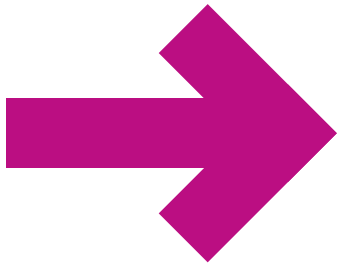
NHS England

Test Beds
the story so far



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Foreword

Healthcare systems around the world are grappling with increasing demand, escalating cost and rising public expectations. Fortunately help is at hand. The retail, travel, recreation, banking and manufacturing industries have used emerging digital technologies to transform the way they do business, increasing their efficiency and improving the way they interact with customers. Healthcare hasn't been as quick. The reasons are different in different countries, but broadly they relate to concerns around privacy, fear of losing the personal touch and humanity of healthcare, affordability and in some countries lack of competition and patient pull.

But these concerns are in many cases paradoxical if not illogical. Digital technology offers opportunities to improve privacy, free up more time for personal interactions, reduce cost and make it easier for patients to navigate their own healthcare. Importantly it can reach both geographies and people that we don't engage with well at the moment.

Increasingly we are digitising and analysing human physiology through wearables and mobile technology to help walkers, cyclists, mountaineers and people with diabetes, dementia or heart conditions. We need to understand how this knowledge can play into healthcare.

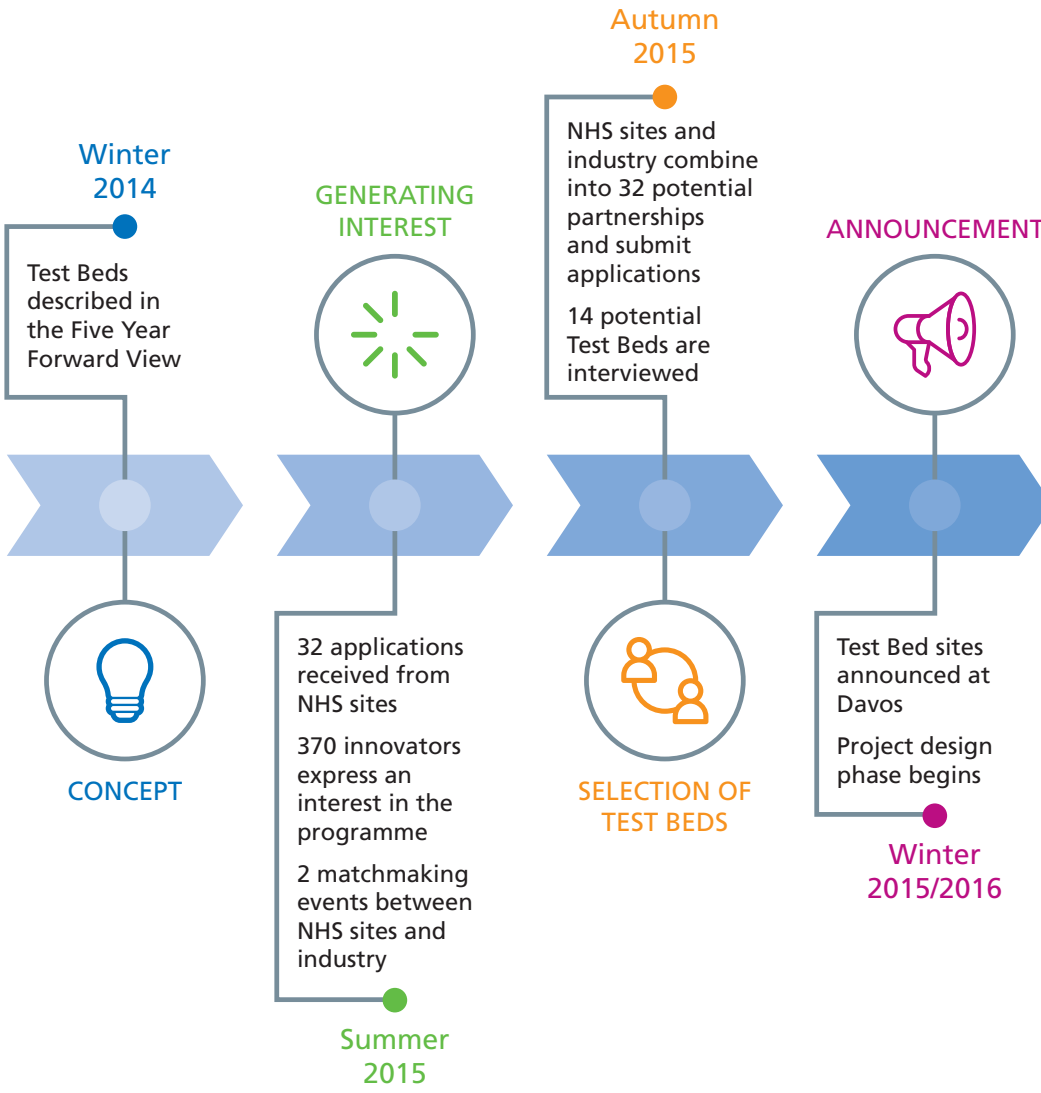
The Test Beds programme attempts to address these issues. It illustrates, in my view, two things. Firstly, it demonstrates that our NHS can work collaboratively with industry to be at the cutting edge of digital solutions to specific issues. Secondly, it demonstrates that the synthesis of different technologies in a joined up way can create

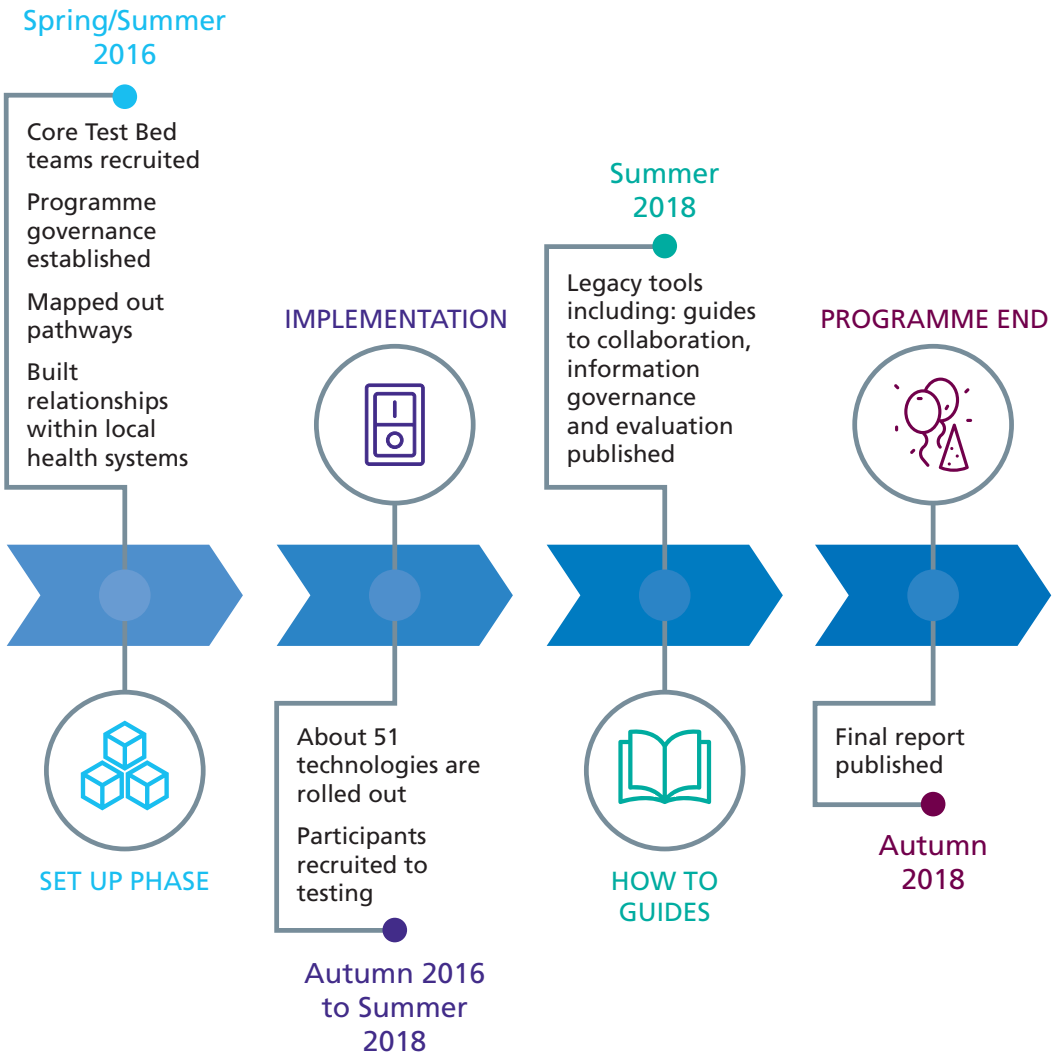
synergistic benefits greater than the sum of the parts - so called ‘combinatorial’ innovation. In time, I hope it will demonstrate that we can provide more of what patients want for the same or less cost.

I am encouraged by the stories in this document; we are already seeing a difference from the implementation of combinatorial technology. The focus now is on generating a robust evidence base so that we can identify what works. This is only the beginning, but it is an opportunity for our NHS and associated industries to be at the forefront of providing solutions to common global challenges.

Professor Sir Bruce Keogh
National Medical Director

Programme timeline




Spring/Summer 2016
Core Test Bed teams recruited
Programme governance established
Mapped out pathways
Built relationships within local health systems
SET UP PHASE
IMPLEMENTATION
About 51 technologies are rolled out
Participants recruited to testing
Autumn 2016 to Summer 2018
Summer 2018
Legacy tools including: guides to collaboration, information governance and evaluation published
HOW TO GUIDES
PROGRAMME END
Final report published
Autumn 2018

1. Introduction

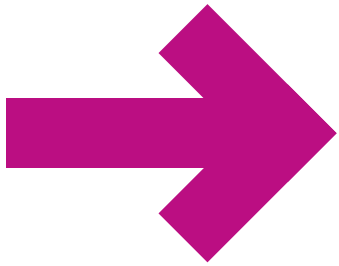
In January 2016, seven Test Beds were announced at the World Economic Forum in Davos. These real-word trials are testing 'combinatorial' innovation (new combinations of products and processes) aiming to improve patient outcomes at the same or less cost than current practice; whilst supporting economic growth.

The Test Beds are forerunners for demonstrating the type of collaboration between the National Health Service (NHS) and industry noted by Sir John Bell in his recent report to government on the Life Sciences Strategy. A conservative estimate is that the programme has leveraged £15 million from industry, alongside £9.5 million investment from NHS England, the Office for Life Sciences (OLS) and Department of Health (DH).

The Test Beds programme is unprecedented in scale: it includes 40 innovators, 51 digital products, eight evaluation teams and five voluntary sector organisations. They work with the NHS infrastructure and professionals in the seven different areas across England; supported by the work of the Academic Health Science Network (AHSN).

This document describes the programme's story so far and how the Test Beds are tackling clinical challenges such as dementia, diabetes and mental health through technology including algorithms, sensors and the Internet of Things. It also shares the learning from the programme to date, so that the rest of the NHS can benefit from the experiences documented.

2. The story so far



2. The story so far

2.1 Programme set-up:

The Test Bed programme originated in the Five Year Forward View and was set up to provide a novel approach to test innovations in health systems, by tackling three well established barriers to the uptake of innovation:

1. Innovations are often implemented in isolation from each other and the infrastructure in which they function
2. There is a comparative lack of robust evidence about their real-world effects, as opposed to experimental or research settings
3. Innovations are often introduced on top of existing working practices and infrastructure, rather than in conjunction

Essentially, Test Beds were established to provide an opportunity to test 'combinatorial' innovation in real-world settings. There was a clear appetite for this; over four months we received expressions of interest from more than 300 worldwide innovators and 32 NHS sites.

Between May and November 2015 the programme, supported by AHSNs, established new NHS-innovator partnerships that became the seven Test Beds announced in January 2016. Lessons from this experience include:

- The importance of clearly defining the problem to solve early on
- Ask industry the right questions about how their products fit into pathways
- Do not underestimate the time required to develop mutually beneficial partnerships, recruit patients and operationalise the innovation

These reflections are being shared with the AHSNs, government and industry as conversations about the wider research and innovation strategy continue. 'How to' guides on key areas will be made available in summer 2018.

The seven Test Beds are identifying solutions to support the transformation of clinical areas highlighted in the Five Year Forward View including: primary care, urgent and emergency care, mental health, dementia and long term conditions. They are doing this through the collaborative working and personalising care, which digital technology provides.

In doing so, they are testing three types of innovation:

1. Predictive algorithms to manage patients at risk of developing a condition
2. Aggregation of data into one place to inform operational and clinical decision making and improve an individual's ability to manage their condition
3. Technology to monitor risk of crisis in clinical pathways or an individuals home or care home

The Test Beds are demonstrating how the NHS can form collaborations with industry at scale, with some partnerships containing up to eight innovation partners.

2.2 Setting up a Test Bed:

Getting the Test Beds set-up took longer than anticipated, but time spent on the areas set out below is essential to testing technology safely and successfully.

Core team

A dedicated team covering: programme management, information governance, research, commercialisation, entrepreneurial skills, clinical lead(s) and communication and engagement skills.

Terms of collaboration

A framework that defines the overall relationship and ways of working. This may be part of a formal collaboration agreement. Agreements should include governance arrangements as well as escalation routes.

Testing phase

Plan in time to design the end-to-end intervention. To be successful, everyone in the partnership should be involved: core team, healthcare professionals, users of technology, innovators and evaluators.

Evaluation

Partner with an evaluation team early to establish a robust protocol covering: (1) set up and design (2) impact evaluation to understand what works (3) process evaluation to understand how and why, and (4) economic evaluation. It is also important to establish data availability.

Information Governance

The core team needs an IG specialist to cover: (1) privacy impact assessments (2) data flow maps and (3) data sharing agreements clearly stating data controllers and data owners etc.

Interoperability and Cyber Security

Digital technologies converging with a clinical pathway or data centre, must ensure all partners are committed to open APIs. Also, ensure robust cyber security measures are in place across all parties.

Communications

Devleoping an internal and external communications strategy covering (1) recruitment strategies for testing (2) engagement with local clinical teams and (3) engagement with user groups to provide a sounding board during development.

Commercialisation

Build in the future product viability from the start. This includes: outlining a business case for interventions and reviewing as testing develops to ensure scalability.

2.3 Testing the innovations:

The Test Bed programme is currently in the testing phase, working with 51 innovations across redesigned clinical pathways and about 4,000 people.

Early anecdotal feedback from patients and clinicians (section 4) shows that the innovations are having a positive impact on the quality of life of people living with a long term condition and changing the way they interact with their healthcare professionals.

Testing will run through until summer 2018, by which time we expect around 15,000 people to have been involved in testing innovations. Data collection from across sites is ongoing.

2.4 Evaluating the innovations:

Testing how to combine digital technologies into clinical pathways, and adjust working patterns requires a different approach from traditional product evaluations. With this in mind we have emphasised the need for all Test Beds to answer questions about impact and process:

1. Did the intervention improve patient outcomes?
2. Did the intervention lower health system costs?
3. What changes were made to the intervention or implementation and why?
4. Have NHS-innovator partnerships worked and why?

Each Test Bed has approached these questions differently and the techniques being used include a randomised control trial, matched control studies, observational studies, feasibility studies and soft system methods.

Eventually, we hope to have a view of the value of each innovation to the NHS. This will be accompanied by an understanding of the conditions that have produced particular outcomes and why, and a better sense of what type of evaluation approaches best suit different types of interventions.

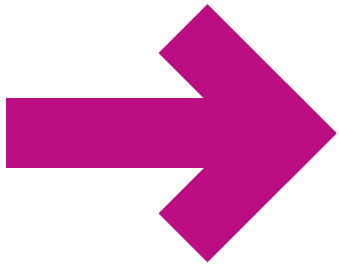
2.5 Spreading innovations that work:

Our spread workstream, delivered in partnership with the AHSN's is developing tools to support the spread of Test Bed innovations to the wider NHS. This involves assisting Test Beds to describe what their solutions are, creating product specifications and developing detailed business cases.

Engagement plans are also important and more than half of the Test Beds have already forged strong links with their local commissioners, Sustainability and Transformation Partnerships and Accountable Care System leaders.

Finally, we have been working with partners in NHS England, DH and OLS to understand what national enablers are required to facilitate the procurement and uptake of proven innovations.

3. The seven Test Beds



Test Beds at a glance

1 Lancashire and Cumbria Innovation Alliance

Improving support for those over 55 with Chronic Obstructive Pulmonary Disease, heart failure and dementia. Integrating technologies and linking them to new care models supporting self-care at home.

Participants **1,600**

Innovators **8**

2 Long Term Conditions Early Intervention Programme

Promoting early intervention to reduce the burden of ill-health by developing a predictive algorithm, redesigning pathways, and training health professionals.

Participants **214,700**

Innovators **2**

3 Diabetes Digital Coach

Providing people with type one and type two diabetes with a selection of integrated 'Internet of Things' digital tools to manage their condition.

Participants **1,000s**

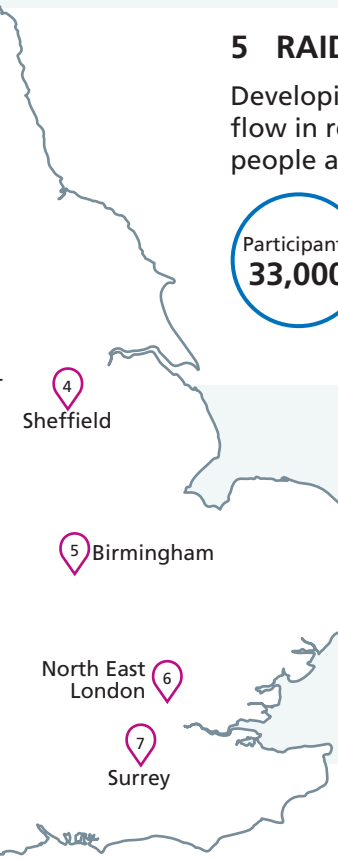
Innovators **8**

4 Perfect Patient Pathway

Improving pathways for asthma, diabetes, falls and frailty by increasing access to technology and facilitating information sharing.

Participants **1,300**

Innovators **7**



5 RAIDPlus

Developing a demand and capacity tool that shows patient flow in real-time and a predictive algorithm to identify when people are going to experience a mental health crisis.

Participants **33,000**

Innovators **2**

6 Care City

Testing a combination of digital devices and software alongside new approaches to service delivery and patient participation.

Participants **4,100**

Innovators **6**

7 Technology Integrated Health Management

Providing people with dementia and their carers with: wearables, monitors and other devices which will combine into an 'Internet of Things' to monitor their health at home.

Participants **1,400**

Innovators **7**

Lancashire and Cumbria Innovation Alliance

Challenge:

This Test Bed is situated across costal and rural areas, covering a population of 1.4 million across 3,800 square miles. There are around 28,000 people living with multiple long-term conditions who often need to visit a GP, attend a hospital appointment or have social care needs; these can be time consuming, costly and difficult for a dispersed population.

Solution:

The Test Bed is working in partnership with the Fylde Coast and Better Care Together Vanguards. Using a population health approach they segment their population's needs and identify those at risk of hospital admission. Through digital technology they are supporting those over 55, with long-term conditions such as Chronic Obstructive Pulmonary Disease (COPD), heart failure, diabetes, or mild-to-moderate demetia, to self-manage at home using connected technologies including: sensors, wearables and monitoring devices that track vital signs.

Interim data indicates that the average age of participants in this project is around 70, challenging assumptions that the frail elderly are not confident technology users.

In partnership with:

Long term conditions early intervention programme

Challenge:

21% of Greater Manchester's population are living with at least two long-term conditions; accounting for about 50% of GP appointments, 60% of outpatient appointments and 70% of inpatient bed days. The focus of this Test Bed is to digitally support those with COPD, heart failure and type two diabetes and in doing so avoid unnecessary appointments.

Solution:

This Test Bed is using a risk stratification tool to identify individuals at risk of developing a long-term condition and provide them with a telehealth solution that remotely monitors their vital signs. This gives round-the-clock clinical support including in the case of deterioration. The risk stratification tool will be enhanced by a predictive algorithm – currently being developed – which will identify someone at risk of developing a condition, such as heart failure, before it happens. This shifts clinical conversations from treatment to monitoring and prevention.

This Test Bed is also testing an education platform that can upskill primary care teams to tackle similar patterns of patient presentation; reducing variation and increasing basic knowledge around the three high priority long-term conditions.

In partnership with:

NHS Heywood, Middleton and Rochdale Clinical Commissioning Group

MSD INVENTING FOR LIFE

verily

Health Innovation Manchester

GMCA GREATER MANCHESTER COMBINED AUTHORITY

NHS in Greater Manchester

Diabetes Digital Coach

Challenge:

Diabetes UK estimates that this condition and its complications cost the NHS around £10 billion a year. Those in the West of England with type one, and type two diabetes, have been managing and monitoring their condition through traditional interactions with healthcare professionals. This can be time consuming and may not encourage behaviour change.

Solution:

Diabetes Digital Coach brings together five digital tools into one integrated platform available through a computer, smartphone or tablet. The tool supports an individual to self-manage through its interactions. As an Internet of Things Test Bed, the data from these tools is brought together in a single dashboard to provide clearer information to users. This platform and the data dashboard are being tested and developed with around 70 people with diabetes, two of whom have a day to day role in the project's governance.

The tool will provide support around health and wellbeing, structured education, dietary support, insulin management and information about how to optimise physical activity.

In partnership with:

West of England Academic Health Science Network · DXC.technology · HEOR · iotUK · mapmyhealth · OVIVA · Routcomes · rescon · CORSHAM INSTITUTE

Perfect Patient Pathway

Challenge:

In Sheffield, 7 in 100 people suffer from three or more long-term conditions including asthma, diabetes and COPD that have a debilitating impact on their lives.

Solution:

Working with patients, this Test Bed is testing four new pathways that support digital self-management. Fitting the technology into the right juncture of a patient pathway is crucial and this project works closely with clinical teams to identify where the technology might create most value.

The digital care home project is one example of this philosophy. Around 2,900 people reside in care homes in Sheffield. In 2016/17 these care home residents attended Accident & Emergency (A & E) 3,000 times and 40% were subsequently admitted to a frailty unit. The Test Bed is testing a new way of working in which staff record residents' vital signs directly onto an app as they complete routine rounds. This information is sent to a care coordination centre where it is reviewed; if alerts are flagged, escalation to the appropriate clinical responder occurs. Routine information is fed through to clinical records; in time developing a more accurate clinical picture for each resident. The hypothesis is that this will result in better condition management in the care home setting; avoiding unnecessary A & E visits.

In partnership with:

RAIDPlus

Challenge:

Every year, around 25,000 people access mental health urgent care services across Birmingham and Solihull. Feedback from staff, service users and their families suggests that crisis access points remain disconnected and difficult. This leads to multiple assessments, increased pressure at the acute end of the pathway, confusion and frustration for patients and their families.

Solution:

The RAIDPlus Test Bed is addressing this by developing and testing two new components: (1) a demand and capacity dashboard to capture real-time data on patient flow and optimise bed and staff availability and (2) the exploration of a predictive algorithm, using different data sources, to identify patients who are at greatest risk of experiencing a mental health crisis.

The aim is that this operational and predictive intelligence will enhance and integrate existing services, resulting in 'smarter triage' which proactively directs people to services most appropriate to their needs straight away.

In partnership with:

NHS Birmingham and Solihull Mental Health NHS Foundation Trust

NHS Birmingham Community Healthcare NHS Foundation Trust

NHS Midlands and Lancashire Commissioning Support Unit

NHS West Midlands Ambulance Service NHS Foundation Trust

west midlands Academic Health Science Network

West Midlands Police

Care City

Challenge:

Across the four London boroughs of Barking and Dagenham, Havering, Redbridge and Waltham Forest, there are approximately 69,000 people living with multiple long-term conditions. In addition, 21,000 people provide unpaid care for 50+ hours a week. This complexity poses challenges to an already fragmented health and care system.

Solution:

By combining digital devices with different ways of working, Care City is testing: (1) a one-stop shop for patients with signs of atrial fibrillation (2) home monitoring to support earlier discharge of patients from hospital and smarter care package planning and (3) use of a gait analysis tool to create personalised exercise programmes to reduce risk of falls.

The aim is to join up the care people receive and promote healthy and independent ageing. The first step for this Test Bed was to test individual technologies in existing clinical pathways. The results of this 'rapid testing' explored product suitability, user-friendliness and value for money. Subsequently clinical pathways were redesigned to incorporate products in the best way and remove redundant working patterns.

In partnership with:

AliveCor, UCLPartners Academic Health Science Partnership, HealthUnlocked, Join dementia research, Canary, St Bernard Location Service, Kinesis Health Technologies, GaitSmart Mobility is Life

Technology Integrated Health Management

Challenge:

Predictions show that by 2020, 19,000 people in Surrey will be living with dementia. With over 850,000 dementia suffers in the United Kingdom and costing £26 billion annually, dementia is one of the main causes of disability in later life. Dementia patients rely on their carers to support their day-to-day living.

Solution:

This Test Bed aims to improve the lives of people with dementia and their carers by using 'Internet of Things' technology – a network of connected devices – to provide real-time information about their daily activities.

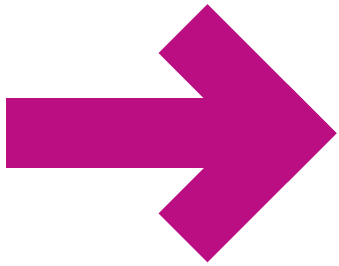
The 'Internet of Things' includes: GPS trackers, door and electricity monitors, motion sensors, vital sign readers and an avatar.

If data identifies a significant deviation, a healthcare professional is immediately alerted. They decide what type of support the individual needs. This may be a call to their carer; a GP appointment; a home visit from the Alzheimer's Society Dementia Navigator or, if necessary, contacting the emergency services. The hypothesis is that this will reduce unplanned hospital admission and delay or postpone the need for nursing home care and relieve stress on carers.

In partnership with:

arqiva · Vision360 · Docobo™ towards a better quality of life · University of Surrey · iot UK · Kent Surrey Sussex Academic Health Science Network · Royal Holloway University of London · Safe Patient Systems · SENSELY how are you feeling today? · Intelesant · Alzheimer's Society Uniting Against Dementia · yecco

4. What is changing?



4. What is changing?

For people living with long term conditions, this programme has brought streamlined access to new digital products which allows increased self-management and independent living. Strong patient participation is crucial to successful testing.

Neera, 21 years old - Care City

Neera was at her local pharmacy when she mentioned odd heart palpitations. Despite Neera's young age, the pharmacist offered her a digital test. In 30 seconds results showed that she had indications of atrial fibrillation. Once at hospital this was confirmed and she was prescribed treatment. Neera is now on medication and managing her heart condition.

June, 74 years old - Technology Integrated Health Management (TIHM)

June suffers from Lewy Body dementia and is cared for by her husband, Phil. Before TIHM, they were visiting A&E around once a month. Now they can monitor June's vital signs at home, and are alerted if needed. June and Phil have only been back to A&E once since January 2017 and feel more confident.

Pat, 68 years old - Lancashire and Cumbria Innovation Alliance

Pat has a long-term lung condition which she has been managing through regular trips to her GP and medication. As part of the Test Bed programme, she is able to take her own readings for the first time. This has given her more time to enjoy her life, made her feel more assured and given her a greater sense of ownership over her condition.

For healthcare professionals and teams involved in the programme it is changing ways of working and enriching dialogue with patients. Being part of the Test Beds programme has given them the opportunity to feedback insights to innovators and therefore refine products and clinical pathways throughout testing.

General practitioner

Healthcare professionals are excited and interested in the potential of the technologies they are testing. Being able to prevent patients from reaching crisis points, and having more informed discussions with patients about their conditions is a great benefit of the programme so far.

Occupational Therapist

Protocols and ways of working in current patient pathways are changing with the use of digital technology. An important aspect of the Test Beds programme is that professionals who work in these pathways are leading and suggesting the clinical changes required.

Consultant

Implementing technology in current pathways has taken longer than expected, which has been frustrating. However, the increased confidence, wellbeing and improved quality of life that patients in the programme are already reporting is reassuring for healthcare professionals.

For Innovators it is opportunity to test innovations in the real-world; build relationships and develop an understanding of the NHS whilst delivering real change for patients. At times, pace has been slow but testing is now fully underway. Capturing and disseminating the lessons from these partnerships are an essential step to improve future collaborations.

Micro enterprise (less than 10 employees)

Gaining entry into the NHS, with the added value of a robust evaluation was the selling point of the programme for us. In future, greater collaboration at the start of the programme would make the testing phase easier.

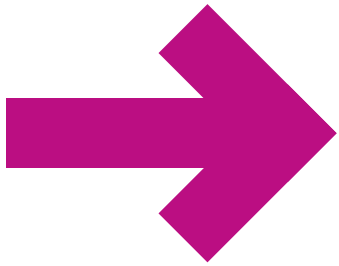
Small business (10 - 49 employees)

This experience is helpful to develop products and prepare for international markets. It is also helping to raise our profile. Getting to implementation has been slow with a few changes in scope and this is hard to manage for a small company, but now, as things are in full swing, it's exciting.

Medium to large company (50+ employees)

We are keen to build links with peers and engage with commissioners and providers of services early on - this is a helpful sense check for product scope and development. The current phase - testing - is exciting and we want to harness the goodwill generated in the health economy.

5. What is next?



Conclusion

The current Test Beds programme will come to an end in summer 2018 with a final report published in the autumn. This will synthesise findings from across the seven Test Beds and highlight successful combinatorial innovations. It will also identify lessons learned from the collaborations to inform future public-private partnerships aiming to deliver innovative change at scale. This information will include: principles for collaborating with industry; considerations around information governance; and advice for commissioning an evaluation for this type of work.

We will also support the Test Beds that have successful innovations to spread them more widely so that others can benefit from improved outcomes at the same or less cost.

This report is intended to give the reader an understanding of the programme and the current work underway across the seven Test Beds. We do not wish to predict impact or over promise but simply signal where we are and what has been learnt so far.

Many digital technologies have the potential to transform health and care but robust evidence is needed to support the deployment and spread this into the real-world. The Test Beds programme is one of the few programmes attempting to generate this type of insight.

If a reflection or Test Bed in this document has sparked your interest, or you want to follow up on references, do get in touch with us by e-mail: england.testbeds@nhs.net.

Acknowledgements

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The two 'Internet of Things Test Beds' – Technology Integrated Health Management and Diabetes Digital Coach – are part of the IoT UK programme delivered by of the Department of Culture Media and Sport and managed via Innovate UK.

Many thanks to the NHS and industry partnerships in the programme; and the Academic Health Science Network for their ongoing commitment and support.

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In association with:

NHS England

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Department of Health

Department for Culture Media & Sport