# Adoption and spread of technology-enabled home sensors in social care: a rapid evaluation

## Study protocol

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# Abstract

## Background

The growing pressures faced by adult social care in England has fuelled interest in technology-enabled care (TEC) to, not only help the system operate more efficiently, but also improve the quality of care and support independent living in people's own homes for longer. The DHSC 2021 White Paper emphasises plans for digital transformation across social care over the next 10 years, including a focus on What Good looks like for social care technology. Subsequent guidance provides a framework on 'what good looks like' intended for use by adult social care providers and local authorities.

Home sensors in social care is a key area in need of improved evidence to inform decisions about implementation and spread beyond current pilot projects, and the development of organisational capacity, knowledge and skills required to deliver and sustain this. There has been a proliferation of digital devices (and new providers) for in-home monitoring that offer potential to support *proactive* and *preventative* care, including assessments/reviews of a person's social care needs, real-time reassurance for carers, and changes in activity patterns to inform early intervention and support. While such technology has been widely deployed through small scale feasibility pilots, it is currently seldom used as part of business-as-usual within social care. This lack of sustained adoption at scale can be attributed to various system-wide complexities that need to be better understood and addressed if such approaches to remote monitoring are to become mainstream practice.

To shape evaluation focus we have sought views from a diverse group of 35 stakeholders including representatives from industry, national advisory bodies for TEC and Adult Social Services, cross-sectoral research networks, Integrated Care Boards and regional TEC leads and academia. Our scoping discussions affirmed widespread interest in in-home monitoring, and surfaced a small number of potentially effective uses of technology-enabled service models within social care.

Such exemplars potentially offer valuable insights into the real-world application and impact of technology-enabled in-home monitoring and, in line with current policy drivers, how such technology may become more systematically embedded within adult social care provision and practice.

The proposed rapid evaluation is intended to inform the strategic ambitions for digital transformation across social care. We will work with the organisational case sites and the DHSC/NHSE Digitising Social Care team to gain a deeper understanding of technology-enabled in-home monitoring within social care ecosystems, and generate transferable lessons on the resources, systems, people and structures needed to achieve sustained adoption at scale.

## Aims, objectives and research questions

The aim of the proposed evaluation is to define good practice in the implementation and use of technology-enabled in-home monitoring 'beyond the pilot', and draw transferable lessons that can inform spread and scale up across social care. The objectives are as follows:

1) To develop a rich picture of complex, technology-enabled change for in-home activity sensing in social care.
2) To surface, explore and help to address the numerous interacting influences on sustained use of such service models in social care.
3) To provide a deeper understanding of staff and service users' experiences using and supporting use of in-home sensing in social care.
4) To assess the impact and value of in-home sensing in social care for services and service-users.
5) Capture and disseminate learning for wider health and social care services and its users.

Underpinning research questions for the evaluation are:

1. What constitutes in-home sensing in the context of supporting social care, who is it for, and how does it help provide care to service users?
2. What impact and value does this have across the care system, and how could this be locally evaluated and monitored in the future?
3. What does sustained adoption at scale look like within the context of technology-enabled in-home monitoring within social care, and how can it be achieved?
4. What structures and resources (financial, organisational, technical, human) are needed to achieve this?

## Design and methods

This evaluation will take a multi-site, mixed-methods (qualitative and quantitative) approach with three organisational cases studies, in order to build a rich picture of the impact and value of in-home sensing in social care and the system-wide factors that influence and shape sustained adoption at scale.

Data collection and analysis will be guided by the NASSS (non-adoption, abandonment and challenges to scale up spread and sustainability) framework, in order to surface and explain the system-wide challenges and complexities in the technology-supported service change.

The project will follow three overlapping phases.

Phase 1 (pre-assessment and groundwork) will focus on project set up, confirming case study sites, and establishing the goals, projected benefits and concerns with regard to the technology-enabled service being evaluated. This will be conducted through a targeted literature review and evaluability assessment with the three case sites.

Phase 2 (formative evaluation) will include qualitative and quantitative data collection, analysed iteratively and through discussion with case site teams. Qualitative data will include interviews with up to 36 staff and system stakeholders (10-12 in each site) to explore the (inter)organisational resources, processes and challenges to implementation. In addition, we will conduct home visit interviews with 15 service users (5 in each site) to illuminate the lived experience of such technology, how it helps them (or not) in their everyday lives, and concerns and/or unintended consequences for the individual and/or their formal and informal networks of care. A key element will be to capture the challenges for users with complex support needs and issues associated with inequalities in access, use and support. The quantitative data will focus on economic-related outcomes in each site. This will take the form of a cost-consequence analysis, which will involve the identification, measurement and valuation of relevant costs and consequences of selected service models.

Phase 3 (summative analysis) will involve data synthesis and cross-case comparisons to draw transferable lessons, report writing and dissemination. This will be supported by cross-site and inter-stakeholder workshops to explore the implications of the evaluation findings for national policy, and draw practical lessons for scale up, spread and sustainability of in-home activity monitoring within social care.

## Timelines for delivery

The project is anticipated to start in spring 2024 and complete over a period of 10 months.

## Anticipated dissemination and impact

Outputs will include a final report with executive summary, including the case study narratives based on the qualitative and quantitative data, summative findings and key recommendations for policy, practice and future evaluations. The final report and executive summary will be made freely available through the DECIDE website. A lay summary will also be made available with the support of a project PPIE group. We will build interest and raise awareness more widely about the project from the outset, and work with our policy customer to inform ongoing national strategy in digitising social care, including feeding into evolving national evaluation frameworks.

## Background and rationale

### There is a growing need for social care services in a climate of funding cuts and workforce crisis

Adult social care provides a wide range of services designed to assist people who are older, and people living with disability, physical or mental illness to maintain independence and wellbeing. These services include personal care (e.g. support with washing, dressing, eating etc.), helping people stay active and social within their communities, and can be within people's homes, day centres, and as residential care.[1] Support can be short-term, with the aim of maximising independence and eliminating the need for ongoing support, or long-term and provided on an ongoing basis.

In 2022/23 in England 835,335 people received long-term care, which was an increase of 2.1% (17,415 people) since 2021/22; and 219,212 people received short-term care in 2022/23, which was similar to the previous year (219,555 people in 2021/22).[2, 3] There has also been an increase for requests for adult social care support, for the first time ever reaching over 2 million requests, from 1.4 million new clients,[3] with large increases particularly evident for those aged 18-64 years old.[4] The demand for social care services has been steadily increasing and is likely driven in part by requests from older adults, but increasingly by requests from working age adults reflecting increasing levels of disability among this population.[5] There is also a rising prevalence of people with the highest social care needs requiring more complex support.[6]

Alongside an increase in requests for support, since 2015/16 there has been a decrease in the number of people accessing support, which is likely due to the reduction in local authority spending power and tightening of the financial eligibility criteria for people to receive publicly funded care.[5] Local government spending on adult social care in England in 2022/23 was £23.7 billion (gross current expenditure), an increase of £1.7 billion (7.9%) from 2021/22.[2] The cost of social care is rising, partly due to increased demand for services and also the increasing cost of providing them.[1] The government funding for local authorities in real-terms, however, has fallen 55% between 2010/11 and 2019/20, reflecting a 29% spending cut in real-terms, which has led local authorities to direct social care spending to those with the greatest needs.[6]

In addition to funding challenges, there is a workforce crisis in adult social care. The social care workforce is much smaller than that required to fulfil the needs of the population, with many staff vacancies, people leaving the sector, and people moving around within the sector, impacting on care continuity.[7] Whilst the number of jobs in adult social care has increased, so too has the number of vacancies.[4] Historically, vacancy rates in social care inversely mirrored those of overall unemployment rates, but for a third consecutive year social care vacancies increased at a rate higher than the overall unemployment rates declined. Pay for care workers has not increased in line with other sectors, and workers increasingly value more flexible working and so are leaving the sector to work elsewhere.[5] Funding cuts have also impacted on unpaid carers (who contribute care equivalent to 4 million paid care workers and without whom the social care system would collapse), as fewer received paid support (27% in 2021/22 compared to 31% in 2015/16); although more received signposting, advice and information (56% in 2021/22 compared to 50% in 2015/16).[5]

### Adult social care policy turns to technology to help overcome challenges

The growing pressures faced by adult social care in England have led people to seek technology-supported solutions.[8, 9] The use of digital technology and technology-enabled care (TEC) in adult social care is perceived by many to not only help the system operate more efficiently, but also improve the quality of care and outcomes for those requiring care and support independent living in people's own homes for longer.[9, 10, 11, 12, 13]

Digitally-enabled care is a central feature of the NHS Long Term Plan, aiming to make processes more efficient to free up staff time, and improve access and quality of care.[14] The Digitising Social Care Transformation Directorate was created in 2019, and has since progressed a programme of work, delivered by a joint unit across NHS England and the Department of Health and Social Care (DHSC), which aims to support and transform adult social care through digital innovation, including generating and utilising evidence to support innovation in the sector. This programme has continued to be reinforced through subsequent policy. The People at the Heart of Care White Paper, published in December 2021, presented a 10-year vision for social care, which includes at least £150m of additional funding over three years to support the adoption of technology and achieve widespread digitalisation, including testing and scaling of technologies for care, increasing the number of providers using digital social care records, improving infrastructure and cyber security, and improving workforce digital skills.[15] This work is further reinforced by DHSC's commitment to support sustained digital transformation of the sector, and the parallel push for digital social care records and improved infrastructure to support digitalisation and use of technology in the sector.[11, 16, 17] This transformation is envisaged through both testing and scaling of new technologies (through 2023 to 2025), and enabling care information to be shared securely with relevant professionals across health and social care, with the vision of improving care quality and safety.[16, 18] Recognising workforce pressures, the programme of work further encompasses training and development opportunities for adult social care staff to develop digital skills.

The DHSC 2021 White Paper emphasises plans for digital transformation across social care over the next 10 years, including the development of guidance on What Good looks like for social care technology. Subsequent guidance provides a framework on 'what good looks like' intended for use by adult social care providers and local authorities. Linking with the vision set out in People at the Heart of Care, the idea is to provide a series of common goals for these organisations and for relevant individuals (e.g. digital leads, directors of adult social care services) to use them to inform and guide digital transformation.

This policy push has been welcome across the sector and more widely (e.g. via user groups, industry), with improvements in quality and efficiency envisaged in the organisation and planning of care, as well as delivery of care in people's homes. There are, however, concerns. These relate particularly to (i) the potential of technology as a 'solution' to the significant challenges currently facing the adult social care sector (see above); (ii) the time and attention needed for implementation across diverse local authority settings and populations, that not only accounts for the additional knowledge, skills, tasks and responsibilities needed to enable TEC provision, but also does so in ways that carefully consider implications for digital equity in service provision; (iii) the fact that many of the expected impacts are focused on healthcare outcomes, rather than specifically social care outcomes; and (iv) the potential for rapid spread and scale up of digital innovation across the sector given the currently limited capacity, funding and skills combined with limited incentives for change when impacts potentially lie beyond social care.[9,11,12] These are compounded by a currently limited (albeit rapidly growing) evidence base to support informed decision making about the development, adoption, implementation, spread and potential scale-up of TEC in this sector.

Home sensors in social care is a key area in need of improved evidence to inform decisions about implementation and spread beyond current pilot projects and the development of organisational capacity, knowledge and skills (e.g. for procurement) required to deliver and sustain this. Through initial scoping work the DECIDE team connected with the Digitising Social Care team at DHSC/NHS England who will act as customer for the work proposed. To shape evaluation focus we have additionally sought views from a diverse group of 35 stakeholders including representatives from industry (e.g. Intelligent Lilli, Whzan), national advisory bodies (e.g. TEC Services Association, Association of Directors of Adult Social Services), cross-sectoral research networks (e.g. Health Innovation Networks), Integrated Care Boards and regional TEC leads and academia.

Our scoping discussions with stakeholders (see above) have affirmed interest in remote in-home monitoring and surfaced a small number of potentially effective uses of technology-enabled in-home monitoring solutions within social care. These TEC solutions vary in terms of technical functions and service models, but typically incorporate the use of installed sensors, an online monitoring dashboard and mobile alert functions to identify/flag activity changes (e.g. Intelligent Lilli). Stakeholders have flagged more advanced solutions as offering linkage to care purchasing budget and care services (e.g. Anthropos, Cascade3D). Such exemplars potentially offer valuable insights into the real-world application and impact of technology-enabled in-home monitoring and, in line with current policy drivers and the work of the Digitising Social Care team set out above, how such technology may become more systematically embedded within adult social care provision and practice.

## There is great potential for the use of telecare in social care, but there is a lack of evidence beyond pilot stages for these to be adopted, adapted and spread to other settings

The NHSX Technology and Digital Skill review in November 2021 highlighted that a range of technology was being used to deliver care (e.g. consumer digital technology or apps, business support or care management systems, support and monitoring digital technologies, and advanced digital technologies), but that awareness and knowledge of these was variable across the workforce and care providers, and low among unpaid carers and those with care needs.[10] The COVID-19 pandemic accelerated the desire for and use of TEC in adult social care, examples of which include telehealth, telecare, telemedicine and telecoaching.[10, 13] However, TEC is not currently being used to its full potential in social care.[9]

Telecare (the continuous remote monitoring of people at home using indoor sensors and personal trigger alarms) is seen as a critical means by which local authorities can maintain social care provision and shift the location of care away from residential care services.[11] Over the last decade, there has been a proliferation of digital devices (and new providers) that offer potential to support *proactive* and *preventative* care, including assessments/reviews of a person's social care needs, real-time reassurance for carers, and changes in activity patterns to inform early intervention and support).[9, 10, 13] Broadly referred to as 'lifestyle monitoring' (referred to hereafter as 'in-home activity monitoring'), proactive telecare offers multifunctional devices that generate data (generally related to activity) that is then aggregated to monitor and manage care needs.[13] In 2023, Glasby highlighted that a culture shift within social care would be required if home sensor TEC were to deliver on their potential, from focusing on dealing with crises to preventing crises.[9] From our scoping conversations with key stakeholders described above, there appears to be an appetite to use in-home activity monitoring for prevention and proactive telecare within social care.

The use of in-home activity monitoring TEC can be broadly categorised into three groups:[13]

1) For **assessment review** - used ad-hoc and on a case-by-case basis to provide insight into individual needs to inform care package assessments and improve independence, whilst taking into account solutions already in place in that person's life.
2) For **reablement** – a short term use of monitoring (e.g. 6-weeks) following an event, such as hospital discharge post-surgery, to monitor progress and personalise care packages, whilst supporting independence.
3) For **long-term monitoring** – used longer term to monitor people and detect changes in behaviour that may require an urgent response (e.g. a lack of movement) or provide gradual insight into changing conditions (e.g. changes in eating, sleep, toilet behaviours).

Published academic literature on the topic of TEC in the UK is sparse and often heavily technology-centric. Crucially, limited research has been conducted in the context of social care and empirical studies have mostly been small-scale and focused on establishing feasibility, data capture and processing with limited attention paid to issues surrounding disadvantaged groups and digital exclusion or how data capture might usefully inform care assessment/practice.

For example the small number of scoping and systematic reviews which focus on TEC tend to consider it from the perspective of remote monitoring within the context of cognitive decline or neurological conditions.[19, 20-22] Technologies include 'distributed systems' (combining data from multiple home sensors and Internet of Things, IoTs), hand-held/mobile devices (e.g. data captures through software/mobile device), and wearables (e.g. GPS and accelerometers), which focus on diagnosis, assessment of behavioural patterns, assistance and therapy, and assessment of real-time location. The reviews are technology-centric, largely aiming to understand technical advances and capabilities, with a particular focus on machine-learning. Almost all are confined to a specific research setting, consisting of feasibility studies with a particular focus on establishing correlations between machine learning/algorithm inferences and trusted/standard measures (e.g. cognitive assessments, paper diaries), as well as small scale/case study trials to evidence psychosocial outcomes (e.g. quality of life, reassurance). The reviews underline the fact that very little research has been conducted within the care service context. As a consequence, little attention has been paid to the implementation of TEC within routine care practice. Of the few studies noted to take place in formal care settings, these are generally based in residential care homes, and still contained within a research/trial context. The lack of evidence and adoption within clinical and care settings is generally acknowledged within the reviews, but still largely framed as a *technical* challenge to be overcome by way of more reliable technology, which is easier to use and addresses issues of privacy and security.

In parallel, a limited number of UK-based empirical studies have been conducted in the last five years on home sensors for monitoring in social care and these have mostly focused on small scale feasibility projects, often focusing on reablement and the prospect of long-term monitoring. One example of in-home activity monitoring for reablement identified in the DECIDE horizon scanning exercise was the use of the Howz app to remotely monitor 19 stroke survivors who lived alone.[23] The app used machine learning techniques to combine data from the user's electricity metre, as well as installed home sensors (movement, light, temperature sensors), in order to recognise their day-to-day routines, and identify 'abnormal' patterns of behaviour.[23] In this eight-week trial, all users considered the technology to be beneficial, despite varying levels of engagement, and the extent to which the technology was implemented was contingent upon household settings (e.g. electricity metres were not always accessible), as well as user preferences and capabilities (e.g. not all wished to use the tablet/mobile devices provided).[23] Similarly, another study of 13 patients undergoing total hip or knee replacement had sensors monitoring the home environment (humidity, light and temperature) and the activity of patients at home.[24] Whilst the patients found the technology to be acceptable, there were practical challenges around ensuring devices were charged and patients remembering to wear the monitors.[24] Practical challenges around the use of sensors were also found in a rapid evaluation of a home sensor with artificial intelligence technology, which indicated that the sensors were not sufficiently stable or effective in collecting reliable data over the required period of time to produce the anticipated benefits of using them.[9] In addition, many people who require care in their own homes may not have the digital infrastructure needed to support remote monitoring.[9] There are also further practical challenges around some systems requiring specialists to set up the technologies in people's homes, providing an additional potential barrier to their use.[9]

One study, focused on the potential for long-term monitoring, explored the use of different home-based medical devices which are designed to identify 'digital biomarkers' of fatigue and sleep disturbance (e.g. activity sensors, bed sensors, wearable ECG and movement monitors, wearable sleep monitor, and bedside breathing and heart rate monitor).[25] These were installed in the homes of participants with a range of health and social care needs (including Huntington's disease, rheumatoid arthritis, systemic lupus erythematosus, primary Sjögren's syndrome and inflammatory bowel disease) as well as healthy individuals.[25] Five weeks after installation, 60 semi-structured interviews were conducted and key themes highlighted importance of 'ease of use/low effort', 'minor disruptions to their daily lives' and 'good support from the study team' in the acceptability of these devices for home use, from the users' perspective.[25] Despite this technology providing the opportunity to monitor long-term, participants in the study used seven different devices and used each device for two weeks, which highlights the infancy of evidence this area. Other studies utilising wearables have been used to monitor mobility in patients with dementia or mild cognitive impairment.[26]

Furthermore, there is very little consideration in the literature on issues of inequalities related to TEC provision and use. Digital inequalities tends to affect those with multiple other kinds of disadvantage such as poverty, low health literacy, poor housing, weak social networks, psychological stress, language and cultural discordance, which together may increase their vulnerability to illness, disease and disability.[27] Tudor Hart's inverse care law (people most in need of health care are least likely to seek it or receive it) reflects two mutually-reinforcing phenomena: worse health in deprived communities and also barriers to their access to healthcare[28]. There is thus an important gap in the literature to explore the lived experience of digital disparities from the perspective of the patient who is disadvantaged, and the intersectionality of multiple markers of disadvantage on people's access and use of TEC within social care.[29]

## Why this evaluation is needed now and who is it aimed at?

There is now substantial evidence that in-home-monitoring can work (technically) and there is some (often anecdotal) evidence that it can deliver benefits in practice. In the rapid evaluation of home sensors in social care, anecdotal examples of sensors benefiting individuals were reported; for instance, the detection of someone having seizures at night; restless nights indicating the onset of vertigo; paramedic response to abnormal heart rate monitoring; the use of a kettle and fridge indicating that someone was regularly eating and drinking.[9] Despite this, there is not systematic evidence that can fully inform decision makers who are considering whether to adopt, adapt and/or spread the technology in their own settings.[9] The rapidity of technological developments and changes in the market, both in specialised technology specifically designed for health and social care but also general consumer technologies, also provides challenges to decision makers as by the time evidence for the effectiveness of a technology is available, the technology can become obsolete.[9, 11]

There is an array of products and services on offer, typically encompassing use of installed activity sensors (e.g. motion, door, environmental), an online activity dashboard (to review and monitor activity data) and text-based alert applications (e.g. based on pre-set parameters or changes in activity patterns). Such technology has been widely deployed through small scale feasibility pilots, but is currently seldom used as part of business-as-usual within social care. This lack of sustained adoption at scale can be attributed to various system-wide complexities that need to be better understood and addressed if such approaches to remote monitoring are to become mainstream practice. Our review of current evidence, alongside scoping discussions with key stakeholders have flagged a series of key challenges that include (but are not limited to):

a. a diverse and evolving technology market that can be challenging to navigate, offering different technical capabilities and associated services, and bringing potential infrastructural challenges (e.g. in relation to interoperability). The evolving technical capabilities and ever-increasing range of products and services in this space brings challenges in establishing a consistent plan and stable service model. Multiple suppliers and devices tend to be used within one service model, and sustaining this (while recognising the need for evolution of both services and technologies) brings complexities to planning and providing technology-enabled services. Local authorities need to balance stability and change in ways that allow them to co-evolve services, alongside wide-ranging technological opportunity and change.
b. a high degree of intra- and inter-organisational variation across social care organisations (e.g. local authorities, technology suppliers, care service providers, alarm response centres), particularly (but not only) in terms of commissioning and procurement approaches, and skills/knowledge about the potential use of technology in social care. Proactive telecare is also currently being explored and applied in different ways in different settings, with variation in outcome focus. This is notable for reablement, in which the technology used for a short-term period (e.g. 6 weeks) to facilitate hospital discharge and inform future care packages; and for long-term monitoring, in which technology is provided as part of ongoing service for actionable insights to changes in activity patterns.
c. limitations in developing a local business case to resource and maintain in-home monitoring services, with a need for local authorities to, not only establish value for money before investing necessary resources and infrastructure, but also provide the resource and infrastructure that such technology requires to 'work' and to demonstrate value. In scoping discussions, attention has tended to focus on the operational aspects of introducing and sustaining technology-enabled service models, with a perceived need to strengthen the economic case and align more closely with regional health and social care strategy. Many people have emphasised the lack the time, resource and expertise to capture and leverage existing data as part of this.
d. challenges of bringing about system-wide change for those progressing towards sustained use of proactive telecare, particularly across inter-organisational boundaries. New ways of working and using sensing data, such as within ARCs (alarm response centres), and connecting this to wider parts of the care system, are key and seen to be achievable. However, scoping discussions have also given a very strong steer that the preconditions, resources (financial, human, technological, infrastructural), and the mechanisms for change to achieve this need to be better understood in the context of adult social care.

e. limited research base, and lack of standardised evaluation framework, which places limits on evidence-informed decision making and potential for evaluation of local/wider technology-enabled services.

Given current priorities in health and social care, the scale of pressures facing the health and care system, and the apparent potential benefits of in-home monitoring, the need for further evaluation on this is urgent.

The proposed rapid evaluation of technology-enabled home sensors is intended to inform the strategic ambitions set out above, working with the DHSC/NHSE Digitising Social Care team to gain a deeper understanding of technology enabled in-home monitoring within social care ecosystems and generate transferable lessons on the resources and structures needed to achieve sustained adoption at scale.

# EVALUATION PLAN

## AIM, OBJECTIVES & RESEARCH QUESTIONS

The aim of the proposed evaluation is to define good practice in the implementation and use of technology-enabled in-home monitoring 'beyond the pilot', and draw transferable lessons that can inform spread and scale up across social care. The objectives are as follows:

1) Develop a rich picture of complex, technology-enabled change for in-home activity sensing in social care.
2) To surface, explore and help to address the numerous interacting influences on sustained use of such service models in social care.
3) To provide a deeper understanding of staff and service users' experiences using and supporting use of in-home sensing in social care.
4) To assess the impact and value of in-home sensing in social care for services and service-users.
5) Capture and disseminate learning for wider health and social care services and its users.

Underpinning research questions for the evaluation are:

1) What constitutes in-home sensing in the context of supporting social care, who is it for, and how does it help provide care to service users?
2) What impact and value does this have across the care system, and how could this be locally evaluated and monitored in the future?
3) What does sustained adoption at scale look like within the context of technology-enabled in-home monitoring within social care, and how can it be achieved?
4) What structures and resources (financial, organisational, technical, human) are needed to achieve this?

## STUDY DESIGN & METHODOLOGY

### Evaluation approach

The study is positioned in the tradition of developmental evaluation; an emergent, flexible approach to evaluating an initiative that captures data that can be fed back to the people leading the initiative to inform ongoing developments, and adapts to the particular needs and challenges of the service change.[30] Given that in-home activity sensing for proactive care is an emerging and evolving model within social care, and includes diverse approaches and technology providers, our focus will be on building a detailed picture on how such technology is used and becomes embedded within social care ecosystems. Working in partnership with three organisational case studies in England (local authorities and collaborating organisations using/supporting in-home monitoring within social care), we will conduct an in-depth analysis of the multiple system-wide influences on the implementation, spread, scaling up and sustainability of in-home activity monitoring within social care, and draw transferable lessons for policy and practice.

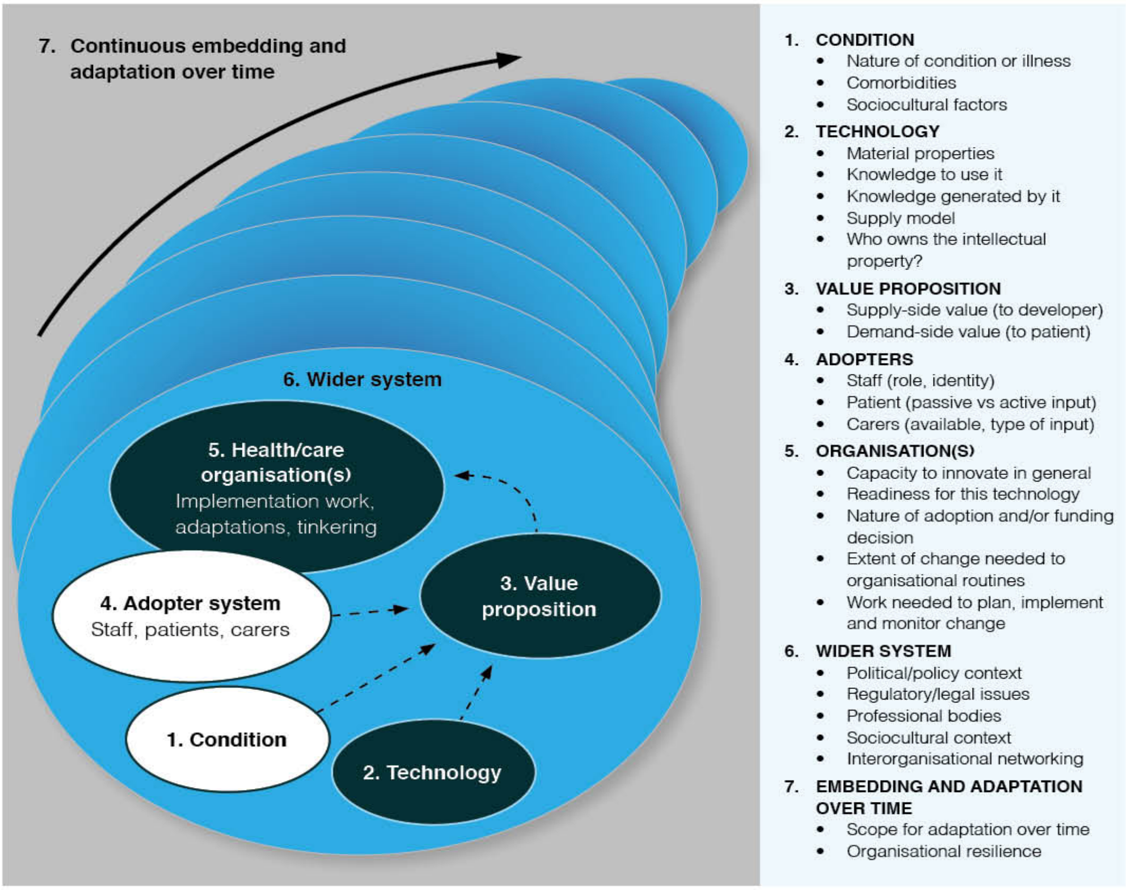
We will work collaboratively with stakeholders in each case study setting to support mutual learning about how the technology impacts quality of care and service-level outcomes, and the organisational changes needed to achieve sustained adoption at scale. This will be supported through different formative channels, including team meetings and workshops. A key element within this component will be to support inter-organisational and cross-sectoral dialogue across key stakeholders, including: i) health and social care professionals and support staff; (ii) service user and carers; iii) TEC and care system leads; iv) regional leads and decision makers (e.g. ICBs/ICSs, HINS), (v) national decision makers/policy-related bodies; and (vi) industry.

Data collection will take a theoretically-informed, mixed-methods (qualitative and quantitative) approach guided by the NASSS (non-adoption, abandonment and challenges to scale up spread and sustainability) framework. The NASSS framework was developed by our team as an analytical tool to surface and explain the challenges and complexities in technology-supported service change.[31] It includes seven interacting domains: the condition or illness, the technology, the value proposition, the adopter system (intended users), the organisation(s), the wider system (especially regulatory, legal and policy issues) and emergence over time (see Figure 1 below). These domains will guide data collection (including interview schedules and sampling strategy), thematic analysis and cross-case comparisons.

In addition, we will look to build on the recently published Consolidated Evaluation Framework for Technology Enabled Care (CEFTEC), which draws on NASSS and other analytical frameworks within the technology-enabled care literature to provide guiding principles on analysis and reporting.[32] Where feasible and helpful, we will feed into this evolving framework as a means of supporting on-going and future evaluation in this sector (see section below on *Anticipated outputs, impact and plans for dissemination*).

The mixed-methods approach will provide a rich picture of each site’s experience and how in-home activity sensing impacts health and social care services and users. Qualitative data collection (including interviews and ethnographic fieldwork) will be conducted with staff, service users, informal carers and other key stakeholders, in order to provide a detailed insight into different perspectives and experiences of the technology within routine care practice.

Quantitative data will include aggregated data of service user and service-level outcomes, accessed in collaboration with the case site teams. This will include service user demographics (age, ethnicity, gender, geography/postcode), duration of use/installation, type and frequency of alerts and economic-related outcomes. Quality of life surveys will be used to evaluate impact on service user independence, social and mental wellbeing. The quantitative data requirements and collection protocols will be established in discussion with the case site teams during Phase 1, and adapted to local capacity and systems. Efforts will be made to maintain consistency across sites.



Note: Adapted from Greenhalgh T, et al. 'Beyond adoption: a new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies'.[1]

**Figure 1: NASSS framework**

The quantitative and qualitative findings will be mutually informing to explore the challenges and outcomes in each setting. For example, quantitative data on changes and differences in use across sites will inform our qualitative study of local contingencies on provision and adoption. Conversely, qualitative data will highlight new ways of working with the technology and unanticipated consequences, which would be important to capture and monitor through quantitative measures in order to understand potential impact on service capacity and value for money.

The different data sources will be drawn together in a detailed case narrative for each case site, with (anonymised and merged) service user case examples as well as key quantitative data. A summative analysis and cross case comparisons will be conducted to draw transferable lessons on the impact and value of in-home sensing, the barriers and challenges faced in shifting 'beyond the pilot' and the structures and resources required for sustained adoption at scale.

## Study design and methods

This evaluation will take a multi-site, mixed-methods approach to understand system-wide factors that influence sustained adoption at scale. This will include three organisational case studies (potential case sites described below). The evaluation will involve a multi-level approach to data collection, including at individual level (service user interviews and narratives), service level (staff interviews, fieldwork and service-level outcomes) and wider-system level (regional and national stakeholder interviews and workshops).

Data collection and analysis will consists of three overlapping phases, with ten constituent work packages (WPs), which are summarised in Figure 2.

<u>Phase 1 (pre-assessment and groundwork)</u> will focus on confirming case study sites and building relationships, agreeing project goals and outcomes, establishing local approvals and processes for data collection, and establishing a PPIE and project advisory group.

<u>Phase 2 (formative evaluation)</u> will include qualitative and quantitative data collection and analysis within each case site. Given the complexity and variation in the use of home sensing in social care, this phase will begin by exploring how the technologies in-use fit within the social care ecosystem, in consultation with case site teams. This will further inform our approach to qualitative data collection with staff and system stakeholders. Qualitative data will include interviews and ethnographic fieldwork with case site staff and system stakeholders to understand the socio-technical work systems involved and the challenges to implementation and use. We will also conduct home visit interviews with 15 service users (5 in each case site) provided with technology for in-home activity monitoring. Qualitative data will be analysed using constant comparative analysis,[33] will be guided by the NASSS framework, and fed back and discussed with case site teams through regular meetings. In addition, quantitative data will explore service-level outcomes with a focus on the economic impact and value. This data will be captured in collaboration with the case site teams, leveraging existing and routinely captured data where possible, including costs/resources, uptake and use, and health and social care related outcomes.

<u>Phase 3 (summative analysis)</u> will include data synthesis and cross-case comparisons to draw transferable lessons, report writing and dissemination. Cross case comparisons will be supported by the case site narratives structured using the NASSS domains. Key findings will be shared and discussed through two stakeholder workshops, in order to explore implications and distil lessons for wider policy and practice.

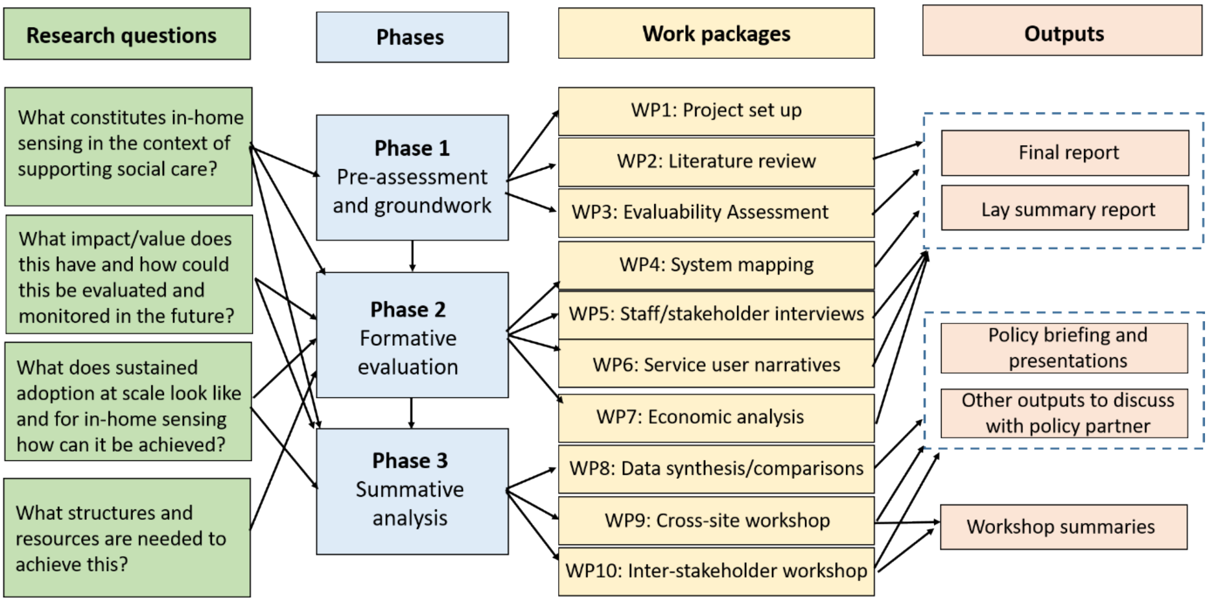


**Figure 2: Summary of evaluation activities and links to research questions**

## Case site sampling

The case sites will include three local authorities (and their collaborating organisations) where in-home sensing is being implemented and sustained as part of service transformation. Case study sites will be selected in consideration of our aim to learn from organisations that are scaling up use of the technology 'beyond the pilot', and with scope for offering broader learning for policy and practice. To this end we will seek a purposive and maximum variation sample of sites with regard to the technology platforms and approaches to proactive monitoring, geographical contexts, and populations serviced (with inequalities being a key theme of interest).

Building on scoping work (see section on *Background and rationale*), we have explored a range of possible sites that meet the above sampling criteria, facilitated by various networking channels, including the DECIDE Steering Committee and Internal Advisory Group, regional Health Innovation Networks, the NHSE/DHSC Digitising Social Care team, professional networks, and advisory bodies (e.g. Telecare Services Associated). In total we have engaged with 10 local authorities regarding participation. These engagements have highlighted the diversity in approaches to in-home sensing in social care, encompassing varied proactive models to assessment, reablement and long-term monitoring. There is significant variation in the (often combined) use of technology platforms and devices, how they connect with wider health and social care processes and systems, and the progress or 'maturity' to embedding and sustaining the service model. From these discussions, we have identified candidate organisations that are using one or more sensor technologies and platforms to support in-home remote monitoring, many of which have expressed interest as a case site. Some example organisations that we have engaged with relevant to this study include:

- **Sheffield City Council,** where they are using in-home sensing to support reablement and long-term monitoring. This follows a funded test-of-change programme over the last 18 months, and they now moving towards scaling up and sustaining the services models. The reablement model uses the **HOWZ platform** (Howz | Technology Enabled Care), which includes passive activity sensors (smart plugs for appliances, motion sensors, door sensors), as well as potential integration of medical devices (e.g. weight, pulse oximeters) to monitor and identify changes in activity patterns and health indicators. For long-term monitoring, they are using Anthropos (Connected care for independent older living (anthropos.io), which consists of activity sensors (motion, fridge sensors, door sensors, and smart plugs for appliance use) to generate data on activity patterns through an online dashboard, with alert functions (e.g. detecting a fall, absence of activity) and actionable insights (changes that inform care provisions or early intervention).
- **Surrey County Council** are using in-home sensing for reablement and long-term monitoring. The reablement model includes **Cascade-3D (**Solutions | cascade3d), which can integrate data from activity sensors in the home, as well as Bluetooth medical devices (e.g. pulse oximeter, blood pressure monitor), to learn usual patterns of behaviour and identify changes in activity and wellbeing. Similar to Sheffield, long-term monitoring is also supported using **Anthropos** to learn activity patterns and identify urgent events and actionable insights.
- **Nottingham City Council and Nottinghamshire County Council** are using **Intelligent Lilli** (Intelligent Lilli - The future of independent living), as part of an ICS-wide programme to support short-term assessment, reablement and long-term monitoring in the community. Intelligent Lilli uses installed sensors to monitor and learn daily patterns trends related to activities of daily living to inform care assessments, and recognise changes in patterns that may indicate a change in condition and raise safety alerts. The technology has been used in a range of care contexts and instances, with a focus on reducing time for hospital discharge,

delaying residential care placements, and supporting independence for people with learning disabilities (e.g. reducing need for night sitting services).

- **Suffolk Country Council** is working with Alcove (Alcove – Alcove Shop (youralcove.com)) to develop a service delivery model for in-home activity monitoring that integrates different sensor devices (including smart plugs, motion and door sensors), as well as two-way communication devices, to personalise monitoring capabilities and alert parameters. It is currently in use within the reablement pathway for short-term monitoring and assessments, and to support long-term monitoring alongside service users' care networks.
- **Essex Country Council,** is using **Anthropos** for short term, ad-hoc assessment as part of care package assessments and reviews. The team are now focusing on developing a service model to embed this technology within the reablement pathway to inform more personalised and cost-effective care packages, speed up discharge processes and avoid readmission.

The initial phase of the evaluation will continue to engage with such organisations and confirm site selection. This will be based on the sampling strategy described above, combined with input from the advisory group, case site capacity to engage, and access to data within the timeframe needed for rapid evaluation (in *WP3 Site selection and evaluability assessment).*

## Data collection and analysis

### Phase 1: Pre-assessment and groundwork – goals, motivations and current practice (months 1-2)

This phase will include preparatory work for the rapid evaluation, including project set up, literature review, case site selection and evaluability assessment. The evaluation team will meet with key contacts within each case site, in order to establish the goals and motivations of the in-home sensing service developments, expected benefits from participation in the evaluation and process for data collection and formative analysis.

#### *WP1: Project set-up and governance*

We will establish project management and governance processes and approvals. This will include the following:

- *Establish the project advisory group:* We will form a project advisory group to guide the project. This will draw on membership from the DECIDE steering committee, and include one or more representatives from our policy customer (the DHSC/NHSE Digitising Social Care team). The meeting format and schedule will be agreed with the group, but we expect these to occur every three months over Teams; beginning with an inception meeting at the start of the project.
- *Establish the project PPIE group:* We will establish a PPIE (Patient and Public Engagement) group specific to this project, drawing from the DECIDE user advisory group and complimenting with 1-2 service user/carer representatives to address knowledge and experience gaps on the topic. The format and meeting schedule will be agreed with the group, but we expect each member will contribute one to two days each over the course of the evaluation.
- *Governance and permissions:* We will gain relevant approvals to access sites and data, and finalise participant documentation.

#### *WP2 Literature review*

A rapid and focused literature review will be undertaken to summarise key existing literature based on thematic analysis, including both peer-reviewed literature as well as grey literature focused on in-home activity monitoring in the UK. The review will help identify common elements of remote monitoring pathways and sensitise us to variables to consider in implementing the evaluation. We will conduct a targeted search strategy using PubMed to identify key sources of academic literature and Google to identify recent, local evaluations of in-home monitoring programmes in social care. The literature review will inform our evaluability assessment (*in WP3 on Site Selection and Evaluability Assessment*).

### *WP3: Site selection and evaluability assessment*

We will confirm case sites based on discussions with the project advisory group regarding the local site contexts and their capacity to engage. As described above, we will seek variation across selected sites with regard to the technology platforms in-use, approaches to proactive monitoring; the regional/geographical contexts and populations serviced (with inequalities being a key theme of interest). The selection process will be supported by preliminary discussions with the TEC team leads within each site to explore and clarify key criteria for meaningful variation across sites.

Following selection of the three case sites, an evaluability assessment will be conducted in each, in order to agree goals and processes for the evaluation. This will include an initial group meeting over Teams, followed by ongoing communication to refine plans and processes for data collection. These meetings will focus on three main aspects:

- *Defining meaningful benefits:* We will establish the goals and motivations of the in-home sensing service developments, expected benefits from participation in the evaluation and future plans building on this.
- *Establish data collection processes:* We will agree relevant data/measures and associated processes and protocols to access and share aggregated data. This will include a review of data availability and requirements for the economic analysis (*in WP7 on Economic Analysis*). This will take a phased approach, beginning with one site, which will subsequently guide the approach/focus in the second and third sites.
- *Establish lines of communication:* We will identify contact points and channels for communication between the case site and evaluation teams, in order to facilitate data collection and formative analysis of emerging data (during Phase 2). This will be supported by a kick-off meeting to build relationships with the local TEC teams in each site.

## Phase 2 – Formative evaluation – service implementation and outcomes (months 2-8)

The second phase will involve a formative evaluation of the in-home monitoring service in each site. This will include qualitative and quantitative data collection and analysis of the service activities and outcomes, guided by the NASSS domains. As part of a formative component we will feed findings back to the case site teams to discuss emerging findings and guide further data collection. The formative channels will be agreed with case site teams, but we expect these will include monthly (virtual/hybrid) meetings with pre-meeting materials/data.

### *WP4 System mapping*

Given the high level of complexity and variation across settings, we will map out the different inter-organisational roles, processes and subs-systems that constitute the technology-enabled service model being evaluated. This will initially provide a preliminary overview of the social and technical subsystems in each case site, which will guide data collection during WP5 (*Interviews with staff and system stakeholders*); which, in turn, will help expand and refine the system map.

The mapping exercise will draw on methodology described by Hussey et al[34] which uses a multi-method collaborative approach to develop system visualisations, with an emphasis on a variety of system viewpoints and different levels (or 'tiers') of detail. For each case site, we will document and visually represent the technology-enabled in-home monitoring service within the social care ecosystem. This will consist of five main steps : i) a workshop to create the base model (working with the TEC lead and wider team to construct the first version of the system); ii) feedback on major components and interactions (with input from representatives from specific sub-systems/sectors during staff interview in WP5, described below); iii) presentation of the revised model (discussing and refining the revised model with the TEC leads); iv) document review (the ecosystem map will be shared with all contributing participants by email, and they will be invited to feedback/comments on the ecosystem map; v) completion and presentation of final map (final map presented to TEC leads to provide feedback). The approach to meeting and gaining feedback will be adaptive to the pace and constraints of a rapid evaluation, involving asynchronous and remote/video meetings.

### *WP5: Interviews with staff and system stakeholders*

We will conduct semi-structured interviews with up to 36 staff and system stakeholders in total (10-12 in each case site) to understand the roles, experiences and perspectives of those who are involved in delivering, supporting and using in-home monitoring within each case site, and in the context of each system (*described in WP4 System mapping*).

The sample is likely to be highly emergent. However, we expect interviews to include the following groups:

- Case site staff: We will interview up to 20 staff (6-8 in each site) using or supporting use of the in-home monitoring technology/service. This will include staff within the local authority and health and social care services, including TEC leads, adult social care and country council staff/managers, care practitioners, ARC managers/operators. Interviews will focus on aspects of their role within the service model, experiences and challenges with regard to implementation and use (including unintended consequence to work practices), perspectives on the clinical/care and service outcomes, and the operational and strategic aspects to achieving sustained adoption within the organisation.
- Regional decision-makers: We will interview up to 10 regional stakeholders (3-4 in each site), including digital programme managers, ICBs, health and social care commissioners. Interviews with this group will focus on the key drivers and facilitators for in-home monitoring and operationalisation of (and potential blocks to) relevant policy.
- Industry: We will interview up to 6 industry representatives (1-2 in each case) from technology providers linked to each case site, such as chief executives and commercial officers, business and strategy leads, technicians and installers. Interviews will focus on the technology and infrastructure, business development, approaches to working with health and social care, the policy and operational facilitators and challenges to implementation and service delivery.

Interviews with staff and system stakeholders will be held at their place of work or conducted remotely by telephone/video, and may be conducted in pairs/groups where appropriate (e.g. colleagues within the same team). Sampling of staff and system stakeholders will be initially guided by the system mapping activity and case site teams, who will introduce them to the evaluation team, followed by 'snowball' sampling (asking interviewees who else we should be speaking to) to explore emerging topics and fill in knowledge gaps.

Where appropriate for gaining further detail on key processes, we will conduct on-site observations and naturalistic interviews (sitting with staff and asking them about their routines and practices while they work). The location for these observations will depend on emerging insights from the interviews, in which further clarity and detail from observations and field notes would inform the analysis. We anticipate this focusing on the practices and ways in which staff use the sensor data and dashboards to inform care decisions and actions (e.g. observing the role of ARC operators). We plan to conduct one fieldwork visit for such observations within each site.

### *WP6: Service user narratives*

We will conduct home visit interviews with up to 15 service users (5 per site) to explore the lived experience and impact of the in-home monitoring technology and service. Each participant (and members of their care network) will be interviewed in their own home on two separate occasions. The first interview will focus on their biographical background, daily lives and routines, condition/care needs, perspectives and experiences with the technology, implications for management of their condition, independence, social and mental wellbeing, and problems or concerns related to the technology/service. The second follow-up interview will be conducted approximately 4 weeks later to explore any changes in use and/or experience of the technology. Each home visit will be approximately one hour (but this will be adaptive and may be shorter, depending on wishes of the participant). Ethnographic field notes will also be taken during the home visit interviews, such as the participant's (and/or carer's) interactions with the technology, technical set-up, configurations and location of devices within the home setting.

Data for each index case will be drawn together using narrative synthesis to produce a summary, as described previously.[35] Each service user narrative will cover (a) the participant's social, cultural, and historical background; (b) experience of their condition/care support need; (c) the people and technologies in their life and how these were linked in relevant networks; (d) their perspective (and caregivers interpretation) on "what mattered" with regard to in-home remote monitoring; (e) the specific technology that had been offered (and how this was used); and (f) the problems that emerged, how these were resolved (or not) over time.

Participants will be identified by the case site staff, who will approach service users to explain the purpose of the evaluation and whether they are interested in being involved. If the participant expresses interest, the staff member will inform the evaluation team and arrange to introduce them.

The analysis will seek to provide a rich picture of the users' lived experience with the technology provided, how it helps (or not) address what matters to them, and concerns and/or unintended consequences for the individual and their formal and informal networks of care. A key element will be to capture the challenges for users with complex support needs and issues associated with inequalities in access and use.

With this in mind, we will purposefully sample for a variation of service users that present a wide range of assisted living needs, comorbidities, ethnicities, demographics, and family/care arrangements; and bearing in mind the range of experience, knowledge and skills relating to use of digital technology and the potential challenges of engaging with this service model. Efforts will be made to ensure the case site teams supporting recruitment will be aware of these requirements, and we will continue to monitor our sample and sampling strategy with our project PPIE group.

### *WP7: Economic analysis*

An economic evaluation of the selected service models will be incorporated into the study. This will take the form of a cost-consequence analysis, which will involve the identification, measurement, and valuation of relevant costs and consequences of the selected service models and the presentation of data in a disaggregated tabular format for comparison.

The cost consequence analysis will be carried out from a public sector perspective. Data related to the direct costs of each service model will be informed by primary research that will account for the cost of service set-up, delivery, maintenance, monitoring, follow-up, and associated administrative activities. Individual-level data on broader resource consequences and associated economic costs will be informed by service providers and user surveys conducted at baseline, at regular intervals during service use and at the time the service ceases to be offered. The user surveys will also assess health-related quality-of-life and broader well-being outcomes using the ASCOT,[36] the EQ-5D-5L[37] and the ICECAP-O.[38] In addition, data on several outcome measures will be collected and reported separately.

We will evaluate two service models: i) a six-week rehabilitation service where monitors are provided for short-term use; ii) long-term provision in which the devices are left permanently in users' homes. Each of these service models will be assessed against a comparable group in which care recipients are not provided with the home sensor service.

The costs and outcome measures we intend to collect for each service user, and a comparable group of care recipients who do not receive the technology-enabled service, are outlined in Appendix A.

Mean and incremental costs and outcomes for each service model will be estimated together with appropriate measures of uncertainty such as standard errors and confidence intervals. To handle potential selection biases within the economic evaluation, we will apply propensity score matching methods to balance the characteristics of individuals in each comparator group and to ensure consistency with the statistical analysis. Our analytical strategy will be informed by recent guidance on the conduct of health economic analyses using individual patient level observational data.[39] A detailed Health Economics Analysis Plan (HEAP) will be written and approved following Phase 1 and prior to the completion of Phase 2 data collection.

## Phase 3 – Summative analysis (months 8-10)

### *WP8: Data synthesis and cross-case comparisons*

The qualitative data (consisting of staff interviews, field notes and service user narratives) will be analysed thematically, guided by the NASSS domains, alongside the quantitative data. This will be synthesised to evaluate the technology-enabled service against the goals and motivations set out in Phase 1 (*in WP3 Site selection and evaluability assessment*), and to create structured narrative documents of each cases site. The narrative documents will be used to support cross-case comparisons to develop a final theorisation of how spread (the extent to which an innovation/approach is adopted more widely within a sector), scale-up (the extent of use/coverage of the innovation/approach) and sustainability (the extent whether the innovation/approach continues to exist longer term) can be supported.[40] We will highlight key practical lessons for implementing and supporting in-home monitoring as 'business as usual', and the impacts and outcomes that should be considered for service development and evaluation.

### *WP9: Cross-site workshop*

Staff and system stakeholders from the three case sites will be invited to a virtual workshop to share perspectives and discuss cross-case findings. The workshop will be structured to elicit shared experience and mutual learning on the challenges, impact and value on in-home sensing in social care. The workshop will be approximately 2 hours, with a plenary session setting out key findings within and across the sites, breakout sessions to share learning across organisational counterparts, and wider discussion to crystallise solutions to policy and practice challenges.

A summary report of the workshop will be written up and shared among attendees to comment and feedback. Key insights from these discussions will feed into the subsequent inter-stakeholder workshop (*WP10 Inter-stakeholder workshop*).

### *WP10: Inter-stakeholder workshop*

We will run a virtual workshop to explore the implications of the summative findings for national policy. The workshop will include participants from the three cases sites (and representatives from the other candidate sites), regional/national policymakers and decision-makers, national TEC advisory bodies, PPIE representatives, industry, academia and other key stakeholders. As in previous studies, we will draw on participatory design principles (e.g. data extracts, service user stories, and break-out brainstorming activities) to support dialogue across different stakeholder groups on current policy/practice, and opportunities and challenges for future development.[41]

The strategic focus of the workshop will be based on evaluation outcomes, with guidance from the project advisory and PPIE groups, and our policy customer. Based on our scoping discussions, this could include, for example, a focus on the development of national toolkits for implementing and sustaining in-home monitoring in social care and/or developing/refining national standard frameworks for evaluating such technology-supported services.

# ANTICIPATED OUTPUTS, IMPACT AND PLANS FOR DISSEMINATION

## Reporting

We will produce a final report with executive summary. This will include the case study narratives based on the qualitative and quantitative data, summative findings and key recommendations for policy, practice and future evaluations.

## Public

The final report and executive summary will be freely available through the DECIDE website. A lay summary will also be produced and made available on the website with the support of the project PPIE group.

## Policy makers

We will build interest and raise awareness more widely about the project from the outset (e.g. project pages on website; social media; using our networks and governance structures to help raise awareness; early communications with DHSC as the policy customer, NIHR, and case study site leads. We will inform ongoing notational strategy in digitising social care, including feeding into evolving evaluation frameworks, such as the new CEFTEC framework.

## Service providers

We will feedback and report to case site teams on service use, impact and experience through the formative component of the evaluation. In addition, the findings and case study narrative documents will provide insight and learning for social care services more widely, helping them establish strategic and business cases for the scale up and sustainability of in-home activity monitoring. Recommendations and learning will include operational and strategic aspects, which will also feed into national policy outputs (e.g. national guiding toolkit for implementation).

## Researchers / evaluators

Open access publications and conference presentations

## PROJECT TIMELINES

The project will be 10 months (see Table 1)

**Table 1: Project timetable**

| | **Month** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Operational objectives** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| **PHASE 1: Pre-assessment and groundwork** | ▓ | ▓ | | | | | | | | |
| ***WP1: Project set-up and governance*** | ▒ | | | | | | | | | |
| Establish the project advisory group | ░ | | | | | | | | | |
| Establish the project PPIE group: | ░ | | | | | | | | | |
| Gain governance and permissions | ░ | | | | | | | | | |
| ***WP 2: Literature review*** | ▒ | ▒ | | | | | | | | |
| Literature terms and searches | ░ | ░ | | | | | | | | |
| Literature synthesis and analysis | ░ | ░ | | | | | | | | |
| Write-up literature review | ░ | ░ | | | | | | | | |
| ***WP 3: Site selection and evaluability assessment*** | ▒ | ▒ | | | | | | | | |
| Case site meetings to establish goals | ░ | ░ | | | | | | | | |
| Assess data availability | ░ | ░ | | | | | | | | |
| Develop data collection protocols | ░ | ░ | | | | | | | | |
| Write-up evaluability assessment report | | ░ | | | | | | | | |
| **PHASE 2 – Formative evaluation** | | ▓ | ▓ | ▓ | ▓ | ▓ | ▓ | ▓ | | |
| ***WP 4: System mapping*** | | ▒ | ▒ | ▒ | ▒ | | | | | |
| System mapping workshops with case sites | | ░ | ░ | ░ | ░ | | | | | |
| Produce and refine ecosystem maps | | ░ | ░ | ░ | ░ | ░ | | | | |
| ***WP5: Interviews with staff and system stakeholders*** | | ▒ | ▒ | ▒ | ▒ | ▒ | ▒ | ▒ | | |
| Fieldwork at the three case sites | | ░ | ░ | ░ | ░ | | | | | |
| Interview up to 36 staff/stakeholders | | ░ | ░ | ░ | ░ | ░ | ░ | ░ | | |
| Analysis of staff/system interviews using NASSS | | | | ░ | ░ | ░ | ░ | ░ | ░ | |
| Write up case site narratives | | | | | | | ░ | ░ | ░ | |
| ***WP6: Service user narratives*** | | | | ▒ | ▒ | ▒ | ▒ | ▒ | ▒ | |
| Conduct 15 service user home visits and interviews | | | | ░ | ░ | ░ | ░ | ░ | | |
| Internal data workshops and analysis | | | | ░ | ░ | ░ | ░ | ░ | | |
| Write up service user narratives | | | | | | | ░ | ░ | ░ | |
| ***WP7:* Economic analysis** | | | ▒ | ▒ | ▒ | ▒ | ▒ | ▒ | ▒ | |
| Review quantitative data/measures | ░ | ░ | ░ | | | | | | | |
| Collect quantitative data within case sites | | | ░ | ░ | ░ | ░ | ░ | ░ | | |
| Descriptive data analysis | | | | | ░ | ░ | ░ | ░ | ░ | |
| Conduct economic analysis | | | | | ░ | ░ | ░ | ░ | ░ | |
| Write up economic analysis summary | | | | | | | | | ░ | ░ |
| **PHASE 3 - Summative analysis** | | | | | | | | ▓ | ▓ | ▓ |
| ***W8: Data synthesis and cross-case comparisons*** | | | | | | | | ▒ | ▒ | ▒ |
| Write up case study narratives using NASSS | | | | | | | | ░ | ░ | |
| Cross-case comparisons and synthesis | | | | | | | | ░ | ░ | |
| ***WP9: Cross-case workshop*** | | | | | | | | | ▒ | ▒ |
| Run workshop with case site staff/stakeholders | | | | | | | | | ░ | ░ |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Write-up cross-stakeholder workshop summary | | | | | | | | | ▨ | ▨ |
| ***WP10: Inter-stakeholder workshop*** | | | | | | | | | | ▨ |
| Run inter-stakeholder workshop | | | | | | | | | | ▨ |
| Write up inter-stakeholder workshop summary | | | | | | | | | | ▨ |
| **Dissemination** | | | | | | | | | | ■ |
| Write up final report | | | | | | | | | | ▨ |
| Write lay summary and resources | | | | | | | | | | ▨ |
| Support policy customer outputs/objectives | | | | | | | | | | ▨ |
| Academic publications/conferences | | | | | | | | | | ▨ |

# PROJECT MANAGEMENT AND QUALITY ASSURANCE

## Quality Assurance

The study may be monitored, or audited by the Sponsor or funder in accordance with the current approved protocol, relevant regulations and standard operating procedures.

# PLANS FOR SERVICE USER AND PUBLIC INVOLVEMENT

We have via the DECIDE user advisory group received inputs that will inform topics the evaluation will explore, and in particular those related to understanding the service users and carer perspectives, ethical implications and unintended consequences of home sensors (e.g. privacy, consent).

As outlined in WP1, we will form a project specific PPIE group, drawing from the DECIDE service user advisory group and complimenting with 1-2 PPIE representatives from other charity groups as needed to address knowledge or experience gaps on the topic. Members will contribute one to two days each over the course of the evaluation.

We will draw on the project PPIE group on activities such as: informing the design of materials to use in interviews and/or workshops to ensure relevance and accessibility, design of the cross case study workshop with service users and carers, participation in the research team workshop and in dissemination. The group will also raise items as a rolling agenda for ongoing discussion, including for example, wider ethnical implications to in-home activity monitoring and how these should be considered in the data collection and analysis study.

# RESEARCH TEAM

Table 2 presents the team members and their corresponding roles and expertise.

**Table 2. Study team members**

| Team member | Role/contribution | Relevant expertise |
|---|---|---|
| Dr Joe Wherton (University of Oxford) | Project leader providing topic, method, and team leadership. Project conception, design, analysis and synthesis, writing of reports/dissemination, project management | Expertise in ethnographic and participatory design methods to inform the development and implementation of technology-supported services for health and social care. |

| | | |
|---|---|---|
| Prof Sara Shaw (PI for Decide, Professor at Oxford University); | Project conception, design, analysis and synthesis, writing of reports/dissemination. | Highly established academic bringing expertise on technology-enabled health care, qualitative, case study and mixed methods design and delivery, and knowledge exchange/impact. Experienced in rapid evaluation and oversight of large research projects and evaluations; overall oversight of all projects under NIHR Decide centre. |
| Dr Stephanie Stockwell | Project conception, design, data collection, analysis and synthesis, writing of reports/dissemination | Expertise in lifestyle behaviours, including physical activity/sedentary behaviour, health over the life course, disease prevention and management, primary care research, and digital health. |
| Dr Nikki Newhouse | Project conception, design, data collection, analysis and synthesis, writing of reports/dissemination | Expertise in conducting mixed-method and embedded research and evaluation, including ethnographic home ethnography and co-design to inform technology-enabled care. |
| Dr Caroline Potter | Project conception, design, data collection, analysis and synthesis, writing of reports/dissemination | Expertise in qualitative and mixed-methods health research, her research explores practices of care and provision of health services at both personal and population levels. |
| Ms Anna Louise Todsen | Project conception, design, data collection, analysis and synthesis, writing of reports/dissemination | Expertise in qualitative and mixed-methods health policy and innovation research. |
| Prof Stavros Petrou | Project conception, quantitative and methodological development, economic analysis, reporting | Highly established economist, with expertise in methodological development within health economic evaluation that directly impact health care policies at national level. |
| Mr Stuart Redding | Project conception, quantitative and methodological development, economic analysis, reporting | Expertise in health economics for health services and policy assessments using primary and secondary economics data. |
| Ms Anica Alvarez Nishio | Project design, writing, and dissemination | Experienced public involvement and engagement consultant, served on and chaired a number of boards/committees (eg NICE, NIHR), interests in the effective usage of data and technology in care delivery, in tackling inequalities, working with marginalised groups. |
| Dr Julie Darbyshire (University of Oxford) | Project Management and PPIE liaison | Experienced in academic project management including multi-site international drug trials, large data analysis studies, and use of digital tools to support healthcare management and delivery. Has led patient/carer stakeholder work packages in a number of NIHR funded research projects. |
| Ms Charlotte Thompson-Grant (University of Oxford) | Project Co-ordination and PPIE liaison | Experienced in academic administrative processes including contracting, budget monitoring, meeting logistics, and liaison across teams. |

# ETHICAL, REGULATORY AND GOVERNANCE CONSIDERATIONS

## Risks and their management

See Table 3 below for our assessment of potential risks and mitigation strategies

| **Risk** | **Impact** | **Likelihood** | **Mitigation** |
|---|---|---|---|
| Challenges to onboarding sites to participate in case studies | High | Low | We have five verbal confirmations of interest to participate as evaluation sites. We have additional meetings scheduled with other potential candidate sites, which we wish to explore before deciding on selection criteria. We will seek to minimise risk by having approached more potential sites and locations than needed and by maintaining open dialogue and following up on conversations. All sites have expressed interest in maintaining dialogue even if not included as a case site, such as participating in stakeholder workshops and hearing about project outcomes. We will be clear with candidate sites from the outset with regard to the work involved in participating and facilitating the evaluation, including the level of data that we expect to collect. We will maintain open lines of communication with candidate sites and other key networks and stakeholders to include an alternative site if any site was to withdraw. |
| Demand pressures on case site staff and system stakeholders and associated challenge to capacity to engage in timely ways | High | Medium | The evaluation requires support from case study sites on diverse grounds such as local governance approvals, helping recruit interviewees, and where applicable timely access to relevant data. We are investing in establishing early relationships with candidate case study sites and local decision makers to help ensure support for the evaluation. We are sharing summary documents on the evaluation and what is required from participants in case studies to support upfront clarity on needs, and what the benefits from participating might be. We will be adaptive to the schedules and constraints on staff during fieldwork, including the timing and modality of interviews. There has been a high level of interest and engagement among candidate sites so far, and we will continue to maintain dialogue throughout the project assisted by the formative component. |
| Risks to researcher safety on field work and home visits | Low | High | We will follow the Oxford and RAND's researcher safety policies, and develop internal protocols for minimising risk; including notifying colleagues of travel plans (location and timing) with check-out/check-in procedures, and ensuring researchers have key contact numbers, and maintain the option to travel with other members of the team. |

| Risk | Impact | Likelihood | Mitigation |
|---|---|---|---|
| Delays in local R&D approvals | High | Medium | All governance approvals to be undertaken as early as possible. Should there be delays in obtaining any local potentially needed R&D approvals, which impact on timelines for primary data gathering (e.g. interviews for case studies) we will communicate these to the policy customer and NIHR in a timely fashion. |
| Loss of key staff on project | High | Low | Oxford and RAND Europe's staffing model allows for flexibility such that in the event of project staff turnover, we can tap into wider expertise. Senior staff at both Oxford and RAND have extensive experience needed to deliver on the evaluations. |
| Loss of data | High | Low | Both Oxford University and RAND Europe have robust, secure and well tested data and IT systems with data backed up in multiple locations to support recovery efforts in the event of data loss. Both The University and RAND Europe have robust policies in place to safeguard data. We will put data transfer agreements in place with any third party (eg evaluation sites) to ensure safe and secure transfer of information. Any transfer of data between researchers at RAND and Oxford University will be in accordance to GDPR. |

## Ethical issues and required approvals

The Research Governance Ethics and Assurance (RGEA) team at the University of Oxford (sponsor) has classified the project as a service evaluation that does not require research ethics approval. All study activities will comply with clinical governance requirements

## Informed consent

All participants will have capacity to provide informed consent. The participant must personally sign and date the latest approved version of the Informed Consent form before any study specific activities are undertaken.

Written and verbal versions of the Participant Information and Informed Consent will be presented to the participants detailing the nature of the study, what it will involve for the participant, the implications and constraints of the protocol, and any risks involved in taking part. It will be clearly stated that the participant is free to withdraw from the study at any time for any reason without prejudice to future care, and with no obligation to give the reason for withdrawal.

The participant will be allowed as much time as wished to consider the information, and the opportunity to question the study evaluation team or other independent parties to decide whether they will participate in the study. Written Informed Consent will then be obtained by means of participant dated signature and dated signature of the person who presented and obtained the Informed Consent. The person who obtained the consent must be suitably qualified and experienced, and have been authorised to do so by the Chief/Principal Investigator. A copy of the signed Informed Consent form will be given to the participant. The original signed form will be retained at the study site.

During the course of the study a participant may choose to withdraw early at any time. This may happen for several reasons, including but not limited to:

- The occurrence of significant distress during study interviews
- Inability to comply with study procedures
- Participant decision

### Discontinuation/withdrawal

Participants may withdraw their consent at any time. Options for participants wishing to withdraw will be explained in the information sheet.

1) Participants may withdraw from all study communication but allow the study team to continue to access their medical records and any relevant data that has been recorded as part of routine standard of care and is held by the study team; i.e., disease progression data, routine patient reported outcome data and quality of life questionnaire data etc.

2) Participants can withdraw from the study but permit data obtained up until the point of withdrawal to be retained for use in the study analysis. No further data would be collected after withdrawal.

3) Participants can withdraw completely from the study and withdraw the data collected up until the point of withdrawal. The data already collected would not be used in the final study analysis*.

*In cases where data have already been incorporated into analysis it will not be possible to exclude these data. It is also not possible to exclude data collected from any group discussions as an individual's data will likely be directly related to that of other participants.

The reason for withdrawal by researcher (and by participant, if this information is volunteered) will be recorded in a study file.

## Data management and storage

### Data Recording and Record Keeping

Datasets collected and collated for this service evaluations will include:

- Observational and ethnographic data from on-site field work. These will be primarily field notes, either completed in digital form at the time or hand-written and transcribed into digital format by the research team at a later date. It is possible this dataset could also include photographs and diagrams. It is difficult to be explicit about the volume/scope of these data but likely to be the equivalent of up to ~50hours of observation. Fieldwork data will be collected by a small number of the DECIDE centre team (~4/5). The resulting data files will be available for analysis by a larger number of people from the DECIDE centre team (~10). Electronic files will be saved on password-accessible areas of the University of Oxford network and remote access to these files will be granted to members of the DECIDE centre team as required for analysis and reporting purposes.
- It is likely that the research team will interview participants about their use of the technology under evaluation. These will generate interview recordings which may be audio only (conducted using digital recorder devices or Teams/Zoom), or audio-visual (e.g., Teams or Zoom). If transcription is required, these recordings will be transferred to professional transcriber services (using services and processes approved by the University of Oxford). During the transcription process any identifying information will be removed. Files for analysis will therefore be considered pseudonymised. The team will need to collect contact

and basic demographic data from participants. The demographic data will be stored alongside a project ID and will not be directly linked to an individual's contact details. Again, it is difficult to be precise about numbers of people who will be interviewed but likely numbers would be 10-15 people per evaluation. Interview data will be collected by a small number of the DECIDE centre team (~4/5). The resulting data files will be available for analysis by a larger number of people from the DECIDE centre team (~10). Electronic files will be saved on password-accessible areas of the University of Oxford network and remote access to these files will be granted to members of the DECIDE centre team as required. The original recordings will be deleted when transcribed files have been checked and there is no further need for the original recording.

- DECIDE will also collect contact details for key personnel involved in the evaluation where this information is required to arrange site activities or similar. This will consist of name, email address, and phone number. These data will be stored in the University of Oxford network files and remote access will be granted as required to those within the DECIDE team.

Data will be collected and stored in accordance with the University of Oxford (Sponsor) data policies.

The University of Oxford requires all projects to register project data sets as 'information assets'. The DECIDE programme reference is IAR 561. This register supports obligations under General Data Protection Regulation (GDPR) and links to 'data protection by design' policies which include initial screening to confirm the level of data protection documentation required. Results of the screening will indicate that either a Data Protection Assessment (DPA) or, for data sets that include special category data, or where activity is likely to result in high risk to those individuals whose personal data are being processed, a Data Protection Impact Assessment (DPIA) form needs to be completed.

Any data generated from this piece of work will be processed in line with this protocol and stored in secure environments at the University of Oxford and RAND Europe. These secure environments are hosted within each institution and are accessible through a dual-authentication password process. As the primary award holder, the University of Oxford will act as the data controller for DECIDE. The University of Oxford data storage servers will therefore be the primary repository for all data. Members of the team who are employed by RAND Europe will be granted remote access to these files. As per any data storage clauses in the individual site agreements, RAND Europe may also store data files pertaining to this piece of work.

## Participant Confidentiality

The study will comply with the General Data Protection Regulation (GDPR) and Data Protection Act 2018, which require data to be de-identified as soon as it is practical to do so. The processing of the personal data of participants will be minimised by making use of a unique participant study number only on all study documents and any electronic database(s). All documents will be stored securely and only accessible by study staff and authorised personnel. The study staff will safeguard the privacy of participants' personal data.

## Access to data

Data will be accessible to the immediate team. This includes employees of The University of Oxford and RAND Europe who will be collecting and analysing the data for this evaluation.

Direct access to the data will also be granted as required to authorised representatives from the Sponsor or host institution for monitoring and/or audit of the study to ensure compliance with regulations.

### Archiving

Identifiable personal data will be deleted as soon as it is practical to do so. De-identified (pseudonymised) data will be stored for a minimum of three years after the end of the project in line with University of Oxford data management and storage policies.

## Sponsorship, indemnity and insurance

The University of Oxford will act as the main sponsor and guarantor for this study.

The University of Oxford maintains Public Liability and Professional Liability insurance, which will operate in this respect.

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# APPENDIX A: Potential data sources for economic evaluation

**Table A1: Proposed data capture to inform economic analysis**

| **DOMAIN** | **DATA** |
|---|---|
| COSTS | **Set up costs** |
| | Software development/implementation |
| | Staff training |
| | Equipment purchase |
| | Refurbishing devices |
| | Installation |
| | |
| | **Running costs** |
| | Monitoring and responding to alarms (staff costs) |
| | Equipment rental |
| | Data collection and analysis to inform future care plans |
| | |
| COSTS OF ADDITIONAL ELEMENTS IN CARE PACKAGE (for users with monitors and those without monitors) | |
| | Number of daily/weekly Carer visits |
| | Other monitoring eg phone calls |
| | Other services such as meals etc. |
| | |
| DEMOGRAPHIC DATA | |
| | Age |
| | Gender |
| | Ethnicity |
| | Underlying health status |
| | Morbidities |
| | Some measure of deprivation/wealth |
| | Anything about family status/living arrangements? (for a support network) |
| | |
| OUTCOMES | |
| | A measure of delayed discharge |
| | Readmissions |
| | Ambulance call-outs |
| | number of carer visits |
| | Mortality rates |
| | GP appointments |
| | Visits from other healthcare professionals |
| | Data on number of falls |
| | UTIs |
| | |
| QUALITY OF LIFE ASSESSMENT AT TIME INTERVENTION WAS OFFERED | |
| | EQ5D |
| | ASCOT |
| | ICECAP-O |
| | |

| | |
|---|---|
| QUALITY OF LIFE AT MIDPOINT OF INTERVENTION (OR STUDY) | |
| | EQ5D |
| | ASCOT |
| | ICECAP-O |
| | |
| QUALITY OF LIFE AT END OF INTERVENTION (OR STUDY) | |
| | EQ5D |
| | ASCOT |
| | ICECAP-O |