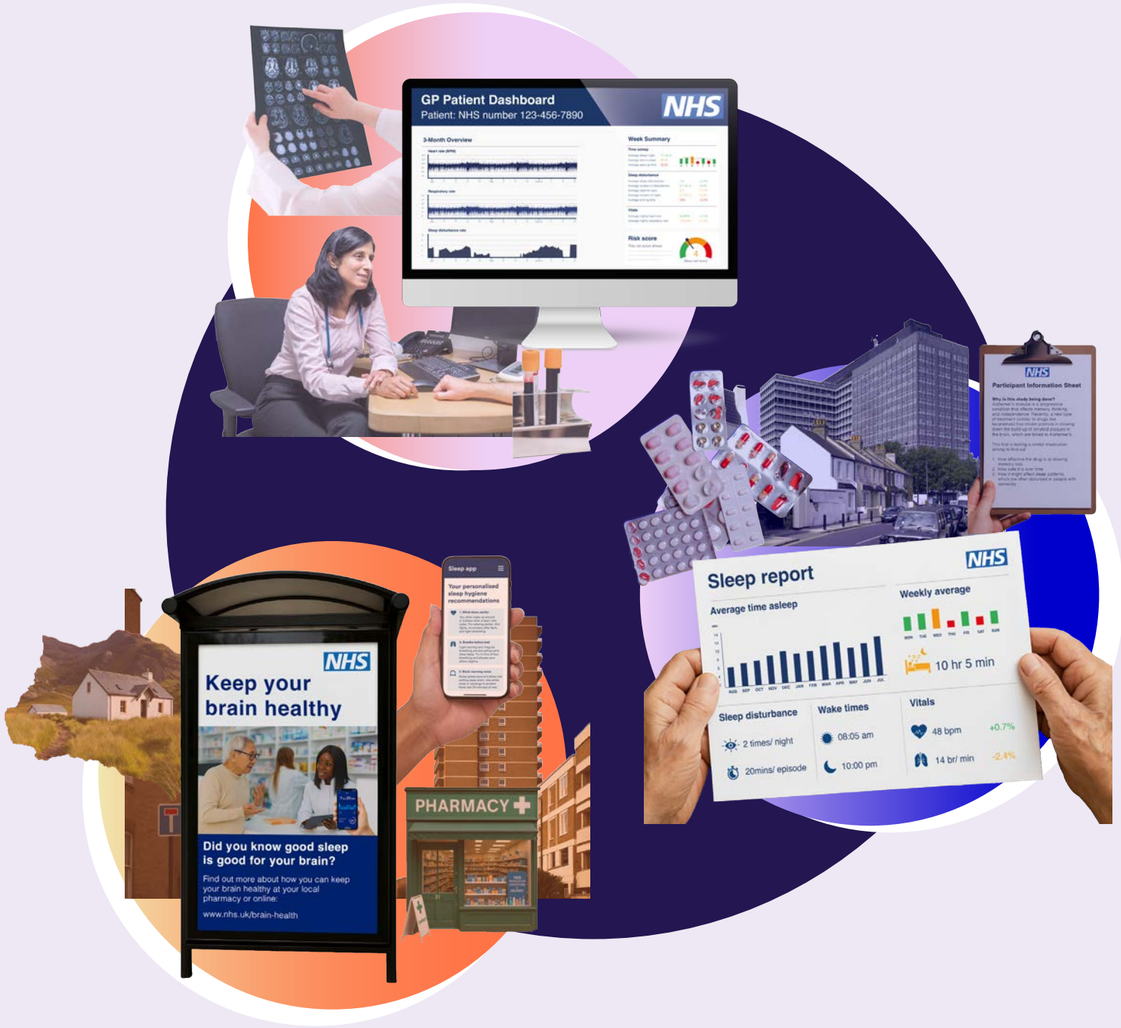
InSleep46: Designing future dementia care through sleep data

Exploring how passive sleep monitoring technologies could reshape dementia prevention, diagnosis, and care through participatory service design.



inSleep46 · Helix Centre · Newcastle University · IMPERIAL · UCL · 1946 National Survey of Health and Development · NIHR | National Institute for Health and Care Research · UKRI Medical Research Council

About this report

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Useful terms

Brain Health Clinic: A new health service model trying to improve the diagnostic pathway so people with mild cognitive impairment and dementia can receive an earlier, quicker, and more specific diagnosis.

Digital Biomarker: Objective, quantifiable measurements of physiological or behavioural data collected through digital devices like wearables or smartphones.

DRI-SI: Dementia Research Institute Sleep Index – a sleep-based digital biomarker under development.

Insight46: A long-running UK birth cohort of 5,362 people born in one week in March 1946, followed as part of the MRC National Survey of Health & Development.

InSleep46: The name of the project using collecting and analysing sleep data from the Insight46 cohort.

MCI: Mild cognitive impairment (MCI) describes memory and thinking problems that are mild but still noticeable.

Minder study: A smart-home monitoring platform using low-cost sensors and AI to detect early health changes, support timely intervention, and reduce hospital admissions for people with dementia.

Sleep Sensor: A contactless, under-mattress sensor capturing sleep-related data.

What is InSleep46?
A research project exploring how passive sleep sensors can support earlier detection, diagnosis, and care for dementia.

Why sleep?
Changes in sleep may signal early shifts in brain health. Passive, under-mattress sensors offer a low-burden way to detect these changes in everyday settings.

What does this report cover?
This summary shares insights from co-design workshops and speculative service scenarios exploring how sleep-sensing technology could be used in dementia care, alongside reflections on practical, ethical, and emotional considerations from a multidisciplinary team.

Who is this report for?
The report is intended for funders, commissioners, policymakers, researchers, practitioners, and people affected by dementia. It offers an accessible companion to the academic paper, supporting real-world translation and setting out tangible next steps for future research and service development.

Why it matters:
This work contributes to national efforts to detect dementia earlier and more fairly, using inclusive, trusted tools grounded in people's daily lives.

Summary

The InSleep46 project brings together a multidisciplinary team from Imperial College London, University College London, Newcastle University, and the Helix Centre, to explore whether non-intrusive sleep sensors can support diagnosis and monitoring of dementia.

About InSleep46

At the heart of InSleep46 is a study with over 250 participants from UCL's Insight46 birth cohort, monitored using under-mattress sleep sensors (cost ~£80) to validate digital biomarkers linked to dementia risk. Alongside this, the Helix Centre and Newcastle University explored how this technology could work in everyday care and support. Through co-design workshops and qualitative research interviews, they developed three speculative service scenarios focused on prevention, diagnosis, and monitoring. They tested these with experts spanning clinical practice, healthcare research, data science, and lived experience. This report captures key insights, outlining opportunities, barriers, and themes to inform future research.

Service scenarios

Three speculative service blueprints were created to explore potential uses of sleep-sensing in dementia care. Scenario 1 focuses on prevention, using sleep sensors in community settings to help promote healthy sleep behaviours and spot early signs of symptoms. Scenario 2 explores diagnostic support in GP clinics, offering sleep data to inform assessment when cognitive or sleep concerns are raised. Scenario 3 focuses on individuals already diagnosed, using ongoing sleep data to inform care, adjust treatment, and support research. These scenarios were used to explore the practical, emotional, and systemic factors that could influence service design and delivery.

Key insights

Participants saw promise in sleep sensing for earlier insight and support. Key priorities included equitable access, clinical validation, and person-centred advice. Views varied on emotional impact; some welcomed reassurance, others feared anxiety. Usability, simplicity, and support were seen as essential. Concerns included short-term vs long-term use, overreliance on single tools, and a preference for individual baselines. System-wide issues, such as workforce capacity, integration, and avoiding added strain, highlighted the need for thoughtful implementation. Flexibility, trust, and clear benefits will be critical to real-world success.

Recommendations

Future research should prioritise validating sleep-sensing technologies for identifying dementia risk. Studies must assess how sleep data translates into meaningful insights and explore emotional impacts like anxiety. Establishing individual sleep baselines should take precedence over population comparisons. Research should evaluate integration across dementia care stages, including asymptomatic and multimorbidity settings, to support joined-up services. Exploring alternative technologies can reduce reliance on a single product. Health economic modelling is needed to assess feasibility, equity, and long-term sustainability. Global perspectives should be considered to ensure adaptability beyond the NHS.

Introduction

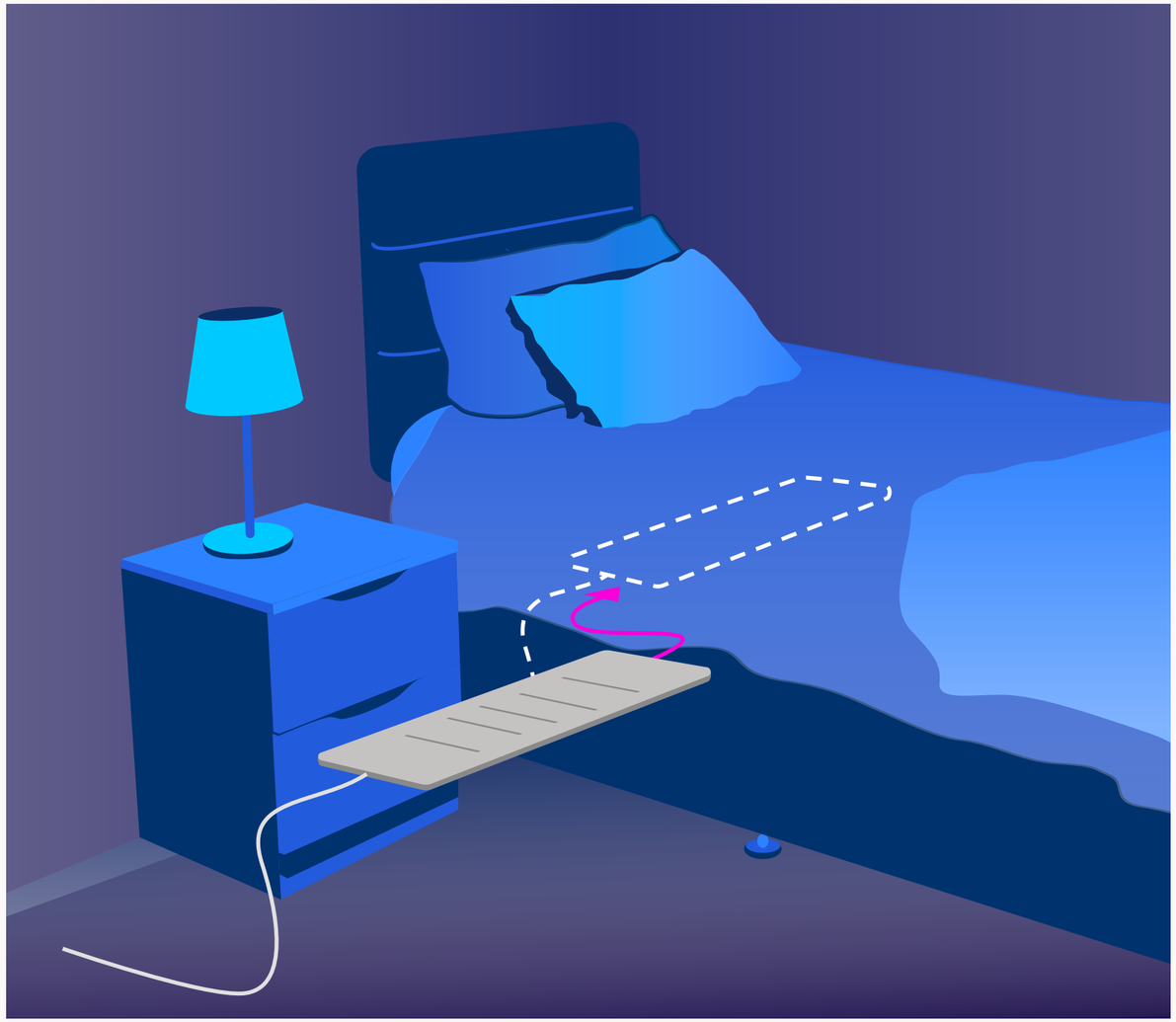
Dementia is one of the most pressing health challenges facing the UK, with around 900,000 people currently living with dementia - a figure set to rise to 1.4 million by 2040 (Alzheimer's Society, 2023). With the first new treatments for Alzheimer's now licenced, early action and prevention are increasingly seen as essential; both to reduce the personal impact of dementia and to alleviate pressure on healthcare services.

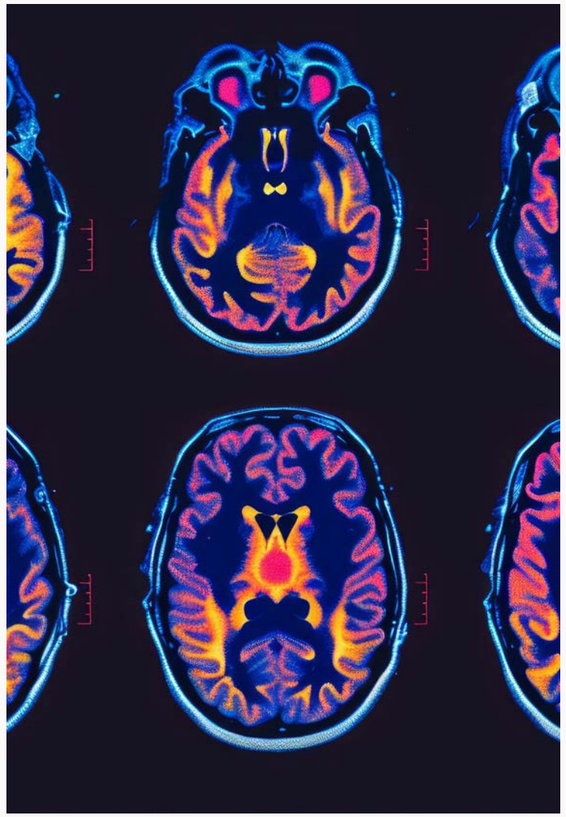
One area of growing scientific interest is how changes in sleep might signal early shifts in brain health. At the UK Dementia Research Institute (UK DRI) Care Research & Technology Centre, researchers have already used under-mattress sleep sensors (pictured) with success as part of the Minder study. These sensors monitor heart rate, respiratory rate, sleep phases, and bed occupancy. Researchers have found these sensors effective in detecting early signs of infection, changes in routine, and abnormal sleep-related behaviours, often before other symptoms become visible.

As contactless, low-cost, tools requiring no daily interaction, the sensors are particularly well-suited to people with cognitive impairment, who may struggle with the discomfort, complexity, or charging requirements of wearable devices. Their "plug-and-play" design makes them a practical option for continuous, passive monitoring in the home.

The UK DRI team have compared the sleep patterns of people known to have dementia with millions of nights of anonymous sleep data from the general population (provided by the sensor manufacturer) to identify sleep behaviours associated with dementia. These differences are combined into a digital biomarker (the DRI Sleep Index), which is being validated in the Insight Cohort

Building on this foundation, the InSleep46 project aims to explore how the sleep-sensing technology might support earlier risk detection, diagnosis, or care in dementia.





The project has two key components. The scientific component of InSleep46 is based on the Insight 46 sub-study, which follows >250 participants from the Medical Research Council (MRC)'s long-running cohort of individuals born in the same week in 1946. Now aged 79, these individuals have been studied throughout their lives and have completed extensive assessments of brain health, including MRI and PET brain scans, cognitive testing, and lifestyle data. In the InSleep46 study, researchers are collecting sleep data from these participants using the same sensor technology used in Minder. By comparing participants' sleep patterns with their brain imaging and health data, the study aims to determine whether sleep behaviour can help identify early signs of poor brain health or dementia risk, potentially paving the way for earlier intervention.

As Professor Jonathan Schott, UK DRI Group Leader and Professor of Neurology at UCL, explains:

"Studying the Insight 46 cohort offers us a unique opportunity to really understand the way sleep behaviour relates to dementia risk. If successful, this technique has huge potential for identifying people within the wider population who might take part in clinical trials or, in due course, treatments to prevent cognitive decline."

Alongside InSleep46's scientific research, the team have established the human-factors component of the research, to explore the practical, ethical, and emotional dimensions of using passive sleep monitoring in people's daily lives.

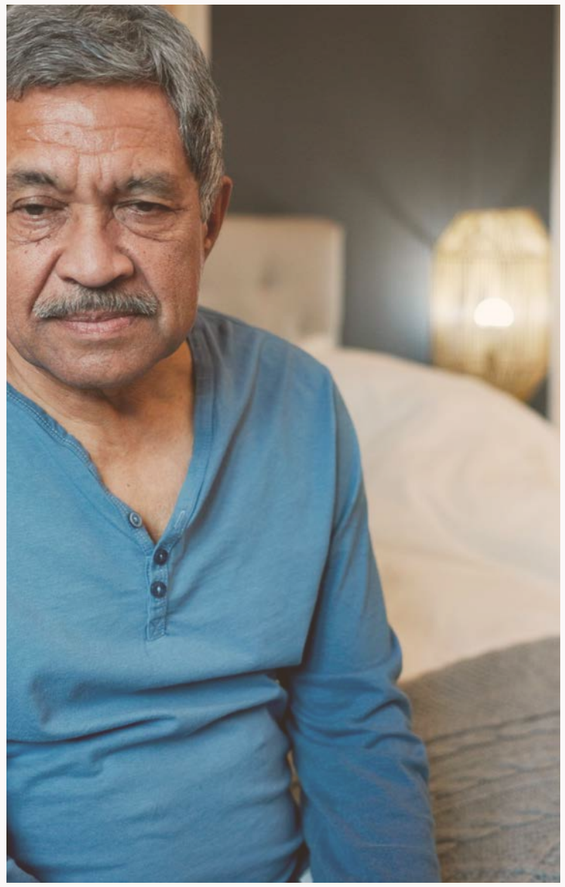
This part of the project is led by the Helix Centre at Imperial College London and Newcastle University. Through co-design workshops with people affected by dementia and interviews with GPs, the team has investigated how acceptable and useful this technology would be in real-world care settings, and what concerns or hopes it may raise for users, families, and professionals.

Participants for the co-design workshops were recruited from outside the Insight46 study in order to protect their privacy and wider Insight46 participation.

This report brings together those insights and outlines future opportunities for using passive sleep data to inform more inclusive, responsive, and preventative approaches to dementia care.

Linking sleep and dementia

Monitoring sleep is an emerging area of interest for brain health and dementia prevention.



There's growing interest in how sleep might help us better understand, and potentially reduce, the risk of dementia. Globally, around 55 million people are living with dementia, and that number could rise to 139 million by 2050 (World Health Organisation, 2017; Alzheimer's Disease International, 2023). It's also the leading cause of disability in older adults. While there is no cure, research shows that up to 45% of cases may be linked to things we can change: such as hearing loss, lack of physical activity, or smoking (Livingston et al., 2024). Sleep is now being explored as one of these "modifiable" risk factors (Frey et al., 2019).

Recent international guidance has strengthened the case for sleep's role in dementia. The World Sleep Society's 2024 consensus recognised poor sleep as a significant risk factor for cognitive decline and called for more routine monitoring of sleep as part of dementia prevention strategies (Ferini-Strambi et al., 2024).

Population studies support this link. Sabia et al. (2021) found that sleeping fewer than six hours a night in midlife was associated with a significantly higher risk of developing dementia later in life. Similarly, a large-scale meta-analysis by Shi et al. (2018) concluded that disturbed or poor-quality sleep may substantially increase dementia risk.

That's why the 2023 World Alzheimer's Report described prevention as both practical and achievable (Alzheimer's Disease International, 2023). Detecting dementia risk earlier, before symptoms begin, could give people access to advice or support, and help researchers understand brain changes that happen before diagnosis (Kivipelto et al., 2020; Lyall et al., 2023; Deckers et al., 2021; Wilson and Jungner, 1968; Ford, Milne and Curlewis, 2023).

Technology could help make early risk detection more practical and scalable. Researchers are now exploring digital biomarkers; patterns in data from everyday technologies that may reveal subtle changes in brain health (Lyall et al., 2023; Soreq et al., 2024). In addition to helping with early detection, digital biomarkers may also support prognosis; helping to track or predict how a condition might progress (Buegler et al., 2020).

Sleep is one of the most promising sources of digital biomarkers. Changes such as restlessness, frequent waking, or daytime drowsiness often occur before memory problems appear and may be early signs of dementia (Koren et al., 2023; Benca and Teodorescu, 2019; Zhang et al.,

2022). These symptoms can also precede other forms of neurodegeneration, such as Parkinson's or Lewy body dementia (Iranzo et al., 2014; Shi et al., 2018).

Tools like the Dementia Research Institute Sleep Index (DRI-SI) and the Minder monitoring system demonstrate how sleep data can be collected passively in real-world settings. These under-mattress sensors monitor heart rate, respiration rate, and movement without requiring interaction, enabling a more accessible, consistent method of tracking wellbeing over time (Soreq et al., 2024).

This approach aligns with the UK's national strategy to expand digital innovation in health and care. The Digital Health and Social Care Plan encourages wider use of remote monitoring technologies, especially those suited for long-term conditions and older populations (NHS England, 2025).

However, embedding these tools into everyday care will require more than technical success. People must feel confident in using them and believe they provide meaningful benefits. Research also shows that people value diagnostic technologies differently depending on cultural context, personal experience, and perceptions of usefulness and harm (Costa and Milne, 2024). While surveys show public support for dementia risk detection (Alzheimer's Research UK, 2019), further engagement is needed to explore views among diverse and underserved communities (Brar et al., 2024).

Bridging research and real-world experience

While the science shows promise, it's just as important to understand how these tools might work in practice.

That's why the InSleep46 project engaged directly with people affected by dementia, members of the public, and GPs. Their insights brought to light questions around trust, responsibility, emotional impact, and health equity, and helped identify what it would take for sleep-sensing to be useful, acceptable, and inclusive.

Insights & evidence

Summary of qualitative research carried out which shaped the insights used to develop the 3 service blueprints.

To explore real-world applications of this technology, the research team conducted workshops with people affected by dementia and members of the public, alongside qualitative interviews with General Practitioners (GPs).

Three workshops held across both London and Newcastle involved 31 members of the public aged between 31 and 82. Participants brought a range of perspectives, including personal and caregiving experiences of dementia. Sessions examined participants' views on the sleep sensor's acceptability, its potential use at home, the value of sleep data insights, and the support needed for confident use.

Interviews with seven GPs were also carried out to provide in-depth perspectives on the potential for sleep data to support dementia risk detection in primary care and how such a tool might be integrated into real-world clinical practice. Their feedback helped identify practical, ethical, and implementation considerations.

All sessions were transcribed and analysed thematically, with the findings published in this academic paper: link to paper.

This analysis helped provide a foundation for the insights used to develop the speculative service blueprints detailed in this report.

Key insights

Insights from people affected by dementia and the public

Interest in early detection
Many participants welcomed sleep tracking as reassurance and an early warning tool, particularly when framed as “brain health” rather than dementia risk. Positive language was seen as key to engagement and reducing fear.

Concerns about anxiety and stigma
Some worried irregular sleep data might increase stress or panic. Others highlighted dementia stigma, stressing the importance of sensitive framing and communication to avoid fear-based reactions and encourage supportive engagement.

Technical and usability barriers
Participants emphasised the need for simple setup and options for those without smartphones. Support services like helplines or printed guides were considered essential to avoid exclusion of less tech-confident users.

Equity and access
Concerns about affordability were strong. Many felt charging users would worsen inequalities, particularly among low-income groups. Participants preferred NHS funding or lending schemes to ensure fair access to monitoring technology.

Holistic brain health support
People wanted sleep insights combined with broader brain health advice - covering exercise, diet, stress management, and mental wellbeing - rather than isolated data. They saw value in a comprehensive approach to preventative health.

Actionable outcomes
Participants wanted clear guidance on interpreting results and next steps. They felt sleep tracking must lead to useful advice or support, not vague or worrying data without follow-up or professional input.

Insights from GPs

Limited time and competing demands
GPs highlighted the challenge of fitting sleep discussions into short consultations already dominated by cardiovascular, mental health, or chronic condition management, leaving little room for complex new data streams.

Lack of training and confidence
Many GPs felt underqualified to interpret sleep data and requested concise, actionable summaries. Some suggested specialist review of data before it reaches primary care to avoid misinterpretation or extra workload.

Demand for evidence and clear benefit
Clinicians wanted strong evidence linking sleep patterns to dementia risk and actionable interventions. They emphasised the need for tools that directly improve patient outcomes rather than providing ambiguous risk information.

Concerns about risk disclosure
GPs worried about the ethics of sharing sleep-derived dementia risk without robust support or interventions, fearing they could cause unnecessary anxiety, confusion, or even harm by raising unresolvable concerns.

Trust and integration
Clinicians preferred NHS-backed and regulator-approved solutions. They felt integration into existing care pathways, such as Health Checks or memory clinics, would improve trust, adoption, and practical implementation of the technology.

Service blueprints

Using the insights from workshops and interviews, the Helix Centre and Newcastle University teams translated the qualitative insights into three speculative service blueprints to explore how sleep-sensing technology could function in real-world care.

These early-stage scenarios were designed to provoke discussion, allow for further testing of assumptions and iterative refinement based on feedback.

The process aimed to strengthen public involvement in the project, guide future research priorities, and help bridge the gap between qualtiative research and innovation.

SCENARIO 1

Prevention service

Prevention-focused public service encouraging proactive self-monitoring of sleep to support long-term brain health.

SCENARIO 2

Diagnostic service

Detection-oriented clinical tool used as part of a wider diagnostic pathway for people at risk of dementia.

SCENARIO 3

Monitoring service

Monitoring-focused service supporting ongoing dementia care, medication management, and research readiness.

Scenario 1: Prevention service

A public health initiative promoting the use of the sleep sensor for people aged 40+, offered through pharmacies or online, to raise awareness of the link between sleep and brain health and to encourage early, positive and personalised lifestyle changes.

Point of access
Community pharmacies, online suppliers.

Monitoring period
Minimum of 3 months recommended.

Support provided
App, user guide, helpline for installation and troubleshooting.

Target users
Adults aged 40+ concerned about brain health and sleep.

Data ownership
Viewed via app; user driven unless shared with GP.

Device ownership
Personal or rented; returned or recycled after use.

Outcomes expected
Increased awareness, behaviour change based on individual biofeedback, and early GP visits if needed.

Cost structure
Self-funded; options to buy or rent (e.g. £3/ month subscription.

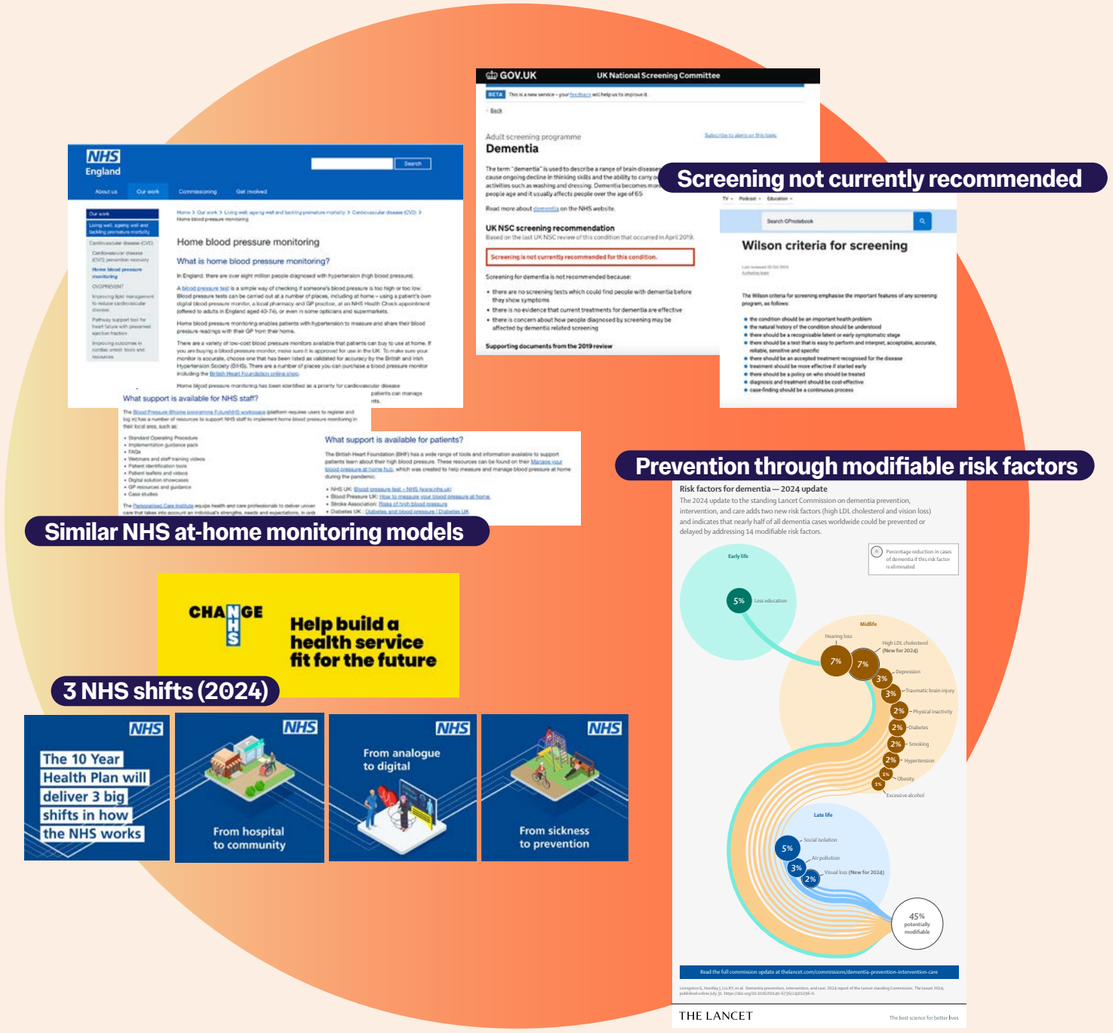
Scenario 1: Insights & evidence

Insights

- Growing appetite to self-monitor health among the health-aware population.
- A wish for early prevention “before it’s too late”.
- GPs concerned about their capacity to learn/ integrate sleep sensor data.
- Question of whether a population-wide approach might have greater impact.

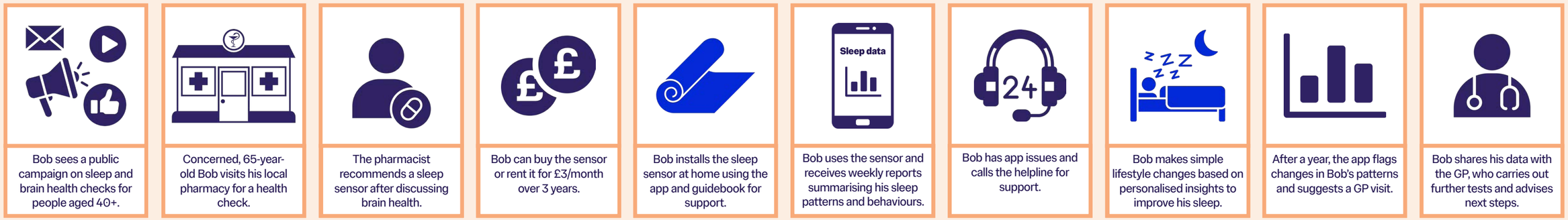
Evidence

- Research suggests up to 45% of dementia cases may be preventable through addressing modifiable risk factors, some of which can be evidenced through sleep monitoring.
- Similar NHS at-home-monitoring models exist (e.g. blood pressure monitors and continuous glucose monitoring for use at home), supporting feasibility and scale.
- Fits within the 3 NHS Shifts: Hospital to Community, Analogue to Digital, Sickness to Prevention (outlined in 2025 NHS 10 year plan).
- Although screening for dementia is not currently recommended, developments in emerging tests, drugs and therapies will likely make dementia screening viable in the future.



Scenario 1: User journey & service map

This diagram represents our speculative pathway to use sleep sensors as part of an **early-detection** service.



Scenario 2: Diagnostic service

An NHS-commissioned diagnostic support service where the sleep sensor is used as one component in a broader toolkit (e.g. alongside blood biomarkers) to support early and confident diagnosis of dementia and/or sleep-related disorders.

Target users
Patients with a mild cognitive impairment (MCI), high dementia risk (e.g. family history, biomarkers), or complaints of poor sleep.

Monitoring period
Minimum of 3 months.

Support provided
Installation guidance, helpline, clinical interpretation of results.

Point of access
GP (possibility to be referred to a Brain Health Clinic).

Data ownership
Managed by clinical teams; optional app access for patients.

Device ownership
NHS-owned; cleaned and reused.

Outcomes expected
Enhanced diagnostic confidence, accurate referrals, early care planning.

Cost structure
NHS-funded.

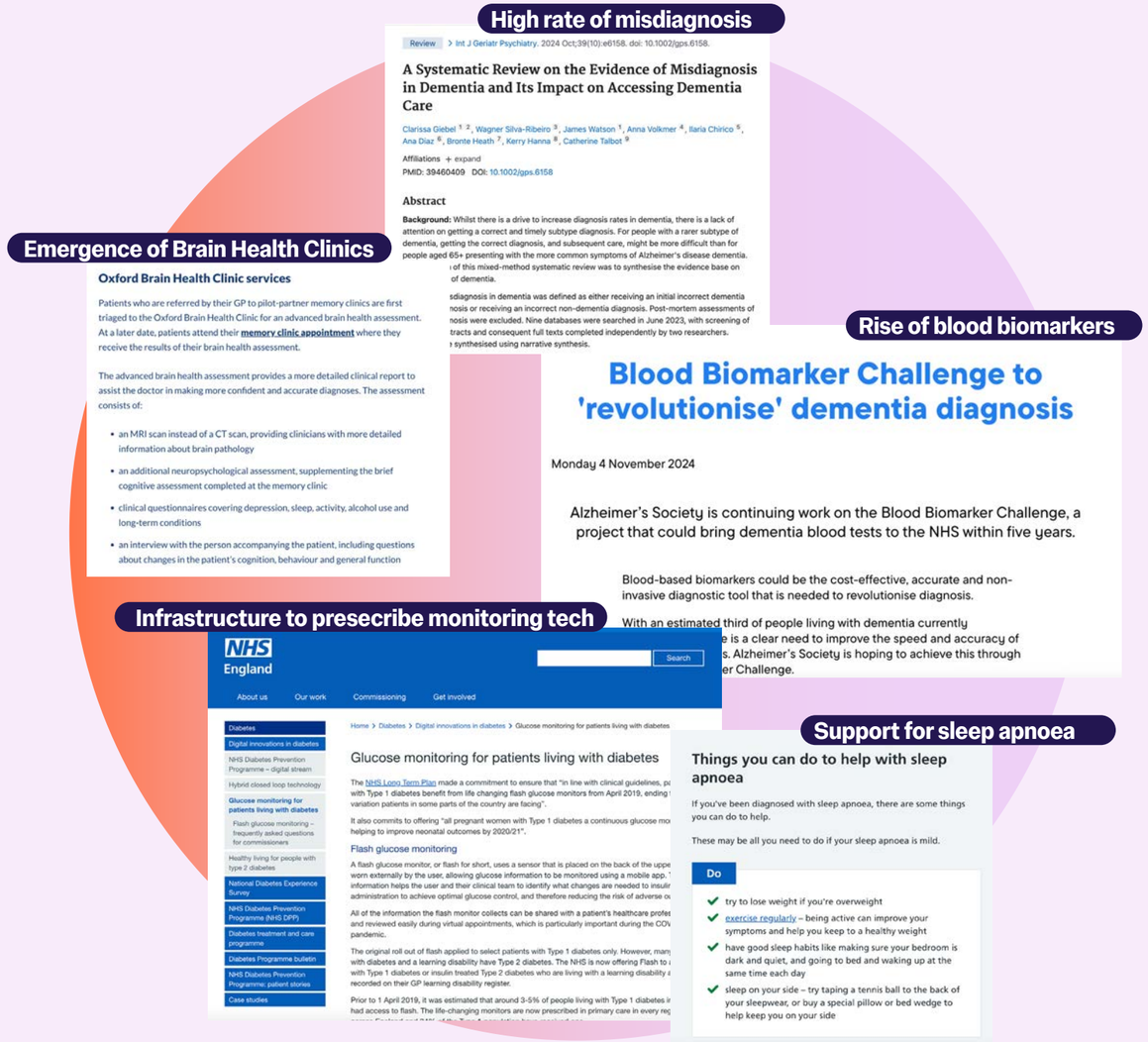
Scenario 2: Insights & evidence

Insights

- Many GPs and people affected by dementia wished for the service to be integrated as part of the NHS to improve trust and uptake.
- Currently, there is no GP protocol for poor sleep quality other than sleep hygiene recommendations – possible scope for a standardised approach.
- Participants felt the sleep sensor had promise being used as part of a diagnostic toolkit, alongside existing or possible future complementary tests and appointments.
- Many felt there was a need for professional interpretation of the sleep sensor results - a GP could offer this and be there to answer any questions people have.
- Scope to fit within existing check-ups of people at higher risk of developing dementia.

Evidence

- Sleep issues may be early indicators or contributing risk factors in dementia.
- Blood biomarkers that detect pathology are showing promise, combining this with symptomatic monitoring through sleep behaviours could be valuable.
- There is already the infrastructure to prescribe monitoring technologies for conditions (e.g. glucose monitors for people living with diabetes).
- High rate of misdiagnosis in dementia, highlights the need for greater accuracy and confidence.
- Emergence of Brain Health Clinics, which aim to provide more confident and accurate diagnosis, could play a role in a future service model.



Scenario 2: User journey & service map

This diagram represents our speculative pathway to use sleep sensors as part of a **diagnostic** service.

PATIENT IDENTIFICATION	PATIENT RECRUITMENT		INSTALLATION		MONITORING	TROUBLE-SHOOTING	ASSESSMENT	FOLLOW UPS	DE-COMMISSIONING
Zaria, 69, is concerned about her memory and has a family history of dementia.	She sees her GP, who orders a blood test showing no elevated dementia risk.	Seen as inconclusive, the GP refers Zaria to the Brain Health Clinic for further tests.	Zaria receives a sleep sensor to use at home for three months as part of her assessments.	She installs the sensor at home. An app is available to track her data.	Zaria lacks a smartphone but gets a text about a sensor issue and calls support to resolve it.	Her sleep data is reviewed alongside other test results to assess brain health.	After three months, Zaria returns to review her results with a doctor.	The doctor explains the findings and discusses treatment options with her.	Zaria is diagnosed with sleep apnea, referred for treatment, and stops using the sensor.

PATIENTS & FAMILIES

- Patient concerned about symptoms of dementia
- Patient with high risk factors (e.g. MCI/ family history/ TBI)
- Patient with sleep apnoea or complaints of poor sleep
- Patient receives sleep sensor as part of further tests
- Patient receives installation guidance online/ via guidebook
- Optional App to view simple version of data collection (no clinical analysis/ summary)
- Person uses sleep sensor (for min of 3 months)
- Patient contacts helpline/ online support for sleep sensor if needed
- Patient receives summary of findings
- Results are inconclusive
- Further use of sleep sensor offered
- Patient is not diagnosed with dementia
- Patient is diagnosed with dementia
- Patient diagnosed with sleep apnoea/ other condition

GP & SPECIALIST CLINICS

- GP carries out tests to investigate further
- Blood tests **do confirm** increased dementia risk (increased p-tau217 levels)
- Patient referred to **memory clinic** for further tests (including cognitive testing, imaging & clinical assessment)
- GP gives sleep hygiene advice and guidance
- Blood tests **don't confirm** increased dementia risk (no increase to p-tau217 levels)
- Patient referred to **brain health clinic** for further tests (including cognitive testing, imaging & clinical assessment)
- Clinical support from Clinics when requested
- GP recieves copy of summary report
- Clinical teams interpret and consolidate sleep report with findings from other tests
- GP/ clinics treat sleep apnoea or other conditions
- GP carries out further investigations
- Referred to specialist support and treatment
- Sensor returned to clinic for cleaning and re-use

SLEEP SENSOR COMPANY

- Sleep sensors (approved for use) supplied to clinics
- Sleep sensor delivered with guidance and support shared
- Technical support provided by company (via App/ phone)
- Sleep sensor data summary report sent to Clinics after three month period of good quality data

Scenario 3: Monitoring service

Designed for people already diagnosed with a mild cognitive impairment (MCI) or dementia, this service enables long-term monitoring of sleep to support infection detection, track medication effects, and support clinical trials.

Point of access
Neurologist-led care teams or specialist clinics

Monitoring period
1 year minimum; ongoing for clinical management.

Support provided
Clinical nurse setup, tech support, monthly summary reports

Target users
Individuals diagnosed with dementia or mild cognitive impairment (MCI), including those in trials.

Data ownership
Handled by NHS/research teams; summaries shared with patients

Device ownership
NHS-owned; reused or recycled through clinics.

Outcomes expected
Better symptom tracking, medication adjustments, enhanced care quality.

Cost structure
NHS-funded (likely via Trusts or clinical trial budgets).

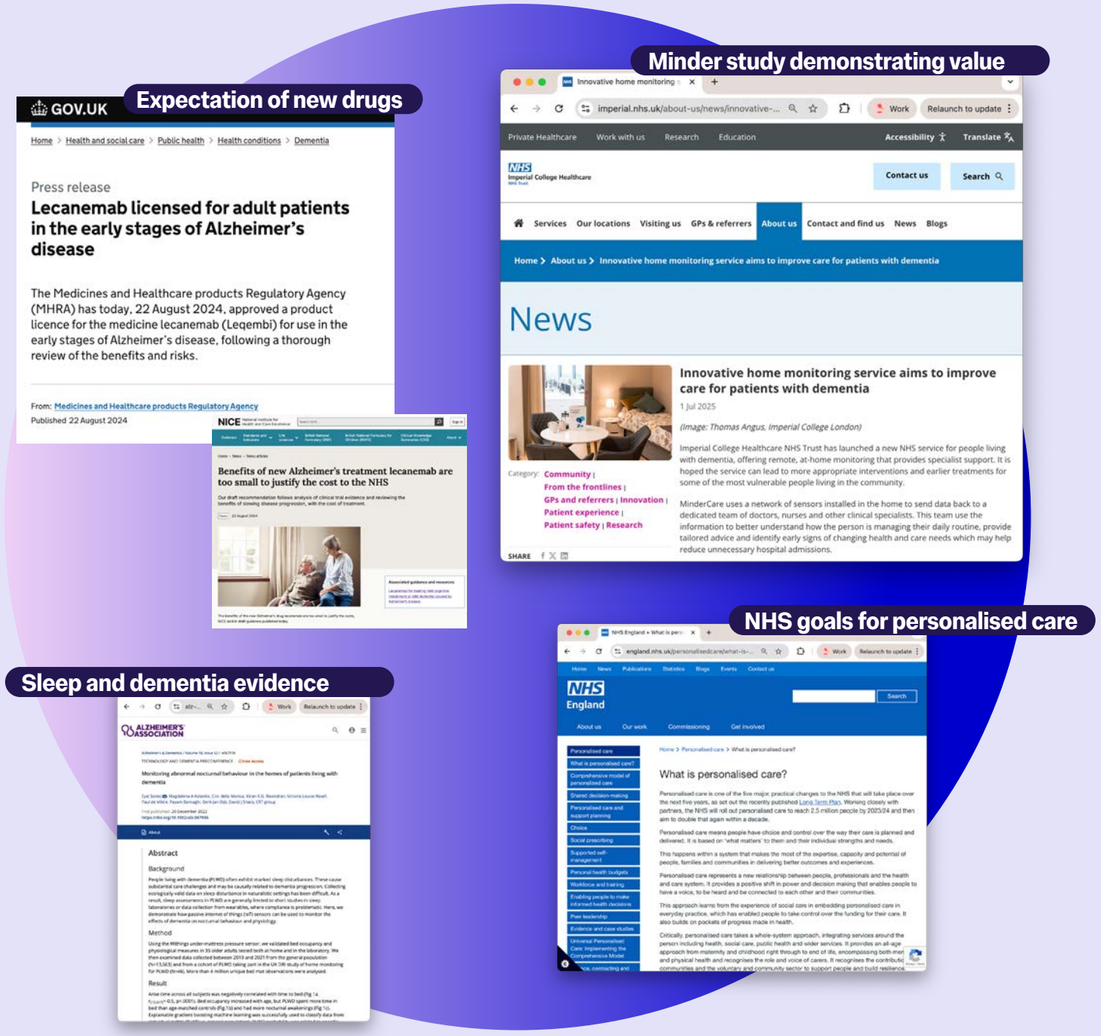
Scenario 3: Insights & evidence

Insights

- Patients and clinicians struggle to track symptoms and side effects between appointments.
- Professional oversight is crucial, as raw data without clinical interpretation may alarm or discourage individuals.
- There needs to be a clear “so what” - continuity of care could be enhanced by regular, passive data collection.
- GPs might not have the capacity to learn/ integrate sleep analysis into their practice.
- Questions about whether the risk of early-stage use might impact already under-resourced services for people diagnosed.

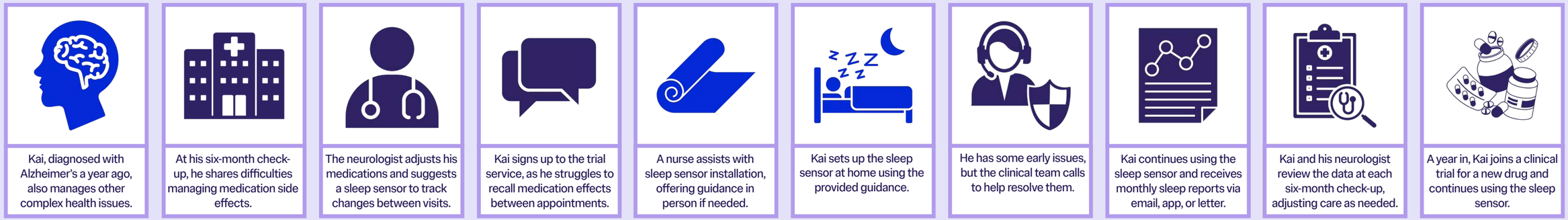
Evidence

- Monitoring sleep may aid in understanding disease progression and the effects of treatment.
- Aligns with NHS goals for personalised care and reducing unnecessary appointments.
- There is an expectation of new therapeutic drugs, sleep sensors could help facilitate clinical trials and evaluate impact.
- Models such as the Minder study have demonstrated the value of at-home monitoring using passive devices such as the sleep sensor.



Scenario 3: User journey & service map

This diagram represents our speculative pathway to use sleep sensors as part of a **post-diagnostic** service.



Key findings

Testing scenarios

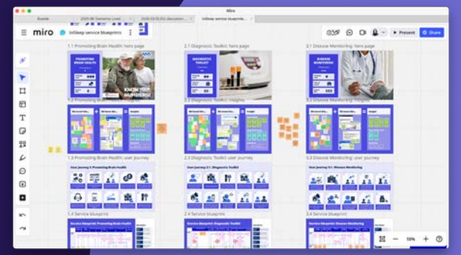
The three service blueprints (scenarios) were developed to understand how a sleep sensor biomarker might be made feasible, desirable, and viable within real-world healthcare and community settings. Whilst the long-term goal is to continue iterating these blueprints collaboratively with members of the public, people affected by dementia and healthcare professionals, in the short term, these blueprints also serve as a tool for shaping future funding proposals and research priorities.

To identify the most relevant opportunities for advancing the work, the scenarios were tested with members of the InSleep46 team, whose expertise spans dementia health inequalities, clinical practice, healthcare monitoring, data science, and lived experience.

Process

Nine team members participated in semi-structured interviews, offering critical feedback on the assumptions, practicalities, and implications of each proposed service model. Their perspectives have been thematically analysed and are summarised in this report, highlighting key opportunities and challenges for translating the research into meaningful service innovation.

The insights from these interviews have been used to provide recommendations for future research.



Comparative findings

Across scenarios, consistent themes include the necessity for robust evidence validation, clear clinical actionability, integration ease into current NHS systems, and equitable access to avoid exacerbating health inequalities. Scenario 1 offers broad population health potential but faces significant barriers in equity and anxiety management. Scenarios 2 and 3 focus on clinical precision but are constrained by higher costs, intensive training requirements, and scalability limitations.

Clinicians prioritise clinical utility and actionable data that integrates seamlessly into their workflow, emphasising the importance of NHS validation for trust and adoption. Technological usability and clear, anxiety-reducing communication are essential across all scenarios.

SCENARIO 1

Prevention service

Equity risks: Favours affluent, tech-savvy users; high costs (£70 + £3/month) and digital exclusion marginalise low-income, rural, or non-English speakers. NHS-funded or lending schemes could improve fairness.

Trust gap: Lacks NHS endorsement or clinical trials, echoing poor NHS Health Check uptake (<25%). Consumer successes like ZOE highlight the value of trusted feedback and personalisation.

Emotional impact: Dementia framing may trigger anxiety; "brain health" or sleep apnoea messaging is preferred.

Actionability: GPs lack pathways beyond sleep hygiene, though detecting treatable conditions (e.g., apnoea) is promising.

Tech & scale: Passive sensors are preferred over wearables but provide limited data. Broad rollout requires user education, solid evidence, and robust infrastructure.

SCENARIO 2

Diagnostic service

Improved access: NHS setting increases accessibility for some, but may miss those delaying help-seeking; combining with Health Checks could expand uptake.

Higher trust: GPs more confident if paired with blood biomarkers or existing pathways. Adoption will depend on clear, actionable outputs.

Emotional impact: Clinical framing reduces anxiety, but 3-month waits may distress some; vague "elevated risk" alerts remain problematic.

Triage tool: Aids referrals in ambiguous cases; useful for early cognitive complaints or unexplained sleep problems. Could provide peace of mind to worried but healthy people.

Evidence needs: Must show value beyond history-taking. Differences between personal and population sleep data remain challenging.

Scalability: Needs NHS funding, defined referral roles, and integration into electronic health records.

SCENARIO 3

Monitoring service

Access issues: Limited to research or specialist care; patients without carers risk exclusion.

High trust: Most credible scenario, particularly for monitoring treatment response, infections, or rapid decline.

Reassurance: Provides peace of mind for families, enabling early alerts to prevent hospitalisations.

Actionability: Supports real-time care plan adjustments and clinical decision-making.

Evidence strengths: Sleep is gaining traction as a secondary endpoint in dementia trials, especially with wearables or biomarkers.

Usability & scale: Passive sensors suit cognitive decline but require carer setup. Large-scale rollout demands infrastructure, technical support, and NHS investment.

Scenario 1: Key findings [Trust & relevance]

Equity of access

Self-selection bias: Concern that the tool may mainly attract health-conscious, affluent, educated, tech-savvy users already engaged with monitoring technologies.

Widening inequalities: Risk of excluding higher-risk groups such as socioeconomically disadvantaged individuals, ethnic minorities, non-English speakers, and people with low digital literacy.

Rural access concerns: NHS Health Check uptake is low (<25%), partly due to remote locations and lack of travel access; similar barriers are likely unless extra support is provided.

Affordability issues: One participant said: "If it's going to cost £70 and then £3.00 a month, they wouldn't even think about it." Cost, combined with limited immediate benefits, can deter use.

Suggested solutions:

- Partner with third-sector organisations (e.g., Alzheimer's Society) for outreach or financial support.
- Community lending models, e.g., via libraries.
- Digital inclusion strategies (Good Things Foundation) encouraging device pools in NHS Trusts.

"It's putting empowerment into the patient's hands, but is the uptake going to be there?"

Trust and validation

Need for NICE-level validation: Without clinical guidelines or NHS endorsement, trust and uptake will remain low.

Accuracy concerns: Participants questioned data reliability due to natural variability and potential inaccuracies or missing data from sensors.

Transparency is essential: Both users and clinicians need clarity on data meaning, suggested actions, and associated risks.

Comparative insight: NHS Health Check uptake is under 25% (Public Health England), while cancer screening rates are 50–75% (NHS England), highlighting a trust and clarity gap this tool must address.

Opportunities:

- Link with key health priorities like cardiovascular or brain health (e.g., Football Association's sports brain health work).
- Adopt consumer-facing models like the ZOE app to build familiarity and engagement.
- Use app-based psychoeducational content to explain dementia risks and sleep's role in prevention.

Emotional impact

Risk of anxiety and panic: Participants warned that, without professional interpretation, receiving poor or unclear results may cause undue emotional distress. One participant noted that without professional interpretation, prolonged sleep tracking might increase anxiety: *"Would I be panicking a little...?"*

Stigma and fear: Dementia is emotionally charged and poorly understood. Messaging must avoid suggesting determinism or inevitability.

Framing matters: Focus on treatable conditions and adjustable risk factors like obstructive sleep apnoea (OSA), which is more actionable and less distressing than speculative dementia prediction. The positive framing of "Brain Health" was seen as preferable to identifying someone's "Dementia Risk".

Device preference: Sleep sensors were seen as less intrusive than wearable devices, especially for older adults or those who dislike sleeping with a smartwatch.

Clinical preference: GPs are more likely to trust data that's validated than commercial wearables.

Clinical actionability

Limited clinical utility: Clinicians questioned the value of the sleep sensor data, noting the lack of clear treatment pathways. Without referral or diagnostic options, responses were often reduced to generic sleep hygiene advice. *"If I have poor sleep, then what?"*

Opportunities:

- Detect underdiagnosed, treatable sleep disorders like OSA
- Preclinical screening for REM sleep behaviour disorder, a known precursor to Parkinson's disease

Communication style matters:

- Recommendations should be visual, simple, and user-facing, focusing on individual baselines and biofeedback - e.g., "You're sleeping for fewer hours each night. Here's what you can do."
- Sleep sensor data could enable app-based nudges and sleep self-management advice, reducing pressure on overstretched primary care services

Scenario 1: Key findings [Delivery & scale]

Evidence maturity

- **Biofeedback for behaviour change:** Potential for impact if following existing models for lifestyle change based on commercial health technologies (e.g. ZOE app, Apple watch)
- **Emerging but limited validated evidence:** Evidence is currently limited for Scenario 1. Stakeholders highlighted the lack of trials showing the effectiveness of sleep monitoring for general prevention.
- **Call for research:** More robust studies, including randomised controlled trials with specific cohorts, are needed to assess the utility in identifying at-risk individuals.

System fit

Challenges in routine care: Without a defined care pathway, the tool risks producing "data without action."

Pressure on GPs: GPs may not have capacity to interpret or act on sleep data unless clear support and protocols are provided.

Fit in non-clinical settings: There is potential for the tool to sit outside the NHS, in wellness or public health spaces, where users can self-manage.

Technology usability

Mixed usability: While passive monitoring is appealing in comparison to wearables, installation and interpretation challenges may remain for older or digitally excluded populations.

Passive sensors vs wearables: One researcher highlighted that a watch feels like a more suitable device because you also get more holistic activity involved (e.g. movement throughout the day, sleep in chairs during the day) as well as sleep at night - which wouldn't be captured in the bed mat

Need for support: A helpline, printed guides, or an in-person setup may be needed to ensure broad accessibility.

Scalability

Scalability concerns: Possibility for widespread population use. However, this would require significant investment in support infrastructure. Risks include poor uptake, especially among underserved groups.

Unique Selling Point: Questions arose over the USP of such a service in comparison to technologies that already exist. The device needs to either be NHS-endorsed for wider uptake or provide clinical interpretation to be unique.

Potential in targeted deployment: Community-based lending schemes or NHS pilots could test the model before large-scale rollout.

Scenario 2: Key findings [Trust & relevance]

Equity of access

Improved access via NHS: NHS involvement improves equity, as individuals already in contact with primary care or memory clinics are more likely to access the service.

Persistent access barriers: Disparities may remain. Many people delay seeking help for memory or sleep issues, meaning some at-risk groups may still be missed.

Geographic inequality: Rural areas face limited access to diagnostic tools like MRI and PET scans, which may reduce service reach and follow-up capability.

Global context: In low and middle-income countries (LMICs), high-cost diagnostics may be unavailable. Tool relevance would depend on affordability and simplified protocols.

"They won't do MRI scans in some places - not available, not funded. We must consider how this applies globally."

Trust and validation

Higher trust in clinical setting: GPs and clinicians indicated greater trust in the tool when integrated within structured NHS diagnostic processes.

Clinical decision support needed: GPs emphasised that results must be actionable, simple, and relevant to diagnosis and treatment decisions.

Data validity questions: Concerns were raised about whether digital sleep data can accurately distinguish dementia subtypes or reflect underlying pathology.

Model behaviour: Participants flagged that individuals might alter sleep behaviour if they know they're being monitored, reducing the objectivity of data.

"We'd need something clear to act on." - GP

Emotional impact

Lengthy wait for results: Introducing a sleep sensor used for 3 months, in comparison to a quick blood test might introduce more emotional distress for patients waiting for results, appropriate context for use is key.

Reduced distress in clinical context: Participants felt anxiety was less likely if clinicians were available to interpret and contextualise results.

Ambiguity risk: Unclear or non-specific findings could still cause distress, especially if flagged as 'elevated dementia risk' without follow-up clarity.

Empowering framing: Positioning the mat as part of a broader diagnostic picture (rather than a stand-alone judgement) could make users feel more in control.

"Feels more comfortable... people would feel more invested if there's a clear outcome."

Clinical actionability

Not for screening: Clinicians stressed this should focus on patients presenting with cognitive or sleep issues, not population screening.

Referral support tool: GPs valued the sensor as a triage aid, especially for borderline cognitive cases or where immediate referral is unclear. *"I would view this more as a stratification tool – identify who needs more testing."*

Blood biomarkers: Sleep data could complement blood tests but is most useful where diagnosis remains uncertain after quicker, less invasive tests. *"Blood tests easier – doesn't impact or affect the rest of your life like a sleep sensor would."*

Possible use cases:

- Cognitive complaints without suspected neurodegeneration: assess whether poor sleep patterns are the cause, providing evidence.
- Cognitive complaints with possible sleep contribution: use for deeper investigation of daily function.
- Growing younger population with sleep issues: offers data for diagnosis or personalised sleep hygiene advice.

Preferred data format: Summarised reports with risk flags, and clear clinical guidance, not raw data.

Who should interpret? GPs or preferably, memory clinics or neurology teams.

Scenario 2: Key findings [Delivery & scale]

Evidence maturity

Establishing baselines: One key challenge is defining personal norms versus population norms - behavioural data varies significantly across individuals and contexts.

Behavioural trends: Sleep may follow weekly or seasonal patterns that influence interpretation - this complexity requires advanced analytics.

Proof required: Ongoing studies must determine whether the sleep monitoring provides unique or additive diagnostic value.

Accuracy and robustness: Questions arose about how accurate and robust the digital sleep biomarker would be and whether it would be accurate in understanding the type of dementia.

"Often digital biomarkers for dementia fail as they don't get a lot of evidence built up, don't think about different types of dementia and don't validate in a big enough clinical cohort and therefore end up stalling"

System fit

Integration potential if evidence: Participants widely agreed Scenario 2 offers the clearest route into NHS pathways, particularly through GPs, memory clinics, or community diagnostic centres; however, evidence is needed to demonstrate value.

Existing platforms: Incorporating sleep data into exisiting Electronic Patient Records would streamline use by clinicians.

Brain Health Clinics: Stakeholders shared mixed opinions about the possible role Brain Health Clinics could play in providing support in the triage process - some sharing optimism for the integration of research into clinical practice, whilst others still viewed them as "controversial" due to self selection bias existing regarding who gets involved in research.

Social prescribing support: One researcher suggested social prescribers could play a role in helping patients access and use a service like this.

"I think it would be really hard to get a clinician to pick this up - don't think sleep markers have as much evidence as other digital tools have"

Technology usability

Setup concerns: Despite passive data collection, some groups (e.g. older adults, those with MCI) may require support during installation.

Use duration: Three-month minimum seen as appropriate for generating reliable data, though some worried about length of time delaying diagnosis and if you'd be able to establish an accurate baseline within this time.

Device acceptability: Sleep sensors were seen as a good compromise for at home monitoring - unobtrusive, objective, and more acceptable than wearables.

Emotional risk: Waiting period and lack of feedback during use may increase anxiety - solutions could include check-ins or app nudges.

Scalability

Strongest scalability case: If NHS funding and digital infrastructure support implementation, Scenario 2 could scale nationally.

Workforce and workflow: Without integration, GPs may struggle with added workload; implementation depends on clarity of roles.

Data burden: Raw outputs must be translated into brief, actionable insights to avoid overloading clinicians.

Enablers:

- Define target users and referral pathways
- Embed in existing NHS platforms
- Include remote and rural users with support services

"The concern is it becomes another digital burden unless designed for clinical use from the outset."

Scenario 3: Key findings [Trust & relevance]

Equity of access

Highly variable access: Access is often limited to those in specialist pathways or clinical trials. People with dementia, especially those without carers or living alone, may struggle to use the sleep sensor effectively.

Inequity in follow-up: Follow-up care varies drastically. Some see a GP annually; others may have no structured support, making standardised ongoing monitoring challenging without system-level reform.

Digital exclusion risk: Some people with dementia might lack the capacity to install or monitor devices, pushing responsibility onto carers, not all of whom may be available or confident in doing so.

Trust and validation

High trust in research/monitoring: This scenario was seen as most credible when used to monitor disease progression or evaluate treatments in trials as it allows clinicians, individuals, families and carers to observe individual change over time.

Two use cases:

- **Established dementia** - real-time monitoring for change over time or early detection of infections;
- **Mild dementia** - provide reassurance to relatives, to explore drug efficacy or support quality of life.

Uncertainty: The "holy grail" of remote cognitive monitoring remains unproven - more data is needed on whether sleep correlates with meaningful outcomes.

"This scenario is the least clear in terms of who might be paying/ buying/ monitoring the service, but it's potentially the most important because it's the most underserved area".

Emotional impact

Generally reassuring: Value for people living with dementia and carers appreciated the potential to observe meaningful changes over time.

Potential for distress: Misinterpretation or lack of professional support may cause anxiety; especially if families are unsure what changes signify.

Support required: Psychological burden may fall on carers if the data raises concern but lacks actionable next steps.

"This could give a voice to people who can no longer describe what's going wrong."

Clinical actionability

Most actionable scenario: Data could inform changes in care plans, medication response, or signal rapid deterioration needing intervention.

Key value: More useful in trial settings or advanced care stages where change detection matters more than diagnosis.

Treatment response tracking: Sleep data could detect how a patient responds to dementia medications before other clinical signs change. Offers a non-invasive, real-world method to assess whether medication is working - especially useful for patients who have difficulty expressing changes themselves.

"Useful for infection detection - if sleep deteriorates, could be a prompt before hospitalisation."

Scenario 3: Key findings [Delivery & scale]

Evidence maturity

Established evidence: Clinical trials increasingly use sleep monitoring to assess outcomes. Support is growing for sleep as a digital biomarker, especially with wearables or blood diagnostics.

Key opportunity – secondary endpoints: Sleep monitoring is highly promising as a secondary endpoint in dementia drug trials, detecting treatment-related changes not visible through standard cognitive assessments.

1. **Sleep pattern disruption** can indicate cognitive decline or improvement before symptoms arise.
2. **Researchers seek ecologically valid, real-world indicators** beyond six-monthly cognitive tests, sleep data provides this granularity.
3. **Though not the primary trial outcome,** secondary endpoints like sleep can assess drug efficacy and influence future research.

Validation needed:

- **Technical:** Can the sensor reliably capture sleep data?
- **Clinical:** Do sleep patterns correlate with meaningful health outcomes?
- **Patient value:** Do patients find sleep monitoring useful and relevant?

Opportunity: Pharmaceutical funding could accelerate progress. *"This might be the first step in disease monitoring – and big pharma could fund it."*

System fit

Strong in research/specialist settings: Trial environments provide the structure and staffing needed to interpret and act on data.

Care fragmentation limits use: Dementia services often lack continuity or infrastructure for ongoing monitoring, making national NHS rollout challenging.

Best fit for high-need cases: Works well for post-diagnosis monitoring, side effect tracking, or infection detection.

"Right now, the system isn't ready - this would be data without action."

Technology usability

Passive design is ideal: Once installed, the sensor requires no input - ideal for users who might have cognitive impairment or limited dexterity.

Holistic perspective: Would the sleep sensor on it's own provide enough data to accurately describe activity in the home?

Practical concerns:

- Requires Wi-Fi and power - not universal in all homes.
- Needs support for troubleshooting, cleaning, or re-use.
- Carers might need to oversee installation and monitoring.

Reusability option: Some suggested the mats could be deployed temporarily - e.g., after diagnosis, or during medication changes - then returned or reused.

"If you could just use it when someone starts treatment, that's cost-effective."

Scalability

Low general scalability: High setup and monitoring demands, limited funding, and unclear ownership make widespread NHS rollout complex without long term infrastructure investment.

High trial scalability: Very feasible within clinical research or high-intensity care models where data interpretation and clinical follow-up are integrated.

Long-term impact potential:

- Early detection of side effects or deterioration
- More efficient use of NHS resources (e.g. avoiding hospital admissions)

"It sounds expensive, but early intervention could save a hospital bed - that's cost-effective."

Cross-cutting insights

01 Trust & validation

Adoption depends on trust in evidence. GPs and participants doubted whether poor sleep predicts dementia. Without robust, real-world validation (especially linking sleep to meaningful clinical outcomes) interest may fade. NHS involvement and transparent protocols were seen as essential for building long-term confidence in the technology's reliability and usefulness.

02 Impact & framing

Monitoring sleep in the context of dementia may trigger anxiety, particularly from unclear results or associations with a feared diagnosis. Participants preferred positive, empowering language (like "brain health") over "risk." Emotional safety depends on sensitive framing, support from professionals, and avoiding data without follow-up or clear explanation.

03 Equity and access

Digital exclusion was a repeated concern. Without careful design, only affluent, tech-savvy users might benefit. Costs, digital literacy, and internet access limit reach. Inclusive models like device lending, community partnerships, or NHS subsidies are essential to ensure underserved groups aren't left out of this emerging approach to care.

04 Clinical actionability

Clinicians were clear: insight without action isn't helpful. Data must lead to next steps (e.g. referral, advice, or reassurance) not just monitoring. Sleep metrics must be interpretable, meaningful, and embedded in pathways. Without integration into decision-making, the technology risks burdening clinicians and confusing users with vague or non-actionable results.

05 System fit & scaling

For NHS uptake, sleep-sensing tools must align with workflows, IT systems, and clinical roles. GPs stressed that tools requiring extra time or training won't scale. Integration into electronic records, summary reports (not raw data), and workforce support are vital to ensure adoption doesn't increase pressure on services.

06 Flexibility & choice

People valued having options. Some preferred passive sensors for simplicity; others liked wearables for richer data. No single format suits everyone. To succeed, technologies must accommodate varying needs, comfort levels, and care contexts; ensuring the service remains accessible, sustainable, and person-centred over time.

07 Broader & global relevance

Sleep-sensing could beneficial to more than just dementia care. Participants saw value for other conditions (like Parkinson's, sleep apnoea, or frailty) where early detection supports wellbeing. They also urged the team to design for lower-resource settings. Simpler, affordable tools may have even greater utility outside the NHS, amplifying global health impact.

08 Continuity & privacy

People wanted care that evolves with them; from early risk to ongoing support, not fragmented stages. Continuity boosts trust, especially when data stays within the NHS. Many voiced concerns about commercial use. Transparent, ethical data governance clearly showing who sees what, and why, is essential to sustaining trust long term.

Recommendations for future research

01 Trust & validation

Conduct rigorous clinical validation studies. Research must robustly validate sleep-sensing tools through longitudinal studies that link sleep data to dementia risk. Evidence must show clinical relevance, real-world reliability, and practical utility. NHS-backed trials can help shift perception from experimental to trustworthy.

02 Impact & framing

Evaluate emotional and psychological impacts with supportive frameworks. Future research must assess how users interpret sleep data, testing emotionally sensitive language and communication tools. Studies should actively mitigate distress through framing, support structures, and measured feedback loops.

03 Equity & access

Ensure equity, accessibility, and affordability. Trials should include digitally excluded and socioeconomically disadvantaged groups. Research must evaluate delivery models like community-based lending, third-sector support, and NHS co-funding to reduce access barriers.

04 Clinical actionability

Develop clear, actionable clinical pathways and referral protocols. Future studies should co-design referral pathways and support tools with clinicians. Sleep-sensing must fit into existing care models and guide tangible outcomes to reduce ambiguity and improve patient care.

05 System fit & scaling

Explore system integration and workforce impacts thoroughly. Research must evaluate the operational implications (clinician time, training, and IT compatibility) ensuring technologies simplify workflows rather than add burden. Pilots should explore embedding within existing NHS infrastructures and scale studies such as InSleep46.

06 Flexibility & choice

Test a diverse range of alternative devices and technological approaches. Explore combinations of wearables, smartphone sensors, and passive systems. Research should assess usability, inclusivity, and acceptability across varied user groups to avoid overreliance on one format.

07 Broader & global context

Expand research to applications beyond dementia. Investigate sleep-sensing in Parkinson's, frailty, sleep disorders, and neurodegeneration to increase funding appeal. **Consider global and non-NHS contexts.** Design and test models for low-resource healthcare systems, ensuring adaptability across countries and infrastructures.

08 Continuity & privacy

Investigate integrated care across dementia stages. Model services that flex from prevention to long-term monitoring, enabling adaptable support. **Address privacy, data governance, and ethical frameworks transparently**. Define and test clear consent models, NHS stewardship, and transparent data use to build user confidence.

Conclusion

The InSleep46 project has opened a crucial window into the potential of sleep-sensing technologies to support dementia prevention, diagnosis, and care. More than just a technical exploration, the work has brought together a diverse community of voices - patients, carers, clinicians, researchers - each with their perspectives on what it means to translate digital innovation into compassionate, effective, and equitable care.

What has emerged is not a single pathway, but a landscape of possibilities shaped by diverse needs, constraints, and aspirations. Participants highlighted not only the promise of early detection and personalised support, but also fears around data, access, and emotional burden. As intended, the scenarios have as reflective tools, helping all stakeholders involved articulate what they would need for these technologies to work in practice.

This report does not provide definitive answers or close the conversation - it hopefully opens new possibilities for how this research can be advanced. The blueprint process has provided a shared foundation for designing services that are grounded in real-world concerns. But it has also raised essential questions about feasibility, sustainability, and trust of any possible future service.

To realise the potential of sleep-sensing technologies in dementia care, the next phase must include real-world pilot studies, clinical trials with robust endpoints, and health economic evaluation. Funders, NHS trusts, and technology partners should work together to create inclusive, scalable service models. Only through such partnerships can sleep data evolve from a promising signal into a reliable tool for early support, equitable care, and improved outcomes.

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