Adoption and spread of home sensors for technology-enabled remote monitoring in social care

Scoping review to inform rapid evaluation

Caroline M. Potter, Stephanie Stockwell, Anna Louise Todsen,
Sonja Marjanovic, Sara E. Shaw, Joseph Wherton

The DECIDE (Digitally Enabled Care in Diverse Environments) centre is a new programme of work for rapid evaluation of technology-enabled remote monitoring in health and care. Funded by the NIHR Health and Social Care Delivery Research (HSDR) programme, the programme is a partnership between the University of Oxford and RAND Europe.

Disclaimer: This is a supplementary report summarising insights from a literature review that forms part of a wider rapid evaluation of technology-enabled remote monitoring in adult social care services provided by local authorities in England. The full evaluation report is available on the NIHR Open Research platform, where it will undergo peer review: https://openresearch.nihr.ac.uk/articles/5-71

Funding information: This project was funded by the National Institute for Health and Care Research (NIHR) Health and Social Care Delivery Research programme, award reference number NIHR167211.

The views expressed are those of the authors and not necessarily those of the NHS, the NIHR, or the Department of Health and Social Care.

Summary

The shift to preventative telecare models involving technologies for proactive remote monitoring has gained considerable momentum since the Covid-19 pandemic. This scoping review of academic and grey literature was part of a rapid evaluation of technology-enabled remote monitoring of Adult Social Care service users by professional and/or informal carers in England. This evaluation focused on novel models of telecare delivery to support *proactive* and *preventative* social care, through 'connected care' platforms in which data from a range of sensors around the home are aggregated and analysed for changes in service users' day-to-day living patterns. These home sensors for remote monitoring are being used by some local authorities in England with the aim of improving the wellbeing of social care service users through the prevention of adverse events such as falls, illness, and malnutrition.

Through review of sources available as of July 2024, we found that the evidence base on implementation and evaluation of home sensors for proactive care is extremely limited. Initiatives to implement proactive remote monitoring within specific local government settings were identified, but there were few examples of robust evidence from independent evaluations. The reported case studies in the literature were for initial implementation stages, and most evidence of evaluation was smaller-scale and qualitative; quantitative data for capturing system-level outcomes was notably absent. We found no examples where proactive remote monitoring had already been scaled up to the level of a standard service offer within local government organisations.

We identified **three key insights from the literature**:

- **The current evidence base reports consensus on the potential benefits of home sensor technology, with some examples of benefits actually experienced by service users reported in the grey literature**. In the studies reviewed, policy makers, strategic decision makers within social care organisations, and technology suppliers agreed on the potential outcomes that these technologies could support: discharging patients from hospital as quickly as possible without compromising on safety, tailoring care packages to real-time needs in order to maximise efficiency in the context of chronic social care workforce pressures, and avoiding or delaying escalation to more intensive forms of care through earlier intervention. However, there remained a tension among decision-makers in prioritising system-level outcomes (focused on cost savings and workforce efficiencies) within an ethos of personalised care (focused on service user outcomes and experience). Examples of benefits experienced by services users from the literature included delays in care home admittance, improvements in health outcomes, nutrition, hydration and medication adherence.
- **There is a mismatch in published literature between anticipated system-level goals and evaluation approaches used to demonstrate the achievement of those goals.** Evaluation of system-level efficiencies, cost savings, and maintained/improved quality of life for target user groups requires larger-scale data that capture a range of health and care outcomes and service use metrics over time. However, we found no examples of quantitative data on longer-term outcomes being used to evaluate these technologies.
- **There is a significant knowledge gap on end user experiences**. The literature most strongly reflected the perspectives of sector leaders, organisational decision-makers, and technology suppliers. The evidence on end user experience of the technology remains sparse, with some indication of organisational difficulties in sustaining use. People with care needs and family carers were the primary users of the technology and much of literature did not include the experiences of local authorities or social care providers as direct users of the technology. The limited evidence incorporating values and experiences of all end users – the social care service users, their family carers, the front-line care professionals, and any other staff responsible for data monitoring and

response – means that it is currently challenging to appreciate the new (often hidden) work that is needed to support the adoption of home sensor technology and its long-term use.

In sum, there is emerging evidence of uptake from numerous pilot studies, but understanding of on-the-ground experiences of using these technologies is limited to small numbers of carer/service user interviews within only a handful of independent evaluations. There is also a lack of available quantitative data to support robust evaluation of longer-term, system-level outcomes and impacts of implementing preventative telecare models. These gaps informed the mixed-methods design for collecting and analysing new primary data for three case studies in DECIDE's evaluation of technology-enabled remote monitoring in social care (full evaluation report available at: https://openresearch.nihr.ac.uk/articles/5-71).

Abbreviations

ADASS	Association of Directors of Adult Social Services
BRACE	Birmingham, RAND and Cambridge Evaluation centre
DECIDE	Digitally Enabled Care in Diverse Environments
DHSC	Department of Health and Social Care
NHS	National Health Service (England)
NIHR	National Institute for Health and Care Research
LGA	Local Government Association
TAPPI	Technology for our Ageing Population: Panel for Innovation
TEC	Technology Enabled Care
TSA	TEC Services Association
UK	United Kingdom

Acknowledgements

Thank you to Nikki Newhouse, Stuart Redding, and Stavros Petrou for their contributions to the overall evaluation, in which this literature review is integrated. Thank you to the RAND Europe Quality Assurance reviewers Jon Sussex and Sarah Parkinson. Thanks also to Charlotte Thompson-Grant, Julie Darbyshire, and Gemma Webb for invaluable administrative and programme management support.

Contents

Introduction

This scoping review of literature was part of a rapid evaluation of technology-enabled remote monitoring within Adult Social Care services in England (full evaluation report available at: https://openresearch.nihr.ac.uk/articles/5-71). The evaluation aimed to increase understanding of how technologies focused on proactive remote monitoring of social care service users can be designed, implemented, spread, scaled and sustained to optimise service user outcomes and to prevent health crises and transitions to more intensive care. The evaluation was funded by the NIHR Health and Social Care Delivery programme and was conducted by DECIDE, a partnership between RAND Europe and the University of Oxford. DECIDE is a centre focusing on rapid evaluation to build the evidence base on technology-enabled care, especially remote monitoring, within a diversity of health and social care settings.

The evaluation focused on novel models of telecare delivery to support *proactive* and *preventative* social care, through 'connected care' platforms on which data from a range of sensors around the home are aggregated and analysed for changes in service users' day-to-day living patterns. There are multiple technology providers of these connected care platforms; some are designed to be used by professional care staff only, while some enable remote monitoring by informal carers. These home sensors for remote monitoring are being used by some local authorities in England with the aim of improving the wellbeing of social care service users through early intervention and prevention of adverse events such as falls, illness, and malnutrition, as well as using the data to inform decision making about care support needs.

This service model presents a high degree of complexity in comparison to the established reactive care model, which relies on safety alerts triggered by users (e.g. pendant alarm) or standalone sensors of specific events (e.g. falls detectors, door exit sensors) that only alert care providers after an event has occurred. A proactive model is intended to reduce occurrence of exacerbations that would lead to crisis events: for example, detecting a urinary tract infection at an early stage (through data showing increased bathroom usage) and providing treatment before the infection becomes severe and requires hospitalisation. With an increasing breadth of digital solutions alongside the analogue-to-digital switchover across UK telecoms by 2027[1], there has been growing interest from commissioners and services to see how sensors and analytics can be used for more personalised and cost-effective care. However, the care sector is still at a low level of maturity in the application and adoption of such technology and the development of proactive care models.

This scoping review of literature builds on our previous horizon scanning and stakeholder engagement, which revealed widespread interest in advancing proactive and preventative models in social care. This shift from reactive to proactive care is reflected in reports across the technology-enabled care sector (e.g. Technology-enabled care Services Association (TSA) special interest group on commissioning proactive and preventative services[2], and Association of Directors of Adult Social Services (ADASS) on harnessing digital technology to enhance experiences of care and support[3]), which highlight the potential role of 'connected care' platforms for informing person-centred care and early intervention.

[1] GOV.UK (2025). Moving landlines to digital technologies. Available at: https://www.gov.uk/guidance/moving-landlines-to-digital-technologies

[2] TSA: TEC Services Association (2023). Proactive and Preventative Services: Definitions and Guidance. Available at: https://www.tsa-voice.org.uk/downloads/proactive__preventative_services_-_definitions_and_guidance_for_commissioners_and_services_final.pdf

[3] Dixon A, Jopling K (2023). Time to act: A roadmap for reforming care and support in England. ADASS report, available at: https://www.adass.org.uk/wp-content/uploads/2024/06/adass-time-to-act-april-2023-1.pdf

But despite much enthusiasm and promise, uptake and use of such solutions in routine provision of adult social care services in England remains low, and the evidence base is still limited.

To support our rapid evaluation on the use of 'connected care' platforms in three selected local authority case sites, the literature review explored the current national terrain with regard to the deployment, use, and evaluation of connected care platforms. The review was guided by the following questions:

- How is proactive and preventative telecare framed within adult social care?
- What type of technologies have or are being used for such service models?
- What approaches have been taken to evaluate such services, and what sort of evidence has this produced?
- What lessons can be drawn about good practice and about evidence gaps in need of future research and evaluation?

Literature review methods

We conducted a structured search of both academic and grey literature relating to the use of home sensors for remote monitoring in adult social care. Searches of academic literature were conducted in PubMed (224 results), Scopus (103 results), Web of Science (97 results), CINAHL (31 results), and Google Scholar (top 100 of 17,700 results) using the following search terms:

Table 1. Search terms for included types of technology, study, care model, and care setting

Technology	**Study type**	**Model**	**Setting**
Telecare	Pilot	Proactive	Social care
Sensor*	Evaluat*	Prevent*	Social Services
Remote monitor*	Trial	Predict*	Community care
Home monitor*	Deploy*	Pattern	Domiciliary

The finalized search string was run through all five academic databases on 14th May 2024:

(telecare OR sensor* OR "remote monitor*" OR "home monitor*") AND (pilot OR evaluat* OR trial OR deploy*) AND (proactive OR prevent* OR predict* OR pattern) AND ("social care" OR "community care" OR "domiciliary" OR "social services")

After removal of duplicates, 458 references were screened using a web-based tool for managing literature reviews (Covidence: https://www.covidence.org/). Following title and abstract screening according to the inclusion and exclusion criteria described below in Table 2, 73 sources underwent independent full-text review by two authors (CMP and JW). Owing to the low volume of academic literature, we reviewed sources dating back to 2005 that gave some limited information on early-stage development of preventative telecare and/or more recent systems that were in the process of being deployed. Ten sources were retained from the search for detailed review and analysis by CMP and JW, and a further three sources were identified through specific searches for additional evidence on projects described in retained articles. Following close reading and data extraction, 8 of the 13 academic articles were excluded because they did not provide sufficient detail for analysis; studies conducted prior to 2010 referred to early developments in proactive monitoring but mainly focused

on standard reactive technologies, and some more recent studies detailed the design and intended use of proactive systems but did not provide sufficient detail on actual deployment. Therefore, only five academic sources informed findings.

Table 2. Inclusion/exclusion criteria

Topic	**Include**	**Exclude**
Date	Grey literature: From 1 Jan 2019 onwards Academic literature: From 1 Jan 2005	Grey literature: Before 1 Jan 2019 Academic literature: Before 1 Jan 2005
Location	England	All other countries
Population	People living in the community including at home or in sheltered accommodation	Care homes, nursing homes
Intervention	Sensor-based technology for proactive and/or preventative care There may be an element of reactive care involved as well, but it must have proactive/preventative aspect, e.g. may be a wearable sensor that is used for reactive care once a fall has happened, but it may also incorporate AI to predicts falls before they happen. There must be an element of remote monitoring that should connect back to the formal care system (could be healthcare, social care, alarm response centres, third sector organisations), not just the individual or their families/informal carers.	Standard reactive/alarm response-based approaches only
Article types	Must include pilot/deployment and/or evaluation reports (or synthesis/review of such pilots/reports) Evaluative nature, some information on implementation influences/ outputs / outcomes/ impacts/ enablers/ challenges as they relate to home sensors or home sensor pathways Written in English language	Promotional and commentary pieces Newspaper articles Written in any other language that is not English

The grey literature search (conducted by SSt and ALT) identified 40 relevant documents for screening using the same inclusion/exclusion criteria via a multipronged approach:

- review of documents identified by key stakeholders on the project advisory group[4];
- searches of key stakeholder websites (between 8th – 10th May 2024) that included the Social Care Digital Innovation Programme, the Local Government Association (LGA) care technology diagnostic and planning resource, ADASS, TSA, TEC Action Alliance, the Digital Technology for Adult Social Care Network, the Adults Social Care Technology Fund, Digitising Social Care Fund, and Social Care Institute for Excellence;
- websites of key home sensor technology providers (Alcove, HOWZ, Antropos, Cascade3d, WHZAN, Intelligent Lilli, Just Checking and DORIS care) (17th May 2024);
- Google searches (3rd June 2024) using four different combinations of key search terms searching the first 50 hits: 'remote monitoring', 'sensors', 'home', 'evaluation', 'social care', 'activity monitoring', 'lifestyle monitoring'.

Following screening, 16 grey literature sources were retained for analysis. A total of 21 sources (5 academic, 16 grey literature) informed the findings below.

Findings

Overview of the literature

We found that the evidence base on implementation and evaluation of home sensors for proactive technology-enabled remote monitoring in adult social care is extremely limited. A previous rapid scan of literature that informed a 2023 evaluation of home sensor technologies outlined gaps in evidence and difficulties in implementing digital technologies in social care more broadly [7], mainly drawing on evidence from before the rapid digital shift prompted by the Covid-19 pandemic. Our review built on this work to identify the most current evidence on implementation of preventative 'connected care' platforms specifically, through expanded searches of multiple academic databases and public-facing platforms.

We identified five academic articles that described three recent evaluations, which each considered evidence from multiple stakeholders and settings. A general review of proactive telecare services using smart home technology in the UK [18,19] drew on primary interviews with stakeholders (mainly the technology designers/suppliers and social care housing providers) and a limited number of interviews with older people. An evaluation of Phase 2 of the Technology for our Ageing Population: Panel for Innovation (TAPPI) project described how six testbed sites had implemented a range of care technologies, including three sites that had piloted proactive remote monitoring [17]. A recent rapid evaluation of proactive remote monitoring within adult social care was conducted by the Birmingham, RAND, and Cambridge Evaluation (BRACE) Centre, which included two local authorities and a national charity provider of social care services as case sites [7,13]. With the exception of the TAPPI evaluation [17], academic sources did not specify where the technology had been piloted or which technology providers were commissioned.

We identified 16 grey literature articles that reflected a variety of stakeholder perspectives, including sector leaders in adult social care [1-4], local government [6], and technology-enabled care [3,21]. Five

[4] The project advisory group comprised six professionals representing local and national government, academia, industry advisory bodies, and the social care workforce. They provided input into the design or the searches and suggestions for literature they were aware of.

initiatives to implement proactive remote monitoring within specific local government settings were identified through local authority sources [5,8,9,15,20], with some evaluation evidence available for Hertfordshire [8] and Kent [9]. Within the context of integrated care systems, relevant implementation efforts were also identified in a home care agency [14] and through collaboration with NHS partners [16]. One technology supplier has produced or sponsored multiple reports that highlight a range of case studies and emerging issues within the sector [2,4,10-12], which are highly informative but also at greater risk of bias towards proactive remote monitoring technologies generally and this supplier's products specifically.

Across the analysed articles, there were few examples of robust evidence from independent evaluations. Many of the grey literature reports provided some information on outputs, outcomes and/or impacts, and challenges/enablers of implementing technology-enabled remote monitoring in social care, but they did not contain clear information on how the claims on impact were arrived at (i.e. the methods that supported the findings were not described). There were some mentions of intentions to evaluate in the future, highlighting the desire to improve the evidence base, but this is still in the early stages. The academic literature provided some evaluation evidence through more robustly described methods, but most data was in the form of qualitative stakeholder interviews, with more representation from suppliers and providers of the technologies rather than end users.

All of the reported case studies were at initial implementation stages with small numbers of service users (usually 30 or fewer) engaged. We found no examples where proactive remote monitoring had already been scaled up to the level of a standard service offer within local government organisations, and only one reference to scale-up in progress (at Reading Borough Council [2]). Accordingly, most evidence of evaluation was smaller-scale and qualitative, rather than capturing system-wide quantitative data.

In the following section we describe how home sensor technologies are intended to work in social care settings, and how they require engagement from a diversity of stakeholders across complex care pathways. We then review the available evidence on impacts and outcomes of the technologies, at both the personal level (service users and their carers) and across the wider health and social care system. Finally, we synthesize the limited but informative evidence on factors that influence the successful (or not) implementation of home sensor technologies for preventative social care, including the reliability of digital infrastructure and organisational capacity for new ways of working.

The technology and application in social care

Technical properties and features

The literature shows that home sensors for remote monitoring in social care capture diverse types of measures spanning behaviours, physiological markers and environment conditions, with motion sensors being the most commonly used. Home sensor technologies include the sensors themselves but also dashboards and IT platforms that allow for the data to be stored and communicated.

The literature included references to sensors that monitor behaviours, physiological markers, and the environment. The most commonly mentioned sensors were motion sensors [4,5,8,9,14,17,18,21]. More specifically, motion sensors were used to detect bathroom use [1,5,10,11,14,15,17], falls [6,17,20], sleep and night-time activity [1,7,9,10,11,13,14,17], fridge door opening [7,13,17], use of medication boxes [8], and use of hydration cups [17]. Smart plugs were used to detect kitchen appliance use [1,7,8,13,14,15,17]. The most commonly used environmental sensors were door sensors [7,8,9,10,13], and sensors were also used for detecting smoke [6,20], heat [4,5,6,17], humidity [17],

and light levels [4]. A small number of articles included physiological sensors (body thermometry, pulse oximeter, blood pressure cuff) [9] and a wearable sensor in the form of a smart watch to measure heart rate, mobility and sleep [3,13,17].

Some devices/systems were explicitly named in the documents: HOWZ [9], Anthropos Connected Care System [5,17], Cascade3d technology [5], Intelligent Lilli [11], Tunstall [6], Amba [17], Miicare [17]. However, most articles did not name the product or used pseudonyms.

Aims and purposes for use

Home sensors are reported to have multiple roles, including early identification of situations where a service user might need intervention to prevent escalation, assessing the nature of care that is needed at multiple time points, and providing reassurance to formal and informal carers that service users are well and/or that timely response will happen in the event of deterioration. These uses reported in the literature spanned short-term and long-term care contexts, supporting diverse social care needs.

Home sensor-based technologies were perceived to be useful for identifying changes in individual behaviours earlier than would otherwise be achieved, in order to facilitate timely intervention from care staff/families, with a view to also helping reduce healthcare resource use and cost [1,2,6,7,9,10,13,14,16,18,21].

Data from home sensors were also perceived to have potential for informing decision-making by care providers and/or informal carers [2,14] and to help tailor care packages based on true levels of need [2,3,7,9,12,13,15,20]. The technology was also perceived as useful for providing more personalized care in a timely manner [21], and informing decisions with regard to moves into residential care [7,13].

Some of the literature discussed the potential role of the continuous monitoring enabled by proactive connected care platforms for providing peace of mind to carers. This use of the technology was also perceived to relieve pressure and burden from the care system and unpaid carers [2,4,7,11,12,13], to help users feel safer and live more independently for longer [6,7,13,21], and to increase privacy by reducing potentially intrusive 'check-ins' [17].

The use of home sensors spanned short-term and long-term care contexts. In the short-term context, home sensors were deployed for reablement to assess and monitor people being discharged from hospital for a limited period of time [1,2,4,6,8,10,11,16]. For the long-term context, home sensors were seen as a way to enable people to live at home for longer by managing risks of deterioration through routine monitoring [2,4,5,6,8,9,10,14,15,21].

One paper referred to the use of sensor data for self-monitoring: specifically, end-users reviewing the data themselves to monitor their own activity and sleeping activity [17]. However, this case was referred to anecdotally as an ad-hoc, user-driven use of the data, as opposed to being part of the service model.

Users and care settings

Home sensor-based technologies can be applied to diverse types of adults with social care needs, with use in some populations appearing to be particularly common (e.g. people with cognitive decline and high-risk groups with more complex care needs).

Home sensors seemed to most commonly be used by people living at home with Alzheimer's or other forms of dementia [4,5,7,9,11,13,15,17] or those receiving care at home who were at risk of more complex care needs [7,11,13,14,17,20]. They were also used for individuals who were at risk of falling [3,7,13], at risk of hospital admission or care home stay [10], individuals living with frailty [16], working age adults with learning disabilities [2,7,13,17], and people discharged from hospital or on discharge-to-assess pathways [1,2,7,13]. In addition, home sensors were used in sheltered or supported housing residents [2,17,18,21].

While the literature indicated that people with care needs and family carers are the primary users of the technology, much of it did not include the experiences of local authorities or social care providers as direct users of the technology. This is despite the literature highlighting the impact that these technologies have on care pathways and the importance of engaging multiple stakeholders in their use [18,19].

Care pathways around the home sensor technologies

Care pathways around home sensor-based technologies involve a nexus of stakeholders who engage with the technology at multiple stages of the pathway: (i) deciding for whom and how to use the technology, (ii) installing the sensor devices and linked dashboards/communications channels, (iii) monitoring and interpreting the data generated by the technology, (iv) acting on insights to inform care planning and support service users, and (v) making decisions on when to stop using the technology.

There are many types of stakeholders with roles to play in effective remote monitoring pathway delivery. Firstly, technology suppliers are important and engage with activities such as providing, installing and maintaining home sensor technologies [1,2,18,19]. Secondly, organisations and professionals formally involved in social care provision can engage with the data and information provided through the technology to inform care decisions (e.g. the sensors identifying service users having support needs that differ from the support they currently received, or that the service user required residential care) [1,2,7,10,13,15,16]. Having dedicated staff to monitor and act on the data generated by connected care platforms was thought to be particularly important in the care pathway [13,17]. Thirdly, informal carers are relevant stakeholders in the care pathway as they can also engage with the data and information to help support the service user's care needs [2,8,9,10,15]. Finally, local authorities such as city/county/district councils as commissioners of care [2,18,19] and the healthcare sector [4,7,8,9,10,11,13,15,16] are important in the care pathway, and can make decisions about how the information should be used and what actions should be taken to support service users.

How the home sensor technologies work

The home sensor technologies need to be installed and maintained, but there is little information on how this process works or on how users are trained to engage with the technologies. The data from the home sensor technologies reaches different types of formal care providers and informal carers, but there is little information on the format of the data or its analysis and use.

There was a lack of explanation regarding the installation of the sensor technology, and how the data produced are used and analysed. One article described the role of social care staff in installing and explaining the uses of the technology to service users and their family members [2], whilst another mentioned the technology company assisting with installing sensors [1]. However, there is little information on the nature of this support, and it is rarely considered in the literature.

Descriptions of the flow of sensor data indicate a range of different people potentially using it, including care practitioners [1,7,9,10,11,13,15], alarm response centres [3,5,6,20], and informal networks of care like family members [2,8,11]. However, the type of data communicated is often not described [1,2,3,5,6,10,11,14,20]. Some sources of evidence mention the ability to view data on a digital dashboard [2,7,8,9,13,15,21], but the nature of the dashboard information is largely not explained. Some articles mention alerting capabilities, but with little detail on how the alerts are triggered and communicated [5,14,21].

Formal carers can potentially use the data to identify needs and to action interventions [3,7,13,16]. This involves informing nominated contacts (e.g. informal carers or families), or emergency services as appropriate, to act upon the information (e.g. booking a GP appointment) or to update them about changing care needs [5,6,10,11,15,21]. Two articles described how social workers engage with the data produced by the sensors and use this to inform care both before and after a potential alert has been made by the system [10,15].

Little detail is provided on the data analytics, including any role for artificial intelligence. Multiple sources mention the use of AI to establish baseline activity using machine learning [2,5,7,13], but the literature does not expand on the type of machine learning model, nor the way in which changes relative to the baseline are used.

Evidence on impacts and outcomes

Impacts on service users

The reported impacts on service users primarily relate to delaying and reducing care home admittances, improving health outcomes, and adapting the living environment to better suit service users' needs.

The majority of grey literature documents provide some information on service user impacts [1,2,3,4,5,8,10,11,14,15,16,21], mainly positive in nature. The most reported service user outcome was avoiding or delaying moving service users into residential care. This was described on the basis that home sensors can help identify the needs of service users and personalise support in line with those needs, such as increasing home visits or installing appropriate home equipment [1,2,8,10,11,16] that enables people to remain in their own homes. One such example was the notification of increased night-time activity and not getting back into bed due to leg pain, leading to the installation of a powered leg lifter [1]. Many of the grey literature sources that provide such examples are however co-authored by technology suppliers; the limited academic literature indicates that the stated impacts may still be more aspirational goals than realised outcomes demonstrated through independent evidence.

The literature also describes how home sensor technologies can potentially help to identify the risk or presence of health conditions, allowing for timely interventions [3,10,14,15,21]. One example was identification of an increase in bathroom visits as a potential indication of a urinary tract infection (UTI), enabling quicker diagnosis and treatment [15]. Similarly, the evaluations also highlighted improvements in areas of nutrition, hydration, and medication adherence following detection of changes in these behaviours via the sensors and then intervention by service users support networks [8,14,21].

The use of home sensors in combination with pendants or smart watches enabled the identification of risk of falls (based on health, motion and sleep data), as well as detection of falls happening in the home. While there was limited information on how home sensors were used for this purpose, some

reports in the grey literature note impacts related to fewer falls happening and faster responses following falls [3,20,21]. However, there was some reporting of false alarms from fall detectors and that this can be disruptive for both the service users and the monitoring centres if it is a regular occurrence [20].

Some reports found that home sensors also led to service users feeling safer at home [2,8,16], and that they generally improved quality of life for service users [2,10,11]. However, these sources seemed to base these claims on positive individual-level feedback rather than robust measurement; there was no indication of quantitative data on quality of life that might support system-level evaluation.

Finally, it was demonstrated that home sensors could also help identify issues in users' living conditions, such as the use of temperature measurements to highlight homes affected by fuel poverty, and connect service users to the relevant services [8,21].

Impacts on informal carers and support networks

The literature highlighted a range of impacts that home sensors can have on families, friends and neighbours of service users, with both positive and negative outcomes reported. Key positive impacts included reassurance, management of care responsibilities and reduced demands/burden. Negative impacts related to unintended consequences for care relationships, as well increased expectations and responsibilities on informal carers. However, these were generally reported as potential, rather than evidenced, impacts.

In terms of positive impacts, some reports provide information on home sensors providing reassurance and peace of mind about the user's wellbeing to informal carers. This was the impact with the strongest evidence base [2,5,8,14,15]. Additionally, home sensors were reported as a way of allowing responsibility to be shared amongst multiple family members, reducing the burden on individual carers [8].

Negative impacts on informal carers related to the risk of information overload, with difficulties "switching off" from their responsibilities, and potential increase in pressure or expectations to take on more responsibilities [8,16].

The type of involvement of informal carers also varied. In most documents reporting on the impacts on informal carers, they had access to dashboards and data from the home sensors. However, two documents described a more indirect involvement of carers only when the remote monitoring data suggested concerns [10,11]. This represented a mediated form of involvement of informal carers, which alleviates some of the pressures directly experienced by them.

Impacts on social care system, local authorities and care staff

The literature highlights several impacts of home sensor technologies on the social care system, including changes in how care is provided, workload management for staff, reassurance to care staff, and economic benefits to the social care system. However, many of these impacts are presented as potential, rather than evidenced, outcomes.

It was reported that home sensors helped inform care packages to ensure the right level of care was provided, helping optimize resource utilization and delay the need for care home admittance [2,3,6,10]. This outcome was also linked to service partnerships for more holistic responses to care needs [2,3].

Similarly, home sensors were found to help care staff identify and prioritize the daily needs of service users, allowing for more efficient management of workloads and ensuring that the most critical needs are addressed first [21]. Care staff perceptions of service user safety, for which home sensors might offer reassurance [14,21] are linked to daily work planning. Home sensors were also seen as having a potential role in monitoring care provision, such as the use of humidity sensors to verify whether care workers were bathing service users, as required [2].

The academic literature further highlighted concerns among care practitioners in relation to added workload associated with home sensing, including additional assessments, the need to support and maintain the technology, and extra time and responsibility monitoring the data [7,17]. Some staff also reported concerns about their caring roles being replaced by such technology [17].

Finally, home sensors were seen to offer economic benefits to the social care system. However, the specific mechanisms were not clearly described. In two documents, it was found from two small scale cost-benefit analyses that home sensors brought financial savings by freeing up capacity of care staff [6,9]. The potential decrease in stress levels of funded carers was also proposed as an area of cost saving, due to a reduction in funded carer breaks [8], although there was a lack of quantitative data to demonstrate this anticipated benefit. Delays in moving into residential care and reductions in care packages were also described as potential areas for cost-savings [4,6,8].

Impacts on healthcare system and NHS staff

Home sensor technologies have potential to reduce unnecessary admissions to hospital, supporting timely discharge and reducing readmission rates, as well as potential to reduce the need for GP appointments and A&E admissions.

The integration of home sensors in social care potentially enables preventative and proactive measures to be implemented that could impact various areas of the healthcare system. In some individual cases, home sensors were able to facilitate detection of deterioration and early intervention, which was thought to prevent complications and shorten recovery times, thereby reducing the length of hospital stays and readmittance rates [5,8,9,10,11,21]. The use of home sensors was also projected to lead to a reduction in GP appointments and a reduction in A&E usage, for example through fewer calls to 999 by people who had a response triggered by the home sensors system [9]. It was also hypothesized that data collected by home sensors could enhance healthcare decisions, as they provide detailed and real-time insights into the patient's health [16]. There was however an absence of larger-scale data against which these claims could be independently validated, suggesting that these system-level outcomes are currently more aspirational goals than demonstrated impacts.

Influences on implementation and use

The existing literature is limited to a small number of sources in exploring the contextual factors that promote or inhibit implementation, scale-up and spread of proactive remote monitoring technologies in adult social care. The academic articles [7,13,17-19] and the evaluation reports found in the grey literature [8,9,16] provide greater detail on the complex organisational and social processes that can influence implementation of innovative technologies in sometimes unexpected ways.

Care context: uncertainty of user groups and goals

As noted above home sensors can be applied across a diverse range of adult social care service users, with the most common being people living at home with cognitive impairment and complex care needs. However, the literature also highlights the challenges in establishing for whom and in what circumstances the technology is to be implemented, leading to difficulties identifying potential beneficiaries. The literature further highlights ethical challenges associated with gaining informed consent from service users living with cognitive impairment [7,13].

The academic literature highlighted ambiguity in how the goals of using the technology were defined by different stakeholders. A review of proactive telecare services using smart home technologies noted that trials of new technological innovations in social care were often supplier-led, and that their aims (market spread and generating profits) could be at odds with those of public bodies (provide a good service, improve service users' health and wellbeing, reduce care needs and system costs) [18,19]. The BRACE evaluation highlighted how the 'fit' of the person to the technology was not always clear at the start of implementation, resulting in uncertainty of the technology's purpose among service users and family carers [7,13].

Technology: weak digital infrastructure and design considerations

The literature highlights the importance of good digital infrastructure, including reliable and secure WiFi connectivity in the home; however, many potential users within the intended cohort do not have a good, or sometimes any, internet connection at home [7,13]. Consistent and secure connectivity in sheltered or supported housing was also a challenge [17].

Established digital infrastructure within the wider care systems that support digital adoption and the implementation of home sensors also plays an important role [2]. Effective use of other digital tools and platforms, such as MS Teams and virtual blackboards, facilitates the management and deployment of home sensor technology by enhancing collaborative working among staff members [16].

The literature also highlights the importance of dashboard usability, so that the sensor data is readily interpreted by end users [7,13,17]. Some articles reported issues with dashboards being unresponsive or not displaying useful data, prompting staff to create their own dashboards [8,21]. Additionally, the lack of formal training for staff on how to use the technology was raised as a challenge [8].

Certain design features of the sensors themselves are influential. Visual indicators like a light showing that the device is operational, and strategic positioning or clear labelling of sensors in a user's environment, can impact user interaction and likely the overall effectiveness of the sensors, but the literature does not describe whether these impacts are predominantly positive or negative [16]. Similarly, it was reported that some users of the technology considered the sensor and hub (the hub receives signals from the sensors and transmits them to the monitoring platform) devices to be too 'bulky' and space-consuming, indicating a need to consider where they are positioned [17].

Cost factors were considered to be a potential barrier, with worries about the affordability of the technology and associated services [8,17]. Questions were raised as to who should pay across the care system, and the extent to which end-users would be expected to pay or contribute to the cost [17].

User perspectives and capabilities

The literature highlighted the need for more support for service users and carers to understand and address concerns they had about remote monitoring, and to ensure regular contact to identify and fix technical issues promptly [8,16]. Privacy concerns about the intrusiveness of the technology and data sharing were noted, particularly among older people who are not tech-savvy [16].

Users' understanding of and trust in technology, when present, were also found to be significant enablers of uptake of home sensors in the evaluations. Staff training programmes were found to help alleviate initial apprehensions about using home sensors [1,8]. Additionally, providing both service users and carers with simple instructions in various formats enhances understanding and reassurance [16].

Organisational capacity, responsibility and funding context

A significant issue identified was the lack of action taken on data provided by the sensors, exemplified by an instance where a change in a user's behaviour was detected but no action was taken and the user subsequently died [1]. Concerns were also raised about the capacity of care providers to respond proactively to alerts within an acceptable timeframe, with ambiguity surrounding who should respond and what an acceptable timeframe would be [8]. Such challenges were linked to current funding models for social care, which mean care providers are paid by time spent on in-person care [7,13]. The literature highlights a lack of clarity over organisational responsibility for proactive or preventative actioning on data and alerts, and for ensuring the technology has been adequately set up and maintained [17]. In addition, organisations need to be clear on which data will be collected and ensuring that data are kept up to date, which enables stakeholders to see the impacts of the technology and supports continuous improvement and adaptation [20].

In-house knowledge and expertise by social care staff regarding home sensors technology was reported as an important factor, especially in relation to procurement decisions within a diverse and evolving market [7]. Additionally, procurement models were highlighted as presenting additional challenges for local authorities, in which minimum purchase requirements limit scope for trying out and piloting technology [17].

In some cases, local 'champions' were set up to explore technology options and to engage with industry and other organisations, in order to build local expertise and to facilitate procurement and implementation processes [7,13]. The literature highlights the importance of engaging with a broad range of stakeholders including care recipients, family members, care workers, managers, and social work teams to build familiarity and confidence in using proactive remote monitoring technologies [14]. However it does not provide detail as to how best to do this in the implementation of home sensor care pathways [14].

Resource limitations were another enduring challenge, with literature noting that a shortage of staff and restricted funding for technological innovation, as well as a lack of time to properly integrate and adapt the technology, limited its uptake and use by formal carers [1,8]. The literature also emphasizes the importance of multidisciplinary teams and skilled, motivated staff who can use the services appropriately without overburdening urgent care systems [16].

Secure funding emerged as an essential enabler, with opportunities available through various funding from the DHSC, NHS, and Proactive Care Fund, although these are not accessible to all [2]. Additionally, some technology providers offered funding for evaluations on the impact of their technology across

the healthcare system [2], though there can be concerns about impartiality and incentives to demonstrate impact.

Finally, it was argued in one study that a wider cultural shift is needed across social care if proactive and preventative approaches to remote monitoring are to be sustained at scale. This will require a change in focus from short-term costs and gains, to a longer-term view on impact including but not limited to economic costs [7].

Key insights from review of the literature

Consensus on system goals: framing preventative telecare within adult social care

There is consensus across the literature on the potential of proactive and preventative telecare to positively address system-level challenges:

- discharging patients from hospital as quickly as possible without compromising on safety, particularly when the person lives alone and/or social care packages are not in place;
- maximising efficiency in the context of chronic social care workforce shortages, to deliver in-person care when and where it is needed most while providing reassurance of safety and wellbeing at other times;
- avoiding or delaying escalation to more intensive forms of care through earlier intervention, enabling people to remain in their own homes with support as an option to residential care.

There is tension among decision-makers, however, in prioritising system-level outcomes (focused on cost savings and workforce efficiencies) within an ethos of personalised care (focused on service user outcomes and experience). As noted below, there is little evidence on how social care service users, their family members, and frontline care staff view the purpose of the technology or the extent to which it aligns with their own goals for living well and providing good care. If service users and the people in their care networks do not see benefit in using the technology at a personal level, then uptake could remain low and the expected system-level outcomes will not be realised. However, based on the literature available, service users and people in their care networks have reported some perceived benefits, indicating that home sensors for proactive care may have potential.

Mismatch with approaches for evaluating preventative telecare service models

There is misalignment with consensus goals of implementing proactive remote monitoring technologies within adult social care to address system challenges (managing the increased demand for care in the context of an underfunded sector and depleted workforce) and a lack of (quantitative) data needed to demonstrate if these aspirational goals are being met. Evaluation of system-level efficiencies, cost savings, and maintained/improved quality of life for target user groups requires larger-scale data that capture a range of health and care outcomes over time. However, we found no examples of quantitative data on longer-term outcomes being used to evaluate these technologies; the very limited quantitative evidence available focused on service user characteristics and rates of initial uptake of the technology [16]. Independent evaluation was limited to the few available academic sources and a small number of grey literature reports, providing mostly qualitative data that was more focused on strategic decisions to trial the technology than ongoing implementation efforts. Evidence of impact is largely limited to individual case examples and unverified projections of cost savings, mainly in grey literature reports with risk of bias owing to input from technology providers or the commissioning Local Authorities. In order to effectively evaluate proactive remote monitoring technologies within social care, a wider range of data needs to be collected and/or made available to researchers, particularly measures such as health-related quality of life that can be used in economic analysis.

Missing perspectives: understanding values and challenges for all end users

The literature provides some emerging evidence of benefit to service users and their families, particularly the dual sense of reassurance that a) the person is coping and additional care is not needed but b) carers will be alerted quickly if the situation changes and needs emerge. However, the evidence on end user experience of the technology remains sparse, and some evidence has indicated difficulties in sustaining use – particularly from the perspective of care staff who are expected to engage with the data produced by remote monitoring systems. For example, in all three BRACE evaluation case sites, 'IndependencePlus' was piloted but ultimately abandoned after poor uptake and performance [7]. The authors presented good qualitative evidence [13] on organisational difficulties in implementation of this specific platform: no consensus on target user groups (with findings that the technology was not suitable for most of their service users), tensions from front-line care staff (worries that it was intrusive and not wanted by service users, and concerns over having to respond to the wide-ranging data on the dashboard), and ongoing disconnect between management and front-line staff (no shared sense of what benefit the technology might yield or how it would impact daily work flow). The review of proactive telecare using smart home technologies [18,19] also conveyed the complexity of care networks engaged in proactive remote monitoring technologies, with a need to understand the concerns and work involved for all who might be 'responders' to the information generated, the support they might need to understand and fulfil their responder role, and for this to be considered in the design of the service.

It is crucial to address this knowledge gap on how use of proactive remote monitoring technologies generate new roles, responsibilities, and (often hidden) workflows for a range of end users; the technology's social and organisational complexity must be understood if implementation efforts are to be sustained, scaled up, and spread beyond pilot projects.

Conclusions

The shift to preventive telecare for users of adult social care services involving proactive remote monitoring technologies has gained considerable momentum in the five years since the Covid-19 pandemic, which prompted a surge of digital innovation in England's health and care system. The consensus discourse on the technology's potential for addressing priority system-level challenges has been driven strongly by technology suppliers and strategic decision-makers in line with overarching policy aims. However, at the time of writing and in spite of emerging evidence from numerous pilot studies, this review indicates that no local authorities in England (in their role as statutory providers of adult social care) have yet demonstrated scale-up and sustained use of these technologies beyond the pilot stage. There is a notable gap in evidence of on-the-ground experiences (from staff and users) of implementing these technologies, particularly how different stakeholders respond to the information presented on data dashboards for each system. There is also a lack of available quantitative data to support robust evaluation of longer-term, system-level outcomes and impacts of implementing preventative telecare models. These gaps have informed the mixed-methods design for collecting new primary evidence within three case study sites in DECIDE's rapid evaluation of proactive remote monitoring technologies for social care (https://openresearch.nihr.ac.uk/articles/5-71).

References

1. ADASS (2022). Digital transformation in social care: How to get it right. https://tec-action.org.uk/wp-content/uploads/2022/08/ADASS-Lilli-report-2022_Med-Res-DPS.pdf
2. ADASS (2024). The Future of Independent Living: How proactive technology can enable people to live the lives they want to lead for longer. https://www.intelligentlilli.com/reports/the-future-of-independent-living
3. ADASS TSA Commission (2021). Exploring How Technology Can Be Truly Integrated Into Adult Social Care. https://www.tsa-voice.org.uk/downloads/pdfs/adass_tsa_commission_report_integrating_technology_into_social_care_final_pages.pdf
4. ADASS and Lilli (circa 2021). The future of data-driven social care: How can we harness information to care more proactively? https://www.intelligentlilli.com/reports/the-future-of-data-driven-social-care
5. Cole S (2024). The power of rich data in commissioning better outcomes. Powerpoint slides from stakeholder: Mole Valley Life.
6. County Councils Network (2023). Adopting the right technology to transform social care. https://tec-action.org.uk/wp-content/uploads/2023/02/Tunstall-Design-Draft-16-1-23-1.pdf
7. Glasby J, Litchfield I, Parkinson S, Hocking L, Tanner D, Roe B, Bousfield J. (2023) New and emerging technology for adult social care – the example of home sensors with artificial intelligence (AI) technology. Health Soc Care Deliv Res 11(9). https://doi.org/10.3310/HRYW4281
8. Hertfordshire Public Health Evidence & Intelligence (2020). Assistive Technology Proof of Concept: Evaluation Report. democracy.hertfordshire.gov.uk/documents/s19716/20071305b Appendix B ITT Bid for Assistive Technology.pdf
9. Kent, Surrey, Sussex Academic Health Science Network (2021) - Technology Integrated Health Management - Health economic evaluation. https://static1.squarespace.com/static/61570f2b03a9f47ce3c25c3d/t/619139d766ada547ff5fc416/1636907491242/TIHM_Report_V1.0+3.pdf
10. Lilli (circa 2022). Starting with Social Care: How to have a whole system impact. https://www.intelligentlilli.com/reports/starting-with-social-care
11. Lilli (circa 2021). Evidencing the success of remote monitoring: Delivering savings and supporting evidence based decision-making in social care. https://www.intelligentlilli.com/reports/evidencing-the-success-of-remote-monitoring
12. Lilli (circa 2023). Implementing an outcomes-based digital solution. https://www.intelligentlilli.com/reports/implementing-an-outcomes-based-digital-solution
13. Litchfield, I., Glasby, J., Parkinson, S., Hocking, L., Tanner, D., Roe, B., & Bousfield, J. (2023). "Trying to Find People to Fit the Tech…": A Qualitative Exploration of the Lessons Learnt Introducing Artificial Intelligence-Based Technology into English Social Care. *Health & Social Care in the Community*, *2023*(1), 9174873. https://doi.org/10.1155/2023/9174873
14. NHS England Transformation Directorate (2020). Intelligent monitoring for proactive care. https://webarchive.nationalarchives.gov.uk/ukgwa/20241101055048/https://transform.england.nhs.uk/ai-lab/explore-all-resources/understand-ai/intelligent-monitoring-proactive-care/
15. NRS Healthcare, Kent and Medway Clinical Commissioning Group, and Kent County Council (2022). Kent Technology Enabled Care Service News. https://nrshealthcare.com/images/professional-pages/kent/Kent-TEC-Newsletter-Edition-4-December-2022.pdf

16. Player and Andrews (2023). Evaluation of the use, applicability and acceptability of digital remote monitoring for people living with frailty in the community, to inform development of frailty virtual wards. https://healthinnovationwessex.org.uk/img/programmes/NIPP%202022-23%20Full%20report.pdf
17. Shojaei R, Holmes H, Burgess G. (2023) TAPPI Phase 2: Evaluation Report. Cambridge Centre for Housing & Planning Research. https://www.housinglin.org.uk/_assets/Resources/TAPPI/TAPPI2-Evaluation-Report.pdf
18. Stirling P, Burgess G. (2020) How does the provision of advanced, predictive telecare and smart home technology for older people affect its outcomes? Cambridge Centre for Housing & Planning Research. https://www.cchpr.landecon.cam.ac.uk/files/media/downloadtemplate_50.pdf
19. Stirling, P., & Burgess, G. (2021). The promises and the reality of smart, digital telecare in England. Housing, care and support 2021;24(2):65-79. https://doi.org/10.1108/HCS-03-2021-0010
20. Stockport Metropolitan Borough Council (2019) - Maximising the Impact of Technology Enabled Care: Implementation phase report. https://www.local.gov.uk/sites/default/files/documents/Stockport%20SCDIP%20Implementation%20report%20April%202019%20WEB.pdf
21. TEC Action Alliance (2023) - Technology enabled lives: Delivering outcomes for people and providers. https://tec-action.org.uk/wp-content/uploads/2023/03/Technology-Enabled-Lives_v07.pdf