

Institution: University of Strathclyde		
Unit of Assessment: B11 Computer Science and Informatics		
Title of case study: Understanding and removing barriers to the wider adoption and implementation of digital health and care technologies		
Period when the underpinning research was undertaken: 2014 – 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Marilyn Lennon	Reader	01/04/2014 – present
Roma Maguire	Professor	01/03/2017 – present
Lisa McCann	Senior Lecturer	01/03/2017 – present
Period when the claimed impact occurred: 2014 – December 2020		
Is this case study continued from a case study submitted in 2014? No		
<p>1. Summary of the impact</p> <p>Research into the social, technological, and organisational barriers and facilitators to the adoption of digital health has led to practical applications in health and care practice throughout Scotland. Recommendations stemming from this research were adopted by the Scottish Government to directly inform Scotland's Digital Health and Care Strategy. As a result of the evaluation methodology developed by the Strathclyde researchers, NHS Scotland now have quicker and easier ways to evidence and procure novel technologies, businesses have faster routes into the care market, and patients have a greater choice of technology for improving their quality of care. This research has directly supported the roll-out of two new diagnostic and screening technologies, and has furthered the expansion of the digital health industry.</p>		
<p>2. Underpinning research</p> <p>Context</p> <p>The adoption of digital health (the use of digital technologies to improve any aspect of health or care) is frequently cited as key to alleviating the growing financial and economic burden on health and social care systems. However, the uptake of health technology by health and social care systems internationally has been slow. Reasons include: a complex multisectoral market; concerns about data governance and security; and, crucially, a continued reliance on time-consuming randomised controlled trials and isolated technology pilots, which often fail to produce the necessary evidence to stimulate wider adoption. In response to this, in recent years there have been increasing calls for alternatives to these trials that can gather evidence on the functionality and workability of new digital technologies in real-world settings and provide service blueprints on how to make them work in practice at scale in multiple contexts.</p> <p>Key Research Findings</p> <p>Using human-computer interaction (HCI) research methods, Lennon, McCann and Maguire of the Digital Health and Wellness Group (DHaWG) developed agile evaluation frameworks to help monitor and assess real world digital health deployments of new technologies as they are implemented in the NHS and other care settings. These frameworks were informed by interviews, action research (observation) and process mapping, with the qualitative findings systematically mapped onto new and existing theoretical and conceptual frameworks to inform future research. In this way, the traditional model of HCI research was extended to include implementation science, resulting in a much more useful framework to explore digital health implementation in practice. DHaWG's evaluation frameworks have been used to assess three large-scale, nationally significant digital health implementation programmes. Embedded within 'Test of Change' processes, these projects involved collaborative partnerships with an NHS board, academic partners, commercial partners and an innovation centre, Scotland's Digital Health and Care Institute (DHI).</p> <p><i>Delivering Assisted Living Lifestyles at Scale (dallas) (2012-2015)</i></p> <p>The dallas project was the largest global evaluation of readiness to implement digital health at scale, and the largest mainstream deployment of technology-supported services in Europe, with over 30 digital care services deployed and tested in the UK. Led by the University of Glasgow, the</p>		

evaluation and dissemination was transferred to the University of Strathclyde with Lennon when she joined in April 2014. Due to existing recognised expertise in both HCI research and Digital Health Evaluation, Lennon led on the capture of real live process evaluation data (usability, acceptability, and feasibility of new products and services) across multiple sites, products and stakeholders throughout the project lifetime. This involved developing a novel, real-time evaluation framework, which allowed the capture and mapping of people, technology, organisations and systems involved in digital health implementation [R1]. This evaluation revealed (i) the need to invest in digitally upskilling the health and care workforce; (ii) a call for guidance to support the consumer health market and alter legacy procurement models in the NHS to promote open innovation; (iii) the need to move away from traditional controlled studies of efficacy to adopt more agile, flexible evaluation frameworks that focus on feasibility, readiness to implement, and innovative health service pathways [R2]. Key implementation lessons stemming from dallas were identified to promote the uptake of digital health, with a focus on flexibility, adaptability and resilience as key implementation facilitators [R3,R4].

National Atrial Fibrillation Programme (2018-2020)

The National Atrial Fibrillation Programme aim to use a new continuous monitoring service, the Bardy Carnation Ambulatory Monitor, to diagnose atrial fibrillation (AF) in secondary care at a much faster rate than the current standard. The tool is a wearable strip that monitors a patient's heartbeat over the course of 14 days while they go about their normal routine, thereby avoiding the need for patients to undergo hospital observation. Lennon and McCann conducted a process service evaluation of the entire programme within a deployment of this device in NHS Lanarkshire (64 patients), provided criteria for selection of the monitoring device, interviewed patients and clinicians to measure readiness to adopt, and generated evidence for Scottish Government and health boards on how to roll the programme out across Scotland [R5].

ScotCap (2018-2020)

ScotCap is a new NHS Scotland service intended to replace or complement existing colonoscopy services with a video capsule that, once swallowed by the patient, films its progress through the body and sends the information to the relevant healthcare service via the cloud. Lennon and Maguire used longitudinal qualitative methods to: capture the barriers and facilitators to acceptance and adoption of this novel screening programme as it was trialled in 800 patients in three NHS health boards in the north of Scotland; and generate evidence for health boards and Scottish Government on how to roll the programme out nationally [R6].

3. References to the research (Strathclyde affiliated authors in **bold**; FWCI at 02/02/2021)

- R1 McGee-Lennon, M., Bouamrane, M. M.,** Grieve, E., O'Donnell, C. A., O'Connor, S., Agbakoba, R., Devlin, A. M., Barry, S., Bikker, A., Finch, T. & Mair, F. S. (2017). A flexible toolkit for evaluating person-centred digital health and wellness at scale. In *Advances in Human Factors and Ergonomics in Healthcare* (pp. 105-118). Springer, Cham. Available from: <https://bit.ly/2Lef1Qw> [FWCI: 1.67; REF2]
- R2 Somers, C., Grieve, E., Lennon, M., Bouamrane, M. M.,** Mair, F., & McIntosh, E. (2019). Valuing mobile health: an open-ended contingent valuation survey of a national digital health program. *JMIR mHealth and uHealth*, 7(1). <https://doi.org/10.2196/mhealth.9990>
- R3 Lennon, M., Bouamrane, M. M.,** Devlin, A. M., O'Connor, S., O'Donnell, C., Chetty, U., Agbakoba, R., Bikker, A., Grieve, E., Finch, T., Watson, N., Wyke, S. & Mair, F. S. (2017). Readiness for delivering digital health at scale: lessons from a longitudinal qualitative evaluation of a national digital health innovation program in the United Kingdom. *Journal of Medical Internet Research*, 19(2). <https://doi.org/10.2196/jmir.6900> [FWCI: 3.24]
- R4 Devlin, A. M., McGee-Lennon, M.,** O'Donnell, C. A., **Bouamrane, M. M.,** Agbakoba, R., O'Connor, S., Grieve, E., Finch, T., Wyke, S., Watson, N., Browne, S., & Mair, F. S. (2015). Delivering digital health and well-being at scale: lessons learned during the implementation of the dallas program in the United Kingdom. *Journal of the American Medical Informatics Association*, 23(1), 48-59. <https://doi.org/10.1093/jamia/ocv097> [FWCI: 2.72; REF2]
- R5 Lennon, M., McCann, L., Horan, S., Kyfonidia, B., Munford, R.,** Bruce, A., Neubeck, L., Barber, M., Brennan, K., & Mooney, P. (2020) Process Evaluation for Technology Enabled Atrial Fibrillation Screening after a Stroke in Scotland. [Report] <https://doi.org/10.17868/72214>

R6 Lennon, M., Macguire, R., Horan, S., Kyfonidis, B., Munford, R., & Jamieson, M. (2020). Process Evaluation of a New Technology Enabled Colon Capsule Endoscopy (CEE) Service in North of Scotland. [Report] <https://bit.ly/2YBSy2N>

Notes on the quality of research: R1-R4 were peer-reviewed ahead of publication. R5 and R6 are reports prepared for the DHI, which is a collaboration between the University of Strathclyde and the Glasgow School of Art and is part of the Scottish Funding Council's Innovation Centre Programme. The DHI is also part-funded by the Scottish Government, and supports innovation between academia, the public and third sectors, and businesses in the area of health and care. The body of underpinning research described has been supported by over GBP800,000 of peer-reviewed funding, including:

- Lennon (CI and lead on evaluation), dallas - Delivering Assisted Living At Scale, Innovate UK, GBP37,000,000 (GBP500,000 for evaluation component), June 2012-June 2015.
- Lennon (PI), ScotCap and AF National Evaluation Programme, Scottish Funding Council and Digital Health and Care Institute, GBP330,000, Jan 2018-March 2020.

4. Details of the impact

The Test of Change approach used by DHaWG in the three programmes discussed (dallas, ScotCap and the National Atrial Fibrillation Programme) ensured that implementation and evaluation were embedded throughout the programmes, from procurement through to implementation, and that evidence was generated to support the adoption of new digital health services within the local context. Real life and real time experiences with patients and clinicians were also captured in order to provide usable insights for others to inform their adoption of services within different clinical sites and contexts. By doing so, Lennon, McCann and Macguire's research has:

- **Informed healthcare policy** by raising awareness of digital health and real-world evaluation in policy debate, and through direct advice to the Scottish Government;
- **Influenced the delivery of healthcare practice and services**, leading to an improved patient experience;
- **Informed expansion of the digital health industry**, by increasing visibility and supplying evidence for deployment business cases.

Informing healthcare policy

The dallas programme reached over 169,000 consumers, businesses, patients and healthcare professionals during its three-year lifespan, and has been repeatedly cited as having significantly raised national awareness of both digital health and real-world evaluation methods throughout the UK [S1-S3, S6, S7]. Director of Innovation and Deputy Chief Executive of the Digital Health and Care Institute (DHI) confirms that dallas '*engaged and inspired others by providing a large scale working example of "how to do innovation in a complex environment"*' [S2]. As a result, the findings of the project, in particular the recommendations stemming from it [e.g. R3], Lennon was invited to present the key findings to the Scottish Government's Digital Health and Care Strategic Oversight Group and lead a workshop on how dallas might inform the key strategic priorities for the Scottish Government's Digital Health and Care Strategy [S3]. Head of eHealth Strategy and Policy for the Scottish Government highlighted how '*these recommendations resonate with the Scottish Government's direction in this area and the workshop and presentation given by Dr Lennon were extremely timely in helping to ensure that Scotland continue to be among the global leaders in the future of digital health and care*' [S3]. R3 was also cited by the Scottish Government in 2018 in two national policy documents on the future strategy for digital health and care delivery in Scotland; for example, the research was used in the Technology Enabled Care: Data Review and Evaluation Options Study (2018) to highlight issues related to implementation of digital health platforms, including '*disempowerment felt by health staff, inequalities of access because of different levels of digital/IT skills, and fears around data safety, especially where platforms are run by non-NHS bodies*' [S4]. Continuing this engagement, Lennon was invited to present these recommendations to the Scottish Government's Digital Health and Care Strategy Advisory Board in 2018, and these recommendations have since been used to directly inform Scotland's Digital Health and Care Strategy [S5].

Influencing the delivery of healthcare practice and services

The evaluation methods developed in the underpinning research have provided the NHS Scotland and other healthcare providers with quicker and easier ways to evidence and procure new digital health technologies. Indeed, the work of DHaWG in documenting and evaluating examples of digital health innovation in complex environments has been acknowledged as contributing significantly to increased digital innovation in Scottish healthcare over the past five years [S2,S6]. As the Director of Innovation and Deputy Chief Executive of DHI confirms, the dallas programme *'influenced the integration of design-led innovation and citizen engagement as fundamental components of health and care service redesign in Scotland'* [S2]. Components of this have also been adopted by regions in Spain, the Netherlands and Norway as part of their service transformation agenda [S1].

DHaWG's report on the National Atrial Fibrillation (AF) Programme [R5] was used by NHS Lanarkshire and the Scottish Government to assess how AF screening devices can be scaled nationally to improve AF screening and reduce the number of strokes. As highlighted by the CEO of DHI, funder on the Programme:

'[Lennon and McCann]'s engagement with NHS Lanarkshire in support of the service redesign in the detection of atrial fibrillation was a key factor in business case development to improve national screening service using digital technologies. This will improve the patient experience, reduce demands on in-patient beds and, in the medium to long term, improve outcomes for patients by reducing the risk of profound disability or death through stroke' [S1].

Likewise, the DHaWG evaluation conducted for the ScotCap programme [R6] formed the foundation for a business case on colon capsule endoscopy (CCE) and enabled the industry partners to improve patient experience by responding to feedback in the evaluation to enhance the comfort and wearability of the recording device and belt worn to transmit images from the capsule [S7]. CorporateHealth International, a Danish Company and partner in the ScotCap project whose specialists provide readings of images from the video capsule, confirms that: *'The service evaluation phase of ScotCap created the foundation for the roll-out of CCE in Scotland'* [S8]. By December 2020, ScotCap had been launched in NHS Highlands & Islands, Greater Glasgow and Clyde, and Tayside (comprising 35% of the Scottish population) [S1,S7,S8]. By reducing the need for in-hospital colonoscopies across Scotland, use of ScotCap significantly reduces waiting times for bowel cancer screenings [S7]. Speaking in media coverage at the time, Chief of Medicine for NHS Greater Glasgow and Clyde stated: *'This exciting development will help cut waiting times and will mean that many patients will avoid the need for more invasive tests'* [S9]. Similarly, the NHS Lanarkshire Associate Medical Director summarised the benefits of the new service: *'It enables us to conveniently explore the entire colon and can help us to detect or exclude cancer more quickly, as well as reducing the waiting time for colonoscopies'* [S9]. This impact has even more significance since the COVID-19 pandemic in Scotland, which has led to widespread delays to health and care practices and the need for telemedicine has become more apparent, as the Managing Director for CorporateHealth International highlights:

'Even though the pandemic complicated the administrative side of the roll-out, the shortfalls of traditional methods have been broadly exposed. To efficiently diagnose patient for GI symptoms, we expect that 5000-10,000 patients will be using the managed service in the next 9 months. Cancers that would have stayed hidden until the waiting list had been cleared will have been detected' [S8].

A collaborating partner from NHS Highlands confirms that, as a result of DHaWG's evaluative work, *'new service models are being adopted... and patients have a greater choice of technology for improving their quality of care'* [S7].

Informing expansion of the digital health industry

For small to medium-sized digital health enterprises, participation in these three digital health implementation programmes has increased their visibility among potential healthcare clients and other clients, and established connections which have led to commercial growth for industry partners [S6]. As the CEO of DHI makes clear:

'DHaWG are working with DHI and procurement teams in the Scottish Government, NHS National Services Scotland and the enterprise umbrella organisation Connected Scotland to allow Scotland to 'procure innovation'. Strathclyde are helping pioneer this 'Innovation Partnership' approach, allowing a competitive R&D process to result in the setting up of a procurement framework, meaning those businesses contributing to innovation have a clearer route to large-scale deployment of digital health technologies' [S1].

This acknowledgment is echoed by CorporateHealth International, who described their Innovation Partnership as *'pivotal': 'the group from DHI and Strathclyde provided scientifically sound patient and service insights. This together provided the evidence needed to convince stakeholders from all functions in healthcare, government, academia, and industry to move forward with the roll-out' [S8].* As a result, businesses are now realising faster routes into the care market [S7].

As an example of this, Sitekit Ltd, a Scottish small and medium-sized enterprise (SME), collaborated with Lennon on the dallas programme, during which time Lennon's research evaluated barriers and facilitators to the adoption of digital personal health records, which was one of Sitekit's core interests [S10]. This provided Sitekit with the necessary know-how to identify commercial opportunities in the emerging Digital Identity market and ultimately set up a new business division within Sitekit for this purpose. Sitekit has since launched the eRedbook, a digital record of a child's growth charts, vaccination data and other NHS health records, which was launched in Liverpool in 2014 and in London in 2017. By late 2020, an estimated 30,000 children had held an eRedbook account [S10]. In 2019, Sitekit became a development partner in the development of the 'Share2Care' Local Health and Care Records (LHCR), a collaborative programme in North West England NHS and Local Authorities, which sees health and care records shared electronically between health and care providers. Currently there are 11 NHS organisations and 9 Local Authorities using the Share2Care LHCR [S10]. In 2020, Sitekit became the prime contractor for the NHS Covid-19 Digital Staff Passport, which enables NHS staff to move more safely and efficiently between NHS organisations to support the COVID-19 response and is used by 67 organisations in NHS England [S10]. Through the development and delivery of digital identity services, Sitekit has grown from 21 employees in 2014 to 72 employees in 2019 and has increased in turnover from GBP1,564,636 in 2014 to GBP8,413,604 in 2019 [S10]. It has delivered digital identity services for NHS, National, Regional and Local Government and the private sector, and in 2019/20, Sitekit's digital identity division was contracted by a major multi-national client in the finance sector to build the prototype of a global-scale digital identity service, which is currently in pilot in Australia [S10].

5. Sources to corroborate the impact

- S1** Corroborating statement from Chief Executive Officer, DHI, dated 17 March 2021.
- S2** Corroborating statement from Director of Innovation and Deputy Chief Executive, DHI, dated 24 January 2019.
- S3** Corroborating statement from Head of eHealth Strategy and Policy, Health Performance and Delivery Directorate, Scottish Government, dated 30 May 2017.
- S4** Scottish Government. *Technology Enabled Care: Data Review and Evaluation Options Study. Summary Report.* May 2018. <https://bit.ly/30BNsVh>
- S5** Scottish Government. *Scotland's Digital Health & Care Strategy: Enabling, Connecting & Empowering.* April 2018. <https://bit.ly/3bGQX37>
- S6** Corroborating statement from UKRI Challenge Director: Audience of the Future & Creative Industries Clusters Programme, dated 1 February 2019.
- S7** Corroborating statement from Research, Development and Innovation Director, NHS Highland, dated 25 February 2021.
- S8** Corroborating statement from Managing Director, CorporateHealth International, dated 23 January 2021.
- S9** Deadline. *New camera technology launched could improve bowel cancer treatment.* 17 December 2020. <https://bit.ly/3eyIT6m>
- S10** Corroborating statement from Chief Executive Officer, Sitekit Ltd, dated 17 March 2021.