10 specialties (Current Health Ltd, Edinburgh, UK).	There was a perception that the VW would create additional workloads which made clinicians wary. This was overcome by demonstrating that the VW did not create additional workloads once implemented.	NR	NR
Tan 2023 (Tan et al., 2023) **Location:** Singapore	DrCovid+ (digital enhancement for the COVID VW programme developed at Singapore General Hospital)	Minor technical issues including downtime and crashes were recorded. Issues were rectified immediately by the research engineering support team.	NR	Total 2822 hospital bed-days saved Approximately 5 times lower staff:patient ratio than in-patient care: 1 consultat, 5 junior doctors and 5 nurses attending >100 patients (compared to 20-30 inpatients) Has reduced need for routine home visits (increasing staff producvitity and saving staff person-days)
Mixed				

Study name and location	VW Name (company)	Healthcare provider usability or acceptability	Patient adherence	Release of staff time for other caring responsibilities
Bircher 2022 (Bircher et al., 2022) **Location:** UK	Maternity VW (Current Health Ltd, Edinburgh, UK).	Authors report: A key challenge was digital transformation. The initial set up and coordination of the MVW required dedication, and a degree of "internal marketing" from enthusiastic individuals to bring the rest of team onboard. The key barrier to engagement was a lack of perceived importance of remote monitoring and co-ordination of maternity services, respiratory, acute and general medicine.	NR	NR
Health Innovation Network 2021 (Health Innovation Network, 2021)*[1] **Location**: UK	Current Health hub (Current Health Ltd).	Authors report: Staff highlighted key factors for success of the VW, such as the being run by the community (not acute) services; pathways in place to ensure emergency treatment is accessed when needed, upskilling staff on when and how to use continuous monitoring, and having a cross-system multidisciplinary team	96% VW patients used the Current Health kit and 4% declined it or requested its removal Mean wearable adherence 68% VW monitoring: 56% generated readings for over 75% of the time, 17% for 50-75%, and 28% for 50% or less.	NR
Fox 2022 (Fox et al., 2022) **Location:** UK	Huma (Huma Therapeutics)	NR	45 (31.5%) did not input data to the app or did not download it.	NR

Study name and location	VW Name (company)	Healthcare provider usability or acceptability	Patient adherence	Release of staff time for other caring responsibilities
KSS AHSN 2020 (Kent Surrey Sussex Academic Health Science Network, 2020)	Huma (Huma Therapeutics)	Survey of 10 staff members: 56% found patient data on the dashboard easy to review. Average acceptability score: 6.9/10.	2 NWL sites: 42% and 74% of patients from each NHS site did not download the app. A further 5% (7 patients) from one site did not use the app after download. 94% of patients who downloaded the app continued to use it.	NR
Inhealthcare 2022 (inhealthcare, 2022) **Location:** UK	CO@Home service / Covid VW (Inhealthcare)	NR	10% of patients recorded as self discharged	NR
Ko 2023 (Ko et al., 2023) **Location:** Singapore	COVID Virtual Ward (run by the National University Health System's existing Hospital-at-Home Programme, Singapore)	NR	Compliance: Proportion of readings for each patient that required reminders: mean 0.91 (SD 0.16) Proportion of overall reminders that triggered a patient submission: mean 0.84 (SD 0.24) Compliance with chatbot: 84% of patients or their caregivers	The staffing ratio was generally lower than that required to staff an inpatient ward or equivalent community facility for these patients
Mid and South Essex ICS 2022 (Mid and South Essex ICS, 2022) **Location:** UK	Whzan Blue Box (Solcolm) implemented by the NHS.	Info provided was across all VW (respiratory, frailty and emergency)	NR	29.5 WTEs , all of who were new appointments

Study name and location	VW Name (company)	Healthcare provider usability or acceptability	Patient adherence	Release of staff time for other caring responsibilities
van der Berg 2022 (van der Berg et al., 2022) **Location:** The Netherlands	Luscii platform (Luscii Healthtech BV)	NR	Compliance*[2] was high in both ED and admissions groups. Median compliance 100% (IQR: 100-100) in both groups at day 9 which is the latest adherence rates are reported. Patients that were recovering/improving had less adherence than those who required oxygen therapy	NR

*[1] Patient episodes analysed, not patients – 5 patients experienced more than 1 episode; this may affect the reliability of results.

*[2] Defined as: the performance of measurements 4 times a day—regardless of which measurements it was (either respiratory rate or oxygen saturation or both).

Abbreviations: COPD – chronic obstructive pulmonary disease, ED – emergency department, IQR – interquartile range, MVW – maternity virtual ward, NR – not reported, SD – standard deviation, UK – United Kingdom, USA – United States of America, VW – virtual wards, WTE – whole time equivalent.

Table C 6: Patient Reported Outcomes

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Step-up care				
Akhtaruzzaman 2022 Location: Bangladesh	Virtual Ward Technologies (Virtual Ward Technologies)	NR	80% agree/strongly agree that they were evaluated adequately 85% agree/strongly agree that they received proper support and advice 95% agreed/strongly agree they were satisfied by the platform 100% agree/strongly agree it is an effective method of providing healthcare during the pandemic	NR

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Moes 2022 (Moes et al., 2022) Location: The Netherlands	SAFE@home corona, including the Luscii platform (Luscii Healthtech BV)	24 completed patient satisfaction and user experience questionnaire. 9/10 (IQR: 8-10) score for the added value of SAFE@home corona. 8.5 score (IQR: 7.8-10.0) contact with medical management centre. Patients stated a median of 4 (IQR: 1-13) times that they wanted additional physician consult.	8/10 score (IQR: 8-10) for usefulness of platform. 10/10 score (IQR: 8-10) for daily assessment of oxygen saturation. 10/10 score for recommending the platform.	NR

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Jakobsen 2015 (Jakobsen et al., 2015) **Location:** Denmark	Not specified (VW technologies used for data transmission and storage)	20 patients in telehealth group completed a user satisfaction questionnaire immediately after discharge. 100% agree/strongly agree it was easy to see health staff on the screen 100% agree/strongly agree it was easy to understand the information given 100% agree/strongly agree it was easy to use medicine box 100% agree/strongly agree it was easy to understand written instructions for equipment use 100% agree/strongly agree they felt confident in using the equipment	NR	The scores of CCQ, SGRQ and EQ-5D improved in both groups over time within the first 30 days after discharge, but the improvement was not significantly different between the telehealth and hospital groups
Step-down care				

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Grutters 2021 (Grutters et al., 2021) **Location:** The Netherlands	Not specified (VW technologies used for data transmission and storage)	30 (91%) of 33 pilot patients competed the satisfaction questionnaire (based on Consumer Quality Index in General Practice questionnaires). 87% took <10 minutes to record and report measurements via the app 100% of patients would recommend home telemonitoring to acquaintances	30 (91%) of 33 pilot patients competed the satisfaction questionnaire (based on Consumer Quality Index in General Practice questionnaires). 97% rated home telemonitoring as user friendly. The majority of patients (87%) were always clear what to do when their oxygen saturation was low; 13% were mostly clear Full study: 93% of patients (n not reported) found the app user friendly.	NR

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Kodama 2021 (Kodama et al., 2021) **Location:** USA	Commercial system (3rd party vendor not specified) (VW technologies used for data transmission and storage)	23 patients completed the satisfaction survey. 74% strongly agreed it was simple to sign up for the program 65% strongly agreed the platform was easy to use 74% strongly agreed that that questions and concerns were adequately addressed in the daily calls 74% strongly agreed they felt confident in taking their vital signs 65% strongly agreed they felt confident in completing the surveys 74% strongly agreed they were satisfied with the care they received	NR	NR
O'Malley 2022 (O'Malley et al., 2022) **Location:** UK	DOCCLA technology (DOCCLA, Sweden)	NR	NR	NR

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Swift 2022 (Swift et al., 2022a) **Location:** UK	CliniTouch Vie (Spirit Digital, Spirit Health Group, Leicester, UK)	NR	NR	NR
van Goor 2021 (van Goor et al., 2021) **Location:** The Netherlands	Luscii platform (Luscii Healthtech BV)	NR	NR	NR
Walter 2023 (Walter et al., 2023) **Location:** USA	Current Care Virtual Care platform (Current Health Inc.)	NR	NR	NR

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Wells 2022 (Wells et al., 2022) **Location:** UK	VW serving 10 specialties (Current Health Ltd, Edinburgh, UK).	The majority of feedback from patients was positive but some technical issues with the monitoring equipment were mentioned as a point of frustration.	290 VW patients or caregivers completed the patient feedback questionnaire. 100% of patients and caregivers said they would recommend the VW to family and friends. Many participants mentioned that being part of the VW increased their confidence leaving hospital. Some patients expressed anxiety about being discharged from hospital. A handful of patients expressed frustration with technical issues with the remote monitoring equipment.	NR
Tan 2023 (Tan et al., 2023) **Location:** Singapore	DrCovid+ (digital enhancement for the COVID VW programme developed at Singapore General Hospital)	NR	NR	NR
Mixed				

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Bircher 2022 (Bircher et al., 2022) **Location:** UK	Maternity Virtual Ward (Current Health Ltd, Edinburgh, UK).	NR	Patient satisfaction survey completed by 24 patients: All areas scored 4 or 5 out of 5: patient information, ease of use, confidence, recommended and overall service.	NR
Health Innovation Network 2021* (Health Innovation Network, 2021) **Location**: UK	Current Health hub (Current Health Ltd).	Current Health patient experience questionnaire and feedback from 3 patients: Most patients would recommend the Current Health devices to family and friends (Net Promoter questionnaire score 55, 'excellent') The service provided peace of mind and was easy and simple to use Patients felt they received the same standard of care as that in a hospital environment, and had their needs addressed far more than they had expected	'Ease of Use' subscale of the validated Telehealth Usability Questionnaire (completed by 37 patients): Overall score: 5.9 (1.1) out of 7 (5.3 or more considered 'high') Patient feedback was largely positive with >87% of patients in positive agreement with each statement in the survey. In particular, 89% found the kit easy to learn to use and 89% thought it simple and easy to understand	NR

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Fox 2022 (Fox et al., 2022) **Location:** UK	Huma (Huma Therapeutics)	89% of app users found the app easy to use with 92% reporting the CVW set-up made them or their family feel reassured.	11 (7.7%) patients did not use the app themselves but required a family member to input and record the data on their behalf. Non-app users: mostly commented on language barriers or inadequate demonstration or explanation of the pulse oximeter and/or the app in the hospital setting prior to discharge. One patient was illiterate and another reported never receiving a pulse oximeter. Language barriers: 48% of non-app users reported an app in another language would have helped. IT Skills: 26% of non-app users reported difficulties with the app use. None reported difficulties using the pulse oximeter. Information and training: 48% of non-app users reported training would have helped them use the app appropriately. Digital access: 4% of non-app user patients did not have a phone, 9% did not have internet service, and 35% did not have smartphone technology and therefore no ability to download or use apps. 4% of the non-app user cohort reported disability affected their ability to use the app.	NR

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
KSS AHSN 2020 (Kent Surrey Sussex Academic Health Science Network, 2020)	Huma (Huma Therapeutics)	95% of patients found the app easy to use (n NR) 90% found the VW experience good or ver good (n NR) 76% (n NR) would be happy to use the VW again.	NR	NR
Inhealthcare 2022 (inhealthcare, 2022) **Location:** UK	CO@Home service (Inhealthcare) used as part of the COVID VW	NR	NR	NR

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Ko 2023 (Ko et al., 2023) **Location:** Singapore	COVID Virtual Ward (run by the National University Health System's existing Hospital-at-Home Programme, Singapore)	Online quality improvement survey sent to all patients post-discharge was completed by 74 patients or caregivers, including family members not living with patient. Overall, 68 (91.9%) felt safe at home (rating ≥4.5), 69 (93.2%) found it easy to take vital signs (rating ≥4.5), and 100% felt help was available if needed and also would recommend the programme to others	NR	NR

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
Mid and South Essex ICS 2022 (Mid and South Essex ICS, 2022) **Location:** UK	Whzan Blue Box (Solcolm) implemented by the NHS.	96% patients were were determined (by physician) to have achieved an ideal outcome.	NR	22% of assessed patients were assessed to have experienced a decline in function comparable to an acute setting. 11% were assessed to have experienced some decline in function, but less than would be expected in an acute setting. None of the patients assessed experienced a worse level of decline compared to that experienced in an acute

Study name and location	VW Name (company)	Patient and carer experience (including preferred place of care and carer strain)	Patient and carer acceptability	Health related quality of life
van der Berg 2022 (van der Berg et al., 2022) **Location:** The Netherlands	Luscii platform (Luscii Healthtech BV)	58/65 VW patients completed the experience and satisfaction questionnaire. The majority agreed (71.2%) or largely agreed (19.2%) that they were satisfied with home tele-monitoring, regarding the information , they had received 62.2% reported sufficient time and attention from the clinical team.	Overall, the platform had a median score of 9/10 (IQR: 8-10). Patients felt safe at home instead of in the hospital (86-94%).	NR

* Patient episodes analysed, not patients – 5 patients experienced more than 1 episode; this may affect the reliability of results.

Abbreviations: CCQ – Clinical Chronic Obstructive Pulmonary Disease Questionnaire, CVW – COVID virtual ward, EQ-5D – European Quality of Life 5 Dimension, IT – information technology, IQR – interquartile range, NHS – National Health Service, NR – not reported, SGRQ – St. George Respiratory Questionnaire, UK – United Kingdom, USA – United States of America, VW – virtual wards.

Appendix D – Economic review study selection

Selection of economic studies was performed alongside the selection of clinical studies. Economic evaluations were considered eligible if they reported total costs, effectiveness, incremental analyses or other economic evaluation outcomes, or measured any relevant cost or resource use associated with the use of technology-enabled VWs. Recent studies and those conducted in a UK NHS setting were prioritised.

Three full text studies were assessed for relevance to economics outcomes and excluded at full text review due to ineligible outcomes (Tan 2023, which is included in the clinical review; and NCT05087082 2022, which is a clinical trial without published outcomes); or being a review with no eligible outcomes (Biancuzzi, 2023).

Appendix E – NHS supply chain costs

Table E1: NHS supply chain costs of medical devices used on a virtual ward

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Pulse oximeter (or an oximeter and pulse reader separately)					
Finger device pulse oximetry SPO2	Paediatric - for measuring blood oxygen levels in children	HENRY SCHEIN MEDICAL	1	1	[redacted]
Finger device pulse oximetry SPO2	Fingertip	HENRY SCHEIN MEDICAL	1	1	[redacted]
Finger device pulse oximetry SPO2	With carry case warranty 24 months	HENRY SCHEIN MEDICAL	1	1	[redacted]
Finger device pulse oximetry SPO2	Oximeter CN130 device LED one colour screen with protective rubber boot 2 x aaa batteries 30 hours continuous use 1 year warranty	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Clip Spo2 with temperature function NON RETURNABLE	WALTERS MEDICAL LIMITED	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Finger device pulse oximetry SPO2	With pouch and lanyard warranty 24 months	HENRY SCHEIN MEDICAL	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger Device spo2 without carry case 12 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger device spo2 with carry case 12 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	With pulse rate pulse bar and LED display screen supplied with lanyard & 2 x AAA batteries 2 year warranty 30 hours continuous use for adult & paediatric use	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	With pulse rate pulse bar and LED display screen supplied with carry case lanyard & 2 x AAA batteries 2 year warranty 30 hours continuous use for adult & paediatric use	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger Device spo2 without carry case 18 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger device spo2 with carry case 18 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger device spo2 without carry case 24 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger Device spo2 without carry case 36 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger Device spo2 without carry case 48 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger device spo2 with carry case 24 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	With pulse rate pulse bar waveform and OLED display screen supplied with carry case lanyard & 2 x AAA batteries 2 year warranty 30 hours continuous use for adult & paediatric use	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger Device spo2 without carry case 60 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger device spo2 with carry case 36 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Continuous Monitoring Oxeygen and Body Temperature	HENRY SCHEIN MEDICAL	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger device spo2 with carry case 48 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Paediatric 3yrs and over and adult Spo2 with pulse rate and strength indication large LED screen display and ambient light shield design lanyard and batteries included	SYRINGA WHOLESALE DISTRIBUTOR	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger Device spo2 with carry case 60 months warranty	PRAXIS MEDICAL LTD	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Finger device pulse oximetry SPO2	Black Single - 3 year drop warranty - supplied with carry case lanyard & 2 x AAA batteries	PROACT MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Blue Single - 3 year drop warranty - supplied with carry case lanyard & 2 x AAA batteries	PROACT MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	With pulse rate pulse bar waveform alarms and OLED display screen supplied carry case lanyard & 2 x AAA batteries 3 year warranty 30 hours continuous for adult & paediatric use	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	With pulse rate pulse bar waveform and OLED display screen supplied with carry case lanyard & 2 x AAA batteries 3 year warranty 30 hours continuous can be used on both adult & paediatrics	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Sensor for pulse oximetry Multi patient use	Finger clip SpO2 device battery operated 30 month warranty automatic switch off auto switch off after 8 seconds	WALTERS MEDICAL LIMITED	1	1	[redacted]
Finger device pulse oximetry SPO2	Compact oximeter with 6 display modes	ALBERT WAESCHLE LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Paediatric 3yrs and over and adult Spo2 with pulse rate pulse waveform and artery check technology ACT ambient light shield design lanyard and batteries included	SYRINGA WHOLESALE DISTRIBUTOR	1	1	[redacted]
Finger device pulse oximetry SPO2	CB31 SpO2 spotcheck measurement with pulse rate pulse bar waveform and OLED display screen in shock proof silicone housing supplied with lanyard & 1 x AAA batteries 3 year warranty 8 hours continuous for adult & paediatric use	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Creative PC-60FW Bluetooth v2.0/4.0 with Carry Case	PROACT MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	H10 Finger oximeter compact & lightweight dual colour oled display spo2 pr bar graph and plethysmogram display single button operation multi direction and multi mode display adjustable brightness without carry case	WHITE MEDICAL	1	1	[redacted]
Finger device pulse oximetry SPO2	Oximeter C1218 device OLED dual colour screen perfusion Index drop proof with carry case neck cord 2 x aaa batteries 30 hours continuous use 5 year warranty	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	With neck cord - 40 hours continuous use - 2 x aaa batteries - 2 year warranty	WHITE MEDICAL	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger device with carry case-neck cord-2 x AAA batteries - 6000 readings - 5 year drop warranty	PROACT MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Radius 7 PPG Doctella Non Returnable	MASIMO UK	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Finger device pulse oximetry SPO2	Finger device with carry case-neck cord-2 x AAA batteries - 6000 readings - 5 year drop warranty	PROACT MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Finger device with carry case-neck cord-2 x AAA batteries - 6000 readings - 5 year drop warranty	PROACT MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Masimo mightysat RX fingertip pulse oximeter Non Returnable	MASIMO UK	1	1	[redacted]
Finger device pulse oximetry SPO2	Nonin Onyx 11finger monitor with carry cases-neck cord-batteries-2500 readings from 2xAAA batteries- 5 year drop inclusive warranty	PROACT MEDICAL LTD	1	1	[redacted]
Finger device pulse oximetry SPO2	Mighty sat rx with Bluetooth PVi RRp	MASIMO UK (E DIRECT)	1	1	[redacted]
Finger device pulse oximetry SPO2	Wireless Bluetooth v4.0 data transfer	PROACT MEDICAL LTD	1	1	[redacted]
spirometer					[redacted]
Base description	**Secondary description**	**Supplier**	**Units**	**Band 1 quantity**	[redacted]
Spirometer	spirometer volume incentive 4000ml without one-way valve 12/cs12/cs	VYAIRE MEDICAL PRODUCTS LTD	12	1	[redacted]
Spirometer	spirometer volume incentive 2500ml without one-way valve 12/cs12/cs	VYAIRE MEDICAL PRODUCTS LTD	12	1	[redacted]
Spirometer	Spirobank Smart Hand held with reusable turbine and free App	INTERMEDICAL (UK) LTD	1	1	[redacted]
Spirometer	MIR Spirobank Smart Oxi with Oximetry and free App for remote/home monitoring	INTERMEDICAL (UK) LTD	1	1	[redacted]
Spirometer	Micro with BT Highly accurate affordable handheld for routine testing and reporting	VITALOGRAPH LTD	1	1	[redacted]
Spirometer	MIR Spirobank Basic Hand held with reusable turbine	INTERMEDICAL (UK) LTD	1	1	[redacted]
Spirometer	Hand held spirometer with reusable turbine	INTERMEDICAL (UK) LTD	1	1	[redacted]
Spirometer	MIR Spirobank II Smart with 1 reusable turbine	INTERMEDICAL (UK) LTD	1	1	[redacted]
Spirometer	MIR SpiroBank II Advanced with Bluetooth Hand held and reusable turbine	INTERMEDICAL (UK) LTD	1	1	[redacted]
Spirometer	MIR SpiroDoc Hand held with reusable turbine	INTERMEDICAL (UK) LTD	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Spirometer	MIR Spirobank Advanced Hand held with reusable turbine and oximeter	INTERMEDICAL (UK) LTD	1	1	[redacted]
Spirometer	MIR SpiroDoc Hand held with reusable turbine and Oximeter with 6 minute walk test	INTERMEDICAL (UK) LTD	1	1	[redacted]
Spirometer	App based hand help for home based and community monitoring with bacterial filter	VYAIRE MEDICAL PRODUCTS LTD	1	1	[redacted]
Spirometer	Hand held app for home based and community monitoring with bacterial filter	VYAIRE MEDICAL PRODUCTS LTD	1	1	[redacted]
Spirometer	NDD EasyOne Air hand held Bluetooth touchscreen ultrasonic device with cradle	INTERMEDICAL (UK) LTD	1	1	[redacted]
Spirometer	Vitalograph Pneumotrac Spirometer with RMS An enhanced diagnostics solution that combines highly accurate Respiratory Muscle Strength and Spirometry testing in one robust portable device	VITALOGRAPH LTD	1	1	[redacted]
blood pressure cuff					[redacted]
Base description	**Secondary description**	**Supplier**	**Units**	**Band 1 quantity**	[redacted]
Sphygmomanometer Digital	Automatic blood pressure monitor with standard adult cuff 22-32cm large display and 60 memory x 2 IHB detection BIHS approved	CIGA HEALTHCARE LTD	1	1	[redacted]
Sphygmomanometer Digital	Fully automatic blood pressure monitor with universal 22-42cm cuff and irregular heartbeat detection	SYRINGA WHOLESALE DISTRIBUTOR	1	1	[redacted]
Sphygmomanometer Digital	Fully automatic BP monitor with standard adult cuff (range 2232cm) BHS classification with WHO blood pressure classification indicator and a 90 reading memory capacity Supplied with 4x AA batteries and 2 year warranty	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Sphygmomanometer Digital	A2 Classic blood pressure monitor	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Fully automatic wrist blood pressure monitor with irregular heartbeat detection	SYRINGA WHOLESALE DISTRIBUTOR	1	1	[redacted]
Sphygmomanometer Digital	Semi automatic upper arm digital blood pressure monitor	SYRINGA WHOLESALE DISTRIBUTOR	1	1	[redacted]
Sphygmomanometer Digital	Fully automatic wrist blood pressure monitor with irregular heartbeat detection and movement detection	SYRINGA WHOLESALE DISTRIBUTOR	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Sphygmomanometer Digital	M2 Basic Automatic Digital Blood Pressure Monitor	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer	Oscillometric and Auscultatory Digital/ Manual Monitor with Cuff and up to 1 Years Warranty Scian Automatic Upper Arm Blood Pressure Monitor LD-582	WILLIAMS MEDICAL SUPPLIES PLC	1	1	[redacted]
Sphygmomanometer Digital	Automatic blood pressure monitor 120 measurement memory	ALBERT WAESCHLE LTD	1	1	[redacted]
Sphygmomanometer Digital	A2 Basic blood pressure monitor	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Semi automatic palm top blood pressure monitor with cuff manual case and 1 AA battery	PROACT MEDICAL LTD	1	1	[redacted]
Sphygmomanometer Digital	Deluxe Digital Fully automatic adult cuff range 2232cm XL easy read display time Date stamp irregular heart beat detector BHS classification WHO classification indicator 90 reading memory capacity 4x AA batteries 2 year warranty	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Sphygmomanometer Digital	Sphygmomanometer Digital	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Sphygmomanometer Digital	Fully automatic PARR technology blood pressure monitor with 24-40cm d ring cone cuff	SYRINGA WHOLESALE DISTRIBUTOR	1	1	[redacted]
Sphygmomanometer Digital	Oscillometric fully automatic monitor upper arm cuff 2 year warranty DS 11 digital measurement inflation irregular pulse movement detection 60 measurement memory dual cuff 22-42cm two year warranty NON RETURNABLE	WHITE MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Oscillometric fully automatic monitor upper arm with cuff 2 year warranty delicare digital movement and irregular pulse detection dual size soft cuff 60 measurement memory measurement on inflation NON RETURNABLE	WHITE MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	New M2 Automatic Blood Pressure Monitor	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Upper arm blood pressure monitor with atrial fibrillation screening and wide fit cuff 22-42cm	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Fully automatic simple one button blood pressure monitor with irregular heartbeat indicator 23-37 cm cuff batteries and carry case non-returnable	PMS (INSTRUMENTS) LTD	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Sphygmomanometer Digital	Oscillometric fully automatic upper arm cuff 2 year warranty big display WHO class sym move irregular pulse detect pulse press display dual size soft cuff twin 60 measurement memory aver date time stamp measurement inflation NON RETURNABLE	WHITE MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Wrist Blood Pressure Monitor	HEALTH-CARE EQUIPMENT & SUPPLIES CO LTD	1	1	[redacted]
Sphygmomanometer Digital	M3 Upper Arm BP Monitor	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Wrist blood pressure monitor with cuff NON RETURNABLE	WHITE MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Oscillometric fully automatic with semi large 23-37cm cuff ISO80369-5 compliant AFib plus screening storage pouch batteries 5 Year warranty NON RETURNABLE	PMS (INSTRUMENTS) LTD	1	1	[redacted]
Sphygmomanometer Digital	Fully automatic simple one button blood pressure monitor with Atrial Fibrillation screening 23-37 cm cuff batteries and carry case non returnable	PMS (INSTRUMENTS) LTD	1	1	[redacted]
Sphygmomanometer Digital	Oscillometric measurement supplied with standard cuff 22-32cm upper arm measurement on inflation dual 60 measurement memory with date and time irregular pulse rhythm and body motion detection NON RETURNABLE	WHITE MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Upper Arm Blood Pressure with AFib Screening	HEALTH-CARE EQUIPMENT & SUPPLIES CO LTD	1	1	[redacted]
Sphygmomanometer Digital	Fully automatic monitor with advanced irregular heart beat indicator and wide range 22-42cm cuff NON RETURNABLE	PMS (INSTRUMENTS) LTD	1	1	[redacted]
Sphygmomanometer Digital	M3 Comfort Blood Pressure Monitor	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Oscillometric measurement supplied as standard a dual cuff 22-32cm measurement on deflation dual 60 measurement memory with date and time cuff wrapping sensor irregular pulse rhythm and body motion detection NON RETURNABLE	WHITE MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Incs pull through strap velcro adult cuff 2 year warranty features irregular heartbeat recognition memory storage up to 99 readings pulse tone date and time NON RETURNABLE	RUDOLF RIESTER GMBH	1	1	[redacted]
Sphygmomanometer Digital	Incs pull through strap velcro adult cuff 5 year warranty features irregular heartbeat recognition memory storage up to 99 readings pulse tone date and time warranty NON RETURNABLE	RUDOLF RIESTER GMBH	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Sphygmomanometer Digital	Premier Blood Pressure Monitor (TriCheck) triple A technology SmoothFit cuff for improved comfort covering 17cm to 32cm 5 year warranty NON RETURNABLE	HEALTH-CARE EQUIPMENT & SUPPLIES CO LTD	1	1	[redacted]
Sphygmomanometer Digital	Digital blood pressure monitor large LCD Backlit includes wide cuff to fit 24-43cm fast and low noise irregular heartbeat detection average BP measurement function	RUDOLF RIESTER GMBH	1	1	[redacted]
Sphygmomanometer Digital	Digital blood pressure monitor large LCD backlit includes small cuff 15-24cm fast and low noise irregular heartbeat detection average BP measurement function	RUDOLF RIESTER GMBH	1	1	[redacted]
Sphygmomanometer Digital	Premier Blood Pressure Monitor (TriCheck) triple A technology supplied with Wide Range cuff 22 - 42cm 5 year warranty NON RETURNABLE	HEALTH-CARE EQUIPMENT & SUPPLIES CO LTD	1	1	[redacted]
Sphygmomanometer Digital	M6 Comfort Digital Blood Pressure Monitorwho are pregnant or have diabetes cuff wrap guide	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	WatchBP home monitor	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Oscillometric Fully Automatic with Wide Range 22-42cm Cuff triple A technology Storage Case Batteries 5 Year Warranty with Irregular Heartbeat Indicator NON RETURNABLE	PMS (INSTRUMENTS) LTD	1	1	[redacted]
Sphygmomanometer Digital	M7 Intelli IT Automatic Blood Pressure Monitor	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Digital blood pressure monitor Large LCD backlit includes wide cuff to fit 24-43cm fast and low noise irregular heartbeat detection average BP measurement function with Bluetooth	RUDOLF RIESTER GMBH	1	1	[redacted]
Sphygmomanometer Digital	Digital blood pressure monitor large LCD backlit includes small cuff to fit 15-24cm fast and low noise irregular heartbeat detection average BP measurement function with Bluetooth	RUDOLF RIESTER GMBH	1	1	[redacted]
Sphygmomanometer Digital	RS7 Intelli IT Automatic Wrist BP Monitor	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Aneroid	Auscultatory desk monitor cuff 2 year warranty digital display LCD column design enclosed in a mercury style case 2mmHg grad hold facility for measurement recall with standard adult cuff inflation bulb and batteries NON RETURNABLE	WHITE MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	BPM inc Intelli wrap cuff covering med and large size	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer	ProBP digital blood pressure device	WELCH ALLYN UK LIMITED	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Sphygmomanometer Digital	Dual digital manual bpm supplied with GS2 wipe clean medium cuff and mains adaptor optional SS S L and XL GS2 cuffs available	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer	Professional PARR digital blood pressure monitor manual auto with S M L medical cuff	SYRINGA WHOLESALE DISTRIBUTOR	1	1	[redacted]
Sphygmomanometer Digital	ProBP with cuff batteries and power supply	WELCH ALLYN UK LIMITED	1	1	[redacted]
Sphygmomanometer Digital	RBP 100 Blood pressure monitor table model 2 year warranty BIHS validated technology 4 LCD screen oscillometric and auscultatory modes with auto deflate average mode 3 interval settings arrythmia detection memory NON RETURNABLE	RUDOLF RIESTER GMBH	1	1	[redacted]
Sphygmomanometer Digital	Nightview automatic wrist blood pressure monitor	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	RBP 100 Blood pressure monitor rail mode 2 year warranty BIHS validated technology 4 LCD screen oscillometric and auscultatory modes with auto deflate average mode 3 interval settings arrythmia detection memory NON RETURNABLE	RUDOLF RIESTER GMBH	1	1	[redacted]
Sphygmomanometer Digital	RBP 100 Blood pressure monitor table model 5 year warranty BIHS validated technology 4 LCD screen oscillometric and auscultatory modes with auto deflate average mode 3 interval settings arrythmia detection memory NON RETURNABLE	RUDOLF RIESTER GMBH	1	1	[redacted]
Sphygmomanometer Digital	RBP-100 Blood pressure monitor wall mode 2 year warranty BIHS validated technology 4 LCD screen oscillometric and auscultatory modes with auto deflate average mode 3 interval settings arrythmia detection memory NON RETURNABLE	RUDOLF RIESTER GMBH	1	1	[redacted]
Sphygmomanometer Digital	RBP 100 Blood pressure monitor rail mode 5 year warranty BIHS validated technology 4 LCD screen oscillometric and auscultatory modes with auto deflate average mode 3 interval settings arrythmia detection memory NON RETURNABLE	RUDOLF RIESTER GMBH	1	1	[redacted]
Sphygmomanometer Digital	Dual digital manual bpm supplied with GS2 wipe clean medium and large cuffs and battery pack and mains adaptor optional SS S and XL GS2 cuffs available	HENRY SCHEIN MEDICAL	1	1	[redacted]
Sphygmomanometer Digital	Dual Measurement Blood Pressure Monitor incl Adult & Large Adult Cuff	HEALTH-CARE EQUIPMENT & SUPPLIES CO LTD	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Sphygmomanometer	Professional PARR digital blood pressure monitor manual auto with S M L medical cuff	SYRINGA WHOLESALE DISTRIBUTOR	1	1	[redacted]
Sphygmomanometer Digital	Dual mode upper arm blood pressure monitor with standard cuff	HENRY SCHEIN MEDICAL	1	1	[redacted]
a thermometer (or other temperature reading device)					[redacted]
Base description	**Secondary description**	**Supplier**	**Units**	**Band 1 quantity**	[redacted]
Thermometer electronic device flexible tip with battery	Digital device with flexible tip for oral axillary or rectal use rapid response measurement 10 Seconds in Celsius & Fahrenheit and water resistant for use with FWH226 single use covers	TIMESCO HEALTHCARE LTD	10	1	[redacted]
Thermometer electronic device flexible tip with battery	Digital with Buzz	ALBERT WAESCHLE LTD	1	1	[redacted]
Thermometer electronic device flexible tip with battery	Oral	KINETIK MEDICAL DEVICES LTD	1	1	[redacted]
Thermometer electronic device flexible tip with battery	Flex Temp Smart	HENRY SCHEIN UK HOLDINGS LTD	1	1	[redacted]
Thermometer electronic device flexible tip with battery	DIGITAL PROBE TESTING TIME 60 SECONDS	PRAXIS MEDICAL LTD	1	1	[redacted]
Thermometer electronic device flexible tip with battery	Medical Digital 10 sec probe	SYRINGA WHOLESALE DISTRIBUTOR	6	1	[redacted]
Thermometer electronic device flexible tip with battery	Waterproof lcd display medical digital unit	ALMOND NURSING LIMITED	20	1	[redacted]
Thermometer electronic device flexible tip with battery	OMRON FLEX TEMP SMART DIGITAL THERMOMETER	WILLIAMS MEDICAL SUPPLIES LTD	1	1	[redacted]
Thermometer electronic device rigid tip with battery	LCD Reading	CREST MEDICAL LTD	1	1	[redacted]
Thermometer electronic device rigid tip with battery	Digital device with rigid tip for oral axillary or rectal use rapid response measurement 10 Seconds in Celsius & Fahrenheit and water resistance for use with FWH226 single use covers	TIMESCO HEALTHCARE LTD	10	1	[redacted]
Thermometer electronic device rigid tip with battery	Oral axillary or rectal use for use with FWH226 single use covers	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Thermometer electronic device rigid tip with battery	Digital	ALBERT WAESCHLE LTD	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Thermometer electronic device rigid tip with battery	ri-gital Digital safety lock and case Can be used for oral and under-arm measurement of body temperature Digital measurement is particularly accurate thanks to the highly sensitive temperature sensor	RUDOLF RIESTER GMBH	10	1	[redacted]
Thermometer electronic device rigid tip with battery	DIGITAL 20 SECOND TESTING SINGLE PATIENT DIGITAL DISPLAY	PRAXIS MEDICAL LTD	1	1	[redacted]
Thermometer electronic device rigid tip with battery	Mercury free Fully automatic Oral or underarm readings Clear LCD display	RELIANCE MEDICAL LTD	288	1	[redacted]
Thermometer electronic device rigid tip with battery	Eco Temp Basic	HENRY SCHEIN UK HOLDINGS LTD	1	1	[redacted]
Thermometer electronic device rigid tip with battery	ri-gital Digital safety lock and case Can be used for oral and under-arm measurement of body temperature Digital measurement is particularly accurate thanks to the highly sensitive temperature sensor	RUDOLF RIESTER GMBH	10	1	[redacted]
Thermometer electronic device rigid tip with battery	Thermometer electronic device rigid tip with battery	RUDOLF RIESTER GMBH	4	1	[redacted]
Thermometer temporal artery device handheld	Non contact infrared for hospital use reusable non invasive uses the temporal artery to measure core body temperature Thermofinder FS-700	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Non contact infrared use with carry case and batteries	PROACT MEDICAL LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Non contact infrared thermometer	DENWARD MANUFACTURING LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Non contact thermometer for Clinicians PROJECTS TEMPERATURE onto the FOREHEAD Correct Measuring Distance Fast Ambient Calibration Stabilisation system for precise temperature readings Warranty 2 years NON RETURNABLE	G H ZEAL LIMITED	1	1	[redacted]
Thermometer temporal artery device handheld	Non contact infrared clinical forehead thermometer zero consumables zero contact 0.2C accuracy 1 second read designed and manufactured in EU clinical grade for hospitals and clinics	TRIMEDIKA LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Infrared LCD Display (Centigrade and Fahrenheit) memory read with 32 Set capacity buzzer reminder alarm threshold setting backlight reminder temperature off setting auto power off measuring duration: 1 second measuring range: 1-5cm	WILLIAMS MEDICAL SUPPLIES LTD	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Thermometer temporal artery device handheld	Non contact infrared clinical grade temperature measurements single button operation forehead temperature measurements calibrated to an oral reference	DENWARD MANUFACTURING LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Non contact infrared use with carry case and batteries	PROACT MEDICAL LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Infrared for measuring body temperature Forehead no touch using infrared technology	CREST MEDICAL LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Forehead Temperature Measuring - NON REFUNDABLE - NON RETURNABLE	DRIVE DEVILBISS HEALTHCARE LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Non-Contact Infrared Forehead	BRAUN & CO LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Infrared Non-Touch Forehead - NON RETURNABLE - NON REFUNDABLE	MEDLINE INDUSTRIES LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Marsden T-100 handheld non-contact digital infrared	MARSDEN WEIGHING MACHINE CO LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Non-Contact clinical grade infrared forehead Clinical grade readings in 1-2 seconds Applicable for all patient types Minimum of 3000 measurements Optional calibration kit available (FWH296 / MPC 12953)	RUDOLF RIESTER GMBH	1	1	[redacted]
Thermometer temporal artery device handheld	Non-Contact clinical grade infrared forehead with Bluetooth connectivity Clinical grade readings in 1-2 seconds Applicable for all patient types Min of 3000 measurements Optional calibration kit available (FWH296/MPC 12953) With Bluetooth	RUDOLF RIESTER GMBH	1	1	[redacted]
Thermometer temporal artery device handheld	Non-Contact Forehead	HENRY SCHEIN UK HOLDINGS LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Handheld Non-Contact Infrared - NON REFUNDABLE	ARBARR ELECTRONICS LTD.	1	1	[redacted]
Thermometer temporal artery device handheld	1R988 Infrared Forehead non-contact battery operated 35 memory function 1sec measure sound alarm high definition display	PRAXIS MEDICAL LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Infrared - measuring body temperature by surface detection	OSCARTECH UK	5	1	[redacted]
Thermometer temporal artery device handheld	Professional Temple	SYRINGA WHOLESALE DISTRIBUTOR	1	1	[redacted]
Thermometer temporal artery device handheld	Non-contact infra red forehead unit	ALMOND NURSING LIMITED	30	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Thermometer temporal artery device handheld	TH03F INFRARED FOREHEAD AND WIDE RANGE THERMOMETER	WILLIAMS MEDICAL SUPPLIES LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Non Contact Infra-red - NON RETURNABLE - NON REFUNDABLE	MICROLIFE HEALTH MANAGEMENT LTD-WATCH BP	32	1	[redacted]
Thermometer temporal artery device handheld	Infrared Forehead	HENRY SCHEIN UK HOLDINGS LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Non-Contact Infrared	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Thermometer temporal artery device handheld	Non-contact for accurate multiple scanning Tri-colour back light green-orange-red fever alert 35 x Memory recall Accuracy 0.2C Reading 1 second Measuring distance 1-4cm Multi-function medical grade for hospitals - clinics - public places	G H ZEAL LIMITED	1	1	[redacted]
Thermometer temporal artery device handheld	Non-contact Clinical accuracy Tri-colour back light green-orange-red fever alert 35 x Memory recall Accuracy 0.2C Reading 1 second Measuring distance 1-4cm Multi-function medical grade for hospitals - clinics - home use children and adults	G H ZEAL LIMITED	1	1	[redacted]
Thermometer temporal artery device handheld	Handheld Non-Contact Infrared With Colour Code Display	ARBARR ELECTRONICS LTD.	1	1	[redacted]
Thermometer temporal artery device handheld	Handheld Non-Contact Infrared Gun Style	ARBARR ELECTRONICS LTD.	1	1	[redacted]
Thermometer temporal artery device handheld	Handheld Non-Contact Infrared Gun Style with Fever Alarm	ARBARR ELECTRONICS LTD.	1	1	[redacted]
Thermometer temporal artery device handheld	Handheld Non-Contact Infrared with BackLight Alarm	ARBARR ELECTRONICS LTD.	1	1	[redacted]
Thermometer tympanic device	Infra red ear thermometer for use with FWH121 Probe Covers	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Thermometer tympanic device	Ear thermometer pro 6000 with small cradle	WELCH ALLYN UK LIMITED	1	1	[redacted]
Thermometer tympanic device	Ear thermometer pro 6000 with large cradle	WELCH ALLYN UK LIMITED	1	1	[redacted]
Thermometer tympanic device	Medical Infrared Ear Thermometer 1 Sec Measurement or Continuous Scanning Mode Fever Alarm PLUG & SECURE Probe Cover Auto Shut Off Low Battery Indicator Self-diagnostics	DENWARD MANUFACTURING LTD	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Thermometer tympanic device	GT520 for temperature taking with probe battery operated LCD display Celsius reading supplied without cradle - Single use covers have to be ordered direct from the supplier as they are unavailable from NHS Supply Chain	WHITE MEDICAL	1	1	[redacted]
Thermometer tympanic device	Requires disposable probe cover application battery operated for use with FWH033 - Genius Device requires periodic calibration some training and can only be returned if it has failed warranty	CARDINAL HEALTH UK 432 LIMITED	1	1	[redacted]
Thermometer tympanic device	Infra-red ear	ALBERT WAESCHLE LTD	1	1	[redacted]
Thermometer tympanic device	Clinical grade with guiding indicator and advanced measuring technology with dispenser box provides an efficient workflow minimising cross contamination guide indicator to ensure proper probe tip placement	DENWARD MANUFACTURING LTD	1	1	[redacted]
Thermometer tympanic device	Clinical grade with guiding indicator and advanced measuring technology with dispenser box provides an efficient workflow minimising cross contamination guide indicator to ensure proper probe tip placement	DENWARD MANUFACTURING LTD	1	1	[redacted]
Thermometer tympanic device	In Ear Temperature Measuring - NON REFUNDABLE - NON RETURNABLE	DRIVE DEVILBISS HEALTHCARE LTD	1	1	[redacted]
Thermometer tympanic device	Inner - Ear	KINETIK MEDICAL DEVICES LTD	1	1	[redacted]
Thermometer tympanic device	Inner Ear	KINETIK MEDICAL DEVICES LTD	1	1	[redacted]
Thermometer tympanic device	Ear and Non-Contact	KINETIK MEDICAL DEVICES LTD	1	1	[redacted]
Thermometer tympanic device	Infrared Ear Temperature Measuring - NON REFUNDABLE - NON RETURNABLE	DRIVE DEVILBISS HEALTHCARE LTD	1	1	[redacted]
Thermometer tympanic device	Infrared Ear supplied with pack of probe covers	BRAUN & CO LTD	1	1	[redacted]
Thermometer tympanic device	Marsden T-120 digital	MARSDEN WEIGHING MACHINE CO LTD	1	1	[redacted]
Thermometer tympanic device	Forehead/Ear Infrared LCD Display Battery Operated With Cover	PRAXIS MEDICAL LTD	1	1	[redacted]
Thermometer tympanic device	Ri-thermo N Professional Battery operated LCD display measuring in Celsius Measuring time 1-2 seconds auto off and memory Supplied in a plastic box with 25 probe covers and smart dispenser	RUDOLF RIESTER GMBH	1	1	[redacted]

Base description	Secondary description	Supplier	Units	Band 1 quantity	Band 1 price (£)
Thermometer tympanic device	Replacement for (FWH308 and FWH322 MPC 1830 and 1831) insert blue (oral - axillary)	RUDOLF RIESTER GMBH	1	1	[redacted]
Thermometer tympanic device	FOREHEAD & EAR INFRARED FC-IR100 LCD DISPLAY BATTERY OPERATED NO COVER	PRAXIS MEDICAL LTD	1	1	[redacted]
Thermometer tympanic device	tymPRO Clinical grade readings in 1-2 seconds Prevents cross infection one hand operation Min 3000 measurements set of batteries Supplied with cradle and twenty probe covers Optional calibration kit available (MPC 12953) With Bluetooth	RUDOLF RIESTER GMBH	1	1	[redacted]
Thermometer tympanic device	Infra-Red Inner Ear Fast Highly Accurate Results Data Displayed within Seconds	RELIANCE MEDICAL LTD	20	1	[redacted]
Thermometer tympanic device	Gentle Temp 521	HENRY SCHEIN UK HOLDINGS LTD	1	1	[redacted]
Thermometer tympanic device	Ri-thermo N Battery operated LCD display measuring in Celsius Measuring time 1-2 seconds auto off and memory Supplied in a plastic box with 25 probe covers	RUDOLF RIESTER GMBH	1	1	[redacted]
Thermometer tympanic device	Infrared Ear	HENRY SCHEIN UK HOLDINGS LTD	1	1	[redacted]
Thermometer tympanic device	Measuring body temperature by surface detection	OSCARTECH UK	5	1	[redacted]
Thermometer tympanic device	For temperature taking with probe battery operated LCD display measuring in Celsius as a minimum reading supplied without cradle for use with FWH226 single use covers	TIMESCO HEALTHCARE LTD	1	1	[redacted]
Thermometer tympanic device	TH809 SERIES INFRARED EAR THERMOMETER	WILLIAMS MEDICAL SUPPLIES LTD	1	1	[redacted]
Thermometer tympanic device	Omron Gentle Temp 521 Thermometer	WILLIAMS MEDICAL SUPPLIES LTD	1	1	[redacted]
Thermometer tympanic device	Tympanic with Non-Contact Mode	ARBARR ELECTRONICS LTD.	1	1	[redacted]

Appendix F – Summary of company submitted evidence for VWs in non-ARI pathways

Clinitouch:

- **Three evaluations of this technology in COPD (UK).** All three were conducted either by NHS staff or in conjunction with NHS staff. Two published evaluations conducted in conjunction with NHS staff.
    - Ghosh S et al. Combined interventions for COPD admissions within an urban setting. Br. J HCM, 2016; 22 (3): 225-233
    - Ghosh S et al. A Cost-effective intervention for patients with severe breathlessness. Br. J HCM, 2018; 24 (11): 1-4

    One unpublished report (Central Lancashire Clinical Commissioning Group).

    All 3 were service evaluations, had no control groups and had different endpoints.

    Patient groups: COPD patients with persistent exacerbations with 2 or more prior admissions in the previous 12 months (mean 3.1 at baseline).

    Results: varied between a 62% and 67% reduction in either COPD specific unscheduled admissions or all cause admissions. Conflicting findings on the effect on CAT scores.

    [redacted]**(Clinitouch)** [redacted]

- [redacted]**One evaluation of platform used by a GP to provide health care to a care home (Australia) (unpublished poster)**
    - Patients: with frailty compared pre-pandemic and during pandemic

    Results: Reduction in GP and nurse visits; increase in medication reviews and GP patient reviews; increase in urgent calls and admissions; improved quality of care; reduced costs.

Feebris

- **Economic impact case study in care home residents (UK)**
    - Healthcare provider acceptability

Lenus

- **COPD support service (UK)**
  - RECEIVER trial: 83 patients with severe COPD compared to 415 control patients (COPD, did not use service)
  - reduction of 0.59 admissions and 4.74 occupied bed days in the year following service onboarding when compared to control. Survival improved compared to controls (12-month mortality = 16.9% vs 24.1%, significance not reported). Levels of patient engagement with daily remote monitoring was very high, over the first week following onboarding the average completion rate of daily PROs across the cohort was 5.57 out of 7 possible entries. The system also received a high system usability scale score (a metric for assessing the usability and learnability of technological systems) of 85/100 from surveyed study participants.

PMD Solutions

- **COPD community virtual ward + continuous respiratory rate (Ireland)**
  - Doherty 2022 proof of concept study evaluating data from 10 patients with moderate to severe COPD demonstrating frequent exacerbations and those enrolled in a pulmonary rehabilitation clinic with advanced levels of COPD.
  - Hospital avoidance in 100% of 18 exacerbations in 10 patients. Average per patient cost reduced from €19,384.00 to €3,376.44, with a 96.7% probability of being both cost saving and cost effective at a €45,000 willingness to pay threshold. Several patient-reported measures also indicated improvement between admission and discharge, including self-management (increase of 29.1%), understanding of COPD (increase of 35.3%), and quality adjusted life years (QALY) (increase by 0.15 of a QALY).

Solcom

- **Care homes (UK) (Solcolm)**
  - Raw data on NHs ED attendance and admissions with and without Whzan
  - Care homes (UK) (MSE partners, 2021) 13 months pre Whzan (Apr 19-Apr 20) and 13 months post Whzan (Jun 20-Jun 21)
  - Non-elective admissions for over 65s saw a 13% reduction during the time period Whzan was implemented due to the impact of COVID vs. admissions from care homes with Whzan saw a 24% reduction over

the same time period. Average length of stay pre-Whzan 6.8 days vs. post Whzan 5.6 days (18% reduction in length of stay).

- Care Homes with Whzan saw 2,790 fewer admissions after Whzan implementation.

- **Care homes (UK) April 2017 to March 2018 (Dave Belshaw, 2019)**
  - 8 care homes of a similar size regularly using the digital tablet intervention against data from 8 care homes who were not using the tablet. 192 fewer non-elective admissions over the year resulting in a saving of £601,920. Fewer ED attendances at every time p oint during the year with a total difference of 336 fewer ED attendances, resulting in a cost saving of £71,232 (ED attendance) and £82,992 (ambulance services). Overall overall approximate cost saving of £756,144 in 1 year for 8 care homes
  - Interrupted time series regression analysis suggested 49.2% reduction in bed days after introduction of the digital tablet.

NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

Health technology evaluation

Assessment report overview

Virtual Ward Platform Technologies for acute respiratory infections

This assessment report overview has been prepared by the Medical Technologies Evaluation Programme team to highlight the significant findings of the external assessment group (EAG) report. It includes **brief** descriptions of the key features of the evidence base and the cost analysis, any additional analysis carried out, and additional information, uncertainties and key issues the committee may wish to discuss. It should be read along with the external assessment report. The overview forms part of the information received by the medical technologies advisory committee when it develops its recommendations on the technology.

Key issues for consideration by the committee are described in section 8, following the brief summaries of the clinical and cost evidence.

This report contains information that has been supplied in confidence and will be redacted before publication. This information is underlined and highlighted in either yellow (for academic in confidence information) or in blue (for commercial in confidence information). Any depersonalised data in the submission document is underlined and highlighted in pink.

This overview also contains:

- Appendix A: Sources of evidence

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1 The technologies

Virtual ward services for acute respiratory infections (ARI) are intended for people who need acute level care and would otherwise be in hospital. This evaluation is considering virtual wards which are technology-enabled. A technology-enabled virtual ward platform comprises of a patient facing app or website, medical devices for measuring vital signs and a digital platform for healthcare providers to monitor patients.

For this assessment, NICE will consider virtual wards platforms that:

- are intended for use by adults in their usual place of residence (where appropriate)
- have been developed to support a step-up or step-down pathway for adults with acute respiratory infections and have the following key features:
    - record all the necessary clinical measurements needed to remotely manage people with acute respiratory infections
    - enable the clinical team to monitor patients at home using software equipment, including an online dashboard of the vital signs
    - the technologies should be device agnostic or integrate with medical devices that have CE or UKCA mark, if required. Data can be entered manually by the user or automatically using connected devices
    - enable case management functionality (the platform ensures the clinical team is alerted when any patient moves outside agreed parameters, allowing them to take appropriate action).
    - are accessible across all staff that need to provide input (such as secondary care and community health)
    - offer direct interoperability with appropriate clinical systems (including data sharing)
- meet the standards within the digital technology assessment criteria (DTAC), including the criteria to have a CE or UKCA mark where

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required. Products may also be considered if they are actively working towards required CE or UKCA mark and meet all other standards within the DTAC.

- are available for use in the NHS.

In total, 20 virtual ward platforms were considered. NICE received information submission from 13 companies listed below:

- Clinitouch (Spirit Health)
- Current Health (Current Health)
- Doccla Virtual Ward solution (Doccla)
- DOC@HOME (Docobo)
- Feebris (Feebris)
- Huma (Huma)
- Inhealthcare Digital Health Platform (Inhealthcare)
- Lenus COPD Support Service (Lenus Health)
- Luscii (Luscii Healthtech)
- RespiraSense Hub (PMD Solutions)
- Virtual Ward Technologies (Virtual Ward Technologies Ltd)
- VitalPatch remote patient monitoring solution (MediBioSense Ltd)
- Whzan Blue Box (Solcom)

NICE acknowledges that the list of virtual wards platforms scoped is not definitive.

NICE will only evaluate a technology if it has or is expected to have regulatory approval (or appropriate regulatory signal, where required) by the planned draft or final guidance publication date. For digital technologies, we expect the technology to also have DTAC.

Virtual ward features

Health Innovation Network on behalf of NHS England (London Region) have created a framework for categorising remote monitoring functionality by 4 key features: clinician facing, patient facing, additional and advanced features and devices supported. The EAG have provided detail of the different features offered by companies in their assessment report, table 2.1. They key aspects are summarised below.

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Clinician facing features

Virtual ward platforms have dashboards with real-time view of clinical parameters of multiple patients. Some technologies have risk stratification and alerts to monitor sustained changes to vitals over time. Some technologies can also monitor adherence.

Patient facing features

Virtual ward platforms can be accessed by patients via apps or a web browser on smart devices. Some technologies offer functionality to send patient reminders and offer video calling and messaging with healthcare professionals. Some technologies also allow patients to be sent and respond to questionnaires, which can be tailored to the condition, as well as provide self-guided educational content.

Additional and advanced features

Some virtual wards have advanced features such as the ability for an app to work offline or more advanced device integration such as the use of patches to monitor vitals signs (including detection of heart arrythmias). Others use artificial intelligence (AI) to review data quality or for risk stratification. Another technology can use ‘mirror image’ technology to allow healthcare professionals to see the patient side of the app. Some companies offer additional services such as the use of in-house healthcare professionals to support implementation and operation of virtual ward platforms.

Devices supported

Some virtual ward platforms are device agnostic, whereas others supply specific devices to monitor vital signs (or can do either based on the need of the trust). Peripheral monitoring devices can either be Bluetooth-enabled or require manual data entry. Some companies offer the use of continuous monitoring devices such as patches, watches and other wearables.

Accessibility and digital inequality considerations

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In addition to the remote monitoring functionality, some technologies have also considered accessibility and digital inequality. Some companies loan smart devices with data and the virtual ward patient app installed to people who do not have access to a smart device or the internet. Some companies also use simplistic patient interfaces for those who may not be used to using digital technologies. The use of Bluetooth enabled monitoring or continuous monitoring devices also reduces the need for a patient to manually record readings as they would be directly transferred to the app. Some companies may loan tablets or monitoring devices with large screens and buttons for people with visual impairments or people who may have problems with manual dexterity. Screen reading software can also be offered for people with visual impairments. Some technologies also offer translation services or the app in multiple languages for people with English as a second language who may have difficulties navigating technology-enabled virtual wards.

1.1 Disease or condition

Respiratory tract infections are infections of parts of the body involved in breathing, such as the sinuses, throat, airways or lungs caused by bacteria or viruses. Symptoms that might indicate an ARI include a cough, sore throat, shortness of breath, or runny nose.

1.2 Patient group

The target population for this assessment is people (aged 16 and over) with a suspected or confirmed ARI (including COVID-19) who are stable or improving but require ongoing monitoring that can be safely provided in their home or usual place of residence. The scope lists the patient criteria for virtual ward care as stated in NHS England's guidance on ARI virtual wards.

The GIRFT programme national specialty report on respiratory medicine states that respiratory problems were among the most common reasons to consult a GP and for acute hospital admissions, even before COVID-19. Admissions for respiratory conditions are growing at around 13% annually, faster than other specialties.

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1.3 Current management

People with suspected ARI either present to NHS111 or primary care for assessment and management, with more severe cases referred for hospital assessment. People can also present directly to A&E or to the ambulance service if their symptoms are more serious. Since the COVID-19 pandemic, the levels of acute respiratory infection (particularly pneumonia caused by COVID-19 infection) have increased. In response to this, the NHS has set up a number of acute respiratory infection (ARI) hubs and acute respiratory infection virtual wards to relieve pressure on other parts of the local healthcare system.

1.4 Proposed management with new technologies

NHS England's ARI virtual ward guidance proposes a pathway which includes clinical assessment to assess suitability for admission to a virtual ward from either a hospital setting as an early discharge or alternative to admission or via direct patient NHS contact. On admission to a virtual ward, plans relating to monitoring, escalation of care and discharge are made. The expected length of an admission is up to 14 days, subject to clinical judgement.

Clinical assessment to assess suitability for admission to a virtual ward should be carried out in person by a clinician. It should include a review of symptoms, function, clinical observations, appropriate diagnostics, clinical severity scoring, overall clinical trajectory and a shared decision-making discussion about any support requirements for the patient or their carers. Suitability of the patient's usual place of residence also needs to be considered, such as access to a fixed or mobile telephone line, running water and electricity. Patient's or their carers would also need the motivation and skills to be able to use a virtual ward platform and the associated medical devices.

An ARI virtual ward should be led by a named consultant practitioner (including a nurse or allied health professional consultant) or suitably trained GP, with access to timely specialist advice and guidance. Virtual ward staff should have access to rapid specialist advice and guidance in and out of hours. Virtual ward staffing is required for a minimum of 12 hours a day (8am–

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8pm), seven days a week, with locally arranged provision for out-of-hours cover, enabling flexibility of service provision as determined by local need.

2 The decision problem

Details of the decision problem are described in the scope. The EAG did not make any changes to the decision problem. They did note that there was no evidence for population subgroups and some outcomes.

3 The evidence

The EAG identified 29 studies (reported in 34 papers) that were relevant to the decision problem, 19 were considered to have best met the scope or were of highest relevance to the UK NHS setting and were prioritised for data extraction including a total of 6,129 people. A full list of studies identified can be found in Table 4.1 of the assessment report, with excluded studies listed in appendix B of the assessment report.

3.1 Summary of evidence of clinical benefit

Study Design

Of the 19 studies that were considered the most relevant and prioritised for data extraction there was:

- 2 randomised controlled trials (RCTs; n=119), 1 comparing virtual wards to standard hospital treatment in Denmark (Jakobsen 2015) and another comparing the Luscii app to usual hospital care in the Netherlands (van Goor et al., 2021)
- 1 prospective cohort study (n=318) comparing a technology enabled virtual ward to a telephone-based virtual ward or historical hospital controls (Kent Surrey Sussex Academic Health Science Network, 2020)
- 3 prospective cohort studies (n=792) extracted as case series due to ineligible comparators (Fox et al., 2022; Tan et al., 2023; Health Innovation Network, 2021)
- 8 prospective (n=3,745) case series (Akhtaruzzaman et al., 2022; Bircher et al., 2022; Inhealthcare, 2022; Kodama et al., 2021; Mid and South Essex ICS, 2022; Moes et al., 2022; van den Berg et al., 2022; Wells et al. 2022)

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- 5 retrospective (n=1,155) case series (Grutters et al., 2020; O'Malley et al., 2022; Swift et al., 2022b; Walter et al., 2023; Ko et al., 2023)

Population and setting

The evidence evaluated virtual ward platforms which facilitated step-up care (1 RCT and 2 case series), step-down care (1 RCT and 7 case series) or both step-up and step-down care (1 cohort study and 7 case series). For studies that reported on mixed step-up and step-down care, most provided evidence in the mixed population. Van den Berg et al. (2022) reported some outcomes for step-up and step-down care subgroups.

In terms of population, 16 studies were on people who had either been admitted to hospital with COVID-19 or those who had COVID-19 being given home monitoring. Two of these studies specifically recruited pregnant people with COVID-19 (Bircher et al., 2022; Moes et al.,2022).

Three studies included other respiratory infections. Jakobsen et al. (2015) randomised people with severe to very severe COPD hospitalised for an acute exacerbation to step-up virtual ward care or standard inpatient care. An evaluation of Whzan Blue Box recruited people with any acute respiratory condition (Mid and South Essex ICS, 2022). An evaluation of Current Health recruited patients from 10 clinical areas, with 75.1% admitted due to COVID-19 or respiratory conditions (Wells et al., 2022).

Intervention

The EAG reported that of the 19 studies evaluated all included virtual ward technologies that allowed patients to input data or capture data automatically and medical staff to monitor patients at home. Of these studies, 14 also reported inclusion of an alert system. In addition to this, 8 technologies identified in the NICE scope were included in 15 of the studies identified:

- Clinitouch (Spirit Health): 1 case series (reported as a case series Swift et al., 2021 on a subset of patients and economic analysis on a larger group of patients [published as a preprint and academic in confidence revision Swift et al., 2022])
- CovidOximetry@Home (InHealthCare): 1 case series (Inhealthcare, 2022)

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- DOCCLA Virtual Ward Solution (Doccla): 1 case series (O'Malley et al., 2022)
- Luscii (Luscii Healthtech):
  - 2 case series done in the Netherlands, 1 in step-down care (Grutters et al., 2020) and 1 in step-up care in pregnant women with COVID-19 (Moes et al., 2022)
  - 1 RCT (done in the Netherlands) comparing step-down care to in-hospital care in COVID-19 patients (van Goor et al., 2021)
  - 1 case series (done in the Netherlands) in both step-up and step-down care (van den Berg et al., 2022).
- Whzan Blue Box (Solcom): 1 case series (Mid and South Essex ICS, 2022).
- Virtual Ward Technologies (Virtual Ward Technologies): 1 case series done in Bangladesh (Akhtaruzzaman et al., 2022).
- Huma (Huma):
  - 1 UK cohort study (Fox et al., 2022) considered as a case series for this evaluation as the comparator was those who chose not to use a virtual ward (did not input data or download app but were offered a virtual ward)
  - 1 comparative UK study on COVID-19 patients in 3 NHS sites using the Medopad platform, an early version of the Huma technology, compared to a telephone-based virtual ward or historical hospital controls (Kent Surrey Sussex Academic Health Science Network, 2020)
- Current Health (Current Health):
  - 1 case series in pregnant people for step-up and step-down care (Bircher et al., 2022)
  - 1 cohort study (considered as a case series for this evaluation due to the control arm being on people with long term conditions) comparing virtual ward to rapid response care in a mixed population (64% COVID-19 patients, but also included long term conditions and emergency episodes) for step up or step down care (Health Innovation Network, 2022)
  - 1 UK study evaluating step-down care in a cohort of patients with a range of indications (68.4% COVID-19 patients and 6.7% were respiratory patients; Wells et al., 2022)
  - 1 case series in the USA using the technology for step-down care (Walter et al., 2023).

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Comparator

The EAG prioritised 3 comparative studies as part of the assessment. Jakobsen et al. (2015) was a RCT on an unnamed telehealth monitoring platform, done in Denmark, which evaluated step-up home monitoring compared to inpatient care. The EAG noted that this study was under recruited and did not achieve the sample size needed in the power calculation. van Goor et al. (2021) was also an RCT comparing the Luscii virtual ward platform for step-down care to usual hospital care in the Netherlands. The third comparative study was a prospective cohort study comparing virtual ward care, using Medopad (an early version of Huma) with telephone-based virtual ward care and historical inpatient data from the early COVID-19 pandemic (Kent Surrey Sussex Academic Health Science Network, 2020).

All other prioritised studies were case studies or evaluated as case studies due to ineligible comparators.

Overall, the EAG noted that limited comparative evidence means that there is limited evidence on the extent to which virtual wards can impact on patient and system outcomes.

Outcomes

The scope of the assessment listed a wide range of outcomes. None of the included studies reported on all outcomes.

Length of hospital or virtual ward stay

- Step-up care: Jakobsen et al. (2015) reported a shorter length of stay in people admitted to a virtual ward for step-up care compared to inpatient stay (percentage of people staying more than 5 days was 17.2% compared to 28.6% respectively, difference not statistically significant). A small case series done in Bangladesh reported a mean stay of 10 (range 8-12) days (Akhtaruzzaman et al., 2022) and with another small case series reporting a median of 6 (IQR 4 to 7) days (Moes et al., 2022). van

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den Berg (2022) reported a median stay of 6.5 days (IQR 1-8) for the step-up subgroup (n = 65).

- Step-down care: 1 RCT reported a significant reduction of 1.6 days mean hospital stay following randomisation (p<0.001; van Goor et al., 2021). However, this study reported a longer total duration of care (virtual ward stay and hospital stay combined or hospital care alone) for those on a virtual ward group (mean 14.1 (SD 7.6) days for the virtual wards group compared to 10.0 (SD 7.0) days in hospital inpatients; p=0.028). Across the case series, mean length of virtual ward stay varied from 3.9 days (IQR 2.4 to 6.7; Wells et al., 2022) to 11.7 days (SD 5.4; Grutters et al., 2021) across 4 studies that reported this outcome. Van den Berg et al., (2022) (n= 213) step-down subgroup reported a median stay of 5 days (IQR 2-8). A mean of 9 days stay reported by the Health Innovation Network study was used to inform the model (Health Innovation Network, 2022). Swift et al. (2022b) reported [redacted]).
- Mixed step-up and step-down care: length of stay ranged from an average of 6 days to 12 days across 5 studies.

Escalation and readmissions

The EAG note that the included studies report escalations and readmissions at varying time points and to different locations, including emergency care and a hospital ward. There is limited comparative evidence to demonstrate whether virtual ward care effects these outcomes when compared to inpatient care or care from home without a technology enabled virtual ward.

Three studies reported on this outcome for step-up care. Due to the small sample size, 1 RCT (Jakobsen et al. 2015) could not confirm whether the incidence of readmission within 30, 90 and 180 days was non-inferior between virtual ward use and inpatient care. For Akhtaruzzaman et al. (2022), 10% of people (3/20) were escalated and hospitalised. A case series on pregnant women reported a hospital readmission rate of 22.2% (6/28) (Moes et al., 2022).

For step-down care, one RCT reported 6.5% (2/31) of people were readmitted to hospital in the virtual ward group compared to 3.2% (1/31) in the inpatient group (van Goor et al., 2021). In the case series, between 2% (InHealthcare,

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2022) and 11.4% (Walters 2023) of people were readmitted to hospital from a virtual ward across 6 studies. A value of 2.9% of people being readmitted within 30 days of virtual ward discharge from Swift et al. (2022) was used to inform the economic model. In terms of escalation to emergency care, Grutters et al. (2021) found 12% (39/320) were escalated to emergency department assessment, and 7% (23/320) hospitalised. These figures differ from the first 33 patients reported in a pilot study (Grutters 2020) which found 18.2% (6/33) were escalated to hospital assessment (none to the emergency department), of which 9.1% (3/33) were admitted. Kodama et al. (2021) reported the highest rate (26%) of people being escalated. These escalations led to 6% being admitted to the emergency department and 1 person being subsequently admitted to a ward.

Studies that included step-up and step-down care, reported escalations were 17.2% (Ko et al., 2023) and 18.3% (Fox et al., 2022). In terms of hospitalisation during virtual ward care, the reported figures were between 6.6% (Bircher et al., 2022) and 22% (Health Innovation Network, 2022), with between 0.4% (Bircher et al., 2022) and 3.6% (van den Berg et al., 2022) admitted to critical care. Within 28 to 30 days of discharge readmissions were between 7% (Health Innovation Network 2022) and 30% (Mid and South Essex ICS, 2022).

Fox et al. (2022) compared app users to non-app users and found no significant difference in the combined rate of readmission or death (18.5% and 26.7%, respectfully). A service evaluation on Medopad, an early version of the Huma platform, found lower rates of hospital admissions in virtual ward users at a central London primary care NHS site. Here 15% (10/67) of Medopad users were admitted compared to 26% (16/61) of people using a telephone-based virtual ward (Kent Surrey Sussex Academic Health Science Network, 2020). In another London NHS site, 16% (8/49) of Medopad users were admitted. In this evaluation 28-day readmission rates at a secondary care site were also reported. Here, 5% (4/75) of patients using Medopad were readmitted, compared to 8.4% (76/900) who used standard care in the baseline period.

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Contacts with other care providers

Evidence for contact with other care providers was limited due to generalisability of evidence in a UK NHS setting. One UK study found GP appointments from one site were an average of 0.23 per person using a virtual ward (Medopad) compared to 0.37 per telephone-based virtual ward user (Kent Surrey Sussex Academic Health Science Network, 2020). Here they also reported fewer numbers of contacts per person in the Medopad group (average 16.3 per patient, n=67) than telephone-based virtual ward group (average 21.5, n=61). Differences were not tested for significance.

One RCT done in Denmark (Jakobsen et al., 2015) found that 25% (4/20) of respondents to the user satisfaction questionnaire had made an acute call outside of planned contacts. Two case series for step-up care, done in the Netherlands, also reported on contact with other care providers. Moe et al. (2022) reported that 25.9% of pregnant women contacted a gynaecologist or supervisor and van den Berg et al., (2022) reported a median of 9 telephone contacts (IQR 7 to 12) with a healthcare professional (n=65 in the step-up subgroup).

One step-down RCT (van Goor 2021) found that 38.7% (12/31) of virtual ward patients made a GP visit, compared with 64.5% (20/31) of hospital patients. Here 80.6% of virtual ward users also contacted a GP by phone compared with 71% of hospital patients. Neither of these were significantly different. In the step-down subgroup of van den Berg et al. (2022) (N=213), there was a median of 9 (IQR 7 to 12) telephone contacts with a healthcare professional.

Release of staff time for other caring responsibilities

Two studies reported evidence on this outcome. Both studies were done in Singapore and unlikely to be generalisable to the NHS (Tan et al., 2023; Ko et al., 2023). Both studies reported staff to patient ratios to be lower on a virtual ward than an inpatient setting. Tan et al. (2023) estimated that staff would be able to care for over 100 patients on a virtual ward compared to 20 to 30 as an inpatient.

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Hospital acquired infection

One UK based study reported data on hospital acquired infections, stating that those across both frailty and acute respiratory virtual wards (1,258 people, 201 of which were on a respiratory virtual ward) were up to 5 times less likely to acquire an infection than acute inpatients (Whzan Blue Box; Mid and South Essex ICS, 2022). However, the EAG noted that the source or further description of the comparison data was not detailed within the report.

Patient adherence

In published evidence, overall adherence was at least 84% in 6 studies (Inhealthcare, 2022; Ko et al., 2023; Kodama et al., 2021; Moes et al., 2022; van den Berg et al., 2022; Walter et al., 2023). Five of these studies required patients to be able to self-monitor or use digital equipment (Ko et al., 2023; Kodama et al., 2021; Moes et al., 2022; van den Berg et al., 2022; Walter et al., 2023; not reported by InHealthcare, 2022), meaning patient selection could have affected adherence. Fox et al. (2022), a UK study focusing on digital exclusion, found that 68.5% used the full digital capabilities of the Huma app, while 31.5% (45 people) did not input data to the app or did not download it. The Kent Surrey Sussex Academic Health Science Network (2020) report found that between 42% and 74% of people from two NHS sites did not download the Medopad app (earlier version of Huma app), with a further 5% (7 people) from one site not using the app after download.

Of the studies reviewed, 9 studies on 4 scoped interventions (Doccla, Clinitouch, Current Health and Luscii) excluded people who did not have access to digital equipment or could not use it correctly (Bircher et al., 2022; Fox et al., 2022; Grutters et al., 2021; Moes et al., 2022; O'Malley et al., 2022; Swift et al., 2021; van den Berg et al., 2022; Walter et al., 2023; Wells 2022). Of these, 2 studies provided access to a suitable smart device (Swift et al., 2021; Wells et al., 2022). Walter et al. (2023) acknowledged that people less adherent to the wearable device (used for continuous monitoring) were more likely to require escalation to physical care.

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Health related quality of life (HRQoL)

One study measuring HRQoL using standardised tools found that scores improved over the first 30 days after discharge. There was no difference in improvement between those randomised to the virtual ward or hospital ward (Jakobsen 2015). However, this study was underpowered and so cannot detect non-inferiority.

One UK study provided qualitative descriptions of functional decline (deconditioning), finding that those on a virtual ward demonstrated comparable (22%) or less decline in function (11%) than expected in an acute setting (Mid and South Essex ICS, 2022).

Healthcare provider usability and acceptability

The service evaluation of Medopad (Kent Surrey Sussex Academic Health Science Network, 2020) surveyed 10 staff members, with 56% finding patient data on the dashboard easy to review and an average acceptability score of 6.9/10. Another study measured the healthcare provider's acceptability of virtual ward care by 8 nurses. It reported high staff confidence in using the virtual ward (6/8, 75%; Jakobsen et al., 2015).

Two UK studies reported staff perceptions of the barriers and facilitators of virtual wards. They acknowledged the key factors success were knowledge of the impacts of virtual wards, coordination with other services and staff training (Bircher et al., 2022; Health Innovation Network, 2021). However, another UK study reported that staff acceptability was lower due to the perception that a virtual ward would create additional workload (Wells et al., 2022). This study also reported adequate training as being another barrier but reported that it was easier to cover staff absence at short notice.

Patient and carer experience and acceptability

Four studies measured patient acceptability in small subgroups of between 24 and 37 people (Bircher et al., 2022; Grutters et al., 2020; Health Innovation

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Network, 2021; Moes et al., 2022). In all studies user satisfaction was high and provided positive feedback.

In the van den Berg et al. (2022) case series, 58 of 65 participants completed a satisfaction survey. Most were satisfied with virtual ward use, 71% were satisfied with the information received, and 94% agreed or largely agreed that they felt safe at home. However, fewer people (62.2%) reported receiving sufficient time with the clinical team. A larger case series surveyed 290 of 852 patients receiving step-down care also summarised responses qualitatively (Wells et al., 2022). Many participants mentioned that being part of the virtual ward increased their confidence leaving hospital. 100% of patients and caregivers said they would recommend the virtual ward to family and friends. However, some people were anxious about being discharged from hospital and some found with technical issues with the remote monitoring equipment frustrating.

A digital exclusion evaluation of Huma (Fox et al., 2022) reported barriers to virtual ward use which included digital literacy skills, such as people not being able to use or having difficulties using the app. In this study a family member completed all app inputs for 11 of 97 app users. Other barriers reported included language barriers, inadequate demonstration or explanation of the pulse oximeter or the app in hospital prior to discharge, and digital exclusion.

No studies provided data to quantify carer burden or experience.

Adverse events

There was no evidence identified which suggested that virtual wards were not safe and reported mortality rates were low.

Discontinuations

Jakobsen et al. (2015) RCT reported 2 discontinuations of virtual ward care (due to hyponatremia and severe dyspnoea with nebuliser failure) compared to 1 discontinuation of inpatient care. van Goor et al. (2021) reported no discontinuations with 1 patient withdrawing due to being randomised to the virtual ward group. Small numbers of discontinuations were reported by 3

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case series as due to telehealth not being appropriate for the patient, hospital admission required within a day of virtual ward admission (Health Innovation Network, 2021), patient experiencing few COVID-19 related complaints (Moes et al., 2022) or at the patient's discretion (Swift et al., 2022).

Mortality

In terms of mortality, 15 studies reported this outcome, occurring either during virtual ward care (Bircher et al., 2022; Health Innovation Network, 2021; Fox et al., 2022; Grutters et al., 2020; InHealthcare, 2022; Jakobsen et al., 2015; Kent Surrey Sussex Academic Health Science Network, 2020; Ko et al., 2023; Moes et al., 2022; Mid and South Essex ICS, 2022; O'Malley et al., 2022; Swift et al., 2022; van den Berg et al., 2022; Walter et al., 2023) or following discharge (Health Innovation Network, 2021; Jakobson et al., 2015; Kent Surrey Sussex Academic Health Science Network, 2020; van Goor et al., 2021).

Mortality during virtual ward care was generally low (up to 3.6%) and no instances were considered related to virtual ward use. However, the EAG do note that there is limited evidence to determine whether there is a difference in mortality on a virtual ward compared to inpatient care or care at home without a technology enabled virtual ward. However, of the comparative evidence reported, the mortality rates for virtual wards were comparable to or lower than the control groups or to crude estimates of expected baseline mortality rates.

The Jakobsen et al. (2015) RCT reported no deaths within 30 days of virtual ward discharge in either arm. Three step-up case series reported mortality rates of 0% (Akhtaruzzaman et al., 2022; Moes et al., 2022) and 3.1% (2/65; 1 was ARI related; van den Berg et al., 2022). The Medopad study in step-up care reported no mortality in 2 sites using a virtual ward and a mortality rate of 0% and 13% (8/61) for telephone virtual ward group at the same sites (Kent Surrey Sussex Academic Health Science Network, 2020). At one of the sites the crude incidence of mortality was reported as being 2% during a baseline period. Three step-down case series reported a mortality rate of between 0%

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(Grutters et al., 2021) and 3.8% (Walter et al., 2023). Six studies of mixed care reported mortality rates of between 0% (Bircher et al., 2022) and 3.6% (van den Berg et al., 2022).

In addition to the evidence summarised here, the EAG additionally extracted data from 4 studies that were deprioritised (due to a concern that patients with milder ARI were recruited) to identify further evidence on patient safety (Ferrua et al., 2021; Marquez-Algaba et al., 2022; Steimer et al., 2021; Yordanov et al., 2020). Results from these studies can be found in section 6 of the EAG's assessment report.

Evidence generalisability

Of the prioritised studies, the EAG had a number of generalisability concerns. These included:

- Reporting of virtual ward admission criteria was unclear
- 16 studies were limited to COVID-19 patients only, only one study (Mid and South Essex ICS 2022) was on people admitted to a respiratory virtual ward. There was also limited reporting of co-morbidities
- 4 of the prioritised studies were done outside of the UK on unnamed interventions or interventions developed locally in the study country.

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Table 1: Summary of RCTs and the UK studies on scoped technologies

Study and design	Participants/ population	Intervention & comparator	Outcome measures and follow up	Key results
Jakobsen et al., 2015 RCT	646 people with severe to very severe COPD, who had an acute exacerbation (step-up care) **Telehealth (virtual ward) (n=29):** age range more than 60 to less than 80 years, 18 (62.1%) female, 28 (96.6%) long-term oxygen user. **Hospital (n=28):** age range more than 60 to less than 80 years, 17 (60.7%) female, 26 (92.9%) long-term oxygen user. Denmark	Unnamed virtual ward platform compared to inpatient hospital care	Duration of stay Contacts with other care providers Health-related quality of life User satisfaction (health professional and patient) Mortality Adverse events	**Duration of stay:** Patients with duration of stay greater than 5 days: Virtual ward: 5 (17.2%) Hospital: 8 (28.6%) **Contacts with other care providers:** 4 of 20 respondents to user satisfaction questionnaire in virtual ward group made an acute call outside of the planned contacts **Health-related quality of life:** Scores of CCQ, SGRQ and EQ-5D improved in both groups over time within the first 30 days after discharge (no significant difference) **User satisfaction (health professional and patient):** 20 patients in telehealth group completed a user satisfaction questionnaire immediately after discharge.100% had positive responses to usability and information given **Mortality:** No patients died within 30 days after discharge in either group

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				Adverse events: 3 discontinued virtual ward use (1 hyponatremia, 1 severe dyspnoea and nebulizer failure, 1 internet failure at patient home and so never received intervention)
van Goor et al., 2021 RCT	62 hospitalised COVID-19 patients randomised 1:1 to virtual ward group or control (hospital care as usual) group. Step-down care **Intervention (n=31)**: Mean age: 55.1: (SD: 13.2) 14 (45.1%) female **Control (n=31):** Mean age: 55.4 (SD, 13.2), 13 (41.9%) female The Netherlands	Luscii app compared to inpatient hospital care	Hospital readmissions Contacts with other care providers Mortality	**Hospital readmissions:** Virtual ward: 2 (6.5%) Hospital: 1 (3.2%) **Contacts with other care providers:** Virtual ward: 2 (5.6%) unplanned hospital visits and 3 (9.7%) emergency department visits Hospital: 2 (6.5%) unplanned hospital visits and 1 (3.2%) emergency department visits GP visits: Virtual ward: 12 (38.7%), 8 for COVID-19. Hospital: 20 (64.5%) GP visits, 19 for COVID-19 p=0.035 Telephone contact with GP by patient Virtual ward: 25 (80.6%) Hospital: 22 (71.0%) p=0.371

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				Mortality (with 30 days discharge): Virtual ward: 0/31 Hospital: 1/31
O'Malley et al., 2022 Retrospective Case series	50 COVID-19 patients of mixed severity discharged from hospital *Average age 58.7 (range 27-89) years, 67.5% male. 31 (72%) were discharged with an ongoing oxygen requirement. UK	DOCCLA technology, no comparator	Waiting time for virtual ward admission Duration of stay Hospital readmission	**Waiting time for virtual ward admission:** Average time from COVID-19 positive PCR test and virtual ward admission 8.1 days **Mean length of virtual ward stay:** 10.3 days (SD 9.7, 95% CI 7.4-13.2) ***Hospital readmission:** Hospital admission due to after deterioration was identified (hypoxia): 4 (9.3%). All occurred within 5 days of discharge. 3 were referred back to virtual ward with supplemental oxygen on second discharge.
Swift et al., 2021 Retrospective Case series Subgroup of economic study. Economic study reported as a pre-print and as an academic in confidence paper revision (Swift et al., 2022)	65 people with COVID-19 discharged from hospital Mean age 56 (range 21.5-87.4) years, 39% female. Economic study on 310 people discharged into the virtual ward to either aid with oxygen weaning in their own home or discharged early to recover at home	CliniTouch Vie, no comparator	Mortality Adverse events Duration of stay Escalation: hospital readmission	**Mortality:** 1/65 (considered unrelated to COVID-19) **Adverse events:** Clotting event: 4/65 people readmitted due to this (an adverse outcome of COVID-19) Withdrawals/discontinuations: 1 patient withdrew at their own discretion not due to the virtual ward technology **Duration of stay:** [redacted]

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	with support. Mean age was [redacted], 40.6% female. UK			[redacted] **Hospital readmission:** 9 (2.9%) within 30 days
Wells et al., 2022 Prospective case series	852 people admitted to the virtual ward who would otherwise have been hospitalised (step-down care). People admitted from 9 different specialties, of which 583 (68.4%) were COVID-19 patients and an additional 57 (6.7%) were respiratory patients. Median age 44 years (IQR 31-39). UK	Current Health, no comparator	Patient satisfaction Barriers to implementation	**Patient satisfaction and barriers to implementation:** 100% of patients and caregivers said they would recommend the virtual ward to family and friends. Majority patient feedback positive but some technical issues with the monitoring equipment reported.
Bircher et al., 2022 Prospective case series	228 pregnant women with confirmed COVID-19 from 3 settings: discharged from	Current Health, no comparator	Length of stay Escalation: hospitalisation or critical care	**Length of virtual ward stay:** 6 days (SD 2.3, range 1-14) **Escalation: hospitalisation or critical care:**

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	hospital, direct contact from patient in community, positive swab from patient in community. Mean age of 30.6 (SD 5.6, range 16 to 44) years, and all stages of gestation. UK		Mortality Patient satisfaction	15 (6.6%) escalated to hospital care **Mortality:** 0/228 **Patient satisfaction:** Patient satisfaction survey completed by 24 patients: All areas scored 4 or 5 out of 5: patient information, ease of use, confidence, recommended and overall service.
Health Innovation Network, 2021 Retrospective cohort study (control group not eligible so extracted as a case series)	**Virtual ward:** 250 patient episodes treated in the virtual ward for COVID-19 (161, 64%), long term conditions (65, 26%, not ARI) or emergency episode (24, 10%, including 19 for 'infection' not further specified). **Control:** Considered ineligible by EAG due to being on people with long term conditions.	Current Health, no comparator	Duration of stay on virtual ward Post-discharge hospital readmission Escalation: hospitalisation, critical care admission Patient adherence Patient satisfaction Mortality Adverse events	**Duration of stay on virtual ward:** Mean 9 days (range less than 1 to 49) **Post-discharge hospital readmission:** **7 days post- discharge:** 5/170 (3%).COVID subgroup 3/106 (3%) **8-28 days after (cumulative):** 15/170 (9%). COVID subgroup 7/106 (7%) **Escalation, hospitalisation, critical care admission:** Hospitalisation while on virtual ward: 51/250 (20%) 43/51 discharged home, 8 died in hospital COVID-19 subgroup: 36 (22%). Critical care admission: virtual ward, 5 (10%); Control, 0/6 (0%). COVID-19 subgroup: 4 (11%).

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	Step-up and step down care Age ranged from 20 to over 80 years old UK			**Patient adherence:** 96% of patients used the Current Health kit and 4% declined it or requested its removal Mean wearable adherence 68% Virtual ward monitoring: 56% generated readings for over 75% of the time, 17% for 50-75%, and 28% for 50% or less. **Patient satisfaction:** Patient feedback (n=37) was largely positive with more than 87% of patients in positive agreement with each statement in the survey. In particular, 89% found the kit easy to learn to use and 89% thought it simple and easy to understand. **Mortality** COVID-subgroup 7 days after discharge: 2 (2%) 28 days after discharge (cumulative): 4 (3%) **Adverse events:** 14 people (6%) stayed on the ward for less than a day after establishing that telehealth was not appropriate for them. 10 of these people required admission to an in-patient bed (4 patients, 2%)
Fox et al., 2022 Prospective cohort study (extracted as a case series)	142 people managed on a COVID-19 virtual ward (step-up and step-down care).	Huma, no eligible comparator. Comparator used in study were people offered the use of a virtual	Readmission rates Adverse outcomes Mortality	**Readmission rates** 26/142 (18.3%) using virtual ward escalated to hospital care

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	97 (67.8%) input data into the app and were considered “app users”. Data available for 65 app users (2 declined to take part and 29 unreachable). Mean age 50.1 years (range not reported) UK	ward but did not use the app.	Patient satisfaction Barriers to use	**Adverse outcomes** Defined as re-hospitalised or died: App users: 18/97 (18.5%) Non-app users: 12/45 (26.7%) No significant difference p=0.27 **Mortality** App users: 1/97 Non-app users: 3/45 **Patient satisfaction** 89% of app users found the app easy to use with 92% reporting the virtual ward set-up made them or their family feel reassured. **Barriers to use** 11 (7.7%) patients required a family member to input and record the data on their behalf. Non-app users most commonly commented on the following barriers: • 48% of non-app users reported an app in another language would have helped. • 26% of non-app users reported difficulties with the app use. • 48% of non-app users reported training would have helped them use the app appropriately.

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				• 4% of non-app user patients did not have a phone, 9% did not have internet service, and 35% did not have smartphone technology. 4% of the non-app user cohort reported disability affected their ability to use the app.
Inhealthcare, 2022 Prospective case-series	2088 referrals to CO@Home. 27 referrals to the COVID virtual ward from the CO@Home service. High-risk and clinically vulnerable patients, including those at risk of health inequalities through disability or deprivation, were prioritised for referral to CO@Home. Patient characteristics not reported Mixed step-up and step-down care UK	CO@Home service (Inhealthcare) used as part of the COVID virtual ward, no comparator	Duration of stay Escalation: hospitalisation (CO@Home only) Patient experience	**Duration of stay** Average stay in CO@Home: 9 days (up to 42 days) Average stay in Covid virtual ward: 9 days **Escalation: hospitalisation (CO@Home only)** 2% admitted to hospital **Patient experience:** Out of 308 respondents, 99% of responses reported the service as either a good or very good experience
Mid and South Essex ICS, 2022 Prospective case series using mixed	201 patients admitted to respiratory virtual ward (April to June 2022).	Whzan Blue Box implemented by the NHS, no comparator	Bed days saved Duration of stay (respiratory virtual ward)	**Bed days saved** Over a 4-month period, 1612 days saved (calculated as number of patients discharged from the virtual ward multiplied by the average length of stay for that ward)

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methods (quantitative, survey and meetings)	114 (56.7%) aged 75 or older. 107 (53%) female. Step-up (n=75) and step-down care (n=100) reported. UK		Hospital acquired infection (all patients) Readmission at 30 days Decline in function	**Duration of stay (respiratory virtual ward):** Average 12 days **Hospital acquired infection (all patients):** Across both frailty and respiratory virtual wards, patients up to five times less likely to acquire an infection than acute inpatients. **Readmission at 30 days** Virtual ward 30-day readmission rate: 30% (unclear if readmitted to virtual ward or hospital) **Mortality** Respiratory virtual ward subgroup: 2/201
Kent Surrey Sussex Academic Health Science Network, 2020 Prospective cohort study	Study reported on 3 sites of implementation. 2 primary care sites: 116 to Medopad virtual ward and 202 to telephone-based virtual ward Secondary care site: 75 to Medopad virtual ward and 387 to telephone-based virtual ward	Medopad, an early version of the Huma technology compared to a telephone-based virtual ward or historical hospital controls	Mortality Emergency attendance or unplanned hospital readmissions User satisfaction (patient and clinicians)	**Mortality:** Secondary care site: Medopad: 0/75 Telephone-based virtual ward: 0/387 Crude mortality March to May 2020: 2% (18/900) Central London primary care site: VW: 0/67 Telephone-based virtual ward: 8/61 (13%) **Emergency attendance or unplanned hospital readmissions:**

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	UK			Central London primary care site: Medopad virtual ward: 10/67 (15%) Telephone-based virtual ward: 16/61 (26%) North west London primary care site: Medopad virtual ward: 8/49 (16%) Telephone-based virtual ward: not reported 28-day admissions Hertfordshire NHS secondary care site: Medopad VW: 4/75 (5%) Early pandemic in-hospital comparator: 76/900 (8.4%). **Contacts with other care providers (average number of GP appointments per patient):** Central London primary care site: Medopad virtual ward: 16.3 per patient (n=67) Telephone-based virtual ward: 21.5 per patient (n=61). **Patient user satisfaction:** 95% of patients found the app easy to use 90% found the virtual ward experience good or very good 76% would be happy to use the virtual ward again (Number of patients answering survey not reported) **Staff user satisfaction:** Survey of 10 staff members:

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				56% found patient data on the dashboard easy to review. Average acceptability score: 6.9/10
Abbreviations: ARI - acute respiratory infection; CI – confidence interval; COPD - chronic obstructive pulmonary disease; EAG - external assessment group; IQR - inter-quartile range; PCR- polymerase chain reaction; RCT- randomised controlled trial; SD - standard deviation.				

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3.2 Summary of economic evidence

The EAG searches identified four studies to form the basis of the economic evidence. It identified two self-published rapid evaluations in a mixed setting of step-up and step-down care, as well as a published study and a pre-print on step-down care alone. Three of the four studies were conducted in UK virtual wards, and one was conducted in a virtual care centre for US military treatment facilities. The EAG use two of these studies to populate their economic model (Health Innovation Network, 2021; Swift et al., 2022). These are summarised below. For full details on the published economic evidence, see section 8.1 of the assessment report.

Health Innovation Network (2021) investigated the impact of virtual wards (Current Health) compared to at home care in a mixed setting of step-up and step-down care. The service was delivered by Croydon Health Services' Rapid Response team who were previously delivering home care. Data was captured for 250 patients that were admitted to the ward. They found that, on average, virtual ward patients required 1.27 daily telephone contacts 0.32 daily home visits. Although the EAG did not consider the comparator eligible for this evaluation, the study reported a cost saving £742.44 per person compared to the rapid responses control group. This study is limited by not being peer reviewed and the control group were not in scope as they had long term conditions rather than an ARI.

Swift et al. (2022) was a cost minimisation analysis of step-down care in a COVID-19 respiratory virtual ward (Clinitouch, Spirit Health) in Leicester, published as a pre-print and academic in confidence revision. The evaluation assumes that the virtual ward care would not result in different health outcomes. Data for 310 people discharged from the hospital (including both

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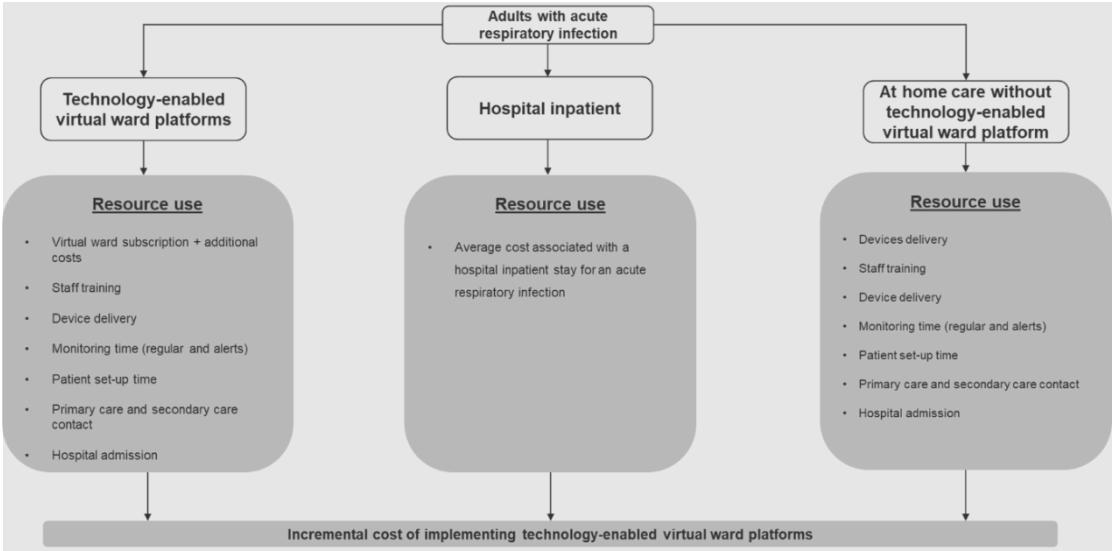
those requiring oxygen and those who did not) estimated mean gross savings to the health care system for of £1,426 ([redacted]) per person.

EAG conceptual modelling

The EAG used a simple cost-comparison model to determine whether virtual ward platform technologies could plausibly be a cost saving intervention for the population of adults with moderate ARI. The simple cost comparison model is platform-agnostic, takes the perspective of the NHS and personal social services, and captures resource use and cost differences between virtual wards and hospital inpatient care or at home care without the use of a technology-enabled virtual ward (at home care) over a 30-day time horizon.

Figure 1 shows the structure of the model. The three arms of the model capture resource use and costs for the virtual ward platform intervention and the inpatient care and at home care comparators.

Figure 1: EAG simple cost-comparison model structure



Due to limited data availability, the EAG have relied on various assumptions to populate the early model. These assumptions include:

- equal efficacy in treatment and no disparity in adverse events between virtual ward platform-delivered care, inpatient care and home care

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- monitoring devices, except for continuous monitoring devices, used across care settings (and virtual ward platforms) are the same, so their use and costs are not captured

- the implementation and training costs of respective platforms can be scaled down to a per person cost based on average virtual ward size. An average ward capacity of 90 has been assumed in the base case.

- inpatient care of ARIs is assumed to be fully captured by a weighted average of NHS cost collection codes and this value has been applied to readmissions to hospital

- the frequency and level of monitoring and checks have been assumed to be the same for people using a virtual ward and at home care due to the likely heterogeneity seen in practice

- the model assumes that the cost per patient increases constantly with the size as a simplifying assumption

- the model does not fully capture the potential quicker de-escalation that may occur from use of virtual wards.

Model parameters

One mixed setting study (Health Innovation Network, 2021) and one step-down study (Swift et al., 2022b) informed some of the model parameters. In addition, company submissions and clinical expert correspondence informed the structure and value of model parameters. Where multiple companies submitted data for the same parameter, averages were taken for the base case and the range of values were adopted as uncertainty intervals for sensitivity analyses.

A population modifier accounts for any potential additional people who would receive virtual ward care that would not have ordinarily required inpatient or at home care. It is set to 1 in the base case and is only applicable when comparing with inpatient care.

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Clinical parameters

The clinical efficacy for treating symptoms of ARI and the incidence of adverse events for all three care settings are assumed to be equivalent, so these are not captured in the model.

Costs and resource use

The resource use assumptions for each of the care settings are described in Table 2 and the unit costs in Table 3. The resource use parameter values were predominantly sourced from company submission documents. The hospital readmission rate of 2.9% (Swift et al., 2022) was assumed to be the same across the three care settings due to the lack of comparative evidence. Two studies (Health Innovation Network, 2021; Swift et al., 2022) included control groups which were treated in the community. Data from these groups were used to inform the inputs for the home care setting arm of the model and, where the control groups lacked data, the remaining inputs were assumed to be the same as in the virtual ward arms. Most of the cost parameter values were sourced from company submission documents, the National Cost Collection for the NHS 2021/2022 (NHS, 2023) and the Personal Social Services Research Unit (PSSRU) Unit Costs of Health and Social Care 2021/2022 (Jones, 2023).

The EAG found that, in the base case, the most costly parameters of the virtual ward were the cost of hospital admissions, home monitoring and home visits. The cost of the virtual ward platform technologies was the fourth most costly parameter, which included all virtual ward items in Table 3 on a per patient basis, excluding any NHS staff training costs.

The EAG notes that some of the assumed resource use inputs are likely to vary based on the different features of the virtual wards.

Table 2: Resource use

Care setting	Resource item	Parameter value	Source
Virtual wards	Average capacity of a virtual ward	90 patients	Company provided (unpublished data)
	Proportion of time that virtual ward devices are in maintenance	31.0%	Clinical correspondence with virtual ward

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			provider via email. May 2023
	Average length of stay on a virtual ward	8.89 days	(Health Innovation Network, 2021)
	Nurse training time per virtual ward	120 minutes	Company provided (unpublished data)
	Respiratory consultant training time per virtual ward	120 minutes	Company provided (unpublished data)
	Nurse time taken to train and set up a patient	22.5 minutes	Company provided (unpublished data)
	Proportion of patients on oxygen	10.0%	(Swift et al., 2022)
	Online dashboard checks by nurse per day	Patients on oxygen: 3.00 Patients not on oxygen: 1.00	Clinical correspondence with virtual ward provider
	Time taken to check by nurse	2 minutes	Assumption
	Online dashboard check by respiratory consultant	Patients on oxygen: 1.00 Patients not on oxygen: 0.50	Assumption
	Time taken to check by respiratory consultant	1 minute	Assumption
	Number of alert-related notifications per stay	Patients on oxygen: 10.03 Patients not on oxygen: 3.37	(Swift et al., 2022)
	Nurse time spent dealing with alerts	27.50 minutes	(Swift et al., 2022)
	Proportion of alerts requiring respiratory consultant input	50.0%	Assumption
	Time taken to check by respiratory consultant	10.00 minutes	Assumption
	Reduction in NHS staff monitoring	Regular monitoring: 50.0% Alarm monitoring: 10.0%	Assumption
	Home visits	1.62	(Health Innovation Network, 2021)
	Outpatient appointments	0.08	
	Emergency attendances	0.24	
	Hospital admissions	0.18	
	111 contacts	0.49	Assumption
Hospital inpatient	Proportion readmitted to hospital	2.9%	(Swift et al., 2022)
At home care	Length of stay	11.09 days	(Swift et al., 2022)
	Number of calls by nurse per day	0.35	(Health Innovation Network, 2021)
	Time taken to call by nurse	27.50 minutes	(Swift et al., 2022)

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	Number of calls by respiratory consultant per day	0.12	(Health Innovation Network, 2021)
	Time taken to call by respiratory consultant	27.50 minutes	(Swift et al., 2022)
	Manual vital checks by nurse per day	Patients on oxygen: 3.00	Clinical correspondence with virtual ward provider via email. May 2023
		Patients not on oxygen: 1.00	
	Time taken to check by nurse	5 minutes	Assumption
	Manual vital checks by respiratory consultant per day	Patients on oxygen: 1.00	Assumption
		Patients not on oxygen: 0.50	
	Time taken to check by respiratory consultant	1 minute	Assumption
	Home visits	2.55	(Health Innovation Network, 2021)
	Outpatient appointments	0.21	
	Emergency attendances	0.24	
	Hospital admissions	0.18	
	111 contacts	0.48	Assumption

Table 3: Unit costs

Care setting	Cost item	Parameter value	Source
Virtual ward	Annual subscription/license cost per person	[redacted]	Company provided – unpublished data
	Tablet/continuous monitoring device	[redacted]	Company provided – unpublished data
	Regular monitoring cost (if supported out by virtual ward company)	[redacted]	Company provided – unpublished data
	Alarm monitoring cost (if supported out by virtual ward company)	[redacted]	Company provided – unpublished data
	Patient set up cost (if supported by virtual ward company)	[redacted]	Company provided – unpublished data
	Device/equipment delivery cost	[redacted]	Company provided – unpublished data
	Device cleaning and maintenance	[redacted]	Company provided – unpublished data
	Virtual ward platform training and implementation cost	[redacted]	Company provided – unpublished data
NHS	Band 8a nurse cost per working hour	£72.00	PSSRU Unit Costs of Health and Social Care. (Jones, 2023)

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	Respiratory consultant cost per working hour	£143.00	PSSRU Unit Costs of Health and Social Care. (Jones, 2023)
	Device collection and delivery	[redacted]	Company provided – unpublished data
	Device cleaning and maintenance	[redacted]	Company provided – unpublished data
	Home visit	£110.07	National Cost Collection for the NHS 2021/2022. (NHS, 2023)
	Outpatient appointment	£185.07	National Cost Collection for the NHS 2021/2022. (NHS, 2023)
	Emergency attendance	£157.62	National Cost Collection for the NHS 2021/2022. (NHS, 2023)
	111 contact	£11.40	(Turner et al., 2021)
	Hospital admission for acute respiratory infection	£1,733.77	National Cost Collection for the NHS 2021/2022. (NHS, 2023)
	Hospital excess bed day cost for acute respiratory infection	£315.80	National Cost Collection for the NHS 2021/2022. (NHS, 2023)

Results

When comparing virtual ward care to hospital inpatient care, virtual wards were found to be potentially cost saving in the base case with estimated cost savings of £872 per patient. Similarly, the analysis of virtual wards compared to at home care estimated cost savings of £115 per patient in the base case. The EAG note that due to the heterogeneity in clinical practice and the difference in the features and costs of virtual ward platforms, the base case is an indicative average.

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Table 4: EAG deterministic base case results

	Virtual wards	Comparator	Difference
Total costs per patient (hospital inpatient care)	£912	£1,784	-£872
Total costs per patient (at home care)	£912	£1,027	-£115

The details of the cost-comparison analyses are provided below.

Virtual wards compared to hospital inpatient care

The deterministic base case model results suggest that virtual wards are potentially cost saving compared to hospital inpatient care. The EAG states that despite the various costs potentially associated with setting up and delivering a virtual ward, it is unlikely to cost more than hospital inpatient care. Table 5 provides a breakdown of the costs associated with aspects of each of the care settings per patient.

Table 5: Cost breakdown for hospital inpatient comparator

	Virtual wards	Hospital inpatient	Incremental
Virtual ward platform costs (includes license, continuous monitoring, patient and set up and implementation costs)	£91	£0	£91
Home delivery and maintenance (provided by NHS)	£18	£0	£18
Home monitoring costs	£233	£0	£233
Home visits	£178	£0	£178
Outpatient appointments	£16	£0	£16
Hospital admission or readmission	£305	£1,784	-£1,479
111 contact	£6	£0	£6
Home set up costs	£27	£0	£27
Total	**£912**	**£1,784**	**-£872**

Virtual wards compared to at home care

The deterministic base case model results suggest that virtual wards are potentially cost saving compared to at home care. The potential incremental cost saving per patient is estimated to be £115. This is markedly smaller than the potential saving of virtual wards when compared to hospital inpatient care.

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Table 6 provides a breakdown of the costs associated with aspects of each of the care settings per patient.

Table 6: Cost breakdown for at home care comparator

	Virtual wards	At home care	Incremental
Virtual ward platform	£91	£0	£91
Home delivery and maintenance (provided by NHS)	£14	£19	£0
Home monitoring	£233	£303	-£70
Home visits	£178	£280	-£102
Outpatient appointments	£16	£39	-£24
Emergency attendance	£38	£38	£0
Hospital admission or readmission	£305	£315	-£10
111 contact	£6	£6	£0
Home set up	£27	£27	£0
Total	**£912**	**£1,027**	**-£115**

Additional analyses

Virtual wards compared to hospital inpatient care

In addition to the deterministic base case, different scenarios were modelled by changing the values of certain parameters when comparing virtual wards to inpatient care. Across all scenarios, virtual wards remained a cost saving intervention when compared to hospital inpatient care. The scenarios included:

- modelling a more comprehensive approach with all potential virtual ward costs (such as device maintenance) and no impact on NHS staff monitoring. Potential cost saving was £794 per person.
- virtual wards leading to a larger population (50% more patients) being treated with milder cases of ARI than would typically be admitted to hospitals. Potential cost saving was £415 per patient.
- considering subscription costs only. Potential cost saving £923 per person.
- exploring heterogeneity of virtual wards' implementation resource use. Here implementation costs were changed from £15,000 in the base case to £500,000. Potential cost savings were £740 per patient.

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The EAG also considered the scenario analysis in equivalent cost of bed days for cost neutrality. In the base case, the average stay on a virtual ward of 8.89 days is equivalent in costs to 2.89 hospital bed days. For the above scenario analyses, the equivalent cost savings in bed days range from 2.73 for the only subscription costs scenario to 4.33 with the 50% larger population with milder ARIs.

One-way sensitivity analysis was conducted on all model parameters. The key drivers of the incremental costs across care settings were the expected costs and resource use of people in hospital with a moderate ARI, the length of stay in virtual wards, the readmission rates of virtual wards and the platform costs for the virtual ward.

Deterministic sensitivity analysis was used to calculate the economically justifiable price (the highest price of providing a virtual ward platform per person whilst still leading to cost savings). This was estimated at £950 per person when compared to inpatient care. The EAG noted that this estimate must be interpreted with caution, citing that uncertainty in the evidence and factors such as population creep, higher readmissions and use of virtual wards solely in step-down care could more likely bring the economically justifiable price closer to £275 or lower.

The EAG also ran probabilistic sensitivity analysis with 1,000 iterations and estimated an average incremental cost of -£851 per person.

Virtual wards compared to at home care

The EAG also conducted scenario analysis comparing virtual wards with at home care. Here, only one scenario, the increased implementation costs, led to virtual wards to be cost incurring compared to at home care. All other scenario analyses estimated virtual wards to be cost saving. The scenarios included:

- more comprehensive approach to include all potential virtual ward costs with no impact on NHS staff monitoring. Potential cost savings of £37 per person.

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- reduced NHS staff monitoring due to virtual ward provider support. Potential cost savings of £75 per person.
- virtual ward implementation costs were changed to £500,000. Virtual wards potentially cost incurring, additional costs of £17 per person.
- considering subscription costs only. Potential cost savings of £166 per person.
- virtual wards being compared to an equal split of hospital inpatient care and at home care. Potential cost savings of £493 per person.

One-way sensitivity analysis was conducted on all model parameters. The key drivers of the incremental costs across care settings are the length of stay, the number of admissions to hospitals, the number of home visits and the number of alert notifications.

The deterministic sensitivity analysis to calculate the economically justifiable price estimated that the highest price a virtual ward could be is £200 per person when compared to at home care. Again, this is subject to much uncertainty and could likely be lower given clinical and practical considerations.

The EAG also ran probabilistic sensitivity analysis with 1,000 iterations for the home care comparison which found the probabilistic incremental cost per person to be -£88.

Key uncertainties in the economic modelling

The EAG notes that due to naïve and limited data throughout, the modelling and, consequently, the results should be considered indicative of likely outcomes, but not wholly certain. It acknowledges that a number of simplifying assumptions had been made to provide a useful tool for early evaluation.

In terms of uncertainly, the only adverse outcome captured was readmissions due to a lack of robust safety data. The model results also do not fully capture differences in step-down care from inpatient care to a virtual ward to step-up care. When compared to home care, the results from the comparison of virtual

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wards and at home care were subject to greater uncertainty than when compared with hospital inpatient care due to assumptions that resource use was similar to virtual ward care.

The EAG acknowledged that as the evidence base grows, and more mature data becomes available, further analyses will be able to add to the findings of the cost-comparison analysis.

4 Heterogeneity of virtual wards

This evaluation on virtual wards platforms have assumed equivalence within the clinical and economic evidence, due to a lack of robust data and a large number of technologies. However, through the evaluation the heterogeneity of virtual ward platforms has been highlighted. Due to the limited evidence available, it is unclear what features drive clinical and cost effectiveness in the different platforms available. The EAG identified 3 key determinants which are likely to impact the effectiveness for different types of technology-enabled virtual wards:

- **interoperability and ease of use:** if a virtual ward is more interoperable and easier for healthcare professionals to use it may improve the efficiency of monitoring and associated staff time.
- **effectiveness of continuous monitoring:** continuous monitoring costs more than spot monitoring. It could identify a change in patient symptoms earlier to allow a more efficient response. Conversely, experts have reported that it could lead to an increase in false positives and additional alerts.
- **additional features:** some technologies have additional features such as predictive AI models of monitoring, or company provided support teams to assist current monitoring. These additional features are likely to cost more, but may lead to improved patient outcomes, efficient monitoring, reduced community care support or other resource use savings.

Transferability of evidence to different virtual ward settings

This evaluation focused on acute respiratory infections as the population for virtual ward use. The EAG notes that no included evidence directly addressed transferability of virtual wards from other settings to an ARI setting, or vice versa. Company submissions did provide evidence that their technologies can

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be used in other settings, including those related to other respiratory conditions as well as care home use. Although the EAG accepts that there are some key outcomes which indicate that virtual wards are safe, the extent to which outcomes are directly transferable to other settings is limited due to the different populations who would use a virtual ward. Some aspects of the evaluation such as the time horizon used in the economic model, clinical outcomes and follow-up would likely be different in other virtual ward populations including those with respiratory conditions that are not acute infections.

5 Ongoing research

The EAG identified 4 ongoing studies, listed in Table 9.1 of the assessment report. Only one of these studies is being done in the UK and is a single arm feasibility study which was due to complete in March 2021 but the trials record has not been updated since January 2021.

Company submissions listed 9 ongoing studies evaluating products by 5 companies (Current Health, Feebris, Docobo, Lenus, PMD Solutions; detailed in Table 9.2 of the assessment report). The EAG found that 4 studies had PICO elements which partly met the scope and 5 were not considered relevant due to at least one PICO element not meeting the scope criteria or having insufficient detail to judge relevance.

6 Evidence gap analysis

The EAG determined that the key evidence gap was the lack of comparative evidence in a UK NHS setting for any of the scoped outcomes.

A full table of the evidence gap analysis for the clinical and economic outcomes can be found in the assessment report (tables 10.1 and 10.2). The EAG concluded that almost all outcomes were classified as ‘red’ due to no data being reporting on the outcome, a lack of comparative evidence, the data being reported in only a few small case series or a lack of UK-based evidence. For clinical outcomes, only length of hospital or virtual ward stay for

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mixed (step-up and step-down) care and admissions or re-admissions for step-down care and mixed care were classed as ‘amber’ due to having 5 to 6 small case series reporting on these outcomes. For economic outcomes, almost all were also classified as ‘red’. Some evidence has been captured on readmissions meaning it was classified as ‘amber’. However, there is not enough evidence to conclude if there are statistically significant differences in readmissions in a virtual ward care, compared with hospital inpatient care or care in the community. Resource use associated with the clinical team and method of access to virtual ward technology platforms for people who do not have access to a smart device or the internet was also amber due to likely variability in practice.

Summary and conclusions of evidence gap analysis

For the purpose of this evaluation an assumption of similarity between virtual ward technology platforms was used. Some evidence was identified, mainly from case series. The key evidence gap is the lack of comparative evidence on the clinical efficacy and safety of virtual ward technologies as an alternative to inpatient care or care at home without a virtual ward technology for people with ARI.

Five small UK case series each provided evidence for length of stay and 1 UK cohort study also provided evidence of admissions or readmissions. The evidence on patient safety outcomes was limited by evidence being reported inconsistently and mainly reporting mortality.

There was not enough evidence to consider whether variations in the features offered by virtual ward platforms, such as continuous monitoring or machine learning assistance impacted on outcomes.

For the economic analysis, the key gaps are:

- Long-term impacts of delivering virtual ward care for future cost or health related quality of life outcomes.
- Analysis of the use of the technology for specific subgroups. For example, differences may occur in patients monitored at home or in

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a nursing home, as well as step-up or step-down care or triage directly to a virtual ward.

- Different factors or additions with virtual ward platforms and their economic impact, such as the impact of using AI predictive monitoring.
- The size of the implementation costs, and how this will vary across different hospitals.

Key areas for evidence generation

The EAG further evidence generation recommendations are summarised in table 7. Although RCTs are the gold standard for answering research questions, the EAG concluded that this is unlikely to be feasible. Instead, comparative data could be collected using controlled cohort studies or non-randomised controlled trials. Interrupted time series designs, involving the comparison of data collected before and after introduction of a virtual ward, would be feasible in trusts that have not yet implemented virtual wards for ARI. These designs would be more susceptible to confounding factors and other issues associated with a lack of randomisation, although still provide useful insight into virtual wards. Alternatively, large registry-based studies contributing substantial datasets would provide more precise estimates of impact and are of relative value when compared to national benchmarking statistics.

The EAG note that for evidence generation and future evaluations the variety of features offered by different virtual ward technology platforms should be considered. This includes detailing outcomes according to the features that are likely to drive health and cost effectiveness. Sub-categorising virtual ward technologies based on their services provided may also provide useful information for decision makers in terms of both clinical and cost outcomes. Due to the lack of comparative evidence, it is currently uncertain as to whether the benefits provided by virtual ward platforms are due to their technology enablement or routine monitoring of patients in their usual place of residence (or both).

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Table 7: Evidence generation recommendations

Research question	Recommended study design	Outcomes
What are the comparative resource and outcome consequences of using virtual wards to treat ARIs	Prospective controlled cohort studies or non-randomised controlled trials comparing to inpatient care (priority), care in the community or home monitoring without a virtual ward platform. Conducted in the UK.	• Time to ARI resolution • Adverse events • Mortality • Admissions to emergency department, hospital wards, intensive care • Length of stay in hospital • Number of care episodes • Staff time • Costs • Patients ineligible for virtual ward care and discontinuations due to adherence and digital barriers • Carer burden • HRQoL and QoL
Which components of virtual wards are likely to drive differences in relevant outcomes	Qualitative studies investigating clinical perspectives on which are the most resource saving features of virtual wards.	Components of virtual wards to interrogate further
	Prospective studies comparing different virtual ward platforms used during the same period of care. Ideally conducted in the UK	Identified from the qualitative studies
What is the cost-effectiveness of virtual wards?	Detailed in the section below on future economic modelling	• Quality of life • Resource use • Cost
How does virtual ward platforms interact with other community care services, such as people already living in community or nursing residences?	No specific study design recommended	• Resource use • Cost
What is the scale of implementation costs, and how might this differ across hospitals?	No specific study design required. However, reporting from NHS trusts on the scale of the implementation would need to be provided.	• Costs • Resource use
Staff acceptability and facilitators to maximise implementation	Qualitative or semi-qualitative studies exploring the barriers and facilitators to implementing virtual wards in a UK NHS setting	• Usability • Acceptability

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		• Other aspects of staff experience • Implementation characteristics • Barriers • Facilitators
Patient uptake of virtual wards and facilitators of adherence	Mixed methods studies assessing patient adherence to virtual wards using different solutions to maximise uptake and adherence	• Patient adherence • Categorisation of solutions for digital exclusion and acceptability • Impact and cost of enhanced support features • Facilitators of uptake

Potential future economic model

The EAG recommends that either a patient simulation or Markov model may be suitable for a future economic model. For either model option, the model will need to be able to capture the point at which a patient care begins for any of the treatment arms, such as de-escalating care from being an inpatient to virtual ward care. This would be captured in daily cycles for the first 30 days. The EAG also suggest adding a long-term aspect into the model to capture any longer-term outputs, guided by clinical feedback. The EAG also state that adaptations would be needed to the early model structure to consider heterogeneity in virtual ward management and the variation in features a virtual ward platform can offer.

7 Equality considerations

NICE is committed to promoting equality of opportunity, eliminating unlawful discrimination and fostering good relations between people with particular protected characteristics and others.

- Technology-enabled virtual wards are often delivered through a smart device. People need regular access to a device with internet access to use the technologies. Additional support and resources may be needed for people who are unfamiliar with digital technologies or do not have access to smart devices or the internet.

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- People with cognitive impairment, problems with manual dexterity, learning disabilities or who have difficulty reading or understanding health-related information may need additional support to use technology-enabled virtual wards. This should be considered when selecting and delivering these interventions.
- Technology-enabled virtual wards should be accessible to people with visual impairments using screen readers, and people with hearing impairments.
- People with English as a second language may have difficulties navigating technology-enabled virtual wards provided in English. Technology-enabled virtual wards providers should consider how to translate these interventions or provide additional support as needed.
- Acute respiratory infections are more common in people who are 65 and Over. This population also has a higher risk of serious illness and worse outcomes.
- People with learning disabilities have higher rates of asthma, COPD and upper respiratory tract infections and poorer measured lung function.
- Pregnant people are at greater risk of developing complications due to acute respiratory tract infections.
- Some pulse oximetry devices have been reported to overestimate oxygen saturation levels in people with darker skin, which may lead to them not being treated when treatment is needed.
- There is evidence to suggest that there is a higher incidence of mortality from respiratory disease in England for men than women. There are differences in help seeking behaviour between men and women, which may increase a man's risk for pneumonia hospitalisation.

Age, sex, disability, race, and pregnancy are protected characteristics under the Equality Act 2010.

8 Issues for consideration by the committee

Virtual ward platform technology features

- Although there is similarity in some aspects of virtual ward platforms, such as the use of patient apps, clinician dashboard and peripheral monitoring devices, there is variation features offered by virtual ward platforms. This includes the use of continuous or spot monitoring devices, risk stratification and additional advanced devices. Are there certain features which could affect patient outcomes including safety? Do some features lead to additional burden on healthcare professionals? Are some features more helpful on deciding whether care needs to be escalated? Do

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platforms have the interoperability to aid referrals, allow for cross-organisation working (such as out of hours care) and allow integration into electronic patient records?
- Are there any reasons for digital or other exclusion to virtual wards not already considered? What are the key features virtual ward platforms which can improve accessibility to this treatment option?
- Is screening needed to decide who should go on a virtual ward in terms or likelihood of engaging and adhering to the monitoring needed? Are there people who would be less suited to a virtual ward, such as those with condition that could reduce ability to use a virtual ward, people in which virtual ward use may increase anxiety or allergies that could prevent the use of wearables?

Patient and carer considerations

- What virtual ward features help patients stay engaged with monitoring? Or help usability to reduce the need to additional support from healthcare professionals or carers or family?
- How can patients report or make an acute call outside of planned contacts or outside of working hours?
- What is the impact on carers on adopting care using a virtual ward platform?

Clinical evidence

- Of the 19 studies prioritised, 16 were on people who had either been admitted to hospital with COVID-19 or those who had COVID-19 being given home monitoring. Three studies included other respiratory infections. How generalisable is the evidence from these populations reported to those treated in the UK now? Would there be any differences in patient characteristics in terms of demographics and co-morbidities?
- Mortality during virtual ward care was generally low and no instances were considered related to virtual ward use. There was limited comparative evidence reporting on adverse events related to virtual ward use. What are the key risks associated with virtual ward delivery? How can these risks be mitigated by virtual ward platforms or otherwise?

Cost evidence

- The conceptual modelling showed that there was a potential cost saving of £872 per person on a virtual ward when compared to inpatient care. When compared to care at home without the use of a virtual ward platform there was a potential cost saving of £115 per person. However,

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there is a high level of uncertainty around these figures due to the limitations in clinical and economic evidence.

- The key drivers of the model were:
  - expected resource use of people in hospital with a moderate ARI
  - length of stay in virtual ward care and at home care.
  - readmissions and home visits in virtual ward care and at home care.
  - level of monitoring time with virtual ward care or at home care.
  - implementation costs required for virtual ward platform technologies, which could vary significantly by geography or trust capabilities.
  - population spill over effects, treating milder patients due to virtual ward platform availability.

Evidence gap analysis

- The EAG identified the key evidence gap is a lack of comparative evidence from a UK NHS setting for comparing virtual wards to standard inpatient care or care from home without the use of a technology-enabled virtual ward.
- The EAG particularly noted that features offered by different virtual ward platform technologies may drive differences in health and cost effectiveness outcomes, which is not captured in the evidence currently. Sub-categorising technologies by the features offered may help future analysis of these technologies.
- What outcomes should be prioritised for future evidence generation?

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NICE Medical Technologies Evaluation Programme

July 2023

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Appendix A: Sources of evidence considered in the preparation of the overview

A Details of assessment report:

- McCool R et al. Virtual Ward Platform Technologies for Acute Respiratory Infections, July 2023

B Submissions from the following companies:

- Spirit Health
- Current Health
- Doccla
- Docobo
- Feebris
- Huma
- Inhealthcare
- Lenus Health
- Luscii Healthtech
- PMD Solutions
- Virtual Ward Technologies
- MediBioSense
- Solcom

C Related NICE guidance

- Acute Respiratory Infection in over 16s: Initial assessment and management (in development) NICE guideline GID-NG10376
- COVID-19 rapid guideline: managing COVID-19 (2021, updated 2022) NICE guideline NG191

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NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

125th MTAC meeting – Friday 21st July 2023

DECLARATIONS OF INTEREST – MTAC 21st July 2023

Declaration of interests register							
Medical Technologies Advisory Committee						**Publication Date: 12 October 2023**	
Topic: GID-HTE10006 Virtual Ward Platform Technologies for acute respiratory infections							
Name	**Role with NICE**	**Type of interest**	**Description of interest**	**Relevant dates**			**Comments**
				Interest arose	**Interest declared**	**Interest ceased**	
Maria Parsonage	Committee member	*Indirect*	*One off honoraria from Chiesi for an evening lecture.*	08.06.2023	08.06.2023	*n/a*	No atcions needed - open declaration at the meeting.
Mr Paul Hepden	Professional expert	*n/a*	*nil*	*n/a*	*n/a*	*n/a*	No action
Dr Adrian Hayter	Professional expert	*Financial*	Medical Director East Berkshire Primary Care	*2020*	*July2023*	*Ongoing*	No action other than open declaration
		Financial	Partner Runnymede Medical Practice	*1997*	*July2023*	*Ongoing*	No action other than open declaration
		Financial	National Clinical Director and Clinical lead Virtual Ward Programme	*2019*	*July2023*	*Ongoing*	No action other than open declaration
		Financial	Associate Non Executive Director Bucks Healthcare Trust	*2021*	*July2023*	*Ongoing*	No action other than open declaration
		Financial	Associate Kaleidoscope Healthcare Consultancy	*2022*	*July2023*	*Ongoing*	No action other than open declaration
Dr Ketan Patel	Professional expert	*Indirect, non-financial*	*Lead researcher in study exploring the impact of integrating respiratory*	*01/08/2018*	*July2023*	*04/10/2021*	No action other than open declaration

			specialists into GP Practices. Research explored impact on COPD guideline adherence, outcomes for COPD patients and extent of COPD misdiagnosis in primary care. Research papers from study have been submitted for publication and are currently undergoing peer review.				
Dr Rebecca Housley	Professional expert	*Indirect, non-financial*	*I am currently the Consultant Nurse overseeing the virtual health hub at Hampshire Hospitals. I currently manage our acute respiratory infection and chronic respiratory condition Virtual wards so have a keen interest in the development of guidelines*	*Dec 2021*	*July 2023*	*Ongoing*	No action
Mr Sam Jackson	Professional expert	*Indirect, non-financial*	*I am currently the Clinical Service Manager overseeing the virtual health hub at Hampshire Hospitals. I currently oversee clinical and operational running of the service*	*April 2020*	*July 2023*	*Ongoing*	No action
Dr Rahul Mukherjee	Professional expert	*n/a*	*nil*	*n/a*	*n/a*	*n/a*	No action
Dr Carlos Echevarria	Professional expert	*n/a*	*nil*	*n/a*	*n/a*	*n/a*	No action

Alan Shepherd	Patient expert	*n/a*	*nil*	*n/a*	*n/a*	*n/a*	No action
Mr David Cruttenden-Wood	Professional expert	*n/a*	*nil*	*n/a*	*n/a*	*n/a*	No action
Naomi Bennett-Steele	Professional expert	*n/a*	*nil*	*n/a*	*n/a*	*n/a*	No action