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Abstract

Remote monitoring for long-term physical health conditions: an evidence and gap map

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Background: Remote monitoring involves the measurement of an aspect of a patient's health without that person being seen face to face. It could benefit the individual and aid the efficient provision of health services. However, remote monitoring can be used to monitor different aspects of health in different ways. This evidence map allows users to find evidence on different forms of remote monitoring for different conditions easily to support the commissioning and implementation of interventions.

Objectives: The aim of this map was to provide an overview of the volume, diversity and nature of recent systematic reviews on the effectiveness, acceptability and implementation of remote monitoring for adults with long-term physical health conditions.

Data sources: We searched MEDLINE, nine further databases and Epistemonikos for systematic reviews published between 2018 and March 2022, PROSPERO for continuing reviews, and completed citation chasing on included studies.

Review methods (Study selection and Study appraisal): Included systematic reviews focused on adult populations with a long-term physical health condition and reported on the effectiveness, acceptability or implementation of remote monitoring. All forms of remote monitoring where data were passed to a healthcare professional as part of the intervention were included. Data were extracted on the characteristics of the remote monitoring intervention and outcomes assessed in the review. AMSTAR 2 was used to assess quality. Results were presented in an interactive evidence and gap map and summarised narratively. Stakeholder and public and patient involvement groups provided feedback throughout the project.

Results: We included 72 systematic reviews. Of these, 61 focus on the effectiveness of remote monitoring and 24 on its acceptability and/or implementation, with some reviews reporting on both. The majority contained studies from North America and Europe (38 included studies from the United Kingdom). Patients with cardiovascular disease, diabetes and respiratory conditions were the most studied populations. Data were collected predominantly using common devices such as blood pressure monitors and transmitted via applications, websites, e-mail or patient portals, feedback provided via telephone call and by nurses. In terms of outcomes, most reviews focused on physical health, mental health and well-being, health service use, acceptability or implementation. Few reviews reported on less common conditions or on the views of carers or healthcare professionals. Most reviews were of low or critically low quality.

Limitations: Many terms are used to describe remote monitoring; we searched as widely as possible but may have missed some relevant reviews. Poor reporting of remote monitoring interventions may mean some included reviews contain interventions that do not meet our definition, while relevant reviews might have been excluded. This also made the interpretation of results difficult.

Conclusions and future work: The map provides an interactive, visual representation of evidence on the effectiveness of remote monitoring and its acceptability and successful implementation. This evidence could support the commissioning and delivery of remote monitoring interventions, while the limitations and gaps could inform further research and technological development. Future reviews should follow the guidelines for conducting and reporting systematic reviews and investigate the application of remote monitoring in less common conditions.

Review registration: A protocol was registered on the OSF registry (https://doi.org/10.17605/OSF.IO/6Q7P4).

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Supplementary material can be found on the NIHR Journals Library report page (https://doi.org/10.3310/BVCF6192).

Supplementary material has been provided by the authors to support the report and any files provided at submission will have been seen by peer reviewers, but not extensively reviewed. Any supplementary material provided at a later stage in the process may not have been peer reviewed.

List of abbreviations

COPD	chronic obstructive pulmonary disease	PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
CVD	cardiovascular disease	SMS	short messaging service
EGM	evidence and gap map	WHO	World Health Organization

Plain language summary

What is this map about?

Remote monitoring is when an aspect of a patient's health, such as blood pressure, is measured at home, and this information is passed to a healthcare professional. We created an evidence and gap map for remote monitoring in adults with long-term physical health conditions. The map is presented as an interactive online table, which can be used to find the number and quality of systematic reviews that address specific questions (e.g. remote monitoring in diabetes). The map does not summarise findings from the reviews (e.g. whether remote monitoring works or not).

What studies are included?

We found 72 reviews investigating whether remote monitoring works and/or how to implement it, including whether it is acceptable to patients, carers and healthcare professionals.

What are the main findings?

Thirty-seven reviews included studies from the United Kingdom. The most common health conditions were heart disease, diabetes and lung conditions. There was little or no evidence for some health conditions (e.g. epilepsy). Data from patients were collected mainly using common devices (e.g. heart rate monitors) and passed to healthcare providers using computer applications, websites and telephone calls. Most feedback received by patients was motivational/educational. There was evidence about the acceptability of remote monitoring for patients, but little for carers and healthcare professionals. Reviews focused on whether remote monitoring affected physical and mental health, health service use, acceptability or implementation.

More than half the included reviews were judged to be low quality; however, they may still include high-quality studies.

What do the findings mean?

The map could help to design and deliver remote monitoring programmes and guide further research and technology development.

Stakeholder and public and patient involvement

Stakeholder and public and patient representatives provided feedback throughout the project.

How up to date is this map?

The map contains reviews published between 2018 and March 2022.

Scientific summary

Background

Ageing populations and rising rates of non-communicable diseases are placing increasing pressure on health and social care services. New models of care are needed to meet these challenges. The use of technology offers opportunities for innovation, with the COVID-19 pandemic demonstrating its potential. Remote monitoring is one application of technology, involving the periodic or continuous measurement of an aspect of a patient's health, such as their blood pressure, at home. This information is passed to a healthcare professional to enable the patient's condition to be managed without the need for them to be seen face to face.

Remote monitoring could benefit individuals, helping people to manage their own health and identifying exacerbations at an earlier stage. By improving communication with healthcare providers, it can also facilitate the delivery of personalised care. Potential benefits for the healthcare system more widely include efficiencies in service use and resulting reductions in cost. However, current reviews of the evidence indicate that remote monitoring may be more effective for some health conditions and in improving certain health outcomes.

To commission and deliver effective remote monitoring interventions, policy-makers and practitioners need evidence on types of remote monitoring that improve health outcomes, as well as the acceptability of these interventions and how to implement them. The need for evidence synthesis on this topic was identified by a stakeholder group from NHS England's NHS @home (an initiative that is using technology to enable people to manage their health at home), which was consulted throughout the production of the map.

Objectives

Our aim was to identify and map the volume, diversity and nature of recent systematic reviews on the use of remote monitoring interventions for adults living with long-term physical health conditions. Our specific research objectives were to:

- map recent systematic reviews of the effectiveness of remote monitoring interventions for adults living with long-term physical health conditions
- map recent systematic reviews of the acceptability and/or implementation of remote monitoring interventions for adults living with long-term physical health conditions.

What is an evidence and gap map?

Evidence and gap maps provide an overview of the evidence on a given topic. They are produced using the same principles as a systematic review. However, instead of summarising effectiveness data or findings from included studies and synthesising this information to answer a specific question, data are extracted on key characteristics of the included studies and presented visually (further description of evidence and gap maps can be found in White H, Albers B, Gaarder M, Kornør H, Littell J, Marshall Z, *et al*. Guidance for producing a Campbell evidence and gap map. *Campbell Syst Rev* 2020;**16**(4):e1125). Evidence and gap maps are typically presented as a table, with rows listing the types and characteristics of the intervention and columns displaying outcomes. This allows the identification of areas of evidence concentration as well as gaps in the evidence. They can be used both to inform evidence-based policy, commissioning and provision of healthcare interventions, and to identify areas for future research.

Methods

A protocol for the evidence and gap map was registered on the OSF (Center for Open Science, Charlottesville, VA, USA) registry (https://doi.org/10.17605/OSF.IO/6Q7P4). We searched MEDLINE, the Cochrane Database of Systematic Reviews, the Cumulative Index to Nursing and Allied Health Literature Complete, EMBASE, Web of Science, Scopus, PEDro physiotherapy database, OTseeker, ProQuest Dissertations & Theses Global, Epistemonikos and Google Scholar for systematic reviews published between 2018 and March 2022 on the effectiveness, acceptability and implementation of remote monitoring interventions for adults with long-term physical health conditions. We also conducted searches of PROSPERO for continuing reviews and completed citation chasing on included studies.

Records identified by the searches were screened at title and abstract level by two independent reviewers, with disagreements resolved through discussion. Full texts were then screened using the same process. As prespecified in the protocol, our inclusion criteria were:

- systematic reviews which used a reproducible search strategy, prespecified inclusion/exclusion criteria and screening methods, conducted quality assessment and reported their method of data analysis
- at least 75% of participants were adults (≥ 18 years) with long-term physical condition(s)
- any type of remote monitoring (defined as the monitoring of a patient's health status without face-to-face contact), with this information being passed to a healthcare professional to guide care (we included reviews in which at least 75% of the primary studies evaluated remote monitoring interventions that met this definition)
- systematic reviews of effectiveness, containing quantitative comparative outcome evaluations (at least 75% of the included primary studies), and systematic reviews synthesising evidence on acceptability and/or implementation, containing primary studies of any design
- systematic reviews published in English
- conducted in high-income countries (at least 75% of the included studies).

Following the identification of a final sample of reviews for inclusion in the evidence and gap map, a standardised form was used to extract data from the reviews. Data were extracted by one reviewer and checked by a second, with disagreements resolved through discussion. Extracted data included study characteristics, patient population, characteristics of remote monitoring interventions and outcomes. Continuing reviews were classified according to their patient population of focus. AMSTAR 2 was used to assess the quality of included reviews.

EPPI-Reviewer 4 (EPPI Centre, Social Science Research Unit, UCL Institute of Education, University of London, London, UK) was then used to create an interactive EGM. Concentrations of systematic reviews and gaps in the secondary research were identified from the map and are summarised below.

We engaged with stakeholders and public and patient involvement (PPI) representatives throughout the production of the evidence and gap map. Our stakeholders were part of NHS England's NHS @home initiative, while the PPI group had five members with experience of a range of health conditions and types of remote monitoring. Input from both groups informed the focus of the project and the presentation of the interactive map.

Results

We included 72 systematic reviews in the map. Of these, 61 focus on the effectiveness of remote monitoring and 24 on its acceptability or implementation, with some reviews including both types of outcome. We also identified 86 continuing reviews judged to be relevant to the review question. Most

of the reviews included studies conducted in North America and Europe; of the latter, 38 reviews included studies based in the UK. Reviews tended to investigate the use of remote monitoring in patients with cardiovascular disease (CVD; 45 reviews), diabetes (25 reviews) and respiratory conditions (23 reviews). Similarly, among the continuing reviews, the majority focus on patients with CVD (36 reviews), although a greater proportion (8 reviews) are investigating remote monitoring for neurological conditions. There was a lack of consistent reporting on further patient characteristics such as age, gender and digital literacy. A wide range of health indicators were monitored, the most common being blood pressure (47 reviews), heart-related (35 reviews) and lung-related indicators (30 reviews), symptoms (27 reviews), treatment adherence (25 reviews) and blood glucose (22 reviews).

The methods used to collect data included common devices, such as blood pressure and blood glucose monitors (48 reviews); symptom tracking [e.g. patients recording their symptoms in a computer application (app) or website, 29 reviews]; wearable devices (e.g. activity trackers, 20 reviews); and implantable devices (e.g. cardioverter defibrillators, 17 reviews). The most common ways of passing data to the healthcare provider were through apps, websites and e-mails (58 reviews); automatically (i.e. without the patient's involvement, 46 reviews) and by telephone calls (33 reviews). Nurses were the healthcare professionals most often reported as involved in the remote monitoring intervention (41 reviews). In most studies, feedback was provided to the patient via telephone (42 reviews) and contained motivational/educational elements (33 reviews). In some interventions, if critical values were registered, the healthcare provider responded by making changes to treatment (28 reviews); fewer included studies where the patient was referred for further medical care (12 reviews).

The outcomes assessed by the included reviews were categorised into six broad-outcome categories, with further subcategories. For physical health outcomes (55 reviews), mortality (23 reviews), blood glucose (16 reviews) and blood pressure (9 reviews) were the largest subcategories; for mental health and well-being outcomes, reviews reported on anxiety and depression (13 reviews) and quality of life (24 reviews); for health service use, hospitalisation (29 reviews) and emergency room visits (16 reviews). For health behaviours and self-regulation, there was most evidence for self-management (14 reviews) as a subcategory; for acceptability and implementation-related outcomes, most reviews reported on acceptability and satisfaction (24 reviews). Eleven reviews reported on both subcategories within the broad category of adherence and compliance. To obtain more precise estimates of specific outcomes, 48 reviews combined the results from individual studies using statistical methods (meta-analysis).

Only 5 of the included reviews were judged to be of high quality and 22 of moderate quality; the rest of the reviews were of low or critically low quality, which means that they had one or more major methodological shortcomings that make their results less reliable. In addition, many of the reviews provided limited information about the evaluated interventions, making the judgement of their relevance and the interpretation of results difficult.

Conclusions

The map shows a number of reviews looking at the effectiveness of remote monitoring and, to a lesser degree, its acceptability and/or successful implementation. These could support the commissioning and delivery of remote monitoring interventions, while 'gaps' in the map could inform the further research and the development of monitoring technologies. Most of the reviews focused on CVD, diabetes and chronic respiratory conditions. While the evidence for less common conditions is limited, there are a number of continuing reviews for some populations, such as patients with neurological conditions. Reviews on acceptability and implementation focused almost entirely on the patients' perspective, with only a small number on the perceptions and experiences of carers and healthcare professionals.

The evidence and gap map and the evidence contained within in it have some limitations. More than half of the included reviews have serious methodological issues and many provided very scant descriptions

of the included interventions. Additionally, a lack of consistent reporting on factors, such as age, gender and digital literacy, means that it is difficult to assess the impact of remote monitoring on equity of access to services. As the map includes systematic reviews, not primary research, we were only able to include evidence for remote monitoring interventions that have been subject to a systematic review. Remote monitoring and related terms are not used consistently in the literature, which created difficulties in identifying all relevant reviews. Finally, the volume of literature found meant that we had to apply strict inclusion and exclusion criteria, so some relevant evidence may have been excluded. For example, while we limited the map to reviews published from 2018, older reviews may contain relevant information, particularly regarding the implementation of interventions.

The COVID-19 pandemic led to the rapid implementation of remote monitoring technology. While there has been a return to face-to-face provision for many services, the pandemic demonstrated the capabilities of technology. Demand for remote monitoring is likely to increase in the future, particularly given the role that it could play in meeting sustainability goals and reducing the environmental impact of health services. Evidence will be needed to support the design and delivery of further remote monitoring interventions. Future reviews should try to adhere more closely to the recommended systematic review methods; report their methods and findings as fully as possible; provide detailed description of the included interventions; report the effectiveness, acceptability and implementation of remote monitoring in all relevant patient groups; investigate the application of remote monitoring in further chronic conditions; and explore acceptability and implementation from a wider range of perspectives.

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Chapter 1 Background

The problem, condition or issue

Changing population demographics and rising rates of non-communicable diseases are placing new demands on the health and social care services.[1] It is estimated that one in seven people in the UK will be aged over 75 years by 2040.[1] Similar patterns are being seen worldwide; by 2050, the proportion of the population over the age of 60 years will double.[2] Owing both to the likelihood of developing chronic conditions with age and lifestyle factors (e.g. low rates of physical activity), there has been an increase in the number of people living with non-communicable diseases such as type 2 diabetes, chronic obstructive pulmonary disorder (COPD) and cardiovascular disease (CVD).[1,3] New models of care are needed to meet the challenges this situation creates for health and social care.

Technology offers opportunities for innovation in service provision that could be used to address some of these challenges.[1,4] This has been recognised in policy, with the World Health Organization (WHO) digital health strategy advocating the use of technology that 'strengthens and scales up health promotion, disease prevention, diagnosis, management, rehabilitation and palliative care'.[5] Within the NHS England Long Term Plan, there are plans to invest in and increase the use of technology in the healthcare system.[6] This aim has been accelerated by the COVID-19 pandemic, which led to rapid adoption of technologies that enabled the remote provision of health services around the world, demonstrating the potential of technology.[7,8]

Defining remote monitoring

Recent years have seen both the development of new devices and systems capable of delivering health services, and the implementation of technology within the healthcare system. The terms used to refer to this provision vary, as do their definitions.[4] eHealth is generally considered to encompass the use of digital health records (often accessed through patient portals, specific websites with secure access for individuals), as well as the delivery of health care via electronic means.[9] Within eHealth, telehealth, telemedicine, telecare and mHealth are all used to refer to the delivery of different types of health care or services via new technologies (e.g. smartphone apps) or older technologies (such as telephones) to aid self-management, diagnosis or treatment.[9,10] Remote monitoring is a further subset of eHealth that could be particularly beneficial for people with long-term conditions.

While multiple definitions of remote monitoring also exist,[11] we define it as:

> *An intervention, involving the monitoring of a patient (using medical devices, applications, clinical investigation results, or other assessment tools), including self-monitoring, and which allows care professionals from a healthcare provider to assess and manage a patient's condition remotely, without the need for the patient to be seen face to face.*

A variety of remote monitoring technologies are available, including invasive (e.g. pacemakers)[12] and non-invasive (e.g. blood pressure monitors),[11] wearable sensors[13] and home sensing technologies, which could be used to monitor falls or night-time disturbances.[14] Some take constant or automatic measurements, while others require the patient to take readings periodically.[15,16] The use of some is specific to certain conditions, such as the measurement of blood glucose by patients with diabetes. Others may provide an indication of health status (e.g. blood pressure, which is used in the monitoring of a range of conditions).

The application of remote monitoring technologies also differs between interventions. Variations include:

- frequency of data upload and whether this is automatic or manual
- the type of healthcare professional involved in the intervention and whether and how they provide feedback

- frequency and mode of contact with healthcare professionals, whether in person or via telephone or mobile application
- the content of feedback, which might include a referral to another healthcare professional or changes to medication.

How the intervention might work

For the individual

Remote monitoring can contribute to effective self-management, improving individuals' knowledge of their condition and assisting them in managing their symptoms.[17] Additionally, it can help to bridge the gap between this self-management and professional health care.[18] By providing data on health status, monitoring can give patients the confidence to contact professionals when necessary and support health assessment and clinical decision-making, including timeliness of care through the identification of exacerbations.[11] It can also enhance communication between patient and provider, assisting in shared decision-making and enabling the delivery of personalised and person-centred care, an important component of quality of care.[4,18]

For the healthcare system

Remote monitoring could have wider benefits for the healthcare system. In the UK, there is increasing financial pressure on the NHS and social care services,[19] creating a need to reduce the costs of health care where possible. Remote monitoring offers opportunities to increase the efficiency of care delivery in a number of ways.[10] First, through more effective use of time, by contributing to enhanced communication, as detailed above, and as it means neither patient nor healthcare professional needs to travel to appointments.[20] It can also reduce health service use, both through the avoidance of unnecessary routine appointments and reducing acute admissions.[21]

In addition to enabling health and social care services to respond to current challenges, remote monitoring and other technologies could help address wider, and urgent, societal problems such as the climate emergency. The NHS *Sustainability Annual Report 2020–21* recognised the sustainability benefits of the implementation of digital technology during the COVID-19 pandemic and discusses how its future use could deliver further benefits.[22] By reducing the need to travel and the associated carbon emissions, these technologies could contribute to improving the sustainability of the healthcare system and the NHS England ambition to reach net zero, as set out in the Health and Care Act 2022.[23]

Existing evidence

Background scoping searches of the literature found reviews on the effectiveness of remote monitoring, as well as factors that influence its acceptability for patients and providers and implementation by healthcare providers.

Effectiveness

Previous reviews of remote monitoring vary in their conclusions on its effectiveness. McBain *et al.*[21] focused on self-monitoring for three chronic conditions (heart failure, hypertension and COPD) in their review of reviews, finding significant reductions in both hospitalisation and re-admissions to hospital as a result of monitoring. However, a 2020 meta-analysis in which the majority of patients had either CVD or pulmonary disease, or were overweight or obese, did not find any statistically significant effects.[15] A range of clinical outcomes were assessed, including body mass index, weight, waist circumference, body fat percentage, systolic blood pressure and diastolic blood pressure.[15] In a narrative synthesis of studies on the impact of using eHealth tools on changes to medication use, there was little evidence of improvement to outcomes such as medication use or quality of life, but tools did lead to positive

medication change and improved patient symptoms.[17] These reviews suggest that the effectiveness of remote monitoring may differ depending on the targeted health conditions and outcomes.

Acceptability and implementation

A number of reviews detail barriers and facilitators to the implementation of remote monitoring interventions. Thomas *et al.*[24] identified six theories of intervention success in their realist review of potential mechanisms reducing or leading to acute care use: (1) targeting populations at high risk; (2) accurately detecting a decline in health; (3) providing responsive and timely care; (4) personalising care; (5) enhancing self-management; and (6) ensuring collaborative and co-ordinated care.

Reviews on the positive and negative aspects of remote monitoring have focused on the views of clinicians,[20] patients[25] and both clinicians and patients.[26] Both groups consider potential benefits to include reduced travel and clinician workload, while raising concerns regarding lower quality of care and additional burden for providers.[20,25,27] Reviews concentrating on the technology itself also indicate the potential for negative impacts on healthcare providers, for example due to the need for increased data processing.[28] Additional barriers to adoption include connectivity[28] and usability issues ranging from difficulties reading devices to the importance of instructions for users.[29]

Why it is important to do this review?

During our initial scoping searches of the literature, we identified a large number of systematic reviews focusing on the effectiveness of remote monitoring, and the acceptability and implementation of these interventions. Remote monitoring is used for a range of health conditions, varying in everything from the aspect of health that is monitored to the application of the technology in the intervention. Understanding this evidence, recognising where evidence is concentrated and identifying where there are gaps is important to support evidence-informed policy, commissioning and provision.[30] Our conversations with relevant stakeholders' contacts at NHS England's NHS @home initiative indicated that knowledge of the breadth of evidence on remote monitoring would be most useful in supporting their work. Concentrations of evidence for certain health conditions or technologies could help inform the development of interventions and the delivery of existing programmes.

It is also important to understand the current evidence base to direct research.[30] Identifying topics which have been the focus of research prevents the duplication of effort, while knowledge of gaps – populations, interventions or outcomes where there are no systematic reviews – can prioritise areas for the future. Remote monitoring is an important topic for research, given ambitions for the use of technology in the health services and its potential to support adaptation to meet changing demands for health care. While COVID-19 has demonstrated how rapidly digital technology can be deployed, there are still many unknowns, with devices often developed by technology firms for the fitness market then adapted for other uses.[31]

Chapter 2 Research question

We aimed to identify, classify, appraise and map recent systematic reviews of the effectiveness of remote monitoring and its acceptability and implementation in people living with long-term physical health conditions. Our research question was:

- What is the volume, diversity and nature of recent systematic reviews about the use of remote monitoring interventions for adults living with long-term physical health conditions?

Our specific research objectives were to:

- map recent systematic reviews of the effectiveness of remote monitoring interventions for adults living with long-term physical health conditions
- map recent systematic reviews of the acceptability and implementation of remote monitoring interventions for adults living with long-term physical health conditions.

Chapter 3 Methods

Defining evidence and gap maps

Evidence and gap maps (EGMs) collate the research on a particular topic, providing an overview by summarising key characteristics of existing studies.[32] They are produced using similar methods to other forms of evidence synthesis, such as systematic reviews. However, unlike systematic reviews, they do not synthesise the findings of research; instead, they allow users to identify and access the research evidence most relevant to their patient groups and intervention focus, or to see where evidence gaps exist.[30,32] To produce an EGM, studies are categorised according to key dimensions (e.g. aims, methods, type of intervention, type of condition). A 'map' is then created by visually representing the number of studies in particular combinations of categories (usually in a two-dimensional grid).[33]

Below, we describe the steps taken to produce this EGM on the effectiveness, acceptability and implementation of remote monitoring for long-term health conditions, as specified in our protocol.[34]

Inclusion criteria

Inclusion criteria for reviews in the map are summarised below and in *Table 1*, with further details provided in *Appendix 1*, *Table 5*. Some systematic reviews included studies that did not meet our criteria; for example, they evaluated other eHealth interventions or were conducted in high- and low-income countries, in addition to relevant primary studies. As specified in our protocol,[34] we considered reviews eligible for inclusion if 75% or more of the included studies met our inclusion criteria. We did not check individual primary studies; our decisions were based on information reported in the review.

TABLE 1 Eligibility criteria for inclusion in the EGM

	Include		
	Acceptability	**Implementation**	**Exclude**
Study design	Systematic reviews including comparative outcome evaluations	Systematic reviews including comparative outcome evaluations, other quantitative designs and/or qualitative studies	Any other study design
Population	Adult (≥ 18 years)		< 18 years
	Long-term physical health condition		No long-term condition
Participants	Patients as described above	Patients, carers and/or healthcare professionals	
Intervention	Any intervention where: • the patient is monitored in their home environment without needing to be seen face to face • data from monitoring is passed on to a healthcare professional		Interventions that are too poorly described to determine whether they meet this definition Multicomponent interventions
Outcomes	Any outcome related to effectiveness, including risk of adverse events and self-efficacy	Any outcome related to acceptability or implementation, including adherence	Cost effectiveness
Publication date	Systematic reviews published in 2018 or later		

Following title and abstract screening and after establishing the volume and nature of the available evidence, we decided to limit inclusion to reviews published since January 2018 for several reasons, as detailed below and further in the section *Departures from the protocol*:

- To make the map more relevant to decision-makers. Remote monitoring technology is changing rapidly (e.g. use of smartphones) and older systematic reviews included studies evaluating technology that is out of date in terms of capability (e.g. unable to automatically transfer data), with associated implications for the generalisability of findings on acceptability and implementation.
- To include reviews containing studies from both before and after the COVID-19 pandemic, which led to the rapid uptake of remote monitoring technology.
- To reduce the number of papers that needed to be screened. Our title and abstract screening produced a large number of full-text articles (*n* = 829), the double-screening of which was beyond our capacity. We, therefore, decided to focus on the more recent and relevant portion of the identified papers.

Types of evidence

This map contains systematic reviews, defined as studies that have collected all the research on a given topic and synthesised it to answer a specific question, usually using prespecified methods to reduce bias.[35] To meet our definition of a systematic review, studies had to have defined a clear research question, used a reproducible search strategy, prespecified inclusion/exclusion criteria and screening methods, conducted quality assessment of included studies, and reported their method of data analysis.[36]

We also considered the design of primary studies included within the systematic review. For reviews of effectiveness, we included those where at least 75% of studies were comparative outcome evaluations, whereas for reviews of acceptability or implementation we included all empirical research regardless of study design. When a review aimed to answer both effectiveness and acceptability or implementation questions and the primary studies addressing the effectiveness question did not meet our study design criteria, we included the review but extracted only data on the primary studies related to acceptability or implementation (see *Types of outcome* for detail on included acceptability and implementation outcome measures).

Type of population

This EGM focused on adult populations (18 years or over) with a long-term physical health condition. We considered long-term physical conditions to be any chronic disease of long duration that is unlikely to be cured completely.[37] These included conditions that typically develop early in life, for example asthma, as well as non-communicable diseases often associated with ageing such as CVD, and the long-term consequences of acute events/treatments, for example transplant patients, or cancer survivors. We excluded interventions that were preventative or focusing on the acute stages of treatment for what might be a long-term condition; for example, reviews of patients undergoing cancer treatment were excluded.

For reviews of effectiveness, we included only those where at least 75% of included primary studies focused on adults with a long-term physical health condition as participants. Additionally, for reviews of acceptability or implementation, we included those seeking the views of carers of adult patients and healthcare professionals using or providing remote monitoring. However, these reviews still had to focus on remote monitoring for adults with a long-term physical health condition as a population.

Types of intervention

Our intervention of focus was remote monitoring, defined as:

> *An intervention, involving the monitoring of a patient (using medical devices, applications, clinical investigation results, or assessment tools), including self-monitoring, and which allows care professionals*

from a healthcare provider to assess and manage a patient's condition remotely – without the need for the patient to be seen face to face.

We included monitoring:

- of objective or self-reported health status
- occurring in the place where a person lives, either their home or a residential setting such as a care home
- using a device or written output, as long as data are transferred to a care professional.

Reviews focusing on multicomponent interventions, such as those where participants attended education or counselling sessions as well as monitoring their health status, were excluded, unless the effects of remote monitoring alone could be distinguished due to the inclusion of an appropriate control or additional intervention group. This is because of the difficulty in determining the effectiveness of remote monitoring if combined with other components.[38] We considered interventions where some education was provided as part of feedback based on data submitted through monitoring, rather than in a separate session, as meeting our definition of remote monitoring. Reviews were only included if at least 75% of primary studies met our definition of remote monitoring.

Types of outcome

We were interested in all outcomes relating to effectiveness and acceptability or implementation. Outcomes of effectiveness included objective (e.g. heart rate, blood pressure) and subjective (e.g. quality of life, self-efficacy) measures as well as outcomes such as the occurrence of adverse events targeted by the intervention (e.g. risk of stroke) or caused by the intervention (e.g. inappropriate shocks from implantable cardioverter defibrillators when used to monitor patients with heart failure). Although we included reviews on use of the health service, those focusing solely on cost effectiveness were excluded, as consultation with stakeholders indicated a greater interest in health-related effectiveness outcomes.

We included reviews of quantitative and qualitative measures of acceptability or implementation, including patient adherence and patient satisfaction. Although acceptability is often considered an aspect of implementation, we decided to report it separately to make it more visible for map users, especially patients, carers and healthcare professionals, who might have a particular interest in this topic.

Types of location

This map contains systematic reviews in which at least 75% of the included primary studies were conducted in high-income countries, as defined by the World Bank (at 3 October 2022).[39] This is both because the funders of this map are working within a healthcare system in a high-income country and as a result of consultation with our stakeholders. While not all healthcare systems in high-income countries are comparable, this criterion ensured the included reviews contained primary studies that were most relevant to users in terms of healthcare system, patient population and social context.

Types of setting

Owing to the focus on remote monitoring, we included only reviews of interventions that took place in the participants' homes, including care homes and other residential settings. Reviews containing primary studies in which initial training on how to use remote monitoring equipment occurred in a hospital or other medical facility were included.

Search methods and sources

Information specialists (NS and AB) developed the bibliographic database search strategies using MEDLINE (via Ovid) in consultation with the review team. The search strategy combined search terms for remote monitoring and evidence syntheses using both controlled vocabulary (e.g. MeSH in

MEDLINE) and free-text search terms. Search terms were partly derived from the titles and abstracts of preidentified systematic reviews of remote monitoring and from initial scoping searches.

Search results were date limited to 2012. However, following title and abstract screening, a post hoc decision was made to further limit the inclusion to reviews published since January 2018 (see *Inclusion criteria and Departures from the protocol* for further details).

Electronic searches

We searched the following bibliographic databases in March 2022:

- Cochrane Database of Systematic Reviews (via the Cochrane Library)
- Cumulative Index to Nursing and Allied Health Literature Complete (EBSCOhost)
- Embase (Ovid)
- MEDLINE (Ovid)
- Web of Science Core Collection (Clarivate)
- Scopus (Elsevier)
- PEDro
- OTseeker
- ProQuest Dissertations & Theses Global (via ProQuest).

Full search strategies for all bibliographic databases and other sources are included in *Appendix 2*.

All records from bibliographic database searches were imported into EndNote™ X9.3 (Clarivate, London, UK) and deduplicated using EndNote functionality and manual checks.

Searching other resources

Epistemonikos (www.epistemonikos.org) was searched on 30 March 2022 to identify relevant systematic reviews. Web searching was completed via Google Scholar using Publish or Perish (Harzing). Citation searching (forwards and backwards) was conducted on reviews that met our inclusion criteria using Scopus (Elsevier), Web of Science (Clarivate), Spidercite (available from SR-Accelerator: https://sr-accelerator.com) and Citation Chaser (available from: https://estech.shinyapps.io/citationchaser). Results from citation chasing were downloaded into EndNote and deduplicated against records retrieved from bibliographic database searches. To identify evidence syntheses from results of citation chasing, a search of All Fields in EndNote for *review or meta or systematic or synthesis* was applied.

Searches of the PROSPERO register (of systematic review protocols, available from: https://www.crd.york.ac.uk/prospero) were conducted on 23 March 2022 to identify continuing reviews. The publication status of each review was checked both in PROSPERO and through a search of title and author names in Google. Records for completed reviews (n = 106) identified from PROSPERO were added to the results from citation chasing and deduplicated against records identified from bibliographic database searches. Records for continuing reviews identified from published protocols or PROSPERO were screened separately as described in *Stage 1: title and abstract* below.

Screening and study selection

Stage 1: title and abstract

On completion of the searches, each member of the review team (SDB, ZZ, NS, AB, JTC, RA) independently applied the inclusion and exclusion criteria (*Table 1* and *Appendix 1*, *Table 5*) to a random sample of citations (n = 100). This pilot screening exercise was intended to establish consistent interpretation of the inclusion criteria. Decisions were discussed in a group meeting, with some clarifications made to the criteria to ensure they were applied in the same way by different reviewers.

Following the initial calibration exercise, two reviewers (SDB and ZZ) independently applied the revised inclusion and exclusion criteria to the title and abstract of each identified citation. Disagreements were solved through discussion. Full-text papers of studies were obtained when both reviewers judged the study to meet the inclusion criteria and for those studies where it was not clear whether the criteria were met from the information in the title and abstract alone.

Two reviewers (SDB and ZZ) also independently screened the published protocols of all continuing systematic reviews identified in the searches. The information reported in the protocols was limited and, for many protocols, it was not possible to establish with certainty whether they meet our inclusion criteria. We therefore included all continuing reviews that were selected for inclusion by at least one of the reviewers and reported them separately in *Appendix 3*.

Stage 2: full text

The full text of each record was assessed independently by two reviewers (SDB and ZZ) to determine whether they met our inclusion criteria (as described above and in *Appendix 1*, *Table 5*). Decisions were made based on the information reported in the review and disagreements were settled through discussion with a third reviewer if necessary.

Data extraction and management

We imported records of the included reviews from the Endnote libraries used for screening into EPPI-Reviewer 4 (EPPI Centre, Social Science Research Unit, UCL Institute of Education, University of London, London, UK). A standardised data extraction coding form was then constructed in EPPI-Reviewer 4. The categories in this form are those from the framework detailed below in *Developing the framework* and can be found in *Report Supplementary Material 1*. The form was piloted by two reviewers (SDB and ZZ) on a sample of included reviews (n = 10) and discussed by the whole review team (SDB, ZZ, NS, AB, JTC, RA). Once revised to ensure that information provided in the reviews was being represented accurately by the categories in the form, data on each category were collected from all included full-text items. We defined items as a single review where they were based on the same searches; these could include multiple reports or publications. Data extraction was conducted by one reviewer (SDB or ZZ) and checked by a second reviewer (SDB or ZZ), with disagreements settled through discussion and, if necessary, the involvement of a third reviewer.

We did not check for duplication of primary studies between reviews. Besides being a difficult and time-consuming process, similar reviews often had a slightly different focus which means that even if most of the included studies overlapped, we still would have had to include the review to capture the breadth of evidence available.

Continuing reviews were grouped according to the patient population on which they focused. One reviewer (SDB) classified the continuing reviews and these classifications were then checked by a second reviewer (ZZ).

Developing the framework

The development of our framework was an iterative process. An initial framework was created using information from key literature (e.g.[9,15,21]) identified during our initial scoping searches and by stakeholders at NHS @home. This was revised and refined following our first meeting with our patient and public involvement (PPI) group (as detailed in *Public and patient involvement*) and through discussion with stakeholders at NHS @home.

Categories were designed to describe the breadth of remote monitoring interventions and outcomes reported in the included reviews, as well as being accessible and easy to use in the interactive map. During data extraction, when information in the included reviews did not fit any categories in the framework, we renamed or adjusted the categories to ensure that all characteristics of the interventions and measured outcomes were included in the EGM. These adjustments were discussed and agreed upon in team meetings. Categories included in the framework are described briefly below, with details given in the data extraction form in *Report Supplementary Material 1*; full definitions are provided in the EGM glossary, which can be found in *Report Supplementary Material 2*.

Within the framework, we aimed to extract data on factors related to diversity and inclusion such as age and gender. A lack of consistent reporting meant that there was not enough information included in reviews on these factors to form categories in the framework.

Methods for mapping

The data on each review entered into EPPI-Reviewer 4 were visualised in an interactive map using EPPI-Mapper, version 1.2.5 (EPPI-Centre, UCL Social Research Institute, University College London, London, UK). Each record in the map contains one review and details the author, year of publication, title, journal and abstract, as well as giving the digital object identifier and a summary of basic information in the review; for example, the number of primary studies included in the review and the definition of remote monitoring used by the authors. Where we found publications that were based on the same searches, we treated these as a single review, providing the details of the additional publications at the end of the study abstract, together with a link to the relevant publication(s).

Characteristics of remote monitoring interventions

The included reviews contained a wide range of remote monitoring interventions. We detail important characteristics of the interventions in the EGM. These are: (1) what was monitored; (2) how it was monitored; (3) the method of passing on the data; (4) the healthcare professional involved; (5) the method of feedback; and (6) the content of feedback. Further information on the subcategories within these categories is provided in the data extraction forms in *Report Supplementary Material 1* and the EGM glossary in *Report Supplementary Material 2*.

Categorisation of outcomes

We included any outcomes on effectiveness, acceptability or implementation in the EGM. We grouped effectiveness outcomes into four broad categories: (1) physical health; (2) mental health and well-being; (3) health behaviours and self-regulation; and (4) health service use. As most reviews of acceptability or implementation were qualitative, we grouped related outcomes within one broad category. Finally, we included one broad category in the map, adherence and compliance, which contained subcategories relating to both effectiveness and acceptability/implementation. *Table 2* lists the subcategories within each of the broad categories, together with examples of measures used to assess them in included reviews.

Filters for presentation

Evidence and gap maps are usually presented in two primary dimensions as a table, with different outcomes as columns and different intervention features as rows (as detailed above). We added additional filters to this EGM. Selecting a filter means the map will only display reviews containing evidence on the specified filter. This allows users to change the subset of reviews shown in the map to those most relevant to their needs (e.g. reviews that include at least one UK-based study). The filters are listed below, with detailed definitions available in *Report Supplementary Material 2*:

1. publication year
2. type of synthesis: meta-analysis, narrative, qualitative, other

TABLE 2 Examples of outcomes of interest in the EGM

Outcome	Subcategory	Examples
Physical health	Mortality	All-cause mortality
	Blood glucose/glycaemic control	Level of glycated haemoglobin; time in glycaemic range
	Blood pressure	Mean arterial pressure
	Other cardiovascular metrics	Peak oxygen consumption; left ventricular ejection fraction
	Detection rate	Detection rate of atrial arrhythmia
	Risk of adverse events	Incidence of stroke
	Weight/body mass index/ waist circumference	
	General health	Six-minute walk distance test
	Other	Kidney related (e.g. serum creatinine); change in Epworth Sleepiness Scale
Mental health/ well-being	Anxiety/depression	Hospital Anxiety and Depression Scale; Goldberg anxiety or depression subscale scores
	Quality of life	Short Form Survey SF-36; St George's Respiratory Questionnaire
Health behaviours/ self-regulation	Self-management or self-care	Heart failure medication management; frequency of communicating with physicians
	Knowledge, understanding	Diabetes knowledge
	Risk factors	Frequency of smoking; frequency of drinking
	Self-efficacy	Ability to monitor the conditions and having insights into living with the conditions
Health care/service use	Hospitalisation	Admission or re-admission (e.g. heart failure-related admission), length of stay
	Emergency room visits	
Acceptability and implementation	Acceptability and satisfaction	Diabetes Treatment Satisfaction Questionnaire; qualitative themes (e.g. lack of trust, peace of mind)
	Usability	Qualitative themes (e.g. functionality)
	Implementation-related	Qualitative themes (e.g. concern about additional burden, out-of-pocket costs for patients, accessibility, difficulties with physical installation of equipment such as finding space)
Adherence/ compliance	With treatment	Continuous positive airway pressure machine usage; adherence to lipid-modifying drugs
	With intervention	Recording weight, pulse and blood pressure; adherence to blood glucose monitoring

3. included study designs: randomised controlled trial plus other study design, other quantitative (e.g. cohort studies, observational studies, other qualitative)
4. population: patients, carers, healthcare professionals
5. patient categories: CVD; neurological conditions; diabetes; respiratory conditions; cancer survivors; kidney disease; other; not clearly defined

6. study region (all regions where studies included in the review were conducted were selected): UK; Europe (not UK); North America; Australia or New Zealand; other; not clearly reported
7. duration of interventions: mean/median duration ≥ 12 months (as reported in the paper); at least one of the included studies had duration ≥ 12 months; not clearly defined
8. study quality (based on AMSTAR 2): high, moderate, low, critically low.

To accompany the map, we produced a brief narrative synthesis, which can be found in the *Results* section below, together with supporting tables and figures.[33] This synthesis details the distribution of reviews across the different intervention and outcome categories as well as the filters for the map.[32]

Quality assessment

An adapted version of AMSTAR 2 was used to assess the quality of reviews included in the map. Quality appraisal was performed by one reviewer (SDB or ZZ) and checked by a second (SDB or ZZ), with disagreements settled by discussion and, if required, a third reviewer.

AMSTAR 2

AMSTAR 2 is a 16-item checklist which considers all aspects of the conduct of a systematic review, from prespecifying a protocol to the assessment and discussion of risk of bias within the review.[40] AMSTAR 2 is intended to critically appraise reviews of quantitative studies of healthcare interventions with randomised or non-randomised designs. This map includes reviews containing a broader range of study designs; accordingly, we adapted certain questions to allow us to appraise the quality of these reviews. These adaptations are based on Lam *et al.*[41] and can be found in *Appendix 4*, *Table 7*.

Items from the checklist are chosen as critical domains and used to determine the overall quality of the review.[40] There are four categories of overall quality: high, moderate, low and critically low. To be considered high-quality, a review can have no more than one non-critical weakness, while to be moderate-quality a review can have more than one non-critical weakness but no critical flaws. Low-quality reviews have a flaw in one critical domain and may have non-critical weaknesses; reviews of critically low quality have more than one critical flaw.

We reflected on the domains used by other researchers for similar topics[41,42] and discussed the most important domains to accurately represent the quality of the included reviews for this area of research within the team.[40] To be considered high-quality, reviews had to have a prespecified protocol, comprehensive search strategy, have described included studies in adequate detail, assessed risk of bias in included primary studies appropriately, and investigated any heterogeneity in their results (for further detail see *Appendix 4*, *Table 7*).

External engagement

Engaging users in the process of evidence synthesis is important to ensure that that outputs produced meet their needs.[43]

Stakeholder engagement

The core stakeholder group for this EGM were members of the NHS @home team within NHS England. A total of seven stakeholders, including the head of implementation, the evaluation lead and team members involved with specific NHS @home programmes (e.g. for heart failure @home and lung health @home), were consulted via e-mail and video meetings throughout the process of developing the EGM. These discussions determined the scope of our review question, the potential value of an EGM given the number of existing studies and systematic reviews, and the inclusion of key intervention and outcome categories in the framework for the EGM, as well as refining the interactive map. *Table 3* details specific changes made to the map as a result of feedback from stakeholders.

Public and patient involvement

We recruited a PPI group at the beginning of the project to gain feedback from people who use remote monitoring technology to manage their heath conditions. The group consisted of five people: one man and four women. Members of the group had a range of health conditions, including hypertension, COPD and sleep apnoea, and experiences of using different technologies (e.g. blood pressure monitors, heart rate monitors) as a patient, carer or both. We held three meetings with this group over the course of the project, arranging meetings to suit the project progress and participant availability. These meetings discussed:

- their experiences of using remote monitoring
- a draft version of the EGM
- the plain language summary and dissemination plans for the EGM.

Changes made to the map as a result of consultation with the PPI group can be found in *Table 3*.

TABLE 3 Changes made to the EGM as a result of stakeholder and PPI consultation

Type of change	Comment	Actions and response
Definitions and language	Stakeholders provided feedback on conditions and interventions included in the map and how they were grouped. Some (e.g. implantable cardiac monitors) were less relevant to NHS @home	We have clearly categorised health conditions and interventions in the map so that users can find reviews that are of most relevance to their needs
	Stakeholders wanted to be able to distinguish between low- and high-quality reviews	Reviews are grouped and displayed in the map according to their quality; we have also added quality as a filter so that users can choose to look at only high- or low-quality reviews
	The PPI groups commented on barriers and facilitators to remote monitoring such as digital literacy	We considered these comments while constructing the data extraction form for the map. These factors were rarely reported so we were not able to collect data on them, but we have commented on them in the report
	The PPI group considered that receiving feedback on the data they were collecting was an important part of remote monitoring	We included method and content of feedback as two data extraction categories
Map presentation	The PPI group thought that the colours representing study quality were not intuitive (darker colours representing lower quality)	We changed the colours representing study quality, so that darker colours indicated higher quality, and added an explanation of this beneath the title (together with other instructions for using the map)
	Stakeholder and PPI groups wanted to know the number of UK studies included in reviews	We have included the number of UK studies in each review in the study summary and there is a filter that can be used to select UK-based studies only
Useability	The PPI group found the size of the map overwhelming when first viewed and were worried about navigating away from the map to view instructions for use	We added basic instructions, including an explanation of how to reduce the size of the map, under the title, so they are easily seen when the map is first opened
	The PPI group commented that an easy-to-read font would make the map more accessible	We changed the font used in the map to Verdana, which is a sans-serif font considered legible for online reading
	The PPI group commented that the white map background made the map harder to read, as did a grey background and pale text in the headers	We changed the header background to dark blue. EPPI-Mapper does not currently have functionality to change the colour of the map background, but we have passed this comment to their development team

Departures from the protocol

Title and abstract screening resulted in a large number of studies (*n* = 829) which needed to be checked at full text. As a result, we decided to restrict our inclusion criteria and limit full-text screening to articles published from 2018 onwards. This was a pragmatic decision, based on the need to reduce the number of studies to screen, but was made following discussion with NHS @home to ensure the relevance of the EGM to stakeholders. Remote monitoring technology is changing rapidly, so the results and conclusions of older systematic reviews are less reliable as they contain more studies on out-of-date technology and do not include more recent primary research studies. Older systematic reviews may also have been duplicated by more recent systematic reviews. Finally, even though the COVID-19 pandemic has accelerated the uptake and experience of remote monitoring in many patient groups, we wanted to capture reviews containing evidence from both before and after February 2020.

Chapter 4 Results

Results of the search and reviews included in the evidence and gap map

Figure 1 provides an overview of the search and screening process. Bibliographic database searches retrieved 12,124 records; 11,256 additional records were then identified through citation chasing or

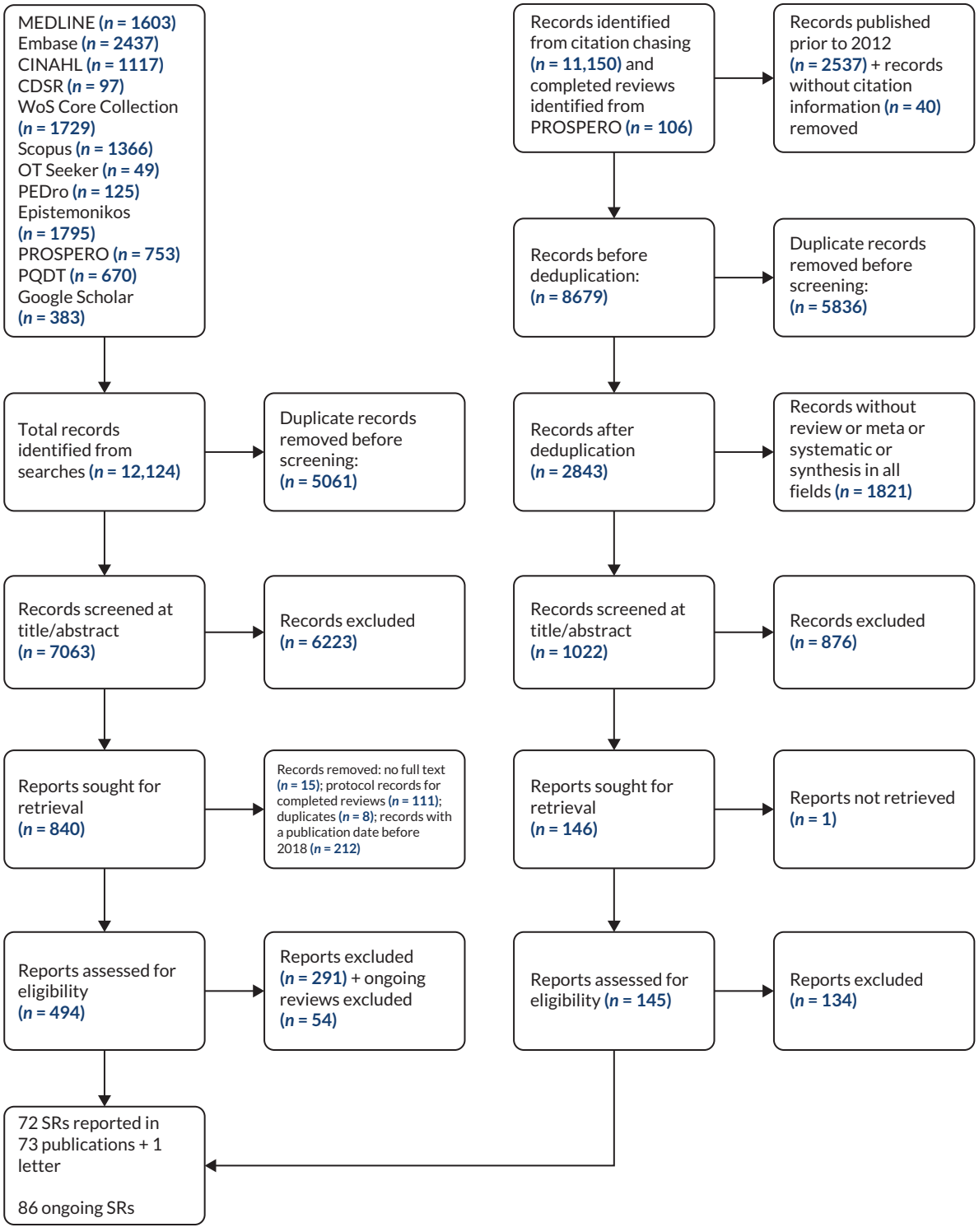

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram.

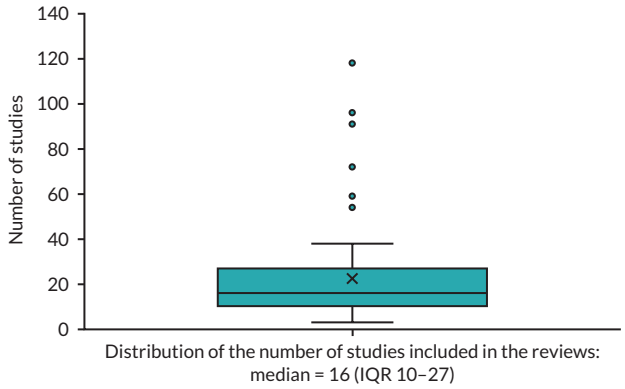

FIGURE 2 Number of studies included in the reviews.

as completed reviews identified from PROSPERO searches. After deduplication, 7063 records from database searches and 1022 records from other sources were double-screened at title and abstract. This resulted in 986 reports which were eligible to be assessed at full text, 639 of which were published from 2018 onwards. These 639 were screened at full text, resulting in 72 systematic reviews (reported in 73 publications) being included in the EGM. The number of primary studies included in the reviews ranged from 3 to 118, median 16 (interquartile range 10–27; *Figure 2*). We found 86 continuing reviews (see *Appendix 3*).

A list of studies excluded after screening at full text, along with reasons for exclusion, can be found in *Report Supplementary Material 3*. The primary reasons for exclusion were that the included interventions did not meet our definition of remote monitoring (*n* = 161) or that the study design did not fit our definition of a systematic review (*n* = 165).

Map of included reviews

The interactive EGM can be found at https://eppi.ioe.ac.uk/cms/Portals/35/Maps/ExeterNIHR/RemoteMonitoring.

An example of the EGM is shown in *Figure 3*. Intervention categories are displayed as rows, outcome categories as columns, and the number of tiles indicate the number of reviews found in the cell. Colour represents study quality (as assessed by AMSTAR 2): dark green tiles indicate high-quality reviews, blue indicates moderate quality reviews, yellow low-quality reviews and pink critically low quality. The map has been prepared to be colour-blind friendly by using a colour palette with suitable shades and levels of contrast.[44]

Individual reviews may be included in more than one category in the EGM, as they measure multiple outcomes, or report on several different types of intervention. Both in the narrative synthesis and in the figures and tables, the number of reviews reported is the total number of reviews found in that category. The sum of reviews for a figure or table, or in a descriptive summary, may therefore be greater than the number of unique reviews included within the category.

Below, we report areas of evidence synthesis concentration and 'gaps' in the EGM. 'Gaps' may show that remote monitoring has not been implemented for a certain combination of characteristics/outcomes (i.e. an 'implementation gap'), that it has been implemented but not evaluated (i.e. an 'evidence gap') or that it has been implemented and evaluated through primary research, but not yet included in a systematic review (i.e. an 'apparent evidence gap').

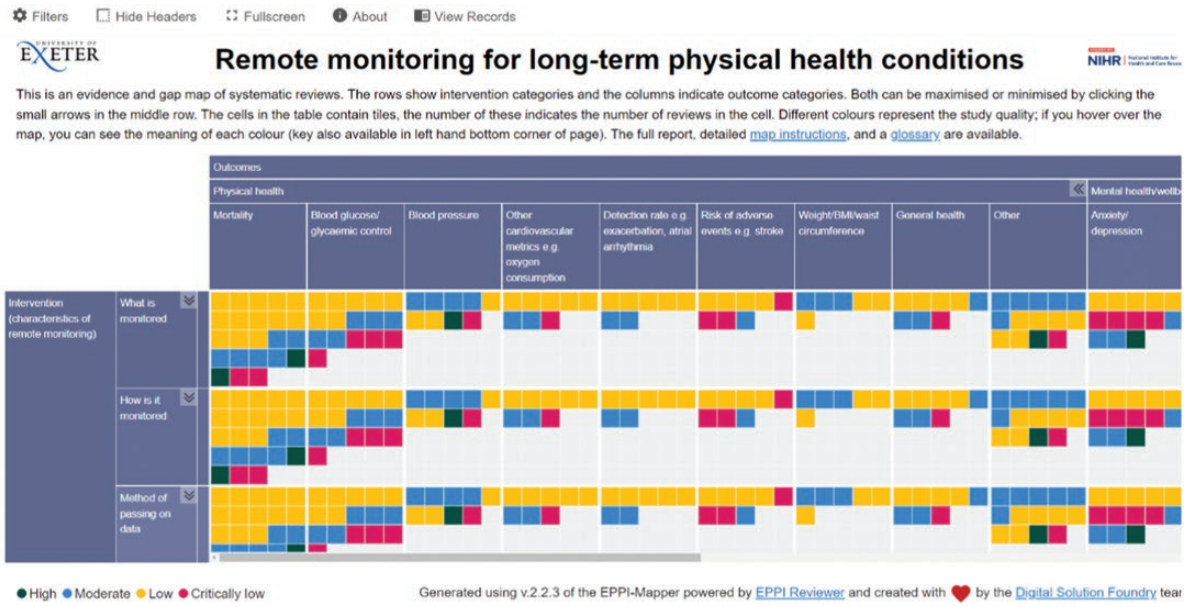

FIGURE 3 Evidence and gap map of included reviews, showing intervention categories as rows and outcome categories as columns (subcategories can be accessed in the interactive map) and study quality (green indicates high quality, blue moderate quality, yellow low quality and pink critically low quality).

Year of publication of included reviews

We included systematic reviews published from 2018 to March 2022. Between 2018 and 2020, the number of reviews published ranged from 11 to 14; a large increase was seen in 2021, with 29 reviews published in that year.

Populations and participants in included reviews

The included systematic reviews focused on patients, with all 72 reporting outcomes from patient populations. There were some reviews that also included data from carers (n = 3) and healthcare professionals (n = 5), but a gap was evident regarding reviews of these populations.

A range of health conditions were represented in the included reviews (*Figure 4*). There was a concentration of evidence synthesis concerning patients with CVD (n = 45), with diabetes (n = 25) and respiratory conditions (n = 23) being the next most studied populations. Reviews tended to concentrate on individual long-term conditions, with only three focusing on patients with multiple morbidities. 'Gaps' in secondary research were evident with respect to cancer survivors and patients with neurological conditions such as dementia (n = 3). Three reviews included primary studies on patient groups that were not clearly defined, referring to, for example, 'general chronic conditions', while seven reviews included studies on other conditions such as inflammatory bowel disease or thyroid disease.

We aimed to extract further data on patient populations (e.g. age, gender, health literacy and digital literacy), so that the map could represent the diversity of populations in which remote monitoring is implemented, as well as factors that might influence the effectiveness or acceptability of remote monitoring for specific populations. However, the inconsistent reporting of these characteristics within the included reviews meant that this was not possible and indicates an evidence 'gap'.

Continuing reviews were classified according to their patient population of focus. Similar to reviews included in the EGM, CVD, diabetes and respiratory conditions are the most common patient populations (*Table 4*). However, a larger proportion of continuing reviews focus on neurological conditions than among the included reviews.

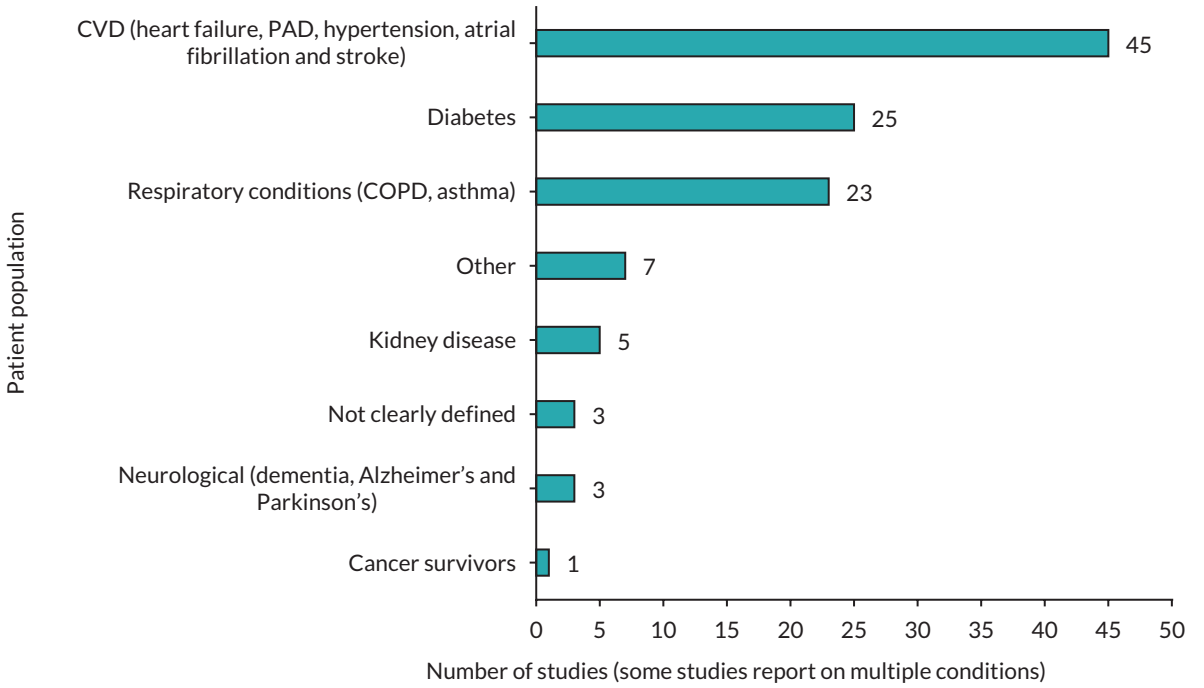

FIGURE 4 Number of included reviews reporting on each patient category. PAD, peripheral arterial disease.

Type of remote monitoring in included reviews

Remote monitoring was used to measure a range of indicators of health status in the included systematic reviews, with several areas of evidence synthesis concentration evident regarding the format and delivery of interventions.

In terms of the indicator(s) of health status measured by remote monitoring, blood pressure (n = 47) was the most commonly used by primary studies in the included reviews. There were also concentrations of evidence synthesis relating to other cardiovascular measures (e.g. heart rate, arrythmia, atrial fibrillation; n = 35) and oxygen-related measures (e.g. blood oxygen saturation or lung capacity; n = 30). Medication/treatment adherence (n = 25), blood glucose (n = 22) and physical activity (n = 20) were the next most measured aspects of health (*Figure 5*). In 44 reviews, other indicators of health were monitored (e.g. weight). While the majority of measures were objective, 27 reviews included studies in which the symptoms were measured, often subjectively; for example, through questions on mood.

TABLE 4 Number of continuing reviews (N = 86) focusing on different patient populations

Patients	Reviews (n)
Cardiovascular disease	36
Respiratory conditions	13
Not clearly defined/reported	11
Diabetes	10
Neurological conditions	8
Other	5
Kidney disease	3
Cancer survivors	0

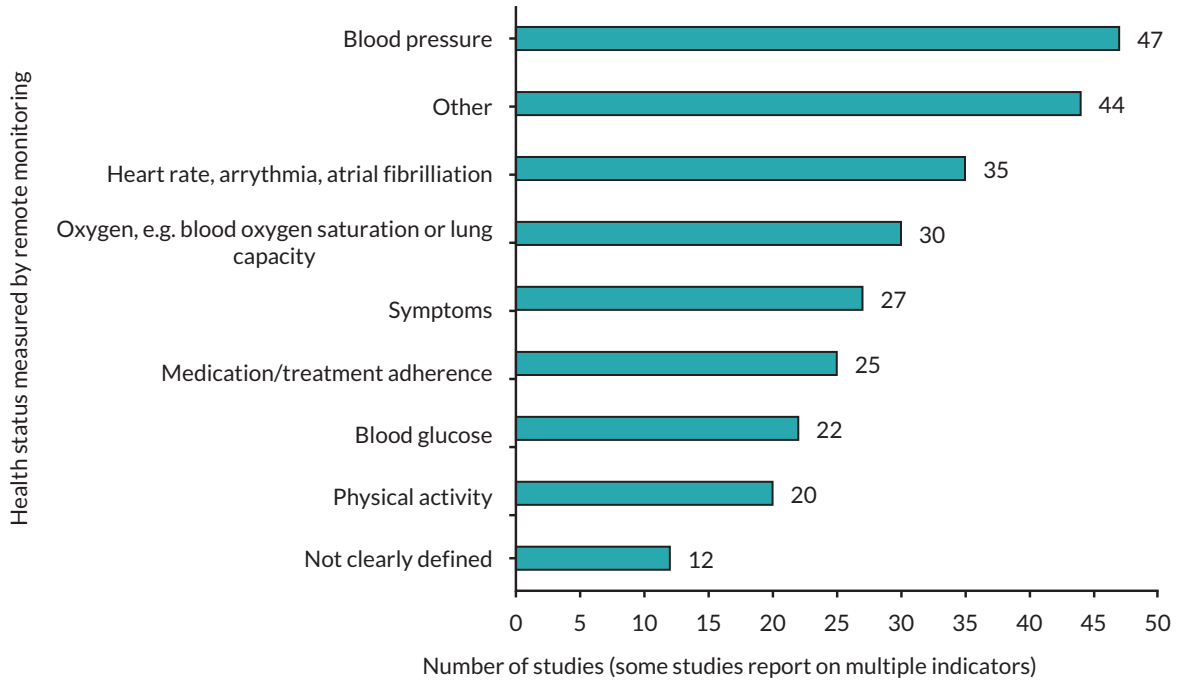

FIGURE 5 Number of included reviews reporting on each category of health status measured by remote monitoring.

Health status was measured using implantable (*n* = 17) or wearable devices (*n* = 20) in some primary studies in the included reviews, but there was a concentration of evidence synthesis regarding the use of 'other' devices (*n* = 48; *Figure 6*). These included spirometers, weighing scales and blood pressure monitors. There were 29 reviews containing studies that used symptom tracking – this is more than the 27 reviews including studies on the monitoring of symptoms as this category also included the use of logbooks to record health indicators such as levels of physical activity. Data were passed from these devices to a healthcare professional via an app, website, e-mail or patient portal in primary studies

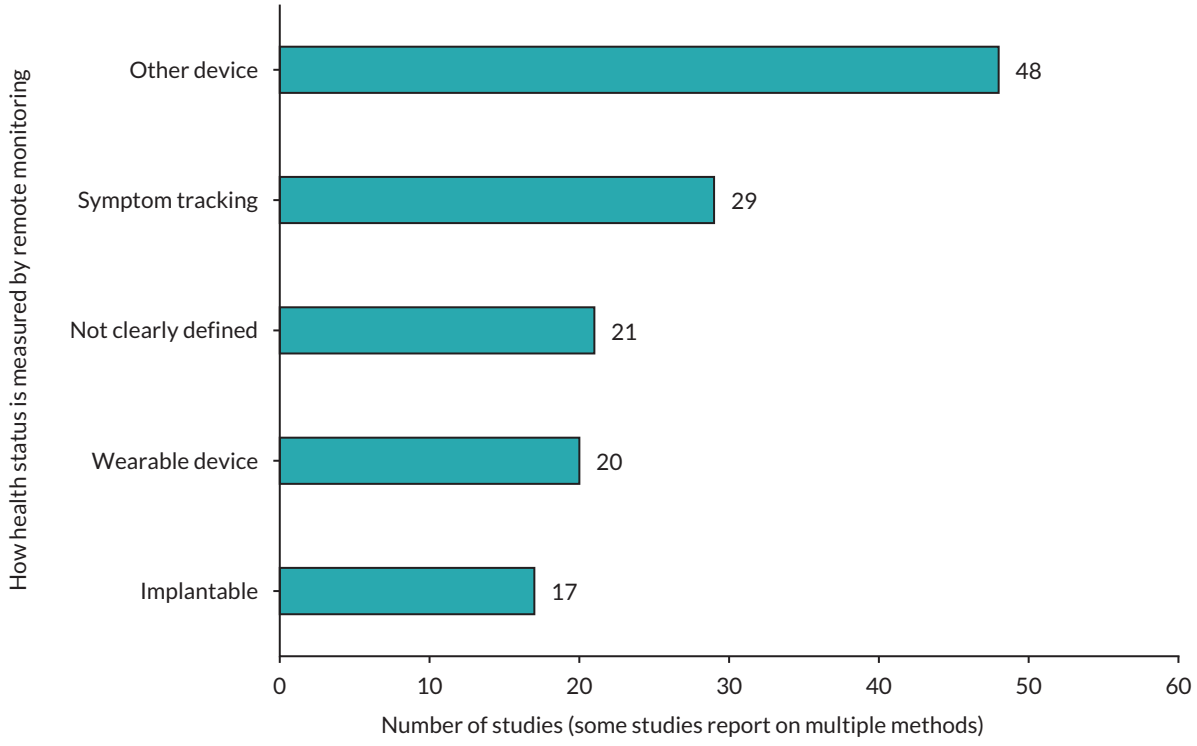

FIGURE 6 Number of included reviews reporting on how health status is measured in remote monitoring interventions.

included in 58 reviews, with 46 containing studies in which data were passed on automatically (*Figure 7*). There were fewer reviews containing studies where short messaging services (SMS; *n* = 10) or face-to-face meetings (*n* = 1) were used to pass on data, although, as noted in the *Discussion*, this does not necessarily indicate a 'gap'.

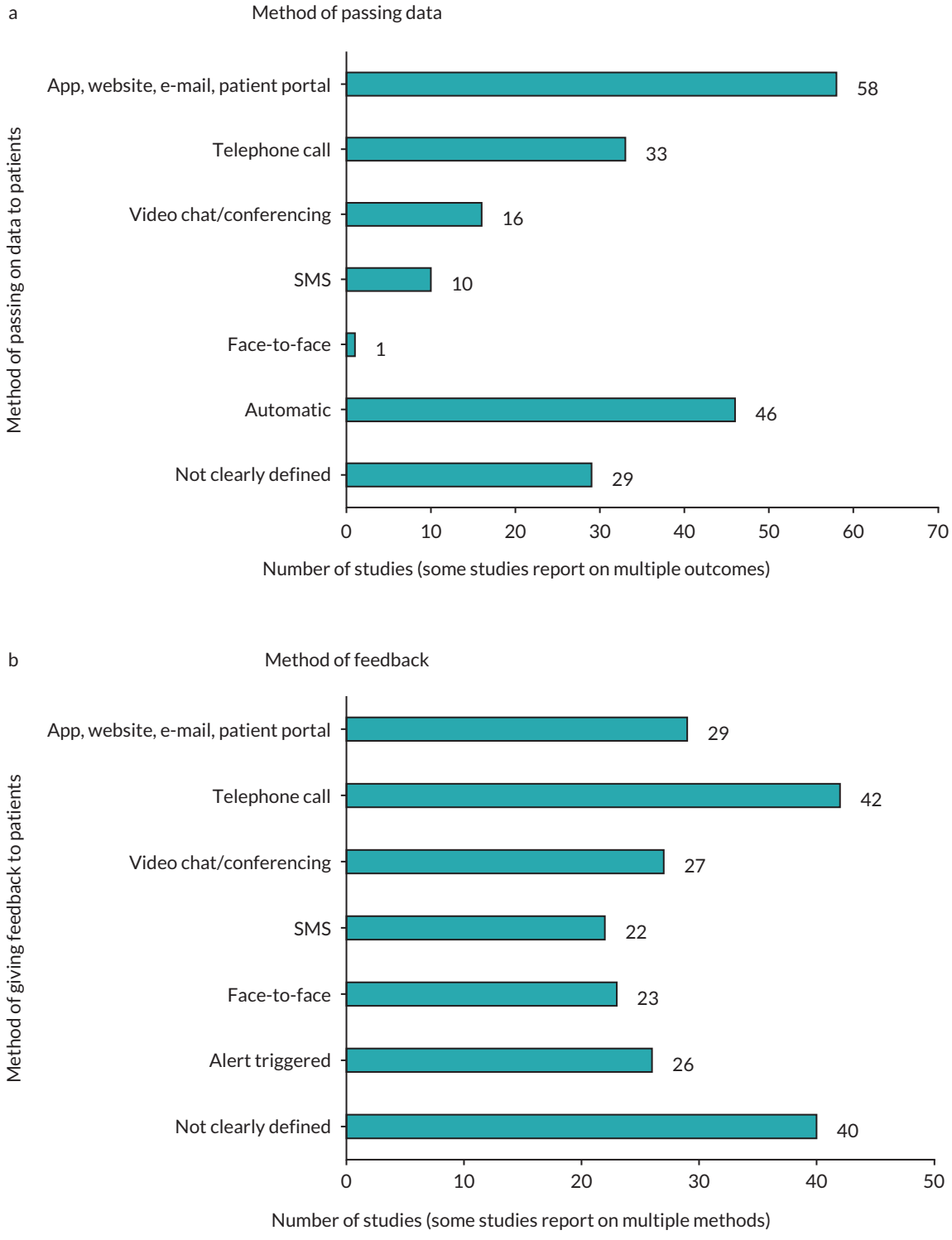

FIGURE 7 Number of included reviews reporting on each category for the (a) method of passing on the data; and (b) for the method of feedback to patients.

The majority of reviews included primary studies in which patients were provided with feedback as a result of remote monitoring. The type of healthcare professional with whom patients had contact was often not clearly defined (*n* = 43); where the role was defined, nurses were most frequently involved (*n* = 41), followed by doctors (*n* = 36) and other healthcare professionals (*n* = 24), for example physiotherapists. A concentration of evidence synthesis was present on the use of telephone calls (*n* = 42) by healthcare professionals to provide feedback to patients, with apps, websites, e-mails or patient portals (*n* = 29), and videoconferencing (*n* = 27) being the next most used methods of providing feedback (see *Figure 7*). No significant gaps were seen in terms of other methods of feedback, with 22 reviews reporting on feedback provided by SMS and 23 on face-to-face feedback. In 26 reviews, abnormal readings from monitoring resulted in an alert being triggered, prompting action by healthcare professionals.

The content of feedback found most often in the included reviews was motivation or education (*n* = 33) and changes to treatment/medication (*n* = 28). There were fewer reviews containing studies in which patients were referred, for example, to the emergency department (*n* = 12) as a result of monitoring. Most reviews also contained studies in which the content of feedback was not clearly defined (*n* = 46).

Outcomes reported in included reviews

The EGM includes 61 reviews that reported on the effectiveness of remote monitoring and 24 concerning its acceptability or implementation. Corresponding to the proportion of reviews that reported on effectiveness, the most common type of synthesis was meta-analysis (*n* = 48). Any outcome relating to effectiveness, acceptability or implementation was included in the map. By outcome, we mean what the remote monitoring intervention was intending to influence. For some interventions, the health indicator that was measured as part of the intervention was the same as the outcome that the intervention intended to influence (e.g. measuring and aiming to improve blood glucose levels in patients with diabetes), whereas in others the indicators measured were different (e.g. measuring heart rate in patients with CVD with the aim of reducing hospitalisations).

We grouped these outcomes into six broad categories, containing subcategories for specific outcomes (*Figure 8*). Four of these broad categories: (1) physical health, (2) mental health and well-being, (3) health behaviours and self-regulation and (4) health service use, contained outcomes associated with

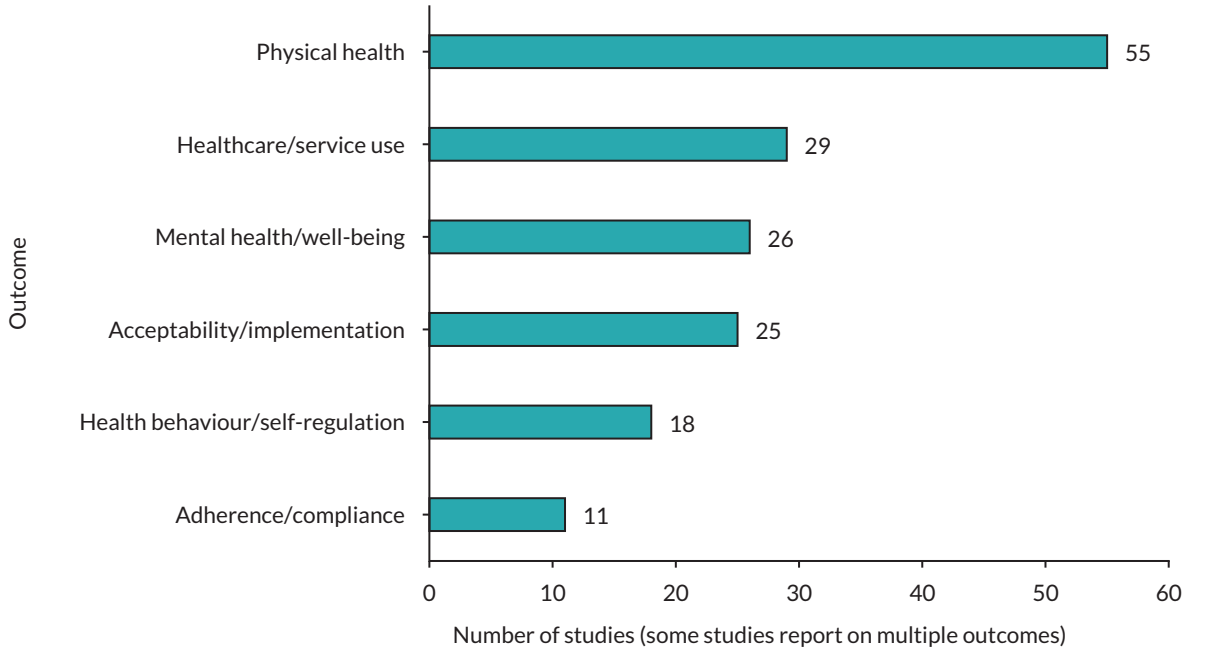

FIGURE 8 Number of included reviews reporting on each broad outcome category.

effectiveness. We used one broad category for acceptability and implementation, and one for adherence and compliance, which contained subcategories for both effectiveness and acceptability outcomes.

There was a concentration of evidence synthesis on physical health outcomes (*n* = 55). Mortality (*n* = 23) and glycaemic control (*n* = 16) were the most frequently described in the reviews. Similar numbers of systematic reviews reported outcomes such as blood pressure (*n* = 9), oxygen consumption (*n* = 8) and risk of adverse events such as stroke (*n* = 8). Fourteen reviews included 'other' physical health outcomes such as cholesterol levels or fatigue. While the focus of most remote monitoring interventions in the reviews was on measuring physical aspects of health, some reported the benefits of these interventions for mental health and well-being (*n* = 26). Outcomes related to anxiety/depression were reported in 13 reviews, while there was a concentration of evidence synthesis on quality-of-life outcomes, with 24 reviews reporting these outcomes.

Self-management or self-care (*n* = 14) was the main outcome reported for the broad category health behaviours and self-regulation (*n* = 18). There were few reviews that included studies on risk factors, for example low physical activity (*n* = 4) or self-efficacy (*n* = 5). Reviews containing information on the impact of remote monitoring on health service use (*n* = 29) tended to focus on hospitalisation (*n* = 29), with fewer focusing on emergency room visits (*n* = 16). There were several aspects of health service use for which we found no evidence of secondary research, such as primary care visits and staff time.

Regarding the acceptability and implementation of remote monitoring (*n* = 25), there was a concentration of evidence synthesis related to the acceptability and satisfaction (*n* = 24) of remote monitoring interventions. There was less secondary research reporting on usability (*n* = 7) and other implementation-related factors (*n* = 9). There were 11 reviews that included studies reporting on adherence and compliance with the intervention.

Certain outcomes had evidence synthesis concentrations for specific health conditions. For CVD, the most common condition in the EGM, 23 reviews reported on hospitalisation, 18 on mortality and 13 on quality of life, whereas only 2 reviews reported on self-efficacy. Blood glucose (*n* = 15) was reported as an outcome for the majority of reviews focusing on diabetes. Few reviews reported on other physical health-related indicators for patients with diabetes; further outcomes with greater evidence synthesis included acceptability and satisfaction (*n* = 11), self-management or self-care (*n* = 7) and quality of life (*n* = 6). Respiratory conditions had evidence synthesis concentrations for acceptability and satisfaction (*n* = 13), hospitalisation (*n* = 12) and quality of life (*n* = 10), with fewer reviews reporting on health behaviours and self-regulation.

Location of studies in the included reviews

Primary studies included in the reviews were global in origin. There was a concentration of evidence from North America and Europe (excluding the UK), with the majority of reviews containing primary studies from these locations (*n* = 52 and 50, respectively). No significant gaps were seen regarding geographic location, with 37 reviews including studies from the UK, 32 from other locations such as Argentina, Japan and Singapore, and 28 from Australia or New Zealand.

Quality of included reviews

The critical appraisal tool for systematic reviews AMSTAR 2 was used to assess the quality of included reviews. The majority of reviews in the map were of low quality (*n* = 33). While few were rated as high quality (*n* = 5), 22 were found to be of moderate quality and 12 were of critically low quality (*Figure 9*). In 56% of included reviews, the reason they were rated of low quality was the lack of a protocol. The majority of reviews described reasons for heterogeneity (92%) and adequately assessed the risk of bias in quantitative comparative evaluations (86%). However, it was often unclear whether the risk of bias in other quantitative study designs or qualitative studies had been assessed adequately (70%). For many

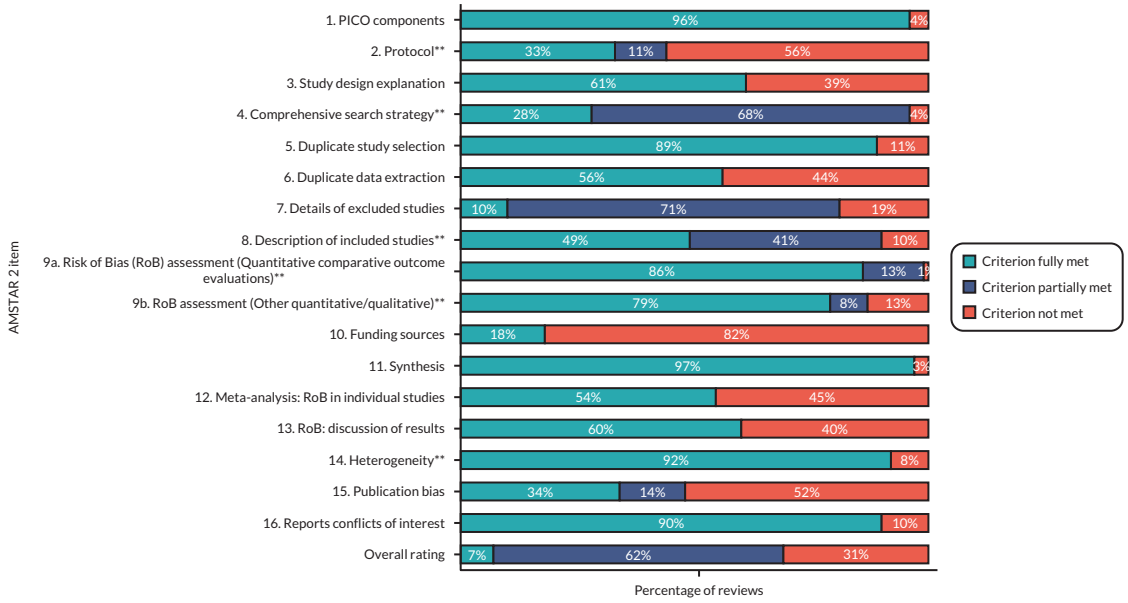

FIGURE 9 Overview of quality of included reviews, by AMSTAR 2 item; **indicates critical domains used to determine overall quality. PICO, population, interventions, comparison type and outcomes.

reviews, while their searches were adequate as they searched at least two databases and provided keywords/a search strategy, their search strategies were not rated as fully comprehensive (68%), as they did not search as extensively as possible, for example in the grey literature or the reference lists of included studies. In terms of non-critical domains, few reviews described the funding sources of studies (82%) or gave full details of excluded studies (71%) but most provided details on the population, intervention, comparator and outcome(s) of focus (96%) and used appropriate methods of synthesis (97%). Additional details can be found in *Appendix 4*, *Table 8*.

Patterns of evidence synthesis concentration and gaps regarding outcome and intervention categories were similar to those reported above across low- and moderate-quality studies. Of the five high-quality reviews, two reported mortality and three acceptability and satisfaction. Of those rated of critically low quality, four reviews included blood glucose as an outcome and three contained acceptability or implementation outcomes. A greater proportion of reviews assessed as critically low reported on patients with diabetes (7 of 25 reviews) than any other patient population.

Chapter 5 Discussion

Summary of main results

This EGM contains systematic reviews of primary studies reporting the effectiveness, acceptability or implementation of remote monitoring interventions. Owing to our stakeholders' priorities, we did not explicitly seek or summarise systematic reviews of relevant economic or cost-effectiveness evidence. We found a considerable volume of research, particularly relating to the effectiveness of remote monitoring. There were some clear areas of evidence synthesis concentration and apparent gaps in the evidence; these are discussed below.

Areas of evidence concentration

Evidence synthesis concentrations in the map indicate that reviews of remote monitoring interventions have focused on certain health conditions, particularly CVD, diabetes and respiratory conditions. Accordingly, certain types of remote monitoring interventions are more represented in the map. For example, those measuring aspects of health related to CVD, such as blood pressure and heart rate, or respiration-related indicators, such as blood oxygen. Understandably, reported outcomes also varied depending on the condition, with concentrations of evidence synthesis for blood glucose for diabetes, mortality for CVD and hospitalisations for both CVD and respiratory conditions. There were also evidence syntheses regarding quality of life as an outcome of remote monitoring for all three of the most common conditions in the EGM.

The map contains a considerable number of reviews on 'other' devices (e.g. blood pressure or blood glucose monitors), reflecting the variety of health indicators that were measured by remote monitoring interventions and the range of technologies available. There was a greater volume of synthesised research on interventions where data were passed on via app, website, e-mail or patient portal, or automatically, than methods such as telephone calls or SMS. This perhaps reflects the fact that remote monitoring is often a form of digital innovation, and that a key aim of these interventions is to improve the efficiency of health care,[9,45] for example through reducing re-admissions.[21] There were further concentrations of evidence synthesis relating to feedback, with feedback being most likely to be provided via a telephone call, and from a nurse, if the healthcare professional involved was reported.

Areas of major gaps in the evidence map and confidence considerations

Fewer reviews were found on the acceptability and implementation of remote monitoring than its effectiveness. This is not necessarily a gap, as separate effectiveness reviews are often conducted for different outcomes, meaning that they are likely to outnumber reviews on implementation-related factors, which typically summarise a wider range of measures within a single review. However, there was a clear gap in reviews reporting on the acceptability of remote monitoring to carers and healthcare professionals, and on factors affecting implementation in specific health conditions.

Actual or apparent gaps in secondary research on outcomes related to the potential benefits of remote monitoring should be highlighted. Some of the benefits of remote monitoring to patients are thought to be as a result of improved knowledge and self-management of their condition;[18] we found a relative lack of reviews focusing on these outcomes. It has been suggested that remote monitoring could improve efficiency in the healthcare system,[10] but reviews of health service use tended to focus on hospitalisations. We did not find any reviews looking at the effectiveness of remote monitoring for outcomes such as reducing staff workload. A small number of reviews reported risk of adverse events

targeted by the intervention (e.g. adverse cardiovascular events) or caused by the intervention (e.g. inappropriate shocks from implantable cardioverter defibrillators when used for monitoring patients with heart failure), but there were no reviews for other adverse events such as communication errors.

The reviews reported a wide range of outcomes, which reflect the diverse impact that remote monitoring can have on patients' physical and mental health, and the healthcare system as a whole (e.g. resource use). Twenty-three reviews reported mortality and eight reported risk of adverse events (e.g. stroke or cardiovascular events). Many of the reported surrogate outcomes (e.g. blood pressure, cholesterol and HbA1c) are well-established predictors of 'harder' outcomes (e.g. mortality, stroke and myocardial infarction) and could be more feasible to use than 'harder' outcomes (e.g. in younger patients with diabetes). Also, the studies reported a wide range of outcomes, including the impact on patients' mental health, well-being and self-efficacy, which are also important to patients. The map could be used to explore to what extent outcomes important to patients are reported in a specific area, but this question as a whole requires further investigation and is beyond the scope of the current project.

Certain patient populations were also under-represented in the map: there was a lack of evidence synthesis on cancer survivors, those with neurological conditions and for other conditions such as inflammatory bowel disease. It should be noted that these were identified as 'gaps' as we found some evidence synthesis for these conditions. As discussed below in *Implications for research*, there are chronic conditions for which we found no secondary research, which are therefore not represented in the map.

There were few reviews that included interventions where SMS or face-to-face contact was used as a method of passing on data resulting from remote monitoring. However, as discussed in *Areas of evidence concentration*, this does not necessarily indicate a gap in the evidence. There were also few reviews that included studies where patients were referred for further medical intervention as a result of remote monitoring. This may be a gap in primary or secondary research, as one purpose of remote monitoring is to identify and react to exacerbations in a patient's condition.[46,47] However, few interventions aimed to identify and react to exacerbations so this may indicate an implementation gap.

We aimed to extract demographic data and factors such as health and digital literacy, which might influence the effectiveness of remote monitoring from included reviews. There was a gap regarding these factors, with a lack of consistent reporting in the reviews, and there is, therefore, an evidence synthesis gap relating to diversity and inclusion in remote monitoring interventions and their impact on health equity.

In general, there was a lack of high-quality reviews in the map. In terms of critical flaws, less than half of the reviews had a published protocol and were rated as having an adequate but not comprehensive search strategy or description of the included interventions. Most of the reviews used appropriate methods for quality appraisal, data synthesis and investigation of heterogeneity. This means that the results from the majority of the included reviews might be biased and should be interpreted with caution, even when the included primary studies are of high quality.

Implications for research

Funders of systematic reviews and review authors should try to address the following issues:

- lack of systematic reviews on remote monitoring in specific health conditions
- failure to adhere to best practice guidelines for conducting systematic reviews and meta-analyses
- failure to report (by review authors and/or authors of studies included in the reviews) essential information related to the intervention, participant characteristics or other aspects of study design.

Cardiovascular disease, diabetes and respiratory conditions such as COPD are among the most prevalent long-term conditions in the UK and worldwide,[48,49] so the focus of research on these diseases is important. However, remote monitoring offers the potential to manage a range of health conditions and, while these conditions may affect smaller numbers of people, remote monitoring could offer them significant benefits. We found few systematic reviews on monitoring for neurological conditions, such as dementia, although there are several continuing reviews in this area and reviews that did not meet our inclusion criteria. As the number of older people living with dementia in the UK is predicted to increase by 80% from 2019 to 2040, and the cost of care is expected to be £94.1 billion by 2040,[50] there is a particular need for evidence synthesis of research on remote monitoring in this patient population. Similarly, systematic reviews are needed on conditions where remote monitoring could increase quality of life, such as inflammatory bowel disease,[51] epilepsy and allergies;[48] these are either potential areas for further research or, if primary research exists, for evidence synthesis.

The fact that 33 (46%) of the 72 reviews included in the map were judged to be of low quality is of particular concern and casts doubt on the usability of the review results for decision-making. Researchers should consult guidance documents such as those produced by the Centre for Reviews and Dissemination[52] and the Cochrane Collaboration[53] when conducting further reviews, as well as referring to PRISMA when reporting reviews.[54] There was a lack of high-quality reviews found, with the absence of a prespecified review protocol being the most common reason for reviews being judged as low quality. Registering a protocol on a recognised database such as PROSPERO (Centre for Reviews and Dissemination, University of York) is an important step in the conduct of a review, avoiding duplication of reviews, providing an understanding of the methods applied and reducing the risk of bias in the review.[52]

Fifty-one per cent of the included reviews failed to report essential information about the intervention, the participants or some other aspect of study design that could affect the interpretation of results. The effectiveness and acceptability of remote monitoring interventions could be affected by a wide range of participant characteristics, such as age, professional role, educational status, health and digital literacy.[55] Future reviews should report such information as fully as possible, and should signal gaps in the reporting of primary studies, to improve the existing evidence base and help determine the impact of remote monitoring on equity of access to services.

Given the complexity of remote monitoring, detailed description of the included interventions and their variation is essential for readers to make informed decisions about the applicability and reliability of results. Researchers may find the TIDier (template for intervention description and replication) checklist useful,[56] which is specifically designed to improve the reporting of healthcare interventions and could be used in conjunction with other CONSORT tools.

Eighty-two per cent of the reviews failed to report information on the funding of the included studies. Reporting such information is important, as this is an area where technologies may be, and often are, commercially produced. In other areas where this is the case, such as drug trials, sources of funding are routinely reported.

Implications for practice and/or policy

The EGM contains concentrations of evidence synthesis on the effectiveness of remote monitoring that could be used to support the commissioning of remote monitoring interventions by healthcare providers. The COVID-19 pandemic resulted in a rapid shift to the use of remote monitoring and other technologies.[7,8] Although there has been a return to face-to-face provision for many services, the pandemic demonstrated both the potential of such technology and its wider acceptability. The NHS plans to increase the use of remote monitoring in the future,[6] through initiatives such as NHS @ home, which is developing home monitoring programmes for various conditions such as heart and lung

disease. As can be seen in the increasing number of reviews per year in the map, and the continuing reviews noted in *Appendix 3*, further evidence synthesis is likely to be available to support the design and delivery of remote monitoring. That said, it is conceivable that evidence from studies conducted pre-COVID-19 might now be less applicable given the recent scale of uptake and levels of acceptability in some contexts. With the pace of developments in remote monitoring technologies and the post-pandemic shifts in the context of their use, there may be a case for conducting reviews exclusively of more recent studies. This evidence could assist in achieving goals regarding the use of digital technologies, such as those set out in the NHS Long Term Plan[6] and the WHO Global Health Strategy.[5]

Diabetes, cardiovascular and respiratory conditions are some of the most common long-term conditions in the UK.[48] As the greatest quantity of evidence syntheses in the EGM relates to these conditions, the map could be particularly beneficial in supporting the commissioning or delivery of remote monitoring for people with these conditions. The map also contains evidence syntheses on the measurement of different health indicators and the use of different types of device, with many then passing on that data using apps, websites or patient portals. Information on the effectiveness of these different intervention features could be used by those delivering remote monitoring to design interventions with the most suitable features for their target populations.

While the map focuses on patients with long-term physical health conditions, evidence in the included reviews could aid healthcare professionals in supporting multiple aspects of patient's health. Having a long-term physical health condition can have implications for mental health,[57] and there is evidence synthesis in the EGM on the impact of remote monitoring on the mental health of those with physical health conditions, particularly quality of life.

The apparent lack of secondary research on families and carers is a problem for the successful implementation of remote monitoring interventions, as these groups often have the main responsibility for monitoring.[55] While there were fewer reviews reporting on the acceptability or implementation of remote monitoring interventions than on their effectiveness, a number were found, including a realist review,[24] which could be used by healthcare professionals to identify key factors to ensure the successful delivery of these interventions.

Limitations

This is a map of systematic reviews, not trials, which is a strength, as high-quality systematic reviews are usually regarded as better for aiding decision-making. However, only including reviews is also a limitation because we were only able to include evidence for remote monitoring interventions that have been included in a systematic review. While some gaps in the map may be implementation gaps or may indicate a lack of primary research, for others, evidence may be available that has not yet been reviewed. As we did not check for duplication between reviews, the EGM may also misrepresent the true volume of evidence within some categories in the map.

As an umbrella term, eHealth, and terms related to the delivery of health care using technology which fall under it, such as telemedicine, are not used consistently in the literature.[4] Whether they encompassed remote monitoring was dependent on how they were defined by the authors in individual reviews. This meant that, in order not to miss any relevant reviews, we had to search for all relevant terms, with the fact that our database searches found only around half of the potentially relevant studies perhaps reflecting the challenges created by these differences in definitions. As definitions were rarely evident in the abstract, this also resulted in a large volume of literature to screen at full text.

The volume of literature meant that we applied strict inclusion and exclusion criteria; as a result, some relevant evidence may have been excluded. Included reviews were published after 2018, so earlier reviews with relevant information, particularly regarding the implementation of remote monitoring, will

have been excluded. However, there have been considerable advances in technology in recent years, including capabilities that aid the implementation of interventions such as passing data automatically from the device to a healthcare provider. These advances make the findings of older reviews less applicable; for example, older technology might need specialist installation and maintenance, whereas new devices can be used immediately, so the impact of these exclusions is not likely to be significant. We also made the decision to include reviews only when 75% or more of included studies met our inclusion criteria, to ensure most evidence in the EGM is of relevance to users. However, a different cut-off point would change the evidence contained in the map. Despite this comprehensive search, authors often failed to clearly report either their interpretation of remote monitoring or the details of the interventions included in the review. When little information was given, we were inclusive, meaning that some information in the map may relate to interventions that do not fit our definition of remote monitoring.

Last, owing to the priorities expressed by our stakeholders (effectiveness, acceptability and implementation), we did not seek to include reviews of economic or cost-effectiveness evidence relating to remote monitoring interventions in the EGM. Some would regard this as a significant limitation of the evidence that we have summarised, given the cost-saving intentions of some types of remote monitoring, and as systematic reviews of economic evaluations or cost-effectiveness studies have been conducted in conjunction with some of the reviews of effectiveness included in our EGM. This could be addressed if an update of this EGM is conducted in the future.

Equality, diversity and inclusion

As stated in the protocol for this EGM,[34] we aimed to extract data on factors such as age and gender, which might relate to the effectiveness of remote monitoring, from the included systematic reviews. However, inconsistencies in the reporting of these variables between reviews meant that this was not possible. While many meta-analyses included in the EGM conducted subgroup analyses, these focused on condition or length/type of intervention rather than demographic factors. It has been noted that remote monitoring tends to focus on narrow patient populations, rather than considering how factors such as age, gender, ethnicity, income and the intersection of these identities might impact its success.[55] Additionally, health and digital literacy were noted as important by a number of reviews (e.g., refs.[55,58,59]) and need further consideration in research.

Our team was small, making it difficult to ensure diversity across a range of groups; we also did not feel comfortable asking team members to disclose information on diversity unless they wished to share this information. However, we did recruit a PPI group with a range of conditions to inform the review, representing the experience of the varied application of remote monitoring. All team members had experience of producing evidence syntheses, including EGMs, and working with stakeholders and PPI groups to achieve this. The review offered opportunities for the development of skills, through sharing knowledge on the conduct of EGMs for team members who had less experience of producing this form of evidence synthesis and mentoring of junior members by team leads in project management.

Public and patient involvement and engagement

While the topic and focus of the EGM were determined by the policy customers at the start of the project, discussions with the PPI group provided context and developed our understanding of the topic as well as confirming its importance. The input of the group informed the categories included in the data extraction form and the design of the EGM, particularly in improving clarity for non-expert users. Overall, PPI was valuable in improving the EGM; the main difficulty we encountered was with the programme (EPPI-Mapper 4) used to develop the EGM, which meant it was not easy to share in its draft stages.

Chapter 6 Conclusions

This EGM is an accessible and interactive tool that provides a comprehensive overview of recent systematic reviews on the effectiveness, acceptability and implementation of remote monitoring interventions for adults with long-term physical health conditions. It could be used by a wide range of stakeholders (e.g. policy-makers, commissioners, patients, clinicians and researchers) to interrogate the available secondary research evidence and access systematic reviews on specific topics (e.g. remote monitoring using implantable devices). This could support the commissioning and delivery of interventions, while identifying apparent gaps in evidence synthesis, which could inform future research and technology development.

The majority of the included reviews investigate the effectiveness of remote monitoring in patients with CVD, diabetes and chronic respiratory conditions, while the number of reviews on other chronic conditions is limited. Reviews on acceptability and implementation focus almost entirely on the patients' perspective, with only a small number on the perceptions and experiences of carers and healthcare professionals.

More than half of the included reviews have critical methodological flaws so their results should be interpreted cautiously, even when the included primary studies are reported to be of high quality. Many of them provide very scant descriptions of the included interventions, which makes the interpretation of results difficult. Additionally, a lack of consistent reporting on patient characteristics such as age, gender and digital literacy means that it is difficult to assess the impact of remote monitoring on equity of access to services. This may reflect either a lack of application of remote monitoring or its evaluation in specific groups.

Future reviews should:

- adhere more closely to the recommended systematic review methods
- report their methods and findings as fully as possible
- provide detailed description of the included interventions ideally using intervention characteristics such as those listed in the map as a template
- report the effectiveness, acceptability and implementation of remote monitoring in all relevant patient groups or highlight the lack of such evidence
- investigate the application of remote monitoring in chronic conditions for which evidence is missing
- explore acceptability and implementation from a wider range of perspectives.

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Contributions of authors

Siân de Bell (https://orcid.org/0000-0001-7356-3849) (Research Fellow) contributed to the development of the protocol, carried out screening, data extraction and quality appraisal, developed the interactive EGM, led PPI engagement, and led drafting of the final report.

Zhivko Zhelev (https://orcid.org/0000-0002-0106-2401) (Research Fellow) carried out screening, data extraction and quality appraisal, developed the interactive EGM, supported PPI engagement, drafted sections of the report and read, provided feedback on, edited and approved the final version of the report.

Naomi Shaw (https://orcid.org/0000-0001-7387-1809) (Information Specialist) contributed to the development of the protocol, designed and ran the search strategies, carried out citation chasing and managed the bibliographic libraries, drafted sections of the report and read, provided feedback on, edited and approved the final version of the report.

Alison Bethel (https://orcid.org/0000-0002-0963-9201) (Information Specialist) contributed to the development of the protocol, designed and ran the search strategies, carried out citation chasing and managed the bibliographic libraries, drafted sections of the report and read, provided feedback on, edited and approved the final version of the report.

Rob Anderson (https://orcid.org/0000-0002-3523-8559) (Professor of Health Services and Implementation Research) provided overall project management and contributed to the scoping process, refining of research questions and protocol, development of interactive EGM, and read, provided feedback on, edited and approved the final version of the report.

Jo Thompson Coon (https://orcid.org/0000-0002-5161-0234) (Professor of Evidence Synthesis and Health Policy) contributed to the scoping process, refining of research questions and protocol, development of interactive EGM, and read, provided feedback on, edited and approved the final version of the report.

Publications

The evidence and gap map is available at: https://eppi.ioe.ac.uk/cms/Portals/35/Maps/ExeterNIHR/RemoteMonitoring.

Price A, de Bell S, Shaw N, Bethel A, Anderson R, Coon JT. What is the volume, diversity and nature of recent, robust evidence for the use of peer support in health and social care? An evidence and gap map. *Campbell System Rev* 2022;**18**:e1264. https://doi.org/10.1002/cl2.1264

Ethics statement

This was an evidence review, based on published systematic reviews, so did not require ethical approval.

Data-sharing statement

This is an evidence synthesis study based on published systematic reviews. It did not generate new data. All data extracted from the reviews, together with links to each publication, can be found in the evidence and gap map, available at: https://eppi.ioe.ac.uk/cms/Portals/35/Maps/ExeterNIHR/RemoteMonitoring. Further information can be obtained from the corresponding author.

Information governance statement

This study did not involve primary research or therefore the handling of any personal information.

Department of Health and Social Care disclaimer

This report presents independent research commissioned by the National Institute for Health Research (NIHR). The views and opinions expressed by authors in this publication are those of the authors and do not necessarily reflect those of the NHS, the NIHR, Medical Research Council, Central Commissioning Facility, NIHR Evaluation, Trials and Studies Coordinating Centre, the HSDR programme or the Department of Health and Social Care.

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Appendix 1 Inclusion and exclusion criteria

TABLE 5 Detailed eligibility criteria for inclusion in the EGM

Category	Include		Exclude
	Effectiveness	Acceptability/implementation	
Population	Adults (≥ 18 years) with a long-term physical health condition, defined as 'a chronic disease, defined as a physical illness that is prolonged in duration, does not often resolve spontaneously, and is rarely cured completely'.[37] This definition included: - hypertension - survivors of cancer or recipients of organ or stem cell transplants as the consequences associated with these are long term - lower back pain/chronic pain as may have physical cause and require long-term management - Parkinson's, dementia, Alzheimer's and other associated conditions as these are neurological, rather than mental, health conditions		- Populations without a long-term health condition. - Children or young people (< 18 years) with long-term health conditions - Patients with cancer (as this is an acute rather than chronic condition) or terminally ill patients (as the focus of care is different) - Frailty, prediabetes and overweight/obese, as these are risk factors not long-term conditions (additionally, frailty has cognitive as well as physical element) - Pre-eclampsia and gestational diabetes as these conditions usually resolve
Study participants	Adults (≥ 18 years) with a long-term physical health condition	- Adults (≥ 18 years) with a long-term physical health condition - Carers of adult patients - Healthcare professionals providing/using remote monitoring	
Interventions	Interventions must involve delivery of remote monitoring, defined as: 'An intervention, involving the monitoring of a patient (using medical devices, applications, clinical investigation results, or assessment tools), including self-monitoring, and which allows care professionals from a healthcare provider to assess and manage a patient's condition remotely, without the need for the patient to be seen face-to-face'		Interventions not meeting the definition or described poorly enough to preclude assessment of intervention type

TABLE 5 Detailed eligibility criteria for inclusion in the EGM (*continued*)

Category	Include		Exclude
	Effectiveness	**Acceptability/implementation**	**Exclude**
	Include monitoring: - where measurements are taken by a patient or carer - of objective or self-reported health status - occurring in the place where a person lives, either their home or a residential setting such as a care home - using a device or written output, as long as data are transferred to a care professional Include tele-rehabilitation unless it is obvious there is not a remote monitoring element (e.g. the intervention focuses solely on physical exercises) or the intervention is time limited (e.g. following angioplasty) Include if another component is communication with a healthcare provider (e.g. measuring blood pressure and having regular remote consultations)		Exclude studies focusing on: - preventative interventions (e.g. fall prevention) - multicomponent interventions including remote monitoring where the effects of remote monitoring cannot be distinguished from other intervention components (e.g. cognitive behavioural therapy) plus an activity tracker - where measurements are taken by a (paid) healthcare professional - if intervention contains communication with a healthcare provider that is not related to monitoring (e.g. monitoring blood pressure and education on it)
Comparator(s)/ control	Any comparator eligible for inclusion. Examples may include wait-list control or treatment as usual, but there has to be either no remote monitoring or a different level or type of remote monitoring		No exclusion
Outcomes	All reported outcomes on effectiveness are of interest, including: - adverse events caused by the intervention (as an important aspect of effectiveness) - self-efficacy	All reported outcomes on acceptability or implementation are of interest, including: - patient adherence (as an important aspect of implementation, especially for interventions that are essentially self-administered) - intervention fidelity (another aspect of implementation) - patient satisfaction (as a construct/outcome domain that overlaps considerably with acceptability)	Exclude measurement of technical efficacy/aspects of remote monitoring devices, for example diagnostic accuracy of gait analysis using a device compared to a lab-based assessment, as these are not related to effectiveness or acceptability/implementation. Exclude monitoring of outcomes related to acute events (e.g. surgical outcomes) Exclude if only outcomes are economic/ cost effectiveness

continued

TABLE 5 Detailed eligibility criteria for inclusion in the EGM (*continued*)

Category	Include		Exclude
	Effectiveness	**Acceptability/implementation**	**Exclude**
Literature type	Published journal articles; theses; continuing systematic review protocols		Conference abstracts or posters without full details; commentary or conceptual papers; editorials; case studies
Study design	Systematic reviews that aim to evaluate the effectiveness, acceptability and/or implementation of remote monitoring interventions, and which: 1. include a clear and prespecified research question 2. have used a search strategy that is sufficiently clear and detailed to be reproducible 3. have prespecified inclusion/exclusion criteria and screening methods 4. have conducted quality assessment of included studies; and 5. report a clearly described method of data analysis[36] Reviews that contained separate analyses or meta-analyses, where not all were relevant, were included		- Systematic reviews that do not meet our definition of a review - Systematic reviews that do not evaluate effectiveness, acceptability and/or implementation - Scoping reviews that do not follow a systematic methodology (e.g. no methodological quality assessment of the included studies was carried out)
	Systematic reviews including comparative outcome evaluations (randomised and non-randomised controlled trials and other study designs, e.g. controlled before-and-after trials, interrupted time series designs)	Systematic reviews including comparative outcome evaluations, other quantitative designs (e.g. single-arm trials, cohort studies, surveys) and/or qualitative studies	
Date	Only systematic reviews published in 2018 or later were included in the evidence map. The publication date specified in our protocol was systematic reviews with searches conducted in 2012 or later. However, prior to screening we decided to change this to systematic reviews published in 2018 or later, to focus the map on more recent and relevant evidence and avoid unnecessary screening of a large number of records		Systematic reviews with searches conducted prior to 2012
Context	Reviews reported in English (primary studies contained in the reviews may have been reported in other languages)		Reviews not reported in English, due to study team expertise and time, and resources constraints
	Conducted within any high-income countries as defined by the World Bank list as published in 2022 If review includes studies from high-income and low- or middle-income countries, include if majority (75%) is high income		Studies conducted in low- or middle-income countries
Duplicate	If the same study (using the same sample) but different publication (e.g. focus on moderating factors) include both (this is counted as one study with multiple reports)		If it is the same publication published in two sources

Appendix 2 Search strategy and databases

MEDLINE (Ovid; search date 24 March 2022)

Ovid MEDLINE ALL <1946 to March 22, 2022>

1 Remote Sensing Technology/ 3617
2 Telemetry/ 10077
3 Telemedicine/ 32700
4 monitor*.ti,ab. 900789
5 3 and 4 [combined with monitor* as telemedicine/ concept much broader to include remote consultations etc] 4977
6 Monitoring, ambulatory/ 8593
7 Wearable electronic devices/ 5748
8 Fitness trackers/ 986
9 ((remote* or home* or digital or virtual* or telephon* or smartphone* or phone* or smartwatch* or smart watch* or ambulatory or app or apps or mobile* or device* or location* or GPS or global positioning or acceleromet* or gyroscop* or wearable*) adj5 monitor*).ti. 10564
10 ((remote* or home* or digital or virtual* or telephon* or smartphone* or phone* or smartwatch* or smart watch* or ambulatory or app or apps or mobile* or device* or location* or GPS or global positioning or acceleromet* or gyroscop* or wearable*) adj2 monitor*).ab. 21761
11 ((remote* or digital or home*) adj2 (sensor* or sensing or tracker or tracking)).ti,ab. 11072
12 (remote* adj2 (measurement* or supervision or surveillance)).ti,ab. 911
13 "distant patient monitoring". ti,ab. 1
14 (biosensor* or biosensing).ti. 18621
15 ((body or motion or inertia* or wearable* or worn or activity or ingestible* or implant* or insertable or patch* or location* or GPS or global positioning or acceleromet* or gyroscop* or wireless or fitness) adj2 (sensor* or sensing or tracker* or tracking)).ti,ab. 23838
16 ((wearable* or sensing) adj2 (device* or system* or technolog*)).ti,ab. 18640
17 (virtual adj2 (ward* or healthcare or "health care" or hospital* or monitor*)).ti,ab. 474
18 telemonitoring.ti,ab. 1805
19 ((telecare or telemedicine or telemetry or telehealth* or m-health* or mhealth* or e-health* or ehealth* or electronic health*) adj8 monitor*).ti,ab. 3017
20 (assistive technolog* adj5 monitor*).ti,ab. 17
21 (smart home* adj5 monitor*).ti,ab. 74
22 (smart house* adj5 monitor*).ti,ab. 2
23 (home automation adj5 monitor*).ti,ab. 9
24 ("Internet of things" adj5 monitor*).ti,ab. 155
25 (gerontechnolog* adj5 monitor*).ti,ab. 1
26 "electronic patient reported outcome".ti,ab. 173
27 (ePROM or ePROMs or ePRO or ePROs).ti,ab. 274
28 1 or 2 13626
29 or/5-27 108332
30 28 or 29 117401
31 (metaanalysis or meta-analysis or metasynthesis or meta-synthesis).ti,ab. 198936
32 (systematic adj (review or overview or search*)).ti,ab. 228569
33 (systematically adj (review* or search*)).ab. 30524
34 evidence synthesis.ti,ab. 5678
35 thematic synthesis.ti,ab. 1109
36 (evidence adj2 map*).ti,ab. 1170
37 ((scoping or rapid or realist or mapping or umbrella) adj2 review).ti,ab. 16692

38 (qualitative adj2 synthesis).ti,ab. 3925
39 ((mixed-stud* or (mixed adj stud*) or (mixed adj method*) or mixed-method*) adj2 review).ti,ab. 836
40 cochrane.jw. 15903
41 systematic reviews.jn. 2245
42 systematic review/ 189020
43 "review of reviews".ti,ab. 711
44 or/31-43 374135
45 30 and 44 1768
46 limit 45 to yr="2012 -Current" 1603

Embase (Ovid; search date: 24 March 2022)

Embase <1974 to 2022 March 23>

1 Remote Sensing/ [not exploded as satellite imagery is narrower term] 11917
2 Telemetry/ 19178
3 telephone telemetry/ 474
4 exp biotelemetry device/ [includes telemetric capsule, implant, electrocardiogam] 2001
5 telemonitoring/ 4378
6 exp telehealth/ 68732
7 monitor*.ti,ab. 1237541
8 6 and 7 [combined with monitor* as telehealth/ concept much broader to include remote etc] 9619
9 ambulatory monitoring/ 12001
10 exp wearable computer/ [narrower terms include smartwatch and activity tracker] 6151
11 wearable sensor/ 1070
12 ((remote* or home or digital or virtual* or telephon* or smartphone* or phone* or smartwatch* or smart watch* or ambulatory or app or apps or mobile* or device* or location* or GPS or global positioning or acceleromet* or gyroscop* or wearable*) adj5 monitor*).ti. 14606
13 ((remote* or home or digital or virtual* or telephon* or smartphone* or phone* or smartwatch* or smart watch* or ambulatory or app or apps or mobile* or device* or location* or GPS or global positioning or acceleromet* or gyroscop* or wearable*) adj2 monitor*).ab. 32169
14 (home* adj5 monitor*).ti. 2974
15 (home* adj2 monitor*).ab. 5612
16 ((remote* or digital or home*) adj2 (sensor* or sensing or tracker* or tracking)).ti,ab. 10448
17 (remote* adj2 (measurement or supervision or surveillance)).ti,ab. 698
18 "distant patient monitoring".ti,ab. 1
19 (biosensor* or biosensing).ti. 19868
20 ((body or motion or inertia* or wearable* or worn or activity or ingestible* or implant* or insertable or patch* or location* or GPS or global positioning or acceleromet* or gyroscop* or wireless or fitness) adj2 (sensor* or sensing or tracker* or tracking)).ti,ab. 27879
21 (virtual adj2 (ward* or healthcare or "health care" or hospital* or monitor*)).ti,ab. 670
22 telemonitoring.ti,ab. 2720
23 ((telecare or telemedicine or telemetry or telehealth* or m-health* or mhealth* or e-health* or ehealth* or electronic health*) adj8 monitor*).ti,ab. 4680
24 (assistive technolog* adj5 monitor*).ti,ab. 22
25 (smart home* adj5 monitor*).ti,ab. 74
26 (smart house* adj5 monitor*).ti,ab. 2
27 (home automation adj5 monitor*).ti,ab. 7
28 ("Internet of things" adj5 monitor*).ti,ab. 152
29 (gerontechnolog* adj5 monitor*).ti,ab. 1

30 "electronic patient reported outcome".ti,ab. 305
31 (ePROM or ePROMs or ePRO or ePROs).ti,ab. 720
32 or/1-5 37406
33 or/8-31 120065
34 32 or 33 142626
35 (metaanalysis or meta-analysis or metasynthesis or meta-synthesis).ti,ab. 256658
36 (systematic adj (review or overview or search*)).ti,ab. 278501
37 (systematically adj (review* or search*)).ab. 37779
38 evidence synthesis.ti,ab. 6270
39 thematic synthesis.ti,ab. 1252
40 (evidence adj2 map*).ti,ab. 1277
41 ((scoping or rapid or realist or mapping or umbrella) adj2 review).ti,ab. 17807
42 (qualitative adj2 synthesis).ti,ab. 4418
43 ((mixed-stud* or (mixed adj stud*) or (mixed adj method*) or mixed-method*) adj2 review).ti,ab. 890
44 cochrane.jw. 23690
45 systematic reviews.jn. 2268
46 "systematic review"/ 337681
47 exp meta-analysis/ 241798
48 "review of reviews".ti,ab. 818
49 or/35-48 578110
50 34 and 49 2743

CINAHL Complete (EBSCO; search date 24 March 2022)

S45 S29 AND S43 Limiters – Published Date: from 20120101 onwards (1117)
S44 S29 AND S43 (1281)
S43 S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 (220,592)
S42 TI "review of reviews" OR AB "review of reviews" (343)
S41 (MH "Meta Analysis") (61,283)
S40 (MH "Systematic Review") OR (MH "Scoping Review") (111,189)
S39 JN systematic reviews (220)
S38 AB (((mixed-stud*) or (mixed N0 stud*) or (mixed N0 method*) or (mixed-method*)) N2 review) OR TI (((mixed-stud*) or (mixed N0 stud*) or (mixed N0 method*) or (mixed-method*)) N2 review) (666)
S37 AB qualitative N2 synthesis OR TI qualitative N2 synthesis (2438)
S36 AB ((scoping or rapid or realist or mapping or umbrella) N2 review) OR TI ((scoping or rapid or realist or mapping or umbrella) N2 review) (9786)
S35 AB evidence N2 map* OR TI evidence N2 map* (590)
S34 AB thematic synthesis OR TI thematic synthesis (926)
S33 AB evidence synthesis OR TI evidence synthesis (3539)
S32 AB systematically N1 (review* or search*) (13,064)
S31 TI (systematic N1 (review or overview or search*)) OR AB (systematic N1 (review or overview or search*)) (132,543)
S30 TI (metaanalysis or meta-analysis or metasynthesis or meta-synthesis) OR AB (metaanalysis or meta-analysis or metasynthesis or meta-synthesis) (92,251)
S29 S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 (35,725)
S28 AB (ePROM or ePROMS or ePRO or ePROs) OR TI (ePROM or ePROMS or ePRO or ePROs) (123)
S27 AB electronic patient reported outcome* OR TI electronic patient reported outcome* (258)

S26 AB (gerontechnolog*) N5 monitor* OR TI (gerontechnolog*) N5 monitor* (3)
S25 AB ("internet of things") N5 monitor* OR TI ("internet of things") N5 monitor* (32)
S24 AB (home automation) N5 monitor* OR TI (home automation) N5 monitor* (2)
S23 AB (smart house*) N5 monitor* OR TI (smart house*) N5 monitor* (1163)
S22 AB (smart home*) N5 monitor* OR TI (smart home*) N5 monitor* (21)
S21 AB (assistive technolog*) N5 monitor* OR TI (assistive technolog*) N5 monitor* (21)
S20 AB ((telecare or telemedicine or telemetry or telehealth* or m-health* or mhealth* or e-health* or ehealth* or electronic health*) N8 monitor*) OR TI ((telecare or telemedicine or telemetry or telehealth* or m-health* or mhealth* or e-health* or ehealth* or electronic health) N8 monitor*) (1355)
S19 TI telemonitoring OR AB telemonitoring (916)
S18 TI (virtual N3 (ward* or healthcare or "health care" or hospital* or monitor*)) OR AB (virtual N3 (ward* or healthcare or "health care" or hospital* or monitor*)) (690)
S17 TI ((wearable* or sensing) N3 (device* or system* or technolog*)) OR AB((wearable* or sensing) N3 (device* or system* or technolog*)) (2702)
S16 TI ((body or motion or inertia* or wearable* or worn or activity or ingestible* or insertable or implant* or patch* or location* or GPS or global positioning or acceleromet* or gyroscop* or wireless or fitness) N3 (sensor* or tracker*)) OR AB ((body or motion or inertia or wearable* or worn or activity or ingestible* or insertable* or implant* or patch* or location* or GPS or global positioning or acceleromet* or gyroscop* or wireless or fitness) N3 (sensor* or sensing or tracker* or tracking) (5528)
S15 TI (biosensor* or biosensing) OR AB (biosensor* or biosensing) (635)
S14 TI "distant patient monitoring" OR AB "distant patient monitoring" (670)
S13 TI (remote* N3 (measurement* or supervision or surveillance)) OR AB (remote* N3 (measurement* or supervision or surveillance)) (224)
S12 TI ((remote* or digital or home*) N3 (sensor* or sensing or tracker* or tracking)) OR AB ((remote* or digital or home*) N3 (sensor* or sensing or tracker* or tracking)) (898)
S11 AB ((remote* or home* or digital or virtual or telephon* or smartphon* or phone* or smartwatch* or smart watch* or ambulatory or app or apps or mobile* or device* or location* or GPS or global positioning or acceleromet* or gyroscop* or wearable*) N3 monitor*) (9984)
S10 TI ((remote* or home* or digital or virtual or telephon* or smartphon* or phone* or smartwatch* or smart watch* or ambulatory or app or apps or mobile* or device* or location* or GPS or global positioning or acceleromet* or gyroscop* or wearable*) N3 monitor*) (3860)
S9 S1 OR S4 OR S5 OR S6 OR S7 OR S8 (18,509)
S8 S2 AND S3 (2957)
S7 (MH "Fitness Trackers") (284)
S6 (MH "Wearable Sensors+") (6386)
S5 (MH "Blood Pressure Monitoring, Ambulatory") (4018)
S4 (MH "Electrocardiography, Ambulatory") (3312)
S3 TI monitor* OR AB monitor* (172,095)
S2 (MH "Telehealth+") (31,245)
S1 (MH "Telemetry") (2178)

Web of Science Core Collection (Clarivate; search date 24 March 2022)

The web of science core collection includes the following databases: Science Citation Index Expanded; Social Sciences Citation Index; Arts and Humanities Citation Index; Conference Index – Science; Conference Proceedings Citation Index – Social Science and Humanities; and the Emerging Sources Citation Index.

34 #10 AND #30 and 2022 or 2021 or 2020 or 2019 or 2018 or 2017 or 2016 or 2015 or 2014 or 2013 or 2012 (Publication Years) and Chemistry Analytical or Geosciences Multidisciplinary or Physics

Applied or Ecology or Biodiversity Conservation or Water Resources or Environmental Studies or Meteorology Atmospheric Sciences or Engineering Civil or Forestry or Green Sustainable Science Technology or Geochemistry Geophysics or Electrochemistry or Construction Building Technology or Energy Fuels or Plant Sciences or Engineering Industrial or Food Science Technology or Geography or Marine Freshwater Biology or Zoology or Agronomy or Veterinary Sciences or Agriculture Dairy Animal Science or Agriculture Multidisciplinary or Polymer Science or Physics Condensed Matter or Chemistry Inorganic Nuclear or Engineering Manufacturing or Mathematics Applied or Oceanography or Regional Urban Planning or Urban Studies or Engineering Chemical or Physics Multidisciplinary or Soil Science or Astronomy Astrophysics or Chemistry Applied or Engineering Mechanical or Geology or Limnology or Materials Science Ceramics or Metallurgy Metallurgical Engineering or Mathematics or Physics Atomic Molecular Chemical or Agricultural Economics Policy or Archaeology or Architecture or Crystallography or Engineering Geological or Entomology or Fisheries or Folklore or Industrial Relations Labor or Ornithology or Paleontology or Mining Mineral Processing or Physics Fluids Plasmas or Physics Mathematical or Transportation or Transportation Science Technology (Exclude – Web of Science Categories) and Environmental Sciences (Exclude – Web of Science Categories) and Geography Physical or Materials Science Multidisciplinary or Mathematical Computational Biology (Exclude – Web of Science Categories) 1729

33 #10 AND #30 and 2022 or 2021 or 2020 or 2019 or 2018 or 2017 or 2016 or 2015 or 2014 or 2013 or 2012 (Publication Years) 2350
32 #10 AND #30 2638
31 #10 AND #30 2638
30 #11 OR #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 OR #29 481,603
29 ((remote* or home* or digital or virtual* or telephon* or smartphone* or phone* or smartwatch* or "smart watch" or ambulatory or app or apps or mobile* or device* or location* or GPS or "global positioning" or acceleromet* or gyroscop* or wearable*) NEAR/5 monitor*) (Title) 26,217
28 ((remote* or home* or digital or virtual* or telephon* or smartphone* or phone* or smartwatch* or "smart watch" or ambulatory or app or apps or mobile* or device* or location* or GPS or "global positioning" or acceleromet* or gyroscop* or wearable*) NEAR/2 monitor*) (Abstract) 54,920
27 ((remote* or digital or home*) NEAR/2 (sensor* or sensing or tracker or tracking)) (Title) or ((remote* or digital or home*) NEAR/2 (sensor* or sensing or tracker or tracking)) (Abstract) 143,327
26 (remote* NEAR/2 (measurement* or supervision or surveillance)) (Title) or (remote* NEAR/2 (measurement* or supervision or surveillance)) (Abstract) 7137
25 "distant patient monitoring" (Title) or "distant patient monitoring" (Abstract) 5
24 biosensor* or biosensing (Title) 38,864
23 ((body or motion or inertia* or wearable* or worn or activity or ingestible* or implant* or insertable or patch* or location* or GPS or "global positioning" or acceleromet* or gyroscop* or wireless or fitness) NEAR/2 (sensor* or sensing or tracker* or tracking)) (Title) or ((body or motion or inertia* or wearable* or worn or activity or ingestible* or implant* or insertable or patch* or location* or GPS or "global positioning" or acceleromet* or gyroscop* or wireless or fitness) NEAR/2 (sensor* or sensing or tracker* or tracking)) (Abstract) 172,971
22 ((wearable* or sensing) NEAR/2 (device* or system* or technolog*)) (Title) or ((wearable* or sensing) NEAR/2 (device* or system* or technolog*)) (Abstract) 82,883
21 (virtual NEAR/2 (ward* or healthcare or "health care" or hospital* or monitor*)) (Title) or (virtual NEAR/2 (ward* or healthcare or "health care" or hospital* or monitor*)) (Abstract) 1,848
20 telemonitoring (Title) or telemonitoring (Abstract) 2478
19 ((telecare or telemedicine or telemetry or telehealth* or m-health* or mhealth* or e-health* or ehealth* or "electronic health" or "electronic healthcare") NEAR/8 monitor*) (Title) or ((telecare or telemedicine or telemetry or telehealth* or m-health* or mhealth* or e-health* or ehealth* or "electronic health" or "electronic healthcare") NEAR/8 monitor*) (Abstract) 5071
18 (assistive technolog* NEAR/5 monitor*) (Title) or (assistive technolog* NEAR/5 monitor*) (Abstract) 48
17 (smart home* NEAR/5 monitor*) (Title) or (smart home* NEAR/5 monitor*) (Abstract) 654

16 (smart house* NEAR/5 monitor*) (Title) or (smart house* NEAR/5 monitor*) (Abstract) 32
15 (home automation NEAR/5 monitor*) (Title) or (home automation NEAR/5 monitor*) (Abstract) 200
14 ("Internet of things" NEAR/5 monitor*) (Title) or ("Internet of things" NEAR/5 monitor*) (Abstract) 1880
13 (gerontechnolog* NEAR/5 monitor*) (Title) or (gerontechnolog* NEAR/5 monitor*) (Abstract) 1
12 "electronic patient reported outcome" (Title) or "electronic patient reported outcome" (Abstract) 217
11 ePROM or ePROMs or ePRO or ePROs (Title) or ePROM or ePROMs or ePRO or ePROs (Abstract) 958
10 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 524,827
9 metaanalysis or meta-analysis or metasynthesis or meta-synthesis (Title) or metaanalysis or meta-analysis or metasynthesis or meta-synthesis (Abstract) 260,900
8 systematic NEAR/1 (review or overview or search*) (Title) or systematic NEAR/1 (review or overview or search*) (Abstract) 303,005
7 systematically NEAR/1 (review* or search*) (Abstract) 36,013
6 TI = (evidence synthesis or "review of reviews") OR AB = (evidence synthesis or "review of reviews") 70,987
5 thematic synthesis (Title) or thematic synthesis (Abstract) 2610
4 evidence NEAR/2 map* (Title) or evidence NEAR/2 map* (Abstract) 2847
3 TI=(((scoping or rapid or realist or mapping or umbrella) NEAR/2 review)) OR AB = (((scoping or rapid or realist or mapping or umbrella) NEAR/2 review)) 24,788
2 (qualitative NEAR/2 synthesis) (Title) or (qualitative NEAR/2 synthesis) (Abstract) 4813
1 ((mixed-stud* or mixed-method*) NEAR/2 review) (Title) or ((mixed-stud* or mixed-method*) NEAR/2 review) (Abstract) 1183

Scopus (Elsevier; search date 30 March 2022)

Restricted to: medicine, computer science, engineering, biochem, health professions, social sciences, psychology, pharmacy, immunology, dentistry

(((TITLE-ABS((telecare OR telemedicine OR telemetry OR telehealth* OR m-health* OR mhealth* OR e-health* OR ehealth* OR "electronic health*") W/8 monitor*))) and (((TITLE-ABS({review of reviews}))) or ((TITLE-ABS((mixed-stud* OR (mixed W/1 stud*) OR (mixed W/1 method*) OR mixed-method*) W/2 review))) or ((TITLE-ABS(qualitative W/2 synthesis))) or ((TITLE-ABS(evidence W/2 map*))) or ((TITLE-ABS({thematic synthesis}))) or ((TITLE-ABS({evidence synthesis}))) or ((ABS(systematically W/1 (review* OR search*)))) or ((TITLE-ABS(systematic W/1 (review OR overview OR search*)))) or ((TITLE({metaanalysis} OR {meta-analysis} OR {metasynthesis} OR {meta-synthesis}))))) or ((((TITLE(virtual W/2 (monitor*)))) or ((TITLE-ABS(virtual W/2 ("health care")))) or ((TITLE-ABS(virtual W/2 (healthcare)))) or ((TITLE-ABS(virtual W/2 (ward*)))) or ((TITLE-ABS(virtual W/2 (ward* OR healthcare OR "health care" OR hospital* OR monitor*)))) or ((TITLE-ABS({telemonitoring}))) or ((TITLE-ABS("assistive technolog*" W/5 monitor*))) or ((TITLE-ABS("smart home*" W/5 monitor*))) or ((TITLE-ABS("smart house*" W/5 monitor*))) or ((TITLE-ABS("home automation" W/5 monitor*))) or ((TITLE-ABS("Internet of things" W/5 monitor*))) or ((TITLE-ABS(gerontechnolog* W/5 monitor*))) or ((TITLE-ABS({electronic patient reported outcome}))) or ((TITLE-ABS({ePROM} OR {ePROMs} OR {ePRO} OR {ePROs})))) and (((TITLE-ABS({review of reviews}))) or ((TITLE-ABS((mixed-stud* OR (mixed W/1 stud*) OR (mixed W/1 method*) OR mixed-method*) W/2 review))) or ((TITLE-ABS(qualitative W/2 synthesis))) or ((TITLE-ABS(evidence W/2 map*))) or ((TITLE-ABS({thematic synthesis}))) or ((TITLE-ABS({evidence synthesis}))) or ((ABS(systematically W/1 (review* OR search*)))) or ((TITLE-ABS(systematic W/1 (review OR overview OR search*)))) or ((TITLE({metaanalysis} OR {meta-analysis} OR {metasynthesis} OR {meta-synthesis}))))) or ((((TITLE-ABS({review of reviews}))) or ((TITLE-ABS((mixed-stud* OR (mixed W/1 stud*) OR (mixed W/1 method*) OR mixed-method*) W/2 review))) or ((TITLE-ABS(qualitative W/2 synthesis))) or ((TITLE-ABS(evidence W/2 map*))) or ((TITLE-ABS({thematic synthesis}))) or ((TITLE-ABS({evidence synthesis}))) or ((ABS(systematically W/1 (review* OR search*)))) or ((TITLE-ABS(systematic W/1 (review

OR overview OR search*)))) or ((TITLE({metaanalysis} OR {meta-analysis} OR {metasynthesis} OR {meta-synthesis}))))) and ((TITLE((remote* OR home* OR digital OR virtual* OR telephon* OR smartphone* OR phone* OR smartwatch* OR "smart watch*" OR ambulatory OR app OR apps OR mobile* OR device* OR location* OR GPS OR "global positioning" OR acceleromet* OR gyroscop* OR wearable*) W/5 (monitor*))))) or ((((TITLE-ABS({review of reviews})))) or ((TITLE-ABS((mixed-stud* OR (mixed W/1 stud*) OR (mixed W/1 method*) OR mixed-method*) W/2 review))) or ((TITLE-ABS(qualitative W/2 synthesis))) or ((TITLE-ABS(evidence W/2 map*))) or ((TITLE-ABS({thematic synthesis})))) or ((TITLE-ABS({evidence synthesis})))) or ((ABS(systematically W/1 (review* OR search*)))) or ((TITLE-ABS(systematic W/1 (review OR overview OR search*)))) or ((TITLE({metaanalysis} OR {meta-analysis} OR {metasynthesis} OR {meta-synthesis}))))) and ((ABS((home* OR digital OR virtual* OR telephon* OR smartphone* OR phone* OR smartwatch* OR "smart watch*" OR ambulatory OR app OR apps OR mobile* OR location* OR GPS OR "global positioning" OR acceleromet* OR gyroscop* OR wearable*) W/2 (monitor*))))) or ((((TITLE-ABS({review of reviews})))) or ((TITLE-ABS((mixed-stud* OR (mixed W/1 stud*) OR (mixed W/1 method*) OR mixed-method*) W/2 review))) or ((TITLE-ABS(qualitative W/2 synthesis))) or ((TITLE-ABS(evidence W/2 map*))) or ((TITLE-ABS({thematic synthesis})))) or ((TITLE-ABS({evidence synthesis})))) or ((ABS(systematically W/1 (review* OR search*)))) or ((TITLE-ABS(systematic W/1 (review OR overview OR search*)))) or ((TITLE({metaanalysis} OR {meta-analysis} OR {metasynthesis} OR {meta-synthesis}))))) and ((TITLE-ABS((remote* OR digital OR home*) W/2 (sensor* OR sensing OR tracker OR tracking))))) or ((((TITLE-ABS({review of reviews})))) or ((TITLE-ABS((mixed-stud* OR (mixed W/1 stud*) OR (mixed W/1 method*) OR mixed-method*) W/2 review))) or ((TITLE-ABS(qualitative W/2 synthesis))) or ((TITLE-ABS(evidence W/2 map*))) or ((TITLE-ABS({thematic synthesis})))) or ((TITLE-ABS({evidence synthesis})))) or ((ABS(systematically W/1 (review* OR search*)))) or ((TITLE-ABS(systematic W/1 (review OR overview OR search*)))) or ((TITLE({metaanalysis} OR {meta-analysis} OR {metasynthesis} OR {meta-synthesis}))))) and ((TITLE-ABS((body OR motion OR inertia* OR wearable* OR worn OR activity OR ingestible* OR implant* OR insertable OR patch* OR location* OR GPS OR "global positioning" OR acceleromet* OR gyroscop* OR wireless OR fitness) W/2 (sensor* OR sensing OR tracker* OR tracking))))) AND (LIMIT-TO (PUBYEAR,2022) OR LIMIT-TO (PUBYEAR,2021) OR LIMIT-TO (PUBYEAR,2020) OR LIMIT-TO (PUBYEAR,2019) OR LIMIT-TO (PUBYEAR,2018) OR LIMIT-TO (PUBYEAR,2017) OR LIMIT-TO (PUBYEAR,2016) OR LIMIT-TO (PUBYEAR,2015) OR LIMIT-TO (PUBYEAR,2014) OR LIMIT-TO (PUBYEAR,2013) OR LIMIT-TO (PUBYEAR,2012)) AND (LIMIT-TO (SUBJAREA,"MEDI") OR LIMIT-TO (SUBJAREA,"COMP") OR LIMIT-TO (SUBJAREA,"ENGI") OR LIMIT-TO (SUBJAREA,"BIOC") OR LIMIT-TO (SUBJAREA,"HEAL") OR LIMIT-TO (SUBJAREA,"SOCI") OR LIMIT-TO (SUBJAREA,"PSYC") OR LIMIT-TO (SUBJAREA,"PHAR") OR LIMIT-TO (SUBJAREA,"IMMU") OR LIMIT-TO (SUBJAREA,"DENT"))

Cochrane Database of Systematic Reviews (Wiley; search date 28 March 2022)

www.cochranelibrary.com

Custom date range: from 01/01/2012 onwards

#1 MeSH descriptor: [Remote Sensing Technology] explode all trees
#2 MeSH descriptor: [Telemetry] explode all trees
#3 MeSH descriptor: [Telemedicine] explode all trees
#4 (monitor*):ti,ab,kw
#5 #3 AND #4
#6 MeSH descriptor: [Monitoring, Ambulatory] explode all trees
#7 MeSH descriptor: [Wearable Electronic Devices] explode all trees
#8 MeSH descriptor: [Fitness Trackers] explode all trees
#9 ((remote* or home* or digital or virtual or telephon* or smartphon* or phone* or smartwatch* or smart watch* or ambulatory or app or apps or mobile* or device* or location* or GPS or global positioning or acceleromet* or gyroscop* or wearable*) near/2 monitor*):ti,ab,kw
#10 ((remote or digital or home*) near/2 (sensor* or sensing or tracker* or tracking)):ti,ab,kw

#11 (remote* near/2 (measurement* or supervision or surveillance)):ti,ab,kw
#12 ("distant patient monitoring"):ti,ab,kw
#13 (biosensor* or biosensing):ti
#14 ((body or motion or inertia* or wearable* or worn or activity or ingestible* or insertable or implant* or patch* or location* or GPS or global positioning or gyroscop* or wireless or fitness) near/2 (sensor* or sensing or tracker* or tracking)):ti,ab,kw
#15 ((wearable* or sensing) near/2 (device* or system* or technolog*)):ti,ab,kw
#16 (virtual near/2 (ward* or healthcare or "health care" or hospital* or monitor*)):ti,ab
#17 telemonitoring:ti,ab,kw
#18 ((telecare or telemedicine or telemetry or telehealth* or m-health* or mhealth* or e-health* or ehealth* or electronic health*) near/8 monitor*):ti,ab,kw
#19 ((assistive technolog*) near/5 monitor*):ti,ab,kw
#20 ((smart home*) near/5 monitor*):ti,ab,kw
#21 ((smart house*) near/5 monitor*):ti,ab,kw
#22 (("home automation") near/5 monitor*):ti,ab,kw
#23 (("internet of things") near/5 monitor*):ti,ab,kw
#24 (gerontechnolog* near/5 monitor*):ti,ab,kw
#25 "electronic patient reported outcome":ti,ab,kw
#26 (ePROM or ePROMs or ePRO or ePROs):ti,ab,kw
#27 #1 or #2 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 (113, limited to 1/1/2012: 97)

PROSPERO (Centre for Reviews and Dissemination, University of York; search date 28 March 2022)

www.crd.york.ac.uk/prospero

#1 MeSH DESCRIPTOR Remote Sensing Technology EXPLODE ALL TREES 1
#2 MeSH DESCRIPTOR Telemetry EXPLODE ALL TREES 4
#3 MeSH DESCRIPTOR Telemedicine EXPLODE ALL TREES 724
#4 monitor* 7031
#5 #3 AND #4 199
#6 MeSH DESCRIPTOR Monitoring, Ambulatory EXPLODE ALL TREES 59
#7 MeSH DESCRIPTOR Wearable Electronic Devices EXPLODE ALL TREES 105
#8 MeSH DESCRIPTOR Fitness Trackers EXPLODE ALL TREES 28
#9 (((remote* or home* or digital or virtual* or telephon* or smartphon* or phone* or smartwatch* or smart watch* or ambulatory or app or apps or mobile* or device* or location* or GPS or global positioning or acceleromet* or gyroscop* or wearable*) AND monitor*)):TI 132
#10 (((remote* or digital or home*) AND (sensor* or sensing or tracker* or tracking))):TI 11
#11 (((remote*) AND (measurement* or supervision or surveillance))):TI 7
#12 ("distant patient monitoring"):TI 0
#13 "distant patient monitoring" 0
#14 (biosensor or biosensing):TI 2
#15 (((body or motion or inertia* or wearable* or worn or activity or ingestible* or implant* or insertable or patch* or location* or GPS or global positioning or acceleromet* or gyroscop* or wireless or fitness) AND (sensor* or sensing or tracker* or tracking))):TI 84
#16 (((wearable* or sensing) AND (device* or system* or technolog*))):TI 144
#17 ((virtual AND (ward* or healthcare or health care or hospital* or monitor*))):TI 18
#18 telemonitoring 163
#21 ((telecare or telemedicine or telemetry or telehealth* or m-health* or mhealth* or e-health* or ehealth* or electronic health*) AND monitor*):TI 8
#22 "assistive technology" AND monitor* 23

#23 smart home* AND monitor* 10
#24 smart house* AND monitor* 1
#27 home automation AND monitor* 1
#30 "internet of things" AND monitor* 10
#33 gerontechnolog* AND monitor* 4
#36 "electronic patient reported outcome" 11
#39 eprom or eproms or epro or epros 14
#42 #1 OR #2 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #21 OR #22 OR #23 OR #24 OR #27 OR #30 OR #33 OR #36 OR #39 753

OT Seeker (search date 30 March 2022)

www.otseeker.com

Total records: 49

Any Field: remote* AND Method: Systematic Review: 12
Any Field: wearable* AND Method: Systematic Review: 3
Any Field: telemonitoring AND Method: Systematic Review: 4
Any Field: telemetry AND Method: Systematic Review 1
Any Field: telecare AND Method: Systematic Review: 11
Any Field: telemedicine AND monitor* AND Method: Systematic Review: 5
Any Field: telehealth* AND monitor* AND Method: Systematic Review 0
Any Field: ehealth* AND monitor* AND Method: Systematic review 2
Any Field: e-health* AND monitor* AND Method: Systematic Review 3
Any Field: mhealth* AND monitor* AND Method: Systematic Review 0
Any Field: m-health* AND monitor* AND Method: Systematic Review 6
Any Field: virtual AND monitor* AND Method: Systematic Review 2
Any Field: virtual AND ward* AND Method: Systematic Review 0
Any Field: biosensor* AND Method: Systematic Review 0

PEDro (search date 28 March 2022)

https://pedro.org.au

Total: 125 records (not deduplicated)

Title/Abstract: remote* AND Method: Systematic Review 47
Title/Abstract: wearable* AND Method: Systematic Review: 35
Title/Abstract: telemonitoring AND Method: Systematic Review: 12
Title/Abstract: telemetry AND Method: Systematic Review 2
Title/Abstract: telecare AND Method: Systematic Review 0
Title/Abstract: telemedicine monitor* AND Method: Systematic Review 4
Title/Abstract: telehealth* monitor* AND Method: Systematic Review 4
Title/Abstract: ehealth* monitor* AND Method: Systematic review 7
Title/Abstract: e-health* monitor* AND Method: Systematic Review 3
Title/Abstract: mhealth* monitor* AND Method: Systematic Review 4
Title/Abstract: m-health* monitor* AND Method: Systematic Review 2
Title/Abstract: virtual monitor* AND Method: Systematic Review 5
Title/Abstract: virtual ward* AND Method: Systematic Review 0
Title/Abstract: biosensor* AND Method: Systematic Review 0

ProQuest Dissertations and Theses Global (search date 31 March 2022)

(title(qualitative NEAR/2 synthesis) OR abstract(qualitative NEAR/2 synthesis) OR abstract((mixed-stud* or mixed-method*) NEAR/2 (review)) OR title((mixed-stud* or mixed-method*) NEAR/2 (review)) OR title((scoping or rapid or realist or mapping or umbrella) NEAR/2 (review)) OR abstract((scoping or rapid or realist or mapping or umbrella) NEAR/2 (review)) OR (abstract(evidence NEAR/2 map*) OR title(evidence NEAR/2 map*)) OR (abstract(thematic synthesis) OR title(thematic synthesis)) OR (abstract(evidence synthesis or "review of reviews") OR title(evidence synthesis or "review of reviews")) OR abstract((systematically) NEAR/1 (review* or search)) OR abstract((systematic) NEAR/1 (review or overview or search*)) OR title((systematic) NEAR/1 (review or overview or search*)) OR (title(metaanalysis or meta-analysis or metasynthesis or meta-synthesis) OR abstract(metaanalysis or meta-analysis or metasynthesis or meta-synthesis))) AND ((title(remote* OR home* OR digital OR virtual* OR telephon* OR smartphone* OR phone* OR smartwatch* OR "smart watch" OR ambulatory OR app OR apps OR mobile* OR device* OR location* OR GPS OR "global positioning" OR acceleromet* OR gyroscop* OR wearable*) AND (title(monitor* OR sensor* OR sensing OR tracker OR tracking) OR abstract(monitor* OR sensor* OR sensing OR tracker OR tracking))) OR (title(measurement* OR supervision OR surveillance) AND title(remote*)) OR title(sensor* OR sensing OR tracker* OR tracking) OR title(wearable*) OR (abstract(wearable*) AND abstract(device* OR system* OR technolog*)) OR (title(telecare OR telemedicine OR telemetry OR telehealth* OR m-health* OR mhealth* OR e-health* OR ehealth* OR "electronic health" OR "electronic healthcare") AND title(monitor*)) OR (abstract(telecare OR telemedicine OR telemetry OR telehealth* OR m-health* OR mhealth* OR e-health* OR ehealth* OR "electronic health" OR "electronic healthcare") AND abstract(monitor*)))

Epistemonikos (search date 30 March 2022)

www.epistemonikos.org/

TABLE 6 Search strategy table

Advanced search	All results	Systematic reviews	Broad synthesis
Title/abstract: (remote*) and (monitor* or track* or sens*)	2850	395	39
wearable AND title/abstract (monitor* or track* or sens*)	362	165	8
Title/abstract: telemonit*	394	87	6
Title: Telemetry	47	6	0
Title: telecare	112	15	0
Title: Telemed*	2640	353	55
Title: Telehealth*	1708	284	46
Title: ehealth*	385	201	25
Title: mhealth	406	183	16
Title: "mobile health"	474	199	13
Title: m-health	38	13	0
Title: Virtual and (monitor* or track* or sens*)	40	6	0
Title: Virtual AND (ward* or clinic*)	319	36	2
Biosens*	335	18	0

Total: 2171

Duplicates and pre-2012 removed: 376

Copied across: 1795

Google Scholar (search date: 30 March 2022)

Searched via Publish or Perish (Harzing)
Google Scholar (all in title) using Publish or Perish
Remote monitoring and systematic review = 46
Wearable and systematic = 164
Mobile and health and systematic = 235
De-duped in separate library
383 records copied to main EndNote library

Appendix 3 List of continuing systematic reviews

Continuing reviews have been categorised according the patient population of focus, using the categories defined in the EGM (reviews with multiple patient populations can be found under 'Not clearly defined/reported').

Cardiovascular disease (36)

Al-Abdouh A, Mahmoud B, Jabri A. Efficacy of implanted device telemonitoring in patients with heart failure: a meta-analysis of randomized controlled trials. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=238122

Azmi Nabila KA, Noor MI, Wibowo RA, Sofro ZM. Evaluating the effectiveness of telemonitoring in primary hypertension management: a systematic review and meta-analysis. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=268119

Brahmbhatt D, Cowie M, Gallagher A. Facilitators and barriers to effective remote monitoring of heart failure patients using cardiovascular implantable electronic devices. PROSPERO 2018. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=100043

Calderon EHC. Effect of remote monitoring of implantable cardiac pacemakers. A systematic review and meta-analysis of randomized controlled trials. PROSPERO 2020. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=203615

Cheong A, Xu F, Wang S. Outcomes in patients with CIEDs followed up via remote monitoring: a systematic review and meta-analysis. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=277010

de Barros K, Martins MAP, Praxedes M, Ribeiro ALP. Effectiveness and usability of mobile health applications for medication adherence in patients with heart failure: a systematic review protocol. *JBI Evid Synth* 2021;**19**:2777–82. https://doi.org/10.11124/JBIES-20-00399

Fatrin S, Auliani S, Pratama S, Margaret SP, Brunner TM, Siswanto BB. Outcome of telemedicine in heart failure patients. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=271540

Hwang M, Aekyung Chang A. The effect of nurse-led digital health intervention for patient with hypertension: a systematic review and meta-analysis. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=2

Igai Y, Negishi Y, Kato E, Ishikawa K, Harada T, Kamei T. Effectiveness of telemonitoring by healthcare providers on health outcomes for patients with chronic heart failure: a systematic review and meta-analysis. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=237639

Jin K, Hafiz N. Evidences on the cardiovascular benefits in the use of wearable devices in adults with cardiovascular disease? PROSPERO 2019. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=162045

Kelly S, Wells G. Qualitative synthesis of patient- and healthcare provider-reported barriers to virtual follow-up and care models for patients with cardiovascular implantable electronic devices. PROSPERO 2020. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=160533

Koo K, Ferguson C, Liang-Han L, Cleland J, Inglis S. Implantable device monitoring versus usual care for managing individuals with heart failure [Cochrane protocol]. PROSPERO 2019. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=148354

Lee WL, Syazwani N, Zulfazli I, Suhaimi RA. A systematic review protocol on the use and the effectiveness of wearable electronic activity tracking system (EATs) for patients with coronary heart disease

undergoing cardiac rehabilitation program. PROSPERO 2018. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=106366

Maximidou T, Mons U. Impact of wearable activity trackers on the prognosis of coronary artery disease – a systematic review and meta-analysis of randomized controlled trials. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=252651

McGee M, Ray M, Sverdlov A. Benefits of remote monitoring in patients with cardiac implantable electronic devices who have heart failure: systematic review. PROSPERO 2019. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=129270

Mikulski B, De Marchi A. Effects of using mHealth apps on medication adherence in patients with arterial hypertension. PROSPERO 2020. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=205973

Moura Dantas de Lima T, da Silva de Lima e Silva EH, Santos da Costa MG. Systematic review of remote monitoring in patients with implantable cardioverter defibrillator (ICD) with ventricular arrhythmia. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=242864

Nagy KV, Hernandez-Montfort J, Al-Hussaini A, Stafylas P. Contemporary non-invasive remote monitoring longitudinal impact in adults with chronic systolic heart failure related hospital admissions: systematic review and meta-analysis. PROSPERO 2019. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=145815

Ogbu I, Dota A. Remote pulmonary artery hemodynamic monitoring in chronic heart failure: Systematic review and meta-analysis. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=261416

Patel H, King-Shier K, Hayden A. A systematic review of wearable monitoring technology for heart failure management. PROSPERO 2020. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=209743

Pei X. The effectiveness of telemedicine interventions in high blood pressure monitoring: a systematic review and meta-analysis. PROSPERO 2020. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=211461

Rebolledo Del Toro M, Muñoz Velandia OM, García Peña AA, Fernández Ávila DG, Barahona Correa JE, Herrera Leaño NM. Effectiveness of mobile telemonitoring applications in heart failure patients. PROSPERO 2022. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=299516

Reis L, Mesquita E, Carraro A, Périssé L, Neto N, Rodrigues T, *et al.* Telemedicine in heart failure during the pandemic: a systematic review. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=224057

Scholte N, Gürgöze M, Aydin D, van der Boon R, Brugts J, Boersma E. Effects of non-invasive and invasive telemonitoring on heart failure outcomes: a state-of-the-art systematic review and meta-analysis. PROSPERO 2022. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=306677

Srigati SA, Aliyah SF, Aryasatya DWB. The impact of telemedicine for heart failure management during COVID-19 pandemic: a systematic review of cohort studies. PROSPERO 2022. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=306241

Somberg C, Eastland T, Allen J, Schooley A. Effect of nurse-led telehealth on rehospitalization and quality of life among community-dwelling adults with heart failure: a quantitative systematic review protocol. PROSPERO 2022. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=313122

Thanigaimani S, Golledge J. Systematic review of sensors and wearables to improve walking performance in peripheral artery disease. PROSPERO 2022. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=308138

Tourais Matos Sousa JM, Moreira E, Sousa Pinto BS, Viana Pinto J, Pinto R, Azevedo LF, *et al.* Effectiveness of non-invasive home telemonitoring in outpatient care for patients with heart failure: a systematic review and meta-analysis. PROSPERO 2019. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=146396

Tourais Matos Sousa JM, Silva Cardoso JS, Azevedo LF, Moreira RPE. The effectiveness of non-invasive home telemonitoring in outpatient care for patients with heart failure: a systematic review. PROSPERO 2018. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=88522

Veres B, Schwertner W, Kiss B, Engh M, Kosztin A, Merkely B. Continuous invasive remote monitoring in patients with heart failure compared to regular in-clinic follow-up: A systematic review and meta-analysis. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=299820

Warraich H, Maqsood MH. Telemonitoring in heart failure patients: an updated systematic review and meta-analysis. PROSPERO 2020. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=184381

Wireklint Sundstroem B, Josephsson H, Olofsson S. Patient participation in self-monitoring in case of heart failure and home-based care, by means of patient experiences: a integrative systematic review. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=244252

Wu Y, Zhao P, Li W, Cao MQ, Du L, Chen JC. The effect of remote health intervention based on internet or mobile communication network on hypertension patients: protocol for a systematic review and meta-analysis of randomized controlled trials. *Medicine (Baltimore)* 2019;**98**:e14707. https://doi.org/10.1097/MD.0000000000014707

Yong J. Effects of wearable devices in adults with cardiovascular disease: a systematic review and meta-analysis of randomized controlled trials. PROSPERO 2020. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=186489

Zhiqiang Wang Z, Jin X, Tang Z, Kang Y. The practical effect of remote cardiac rehabilitation technology on patients with heart disease. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=271283

Zito A, Princi G, Romiti GF. Remote monitoring strategies for guided management of patients with heart failure: a systematic review and meta-analysis. PROSPERO 2022. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=308167

Neurological conditions (8)

de Barros Gonze B, di Paschoale Ostolin TLV. Effectiveness of telehealth oriented to the attention and care of adults with neurological diseases before and during the COVID-19 pandemic: a systematic review. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=250334

Gebrye T, Fatoye F, Anazodo C. Effect of tele-rehabilitation on quality of life in stroke patients: a systematic review and meta analysis. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=295888

Harris P. Factors influencing physical activity sensor use for self-management in stroke patients and older at-risk adults – a systematic review and thematic synthesis. PROSPERO 2020. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=211472

Quel de Oliveira C, Scianni A, Vehagen A. Telerehabilitation to improve functional outcomes in individuals with neurological conditions. PROSPERO 2020. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=160327

Seri E, Bilotta F. Technology-assisted clinical management of brain injured patients after hospital discharge. PROSPERO 2021. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=255515

Wade R, Simmonds M, Meader N, Fulbright H. Devices for remote continuous monitoring of people with Parkinson's disease: a systematic review and economic analysis. PROSPERO 2022. URL: www.crd.york.ac.uk/prospero/display_record.php?RecordID=308597

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Appendix 4 Adaptations to and results of AMSTAR 2 assessment

TABLE 7 AMSTAR 2 questions for quality appraisal, including adaptations for different study designs and chosen critical domains

	Quantitative comparative outcome evaluations (e.g. RCTs)	Other quantitative studies (e.g. single-arm evaluations, survey studies)	Qualitative
1	Did the research questions and inclusion criteria for the review include the components of PICO?	Did the review have a clear research question and inclusion criteria?	
2**	Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?		
3	Did the review authors explain their selection of the study designs for inclusion in the review?		
4**	Did the review authors use a comprehensive literature search strategy?		
5	Did the review authors perform study selection in duplicate?		
6	Did the review authors perform data extraction in duplicate?		
7	Did the review authors provide a list of excluded studies and justify the exclusions?		
8**	Did the review authors describe the included studies in adequate detail?		
9**	Did the review authors use a satisfactory technique for assessing RoB in individual studies that were included in the review?	Did the review authors use a satisfactory technique for assessing the methodological limitations of individual studies that were included in the review?	
10	Did the review authors report on the sources of funding for the studies included in the review?		
11	If a synthesis was performed, did the review authors use appropriate methods to combine the results of individual studies?		
12	If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	Not applicable	
13	Did the review authors account for RoB in individual studies when interpreting/discussing the results of the review?	Did the review authors account for methodological limitations in individual studies when interpreting/discussing the results of the review?	
14**	Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?	Did the review authors provide a satisfactory explanation for, and discussion of, variations in study characteristics and outcomes observed in the results of the review?	Did the review authors provide a satisfactory explanation for, and discussion of, variations in perspective observed in the results of the review?
15	Did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review? *Partial Yes – where reviews of quantitative studies (with or without meta-analysis) have discussed the likelihood and impact of publication bias*		Not applicable
16	Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?		

PICO, population, interventions, comparison type and outcomes; RoB, risk of bias.
** Indicates the critical domains which will be used to assess overall study quality.

Rating overall confidence in the results of the review

High

No or one non-critical weakness: the systematic review provides an accurate and comprehensive summary of the results of the available studies that address the question of interest.

Moderate

More than one non-critical weakness: the systematic review has more than one weakness but no critical flaws. It may provide an accurate summary of the results of the available studies that were included in the review. (Multiple non-critical weaknesses may diminish confidence in the review and it may be appropriate to move the overall appraisal down from moderate to low confidence.)

Low

One critical flaw with or without non-critical weaknesses: the review has a critical flaw and may not provide an accurate and comprehensive summary of the available studies that address the question of interest.

Critically low

More than one critical flaw with or without non-critical weaknesses: the review has more than one critical flaw and should not be relied on to provide an accurate and comprehensive summary of the available studies.

TABLE 8 Results of assessment of methodological quality of studies using AMSTAR 2

+	= Yes	?	= Partial yes	–	= No	NA	N/A, not applicable

Author	Year	1	2*	3	4*	5	6	7	8**	9a*	9b*	10	11	12	13	14*	15	16	Overall rating
Alotaibi[60]	2020	+	?	+	?	+	+	?	?	+	N/A	+	+	–	+	+	–	+	M
Althobiani[47]	2021	+	+	–	?	+	–	–	?	+	+	–	+	N/A	–	–	+	+	L
Aronow[61]	2018	+	?	–	?	+	–	–	–	+	N/A	–	+	+	+	+	–	+	L
Auener[62]	2021	+	–	+	?	+	–	?	?	+	N/A	–	–	N/A	+	+	+	+	L
Barken[58]	2019	+	–	+	+	+	–	?	+	?	+	–	+	N/A	+	+	N/A	+	L
Batalik[63]	2020	+	–	–	?	+	–	–	+	?	N/A	–	+	N/A	+	–	+	+	CL
Bauce[64]	2018	+	–	–	?	+	–	?	+	+	+	–	+	N/A	–	+	+	+	L
Blok[65]	2021	+	–	+	+	+	–	–	?	+	N/A	–	+	–	–	+	+	+	L
Cano[66]	2018	+	–	–	–	–	–	+	+	+	N/A	–	+	–	+	–	+	–	CL
Castelyn[67]	2021	+	+	+	?	+	+	?	+	+	-	–	+	–	–	–	–	+	L
Chan[68]	2021	–	–	–	?	+	+	?	+	+	+	–	+	N/A	+	+	+	+	L
Chan[69]	2021	+	–	+	?	+	–	?	?	+	-	–	+	N/A	+	+	+	+	CL
Chen[70]	2020	+	–	–	?	+	–	–	+	+	N/A	–	+	–	–	+	–	+	L
Choi[71]	2020	+	+	–	+	+	+	?	?	+	N/A	–	+	+	-	+	–	–	M
Choi[72]	2021	+	+	+	+	+	+	?	?	+	N/A	–	+	+	+	+	–	+	H
Clark[45]	2021	+	+	+	+	+	+	+	?	+	+	+	+	N/A	+	+	–	+	H
Cowart[73]	2020	–	–	+	?	+	–	?	–	+	N/A	+	+	N/A	–	+	+	+	CL
De Ridder[74]	2019	+	–	–	?	+	–	?	?	+	N/A	–	+	N/A	+	+	+	+	L
Drews[75]	2021	+	-	-	?	-	-	?	+	+	N/A	+	+	+	+	+	–	+	L
Ferguson[27]	2021	+	-	+	?	+	+	?	+	?	+	–	+	N/A	+	+	N/A	+	L

continued

TABLE 8 Results of assessment of methodological quality of studies using AMSTAR 2 (*continued*)

Author	Year	1	2*	3	4*	5	6	7	8**	9a*	9b*	10	11	12	13	14*	15	16	Overall rating
Foong[76]	2020	+	+	+	+	+	+	?	–	?	+	–	+	N/A	–	+	N/A	+	L
Gao[77]	2020	+	–	+	?	+	+	?	–	+	N/A	–	+	+	–	+	–	+	CL
Golledge[78]	2022	+	+	+	?	–	–	?	+	+	N/A	–	+	+	+	+	–	+	M
Hajduczok[79]	2021	+	–	–	+	+	+	?	+	+	N/A	+	+	+	–	+	–	+	L
Halawa[80]	2019	+	–	–	+	+	+	-	?	+	+	–	+	+	–	+	–	+	L
Hong[81]	2019	+	–	+	?	+	+	?	?	+	N/A	–	+	+	+	+	?	+	L
Hu[82]	2019	+	–	-	?	+	–	?	+	+	N/A	–	+	–	–	+	–	+	L
Hu[83]	2021	+	?	+	?	+	–	?	?	+	N/A	–	+	–	+	+	–	–	M
Ikpeama[84]	2019	+	–	-	?	–	–	-	?	–	–	–	+	N/A	–	–	+	–	CL
Iqbal[11]	2021	+	+	-	?	+	+	?	+	+	+	–	+	–	+	+	+	+	M
Jang[85]	2020	+	–	+	?	+	+	?	?	+	N/A	–	+	+	+	+	–	+	L
Jang[86]	2021	+	+	+	?	+	–	?	+	+	N/A	–	+	+	+	+	–	+	M
Janjua[87]	2021	+	+	+	+	+	+	+	+	+	N/A	+	+	+	+	+	?	+	H
Kaihara[88]	2021	+	–	+	?	+	–	?	+	+	N/A	–	+	+	+	+	?	+	L
Kirakalaprathapan[89]	2022	+	+	+	?	+	+	?	+	+	N/A	–	+	N/A	+	+	+	+	M
Kitsiou[90]	2021	+	+	-	?	+	+	+	+	+	N/A	+	+	+	+	+	–	+	H
Klak[91]	2021	+	+	+	?	+	+	?	+	?	?	+	+	–	–	+	–	+	M
Lee[92]	2018	–	–	+	?	+	+	?	?	+	N/A	+	+	N/A	–	+	+	+	L
Lelli[93]	2019	+	–	+	–	+	–	?	+	+	N/A	–	+	–	–	+	–	+	CL
Leo[94]	2021	+	+	+	?	+	+	+	?	+	+	–	+	+	+	+	–	+	H
Li[95]	2021	+	–	+	?	+	+	?	–	?	+	–	+	N/A	+	+	N/A	+	CL
Liu[96]	2020	+	–	+	?	+	+	?	+	+	N/A	–	+	+	–	+	–	+	L

TABLE 8 Results of assessment of methodological quality of studies using AMSTAR 2 (*continued*)

Author	Year	1	2*	3	4*	5	6	7	8**	9a*	9b*	10	11	12	13	14*	15	16	Overall rating
Lu[46]	2021	+	+	-	?	+	+	?	+	+	N/A	–	+	–	+	+	?	+	M
Lunde[13]	2018	+	+	-	?	+	–	?	+	+	N/A	–	+	+	+	+	+	+	M
Luo[97]	2019	+	+	+	+	+	–	?	+	+	N/A	–	+	+	–	+	?	+	M
Ma[98]	2021	+	–	+	?	+	+	?	?	+	N/A	–	+	–	–	+	N/A	+	L
Maiorino[99]	2020	+	–	+	+	+	+	+	?	+	N/A	+	+	+	+	+	–	+	L
McFarland[100]	2019	+	–	–	?	–	–	?	+	+	+	–	+	+	+	+	-	+	L
Mhanna[101]	2021	+	–	+	?	+	–	?	?	+	N/A	+	+	+	+	+	-	+	CL
Morken[102]	2022	+	?	+	+	+	+	–	?	+	+	–	+	N/A	+	+	+	+	M
Murphie[103]	2019	+	+	–	?	+	–	?	+	+	N/A	–	+	N/A	+	+	+	+	M
Nick[104]	2021	+	+	–	+	+	+	+	+	+	N/A	–	+	N/A	+	+	?	+	M
Ontario HTA[105]	2018	+	–	+	+	–	–	?	+	+	N/A	–	+	+	+	+	?	-	L
Park[106]	2021	+	–	+	+	+	+	?	+	+	N/A	–	+	–	–	+	-	+	L
Pekmezaris[107]	2019	+	?	+	+	+	+	?	+	+	N/A	–	+	–	–	+	+	-	M
Salehi[108]	2020	+	–	–	–	+	+	–	?	+	N/A	–	+	–	–	+	-	-	CL
Shaw[109]	2020	+	+	+	+	+	+	?	+	+	N/A	–	+	–	+	+	-	+	M
So[110]	2019	+	–	+	?	+	+	?	?	+	N/A	–	+	–	–	+	?	+	L
Sul[111]	2020	+	–	–	?	+	+	?	?	+	N/A	–	+	–	+	+	+	+	L
Tan[112]	2021	+	+	–	?	+	–	–	?	+	N/A	–	+	–	–	+	+	+	M
Tchero[113]	2019	+	–	+	?	+	+	–	?	+	N/A	–	+	+	–	+	-	+	L
Thomas[24]	2021	+	+	–	?	+	+	–	+	+	+	–	+	N/A	+	+	?	+	M
Tse[114]	2018	+	?	–	+	–	–	–	?	+	+	–	+	–	–	+	-	+	M
Tse[115]	2019	+	?	+	?	–	+	?	–	+	+	–	+	+	+	+	-	+	L

continued

TABLE 8 Results of assessment of methodological quality of studies using AMSTAR 2 (*continued*)

Author	Year	1	2*	3	4*	5	6	7	8**	9a*	9b*	10	11	12	13	14*	15	16	Overall rating
Udsen[116]	2022	+	+	–	+	+	+	?	+	+	N/A	+	+	–	+	+	-	+	M
Van Opstal[117]	2022	+	+	+	?	+	+	?	+	+	+	–	+	N/A	–	+	N/A	+	M
Walker[25]	2019	+	–	+	?	+	–	?	–	?	+	–	+	N/A	+	+	N/A	+	CL
Wiegel[59]	2021	+	–	+	?	+	–	?	?	+	+	–	+	N/A	+	+	+	+	L
Woo[118]	2018	+	–	+	+	+	–	?	?	?	?	–	–	N/A	–	-	N/A	+	CL
Yun[119]	2018	+	–	+	?	+	+	?	?	+	N/A	+	+	+	–	+	-	+	L
Zhang[18]	2021	+	?	+	?	+	+	?	+	?	N/A	–	+	–	+	+	+	+	M
Zhu[120]	2020	+	–	–	?	+	–	–	?	+	N/A	–	+	+	+	+	-	+	L

* Indicates key domains, used to determine the overall study rating. CL, critically low; H, high; L, low; M, moderate.

EME
HSDR
HTA
PGfAR
PHR

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