

Innovating for improved healthcare: Sociotechnical and innovation systems perspectives and lessons from the NHS

Sonja Marjanovic,^{1,*} Marlene Altenhofer ,¹ Lucy Hocking,¹ Joanna Chataway ² and Tom Ling ¹

¹RAND Europe, Westbrook Centre, Milton Road, Cambridge, CB4 1YG, UK and ²Department of Science, Technology, Engineering and Public Policy, University College London, Euston House (8th Floor), 24 Eversholt Street, London, NW1 1BS, UK

*Corresponding author. E-mail: smarjano@rand.org

Abstract

Healthcare systems with limited resources face rising demand pressures. Healthcare decision-makers increasingly recognise the potential of innovation to help respond to this challenge and to support high-quality care. However, comprehensive and actionable evidence on how to realise this potential is lacking. We adopt sociotechnical systems and innovation systems theoretical perspectives to examine conditions that can support and sustain innovating healthcare systems. We use primary data focussing on England (with 670 contributions over time) and triangulate findings against globally-relevant literature. We discuss the complexity of factors influencing an innovating healthcare system's ability to support the development and uptake of innovations and share practical learning about changes in policy, culture, and behaviour that could support system improvement. Three themes are examined in detail: skills, capabilities, and leadership; motivations and accountabilities; and collaboration and coordination. We also contribute to advancing applications of sociotechnical systems thinking to major societal transformation challenges.

Key words: innovation; healthcare; health; improvement; policy; sociotechnical; systems; NHS

1. Innovating in healthcare: the need for a systems perspective and for solutions-focused research

Publicly-financed healthcare systems around the world face increasing pressures to deliver high-quality care with limited resources (de la Maisonneuve and Oliveira Martins 2014; Ward and Chijoko 2018). The pressures are accentuated by ageing populations, growing burdens of chronic diseases and comorbidities, and related changes in the nature of demand as well as drives towards more personalised treatment provision, all of which pose challenges to the sustainability of existing healthcare systems (Chataway et al. 2012; de la Maisonneuve and Oliveira Martins 2014; DG for Economic and Financial Affairs 2018). Initiatives to improve the quality, safety, and productivity of healthcare services, to invest in prevention and health-seeking behaviours, and to innovate in how services are delivered, are key parts of efforts to ensure a healthcare system that meets the needs of individual patients and of the wider population (Marjanovic et al. 2017; Deloitte 2019).

Healthcare decision-makers increasingly recognise the potential of innovation to help respond to the challenges they face and to support high quality, safe, and effective care (Department of Health 2018; Nolte 2018; NHS England n.d.). In this article, we are interested in better understanding the conditions that support and sustain innovating healthcare systems. For the purposes of this article, we define healthcare innovation as any product, technology or service that is new to the health system, or applied in a way that is new, and is aimed at delivering improved or more efficient healthcare. We do not assume that innovation is inherently and always beneficial, but have chosen to focus on cases where evidence suggests likely benefit.

Broadly speaking, healthcare innovation and innovating healthcare systems have as their core goal either improved health outcomes or improved economic outcomes, or both. These goals may have different weight in the motivations of different individuals, organisations, and stakeholders (patients and citizens, healthcare professionals, innovators in the public and private sectors, policy-makers, regulators, charities, the research community), and a mix of complementary and conflicting interests influence how health

innovation pathways and promising approaches unfold, in sometimes unpredictable ways (Plsek 2003).

In this article, we are specifically interested in the conditions that support and sustain innovating in the service of healthcare improvement goals. Researchers and policymakers recognise that even innovations with a rigorous and proven evidence base often fail to achieve uptake and spread (Marjanovic et al. 2017; NHS Digital 2017; Greenhalgh and Papoutsis 2019). In England, for example, the National Health Service (NHS) Innovation Scorecard captures data on the uptake of healthcare innovations and shows high variations in uptake of even those innovations that have a positive National Institute for Health and Care Excellence (NICE) technology appraisal and are recommended by NICE guidance. Whereas some variation in uptake may be warranted (e.g. given differing population needs), there is also much unwarranted variation. This is often related to challenges in the wider system supporting innovation—be they related to resource availability, incentives and accountabilities, information flows, workforce capacity and capabilities, or other factors (Marjanovic et al. 2017). Similarly, access to support for entrepreneurial activities is also patchy and variable across England (Marjanovic et al. 2017).

Historically, much of the health innovation literature has focused on innovation from an industrial strategy or economic competitiveness perspective (Malerba and Orsenigo 2002; Chataway et al. 2006; Schot and Steinmueller 2017). Overall, there is less comprehensive evidence on how to support innovating for the purpose of healthcare services improvement, with some notable exceptions (Greenhalgh et al. 2004; Albury et al. 2018; Cox et al. 2018; Collins 2018 Greenhalgh and Papoutsis 2019). In addition, most studies consider how innovation works and the challenges or enablers of innovation in an organisational context. There are few comprehensive studies that consider what needs to happen, across the system, to address bottlenecks in a systemic and sustainable manner (Albury et al. 2018; Cox et al. 2018). There is also a scarcity of studies that go beyond identifying what needs to happen at a relatively-abstract level, to identifying concrete actions that decision-makers can take. Our study addresses this gap and considers the entire healthcare innovation pathway—from issues affecting innovation development through to those implicated in uptake and diffusion through the healthcare system—with a view to identifying robust analytical conclusions alongside practical steps to improve the system.

The insights we draw stem mainly from primary data from England. However, we triangulate our findings against wider, globally-relevant scholarly and grey literature. We believe that the insights we have gained about the dynamics of innovating healthcare systems and the interdependencies at play are of wider relevance, for the UK and internationally.

2. The theoretical context: an innovation systems and sociotechnical systems perspective on healthcare innovation

It is widely accepted that achieving high-quality care requires the alignment of multiple stakeholders, organisations, and behaviours. It is harder, however, to pin down what this means in practice: that is what facets of an innovating healthcare system need to be in place, how different influencing factors can simultaneously be nurtured and coordinated to achieve desired outcomes, and how we understand the multiple processes needed to effect change.

To help explore these issues and to enable us to consider structural, behavioural, and cultural determinants of healthcare innovation trajectories, our study adopts a systems approach to understanding healthcare innovation, and builds mainly on innovation systems (Lundvall 1992; Nelson 1993; Freeman 2008) and sociotechnical systems thinking (Geels 2004, 2011; Geels and Schot 2007; Fuenschilding and Truffer 2014; Broerse and Grin 2017). We use theory as a sensitising device, helping us frame the questions of interest in our empirical enquiries and also helping us to interpret findings.

Although these perspectives emphasise different aspects of innovating systems (as we elaborate on below), both perspectives fundamentally conceptualise an innovating healthcare system as the process, experience, and result of the interactions between diverse institutions, individuals, organisations, networks, ideas, capabilities, values, and behaviours. These interactions are nested within evolving policy priorities (healthcare policy, innovation policy), changing social, political and economic environments, and dynamic healthcare systems.

Innovation *systems* thinking emerged during the 1970s and 1980s, when increased economic pressures and international competition began to expose the limitations of a previously prevailing linear ‘R&D leads to innovation’ school of thought, that could not capture the complexity of innovation processes nor account for unintended consequences such as detrimental effects of industrialisation on health and the environment or the uneven distribution of benefits and gains from medical innovation across geographies (Broerse and Grin 2017; Schot and Steinmueller 2017). It became increasingly recognised that research and innovation do not flow freely, that knowledge is sticky, tacit, and difficult to transfer, and that knowledge and innovation are bound in complex ways with the institutions that produce them (Nelson 1993; Von Hippel 1994). Organisational ability to absorb new knowledge, recombine it in useful ways and establish dynamic capabilities to adapt to changing environments (Cohen and Levinthal 1990; Teece, Pisano and Shuen 1997) emerged as important concepts, and with them the needs for capacity and capability-building.

The varying nature of technological progress in different contexts also came to be recognised and scholars began to highlight the importance of path-dependence and routines in innovation (David 1994; Dosi 1995)—essentially arguing that it is difficult to break established routines and practices, and that doing so takes more than knowledge and skills. To capture these complexities, scholars began to talk about an innovation ‘system’ (e.g. Lundvall 1992; Nelson 1993; Freeman 2008). The idea of a systems perspective on innovation (including healthcare innovation) suggests that innovations flourish (or not), not only because of the features of the innovation itself, but because of the interactions between the innovation, the team and individuals behind it, and wider relationships, structures, institutions, norms, values, policies, and regulations in the environment. In this perspective, the nature of the relationships between organisations and institutions in any ‘system’—be it national, regional, or sectoral—deeply impacts the rate and nature of research and innovation that occur. The innovation systems approach considers not only those who undertake research and innovation but also those in the institutions and organisations that frame demand for it. In this conceptualisation, the interaction between different actors in the system emerges as increasingly important.

Such a perspective is useful in furthering our understanding of the roles of organisational and institutional relationships and feedback loops in enabling translation and impact, and in its

consideration of the roles of learning and history. Although innovation systems thinking acknowledges potential for emergence and the need for adaptiveness, it also places emphasis on how change can be coordinated and to a degree orchestrated and stabilised through the design, governance, and management of the system by various actors and coordinated networks (Consoli and Mina 2009; Proksch et al. 2019).

While this perspective recognises feedback loops and scope for emergence across an innovation pathway, it does not necessarily capture the dynamics of change within a system. It is also critiqued for not giving enough weight and consideration to the way users shape innovation and the fulfilment of societal needs through innovation (Geels 2004). As Geels (2004) highlights: ‘Sometimes, the user side is taken for granted or narrowed down to a selection environment’ (Geels 2004: 898).

We, therefore, go beyond innovation systems thinking to draw upon sociotechnical theory and sociotechnical regimes thinking. The multilevel perspective on sociotechnical systems (Geels 2004) is more attuned to innovating systems as complex adaptive systems, and it considers the process and outcome of innovation to be a result of interdependent social and technical aspects of a complex system that are necessary to fulfil societal functions, in the context of both use and production (Berkhout et al. 2004; Geels 2004; Broerse and Grin 2017). The fulfilment of societal priorities is central to this approach and places more emphasis on the roles and perspectives of end-users and interest groups in influencing the direction of innovation. In the context of our research, this includes primarily NHS staff, patients, and the public (but also others on the demand side such as commissioners and policymakers). Sociotechnical systems thinking considers the production, distribution and use of technologies as interacting sub-functions of a system and is conducive to more explicitly examining the iterative and non-linear nature of innovation across the pathway—with the development, piloting, uptake and spread, and further modification and adaptation of an innovation, coevolving through time (Geels 2004, 2011; Geels and Schot 2007; Fuenfschilling and Truffer 2014).

In this perspective, a sociotechnical regime is the deeply-rooted structure of an existing system that propagates persistence and stability, through informal and formal rules and behaviours (and their underlying values and beliefs), routines, institutionalised practices, and infrastructures that coordinate activities and relationships in a sociotechnical system (Geels 2004, 2011; Geels and Schot 2007; Fuenfschilling and Truffer 2014). A regime is stabilised by strong alignment between social and technical aspects of a system, and can have different degrees of structuration over time (i.e. the rules can guide the behaviours of actors in the system to different degrees over time). Innovation often tends to be limited, incremental, and non-disruptive in established sociotechnical regimes.

However, the scale (and urgency) of the current challenge to the sustainability and performance of healthcare systems that we have outlined at the beginning of this article requires understanding how more radical change and transformation can happen, and how an innovating healthcare system and innovations within it can support system sustainability and public benefit.

In this vein, the literature on how niche disruptions in the landscape can serve to incubate innovations in practice, often involving *initially* small networks of individuals and organisations (Geels and Schot 2007; Schot and Steinmueller 2017), offers some promise. These niches are spaces protected from the established regime (through, e.g. strong new user preferences, new regulatory support, and funding) enabling more radical innovation and transformation

(Geels 2011). In general, the niches work to gradually transform existing regime structures if they are supported and then stabilised by evolving landscape forces (e.g. wider changes in culture, political environments, and the economy). With time, niche innovations can gather momentum, spread and become sustained, facilitated by factors such as learning and information exchange, cost-related or quality-related benefits, advocacy and changes in wider power dynamics, and relations in the external landscape that can create pressures on existing socio-technical regimes. Fuenfschilling and Truffer (2014: 773) discuss: ‘In simplified terms, it is assumed that (a) niche-innovations can increasingly create a sound institutional environment capable of competing with the established regime, (b) landscape developments put pressure on the regime and (c) as a consequence of these two developments, regimes may destabilize and give way to new socio-technical configurations’ (2014: 773).

3. Making sense of theory in a policy and practical context

In a global context, policies in the field of healthcare innovation have developed significantly. Bason (2018) argues that ‘public leaders around the world are demonstrating how a significantly more conscious and systematic approach to creating innovative solutions can effectively address some of our most pressing societal challenges’ (2018: 4). This is also true of the policy and healthcare system in England, where there has been a proliferation of policy initiatives that consider innovation in healthcare, often as part of wider healthcare quality improvement, health service sustainability or productivity agendas. Examples include the *Accelerated Access Review* (Accelerated Access Review 2016), the *NHS Long Term Plan* (NHS England 2019), the *Carter Review* (Lord Carter of Coles 2016), amongst others. Other policy developments, such as the *Life Sciences Industrial Strategy* (Bell 2017), look at healthcare innovation from an industrial strategy perspective.

The vision for innovation and its role in change set out in these policy developments may be bold and radically transformative in design (e.g. looking at the transformative potential role of artificial intelligence, genomics, personalised medicine, innovative integrated care models, and digital health). However, the complexity of socio-technical regimes in the healthcare system implies that transformation in practice is likely to be gradual and incremental, although the ultimate outcomes may be radically transformative with time. In highly-complex sociotechnical landscapes, change and transformation need to occur in a way that does not disproportionately destabilise and have unintended consequences on access to and continuity of safe and effective care. There is a tension between the perceived need for potentially-disruptive innovation and the aims to ensure patient safety and high-quality care with equitable access.

In this context, bringing together insights from innovation systems and socio-technical schools of thought helps in understanding how innovating healthcare systems can be established and nurtured (and our particular empirical focus is on the system in England). More specifically:

- Sociotechnical systems thinking sensitises us to think about how interactions between innovation niches, external landscape forces (e.g. political, socioeconomic, user-demand forces), and established sociotechnical regimes unfold in shaping change and transformation trajectories. In doing so, it puts emphasis on the ‘springboarding’ and stimulus role of niches. It also allows us to give prominence and explicit attention to end-users as central

and influential actors in shaping the innovating healthcare system landscape.

- An innovation systems perspective, in its emphasis on institutions and networks, routines, sticky, and tacit-knowledge, underscores how niche and local approaches can benefit from coordination and orchestration at national, regional, or sectoral levels and that the pace and direction of innovation can be influenced by the exchange of experience between interconnected niches. However, an innovation systems perspective also allows for the possibility that system-level change in established regimes can be driven and springboarded from the centre (i.e. at national levels), rather than only gradually driven through the experience and results of niche experiments. It sensitises us to the possibility of wide-scale change being designed and introduced into a system in a more ‘top-down’ fashion.

Innovations often lead to change where niche experiments gradually interact with the wider landscape to transform existing regimes. We see this in England, for example with various pilots and innovation test-bed initiatives introducing assisted living and self-management technologies for patients with long-term conditions and efforts to test artificial intelligence in screening (NHS England n.d.). It has also been the case with many innovations throughout history: for example, the gradual introduction of coronary angioplasty (Mason 2018) followed various pilot schemes and is now common practice. But the opposite, that is, change introduced through action at national levels (i.e. not through stimulus by niche experiments), can also occur. For example, huge external pressures (e.g. the scale of demand and user expectations, political, and economic pressures) can lead to policy decisions and changes in established sociotechnical regimes at a national level with only limited niche experimentation, testing or evaluation. One example is the change in national policy allowing the use of cannabis oil in some patient groups (NHS England 2018a) mainly due to public pressure. Another is recent ministerial-level support for the controversial roll-out of remote primary care video smartphone-based consultation services to deal with demand pressures on GP services and to extend patient choice (O’Dowd 2018).

Both innovation systems and sociotechnical systems perspectives enable us to focus on the pursuit of not only structural and funding-related but also behavioural and cultural interventions in policy-making and to consider the interactions and interdependencies between multiple stakeholders in an innovating healthcare system and multiple parts of the system. Understanding the interactions within and between innovation system and healthcare system structures and processes is imperative in identifying opportunities for impact on healthcare quality, safety, and cost-effectiveness. Moreover, awareness that these interactions may occur amidst shifting government priorities, socio-economic, political, and cultural contexts, and in evolving policy environments, is crucial. We thus attend to how many different social, structural, and behavioural forces influence the innovating healthcare system.

4. Methods

The research reported here was part of a three-year mixed-methods study focusing on three key research questions:

1. What key factors in the innovating healthcare system influence how innovation pathways unfold, and how do they do so?

2. How has the healthcare innovation system in England evolved in relation to the key influencing factors, and *which* stakeholders have *played key roles* and how?
3. In light of the first two questions, what practical changes to policy, culture, and behaviour can decision-makers consider to improve the support system for innovating in the service of healthcare?

The research received ethical approval from the Alliance Manchester Business School at the University of Manchester, where one of the study Principal Investigators is located, and HRA approval (IRAS 193979). More information on ethical considerations can be found in the [Supplementary Material](#). [Table 1](#) provides an overview of the methods used and how they relate to the study’s research questions.

Across this study, there were 670 contributions from a wide range of different stakeholders in the healthcare system in England ([Table 2](#)). Participants were identified from diverse sources including document and literature review, snowballing, discussions with the study working group and professional networks. We used theoretical sampling and considered expected saturation points. The aim was to capture and reflect on a variety of views of different stakeholders rather than quantify the perspectives or seek statistical representativeness ([Bowling 2002](#)). More detail can be found in the [Supplementary Material](#).

4.1 Workshops

We conducted six regional workshops with a total of 101 participants (9–26 per workshop) in four areas in England from March to June 2016 (round 1), and seven stakeholder-specific workshops with a total of seventy one participants (5–14 per workshop) in December 2017 and January 2018 (round 2). Workshops round 1 aimed to explore how innovating happens in practice in the healthcare system and to discuss the major issues affecting healthcare innovation. Insights from this round are reported in [Marjanovic et al. \(2017\)](#). Workshops round 2 aimed to discuss stakeholder experiences and perspectives in more depth and to inform practical, solutions-focused actions to respond to the challenges facing innovation in healthcare. Detailed notes produced based on workshop insights were analysed within and across stakeholder groups as well as within and across six drivers of innovation identified in the first phase of this study (see results section of this article for further detail). Insights were coded in terms of areas of action, and within them what needs to be done and how, with reference to which stakeholder groups the insights applied to.

4.2 Interviews

A total of 120 interviews were conducted between June and December 2016 (round 1), and an additional seventy-seven interviews between September 2017 and March 2018 (round 2). Interviews round 1 aimed to explore participants’ views and experiences of innovation in more depth than could be captured through workshops. Again, insights from round 1 are reported in-depth in [Marjanovic et al. \(2017\)](#) and drawn on to only a limited extent in this article, where quotes from this phase of the study are referenced by stakeholder group. Round 2 interviews were conducted with participants from stakeholder groups involved in the healthcare system in England ([Table 2](#)). With informed consent, all interviews (across rounds) were conducted by telephone and recorded; they followed a semi-structured interview protocol and were subsequently transcribed. Overall, the analysis of the interviews was thematic ([Braun](#)

Table 1. Methods overview.

Study method	Research question(s)
Workshops in four regions in England (round 1)	RQ1, RQ2
Stakeholder-specific workshops (round 2)	RQ1, RQ3
Semi-structured key informant interviews in four regions in England (round 1)	RQ1, RQ2
Semi-structured thematic interviews with different stakeholders in the health system in England (round 2)	RQ1, RQ3
Survey of stakeholders across the health system in England	RQ1, RQ3
Case vignettes of selected health innovations	RQ1, RQ3
A review of scholarly literature and policy-related documents	RQ1, RQ2, RQ3

and Clarke 2006). The study team developed an initial analysis template using NVivo 10 that followed the protocol questions, but also included space for emerging themes. The template was refined during the analysis process. Interview data were analysed within and across stakeholder groups (for both rounds 1 and 2). In this article, references to interviews that we report on include a stakeholder group-specific identifier (innovation and improvement networks: Networks_INT#; healthcare providers and those from clinical commissioning groups (CCG): ProviderCCG_INT#; charities and patient and public involvement and engagement (PPIE) organisations: CharityPPIE_INT#; private sector: Private_INT#; academics: Academics_INT#; policymakers: Policymaker_INT#).

4.3 Survey

We developed an online survey with six sections, each focusing on one of six drivers of an innovating healthcare system identified in earlier phases of the research (Marjanovic et al. 2017). Based on insights from the earlier phases, we presented survey participants with a list of initiatives and interventions to support the development and uptake of innovation that were identified as important during interviews and workshops round 1, and through a literature and policy document review, and asked them to select those initiatives/interventions that they felt most likely to have an impact on improving the innovation environment in the healthcare system. There were also offered the opportunity to share additional information about information sources on innovation that they access and examples of innovation initiatives, through some open-ended questions. In total 256 individuals responded to the survey (June and August 2017). The survey was analysed quantitatively using R and analysed qualitatively by developing analytical categories based on responses to open-ended questions.

4.4 Case vignettes

We developed fourteen case vignettes on different healthcare innovations, including high-tech tools, diagnostics, digital, and service innovations (Table 3), aiming to provide a mixture of innovation types. The case vignettes explored the enablers and barriers of innovation, from generation to adoption, and the variation in uptake. The case vignettes were developed through semi-structured, telephone interviews with forty-five people involved with the development and/or adoption of the innovations (conducted from September 2017 to April 2018, lasting between 30 and 65 minutes) and desk research. The Supplementary Material details the sources

of evidence for each case vignette. With informed consent, interviews were recorded and transcribed. A more detailed description of the fourteen innovations is provided in the Supplementary Material. Table 3 provides codes used in this article when making references to individual case vignettes.

4.5 Literature and policy document review

A total of 122 articles from peer-reviewed journals and grey literature were identified in a scoping review that adopted a systematic search strategy (Grant and Booth 2009; see Supplementary Material), searching publications published in English primarily on Google Scholar and through snowballing from relevant publications. The aim was to identify areas of interest to explore in the round 2 interviews, workshops, and the survey, and to analyse the data collected against the current knowledge base and policy environment. Thus, in this article, insights from the literature are considered a source of information, together with insights from the other methodological work streams. Data analysis followed a narrative synthesis approach (Pope and Mays 2006).

4.6 Cross-analysis and synthesis

Data within specific workstreams were coded and analysed thematically. Data were also triangulated across methods and data sources, and across stakeholders involved with the research. The research team created an initial coding framework, drawing on the core themes that were explored in the interviews, survey, workshops, case vignettes, and in the literature and policy documents. The triangulation of the evidence from different work streams helped to test key messages that were emerging from individual methodological work streams against each other. The cross-analysis allowed us to arrive at priority areas of action for decision-makers to consider in efforts to support an innovating healthcare system, to determine what needs to be done and how, as well as to identify issues of particular relevance for specific stakeholder groups.

4.7 Limitations

There are limitations to bear in mind when interpreting this article's findings. We aimed to engage with individuals from a wide range of sectors and professions and to provide opportunities for multiple voices to be heard. The selection was not based upon typicality but upon having experiences of health innovation as it occurs in different parts of the system. That being said, some professions were more difficult to engage with than others, and we acknowledge that there are individuals and organisations in the system that were not consulted, but which could have offered relevant insights. Study participants could simultaneously affiliate with more than one stakeholder group. We made a conscious effort to assign participants to the stakeholder group that was most relevant to their primary job role; however, we acknowledge that they may have also expressed views from the perspective of their other roles.

Nevertheless, the combination of methods allowed a high number of very diverse individuals, organisations, and stakeholders to contribute through both individual-level and group-based fora. We are confident that this, together with insights from the wider literature, allows for robust analysis and insights, allowing us to draw out a series of action-areas that could support more receptive innovation spaces.

Table 2. Breakdown of contributions by method and stakeholder group.

Stakeholder group	Workshops round 1	Workshops round 2	Interviews round 1	Interviews round 2	Survey	Case vignettes	Total
Innovation and improvement networks ^a	42	10	38	10	69	0	169
Healthcare providers and commissioners	39	13	42	21	98	19	232
Charities and patient and public involvement organisations	5	8	12	14	23	0	62
Private sector	6	14	7	8	25	17	77
Academics	6	13	11	13	24	0	67
Policymakers	0	13	0	11	15	0	39
Other ^b	3	0	10	0	2	9	24
Total	101	71	120	77	256	45	670

^aExamples include individuals from institutions such as AHSNs, Vanguards, Innovation Hubs, Test Beds, CLAHRCs, and other regional network initiatives.

^bExamples include individuals from local organisations (e.g. local councils), NHS Innovation Accelerator fellows, or interviewees who wished their stakeholder affiliation not to be disclosed.

Table 3. Overview of the fourteen innovations and case vignette codes (more information on each innovation can be found in Box 1 of the [Supplementary Material](#)).

Case vignette innovation	Case vignette code
High-sensitivity troponin assays for detecting heart disorders	CV1
Remote cardiac monitoring devices	CV2
One-step OSNA to assess breast cancer cell spread to lymph nodes	CV3
Prostatic urethral lift (UroLift [®]) minimally-invasive surgical technique for enlarged prostate treatment	CV4
Drug-eluting stents	CV5
Kooth mental health online platform for children and adolescents	CV6
Sleepio digital cognitive behavioural therapy programme	CV7
MoodGYM computerised cognitive behavioural therapy aimed at young people suffering anxiety or depression	CV8
NHS Blood Donor Chair	CV9
Cascade model for genetic testing of familial hypercholesterolemia (FH)	CV10
ENDOCUFF VISION [™] colonoscope attachment device to improve mucosal visibility and aid in detecting abnormalities	CV11
The CHC2DST software for electronic assessment of eligibility for NHS funding for continuing care	CV12
SecurAcath single-use device to secure and stabilise central venous catheters	CV13
HeartFlow FFR _{CT} Analysis, a non-invasive coronary artery disease detection tool	CV14

5. Key factors influencing an innovating healthcare system

The first phase of the research enabled us to identify six key factors influencing an innovating healthcare system and processes and interactions across the healthcare innovation pathway, across healthcare pathways, and across different types of innovations (Fig. 1). These drivers can be seen as interacting subsystems of the overall socio-technical system for healthcare innovation. They are:

- Skills, capabilities, and leadership.
- Relationships and networks.
- Information and evidence environments.
- Motivations and accountabilities (including policy and regulation).
- Public and patient involvement and engagement with innovation.
- Funding, commissioning, and procurement.

In what follows, given space limitations and an effort to balance breadth and depth, we have chosen to focus on key findings and their implications as they relate to three themes in particular, namely: (1) skills, capabilities, and leadership for innovating healthcare systems; (2) motivations and accountabilities; and (3) relationships and networks that can support coordinated cooperation. The other influencing factors outlined above are not of lesser importance but covering all of the issues in one article would have, in our view,

diluted the richness of the learning gained. Insights related to the funding and commissioning environment, PPIE, the information and evidence environment, and evaluation metrics are referred to at a higher level, but will be the focus of other, forthcoming publications.

5.1. Skills, capabilities, and leadership

Delivering successful healthcare innovation requires diverse skills. Skills are also not stagnant, but require updating, refreshing, and replacing as new innovations emerge, or as the organisational and policy landscapes in the healthcare system evolve. For example, digital innovation requires new NHS workforce skills to engage with ever-increasing amounts of data and with new processing and analysis technologies, as well as with associated ethical and data governance considerations. Achieving these capacities requires training and mentoring, and learning through exposure, experience, and networking (Blasinsky et al. 2006; Goetz et al. 2009; Rollins et al. 2010; Cox et al. 2018). In this context, innovating healthcare systems probably function best when there is not an overly high degree of structuration in sociotechnical regimes—but where rules, norms and practices, and institutions have fluidity and adaptability built into their design, governance, and maintenance.

Specific social and technical skills are essential for successful innovation in the healthcare system. Examples of social skills include

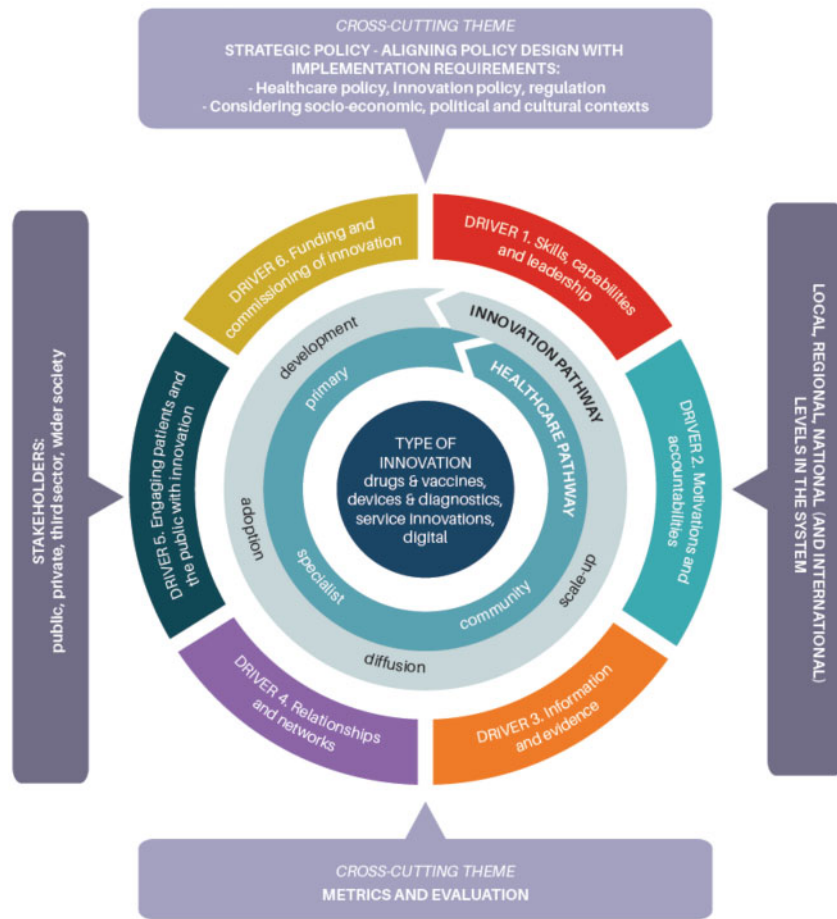


Figure 1. An innovating healthcare system.

distributed leadership capabilities to manage risk and navigate innovation-related activity across professional boundaries and hierarchies; networking, brokerage, and relational skills to create connected communities; and skills to establish a compelling business case for innovation (CV7,9,12,13; Academics_INT8, CharityPPIE_INT2,3,9,14; Networks_INT8,9,10; Policymaker_INT2,3,5,6; Private_INT6,7; ProviderCCG_INT14-16,18,19,21,22; workshops: academics, networks, policymakers, private sector, providers/commissioners; Marjanovic et al. 2017).

In commenting on the power of networking and communication skills, one interviewee emphasised:

... it is all about people. [You need] someone who can work at different levels and can bring different people to the table and can negotiate solutions to sometimes quite challenging problems. (primary care representative)

Learning from case vignettes illustrates the importance of implementation support. For example:

- Uptake of the One-step nucleic acid amplification (OSNA) was facilitated by the NHS National Technology Adoption Centre (NTAC), which created online support tools for hospitals implementing OSNA, including a ‘How to Why to Guide’ toolkit (CV3). OSNA has been found by NICE to be equally or more cost-effective than traditional lymph node analysis methods whilst at the same time improving patient outcomes (NICE, 2013).

- In the case of Kooth, an online mental health and emotional well-being platform for children and adolescents, efforts of the innovating team and its collaborators to provide training to healthcare professionals on how to use the service was seen to help adoption.

Essential technical skills include: science and technology skills related to a specific innovation and clinical area; skills to identify and assess innovation needs and articulate problems looking for solutions; skills to interpret innovation-related evidence; technical skills to enable implementing innovations in organisations; economic analysis and evaluation skills that measure performance of products, technologies, and services over time and at the level of the health system (rather than in organisational silos); data governance; and intellectual property literacy (CV3,6,9,12,13; Academics_INT8; CharityPPIE_INT2,3,9,14; Networks_INT8,9,10; Policymaker_INT2,3,5,6; Private_INT6,7; ProviderCCG_INT14-16,18,19,21,22; workshops: academics, networks, policymakers, private sector, providers/commissioners; Marjanovic et al. 2017).

Participants stated that in the past the innovation capability landscape focused more on technical than social skill development and emphasised capacity-building in skills to support the supply of innovations through programmes, training, and mentorship provided through, for example, the Clinical Entrepreneurs Training Programme; Innovation Hubs and the Small Business Research Initiative (SBRI). However, in recognition of the challenges of translating innovations into solutions adopted by the health service, an

evolution in the policy landscape in recent years has sought to redress the imbalance. National programmes are gradually driving change and often supporting training through regional organisations and networks. With financial and policy support from NHS England, the Department of Health and Social Care and the Office for Life Sciences, skills for innovation uptake are also being established and nurtured. Examples of initiatives focusing on innovation uptake capabilities include the NHS Innovation Accelerator and the refreshed Academic Health Science Networks (AHSNs), which seek to create receptive, connected environments for innovation across the healthcare innovation pathway—from generation and development through to adoption, diffusion, and spread (CV3,4,7,12-14; Networks_INT1,2,5-9). Their efforts are complemented by other regional training programmes supported by Academic Health Science Centres (AHSCs), universities and research institutes, Collaborations for Leadership in Applied Health Research and Care (CLAHRCs), and various clinical networks in hospitals and universities (Academics_INT1,5,8,9,11; CharityPPIE_INT2,3; Networks_INT3-5,8-10; Policymaker_INT2; Private_INT2; ProviderCCG_INT11,15,16,18,19,22).

Our research also points to some key areas of action for health system decision-makers to consider to strengthen the skills, capabilities, and leadership aspects of the sociotechnical regime for an innovating healthcare system, so that the regime might become more conducive to innovating as a central element of the life and function of the health service:

- For healthcare professionals, training, and education about how to engage with, identify, adopt, and sustain innovation needs to happen throughout their career (from early training through to continuing professional development) (CV3,6,13; CharityPPIE_INT2,3; Policymaker_INT2; ProviderCCG_INT15,18,19; workshops: academics, charities/PPIE, networks). For existing training regimes to evolve, policymakers in England would need to work with professional communities and bodies in charge of medical education (e.g. Medical Royal Colleges and Health Education England) to embed innovation-related training into continual professional development and medical education (Academics_INT2; CharityPPIE_INT3; Networks_INT1; Policymaker_INT2,10; ProviderCCG_INT8,16,18; academics workshop). This is not to say that everyone in the NHS needs to be an innovator, but that more people need to understand innovation and its potential impact on the NHS.
- Policymakers, medical education communities, innovation practitioners, and healthcare providers should work together to establish programmes for the private sector on effective engagement with the health service (CV3,13; CharityPPIE_INT2,3; Policymaker_INT2, ProviderCCG_INT15,18,19; workshops: charities/PPIE, private sector). Small businesses in particular rarely have the skills required to engage with the NHS, to create a compelling business case, and to work collaboratively to support embedding innovations (CV10; workshops: charities/PPIE, private sector). A combination of ‘soft’, personal traits of innovators such as entrepreneurial spirit, openness to new ways of working, good communication, and relational skills (Cox et al. 2018), alongside ‘hard’ business case skills, can enable innovation uptake and scaling-up.
- Effective innovation leadership and skills and capability-building go hand in hand. Nurturing effective leadership requires policymakers and healthcare service leaders to more widely identify, mobilise, and embed innovation champions into the system

across different professional groups and hierarchies. While there is some strong leadership for innovation at senior levels in the NHS (private sector workshop), and some willingness to engage with innovation at the frontline (such as NHS Innovation Accelerator fellows, clinical entrepreneurs, innovation champions, and innovation scouts), we found widespread support for scaling-up and spreading innovation leadership capacity across the NHS (CV10,12,13; Academics_INT1,3; CharityPPIE_INT2,3; Networks_INT4; Policymaker_INT6,8; private sector workshop). Innovation champions need to be trusted leaders across professions, with clear responsibilities for supporting innovation, to ensure their sustained impact and responsiveness to national priorities (CV3,13; Academics_INT3,5-8; ProviderCCG_INT16,18; CharityPPIE_INT9; Networks_INT8-10; Policymaker_INT3,5,6; Private_INT6,7; survey; workshops: charities/PPIE, networks, academics, policymakers, private sector, providers/commissioners; Dopson et al. 2002; Aitaoto et al. 2009; Kislov et al. 2017; Albury et al. 2018; Collins 2018).

5.2. Motivations and accountabilities

In contexts requiring profound transformation to respond to sustainability pressures, and responding to pressing social challenges in highly-constrained resource environments, motivating people to innovate is unlikely to work without accompanying accountabilities.

Motivations and accountabilities shape behaviours related to innovation development and uptake. Varied motivations to engage with innovation can coexist including personal beliefs about the value of innovation (for improving the quality, safety, and productivity of care), leadership support and organisational values (demonstrated through releasing time and funding to pursue innovation-related activity and sharing information and evidence), and prospects for reputational, financial, and career-related gains (CV1,2,5,6,12,14; Academics_INT7,8,10,11; Networks_INT1,4,6-8,10; Policymaker_INT2,3,5,6,9,11; ProviderCCG_INT13,16; workshops: networks, policymakers, private sector; survey; Black and Lynch 2004; Blasinsky et al. 2006; Marjanovic et al. 2017; Albury et al. 2018).

Incentives that work best are those that align personal and organisational interests. Making innovation a part of routine practice requires attention to organisational values and ‘fit’. Services that are not embedded, that do not make a healthcare professional’s job easier, or help address NHS quality or productivity goals, are more likely to be short-lived, while projects that ‘mature’ into being part of a core programme are more likely to be sustained (Evashwick and Ory 2003; Martin et al. 2012; providers/commissioners workshop). For example, drawing from the case vignettes in this study:

- The implementation of Continuing Healthcare Checklist and the Decision Support Tool (CHC2DST), software that allows continuing healthcare (CHC) assessments to be conducted electronically, was supported by a wider drive in the NHS for both improvements in CHC assessments and to move away from manual (paper) recording (CV12). Figures from NHS England suggest the software has helped to speed up the CHC process which has improved patient experience (NHS England 2018c). Additionally, an evaluation of the software by IEG4, the developers, suggests that it can save each CCG £380,000 per year (CV12).
- The adoption of high-sensitivity troponin assays to detect heart disorders similarly was facilitated by a compelling business case that aligned with commissioners’ efforts and incentives to meet

waiting time targets, for example in emergency departments (CV1). On an individual hospital basis, NHS Trusts have reported that these assays lead to improvements in patient health, such as reducing unnecessary hospital admissions and reducing costs (Albury et al. 2018).

In England, the incentives for the uptake of innovation have historically been less developed than those that influence entrepreneurial activities and innovation development, such as funding for development and programmes focused on skills for entrepreneurship (Academics_INT1,6,8,10; Networks_INT2,5,8,10; Private_INT2,4,7; ProviderCCG_INT6,11,16,19-22; workshops: academics, networks, private sector). However, we have recently witnessed progress with incentives for and permissive infrastructures for uptake as well (albeit limited and gradual). For example, the performance evaluation systems for the refreshed network of AHSNs (with evolved role and remits) include metrics that incentivise AHSNs' role in facilitating uptake (policymaker workshop). The NHS Innovation Accelerator programme (2018) provides funding and releases time for innovators in the NHS to engage with activities that promote the maturation and uptake of innovations, while NHS England Innovation and Technology Tariff (The AHSN Network 2018) and Innovation and Technology Payment schemes (NHS England 2018b) provide financial incentives. These initiatives are increasingly being embedded into the institutional environment and in health policy, forming central elements of policy developments such as the *Accelerated Access Review* and the *NHS Long Term Plan*.

However, there is more to be done. A policymaking representative commented on current attitudes:

Innovation is currently seen as a “nice to have” as opposed to “a must have” in the NHS. That’s something that definitely needs to change. (policymaker representative)

Although stakeholders did not generally support mandating uptake of innovation, they did tend to agree that strengthened accountabilities are needed (workshop: academics, networks, private sector). Our evidence suggests that a more sustainable system of motivations and accountabilities could be achieved through:

- *Executive leadership, middle management and clinical leaders in healthcare organisations assuming greater responsibility for raising awareness and disseminating information about opportunities to engage with innovation activity, about the performance of innovations and the impact they can on healthcare, and about how innovating fits with individual roles and career pathways* (Academics_INT3,5-8; CharityPPIE_INT9; Networks_INT8-10; Policymaker_INT3,5,6; Private_INT6,7; ProviderCCG_INT16,18; workshops: policymakers, networks, providers/commissioners; Aitaoto et al. 2009; Wright 2009; Wisdom et al. 2014; Collins 2018). Effective information flows are central to innovation and need to be based on an understanding that different stakeholders put varying value on different types and sources of evidence (Kyratsis et al. 2014; Collins 2018). For example, clinicians trust the experiential evidence and views of professional peers and tend to value information and evidence obtained from peer-reviewed sources, systematic reviews, and clinical guidelines (Kyratsis et al. 2014). Managers emphasise evidence about cost implications in addition to considering the quality improvement benefits of innovation, particularly if this evidence was collected from a local area. Non-clinical managers in

healthcare provider organisations are the least likely to use their professional network to access information on evidence compared to doctors, pharmacists, nurses, and allied health professionals (Kyratsis et al. 2014). In our survey, commissioners reported accessing information from participating in various boards and committees, through NHS England portals and from NICE guidelines as important (survey).

- *Stronger monitoring of accountabilities to help tackle unwarranted variation in innovation uptake, for example through embedding innovation into national regulatory and improvement schemes and assessments, more focus on robust ‘adopt or explain why not’ practices, and ensuring that innovation roles within organisations have clear roles, authority, and responsibilities, reflected in performance management and career progression.* Such actions do not mean mandating innovation. But they do mean ensuring accountability for engaging with innovation when appropriate, as not doing so is a risk to safe and effective care (CV1,6,12; CharityPPIE_INT7,11; Networks_INT1; Policymaker_INT1,2,11; Private_INT7, ProviderCCG_INT8,16,18; workshops: academics, networks, policymakers, private sector, providers/commissioners). But unintended consequences need to be carefully considered (Mannion and Braithwaite 2012), such as those that can be associated with benefits from adoption being internalised by only one part of the system (e.g. an innovation benefiting acute care, but externalising costs to primary or community care). The regulation of incentives and accountabilities for engaging with innovation needs to consider whole-system effects.
- *NHS leadership and policymakers also need to pay greater attention to practical enablers for staff to engage with an innovating health system.* Funding is necessary but not sufficient. Funding incentives need to be coupled with a strategy that considers how to release time and headspace for healthcare professionals to engage with innovation and ‘not just firefight’; rewards and recognition also matter (CV9,11; Academics_INT1,3,5,8,10,11; Networks_INT8, ProviderCCG_INT12,17,19; CharityPPIE_INT1,9; Policymaker_INT3,5,6,9; workshops: networks, providers/commissioners, policymakers, private sector, academics, charities/PPIE; Robert et al. 2009).

5.3. Relationships and networks for coordinated cooperation

Our research suggests that innovating health systems require coordination and alignment of initiatives. However, such alignment does not always exist in healthcare sociotechnical regimes.

In the UK, a proliferation of networks and collaborative initiatives seeks to support, enable, and coordinate collaboration for innovation and improvement (Cox et al. 2018). Many are transformational initiatives that are part of (relatively) long-term national strategies and government institutions, but they are implemented and managed at regional levels, through relationships between diverse stakeholders: healthcare professionals, academics, innovators in the private sector and in the NHS, patients and the public, and the third sector (Marjanovic et al. 2017). Although the overall strategies of the government agencies that coordinate them may be long term, their funding commitments are often not. Examples include AHSNs, Test Beds, and Innovation Hubs (Academics_INT13; Networks_INT3,5,7,8,10; Policymaker_INT10, Private_INT2-4,8; ProviderCCG_INT16; workshops: networks, policymakers, private sector, providers/commissioners; survey; Marjanovic et al. 2017). Many of these networked initiatives

offer some coordination by connecting different stakeholders around the development, maturation, and uptake of specific products, technologies, or new service and care models. However, their role in coordinating activities around a specific innovation and across different stakeholder groups is perhaps more developed than their role as coordinators across a portfolio of innovations or between healthcare *innovation* and healthcare *improvement* initiatives in a given region: they suffer to a degree from insufficient alignment, and there is scope for better connecting activities across different regions in England to support impact at pace and scale, to prevent unnecessary duplication and build on existing capacity (Academics_INT4,13; Private_INT2-4,8; Networks_INT3-5,7,8,10; workshop: academics, networks, private sector, charities/PPIE; Castle-Clarke et al. 2017).

Effective coordination can be challenged by multiple forces, for example, a lack of awareness of what else is happening in a socio-technical system, and can be perpetuated by the politics of a social fabric (e.g. ownership and accountability issues). However, in England, closer working between departments or agencies around innovation agendas is beginning to strengthen, partially in recognition of the challenges to coordinating the innovation landscape. For example, NHS England and the Office for Life Sciences have worked together to map the innovation funding landscape as a first step towards more coordinated funding; as part of the implementation of the *Accelerated Access Review* an Accelerated Access Collaborative will oversee the selection of products to that are eligible for a pathway of support for accelerated access and involves multiple agencies, patients, industry, and clinicians (workshops: charities/PPIE). And AHSNs and the NHS Innovation Accelerator are linking up with other institutionalised initiatives to support an innovating health system—such as NHS England financial pull initiatives (e.g. Innovation and Technology Tariff, Innovation and Technology Payment) (source: personal communication with project working group).

Our study evidence suggests a series of actions that could be considered by decision-makers to strengthen the relationships and networks elements of innovating health system in transition:

- *A better-aligned system would require closer collaboration between different government departments involved in research, innovation, and healthcare, and ensure that different health innovation organisations and initiatives understand their respective capabilities and service offerings better, and work closely with initiatives focused on healthcare quality improvement* (Academics_INT2-5,7,8,11; Networks_INT5,6,9,10; Policymaker_INT3,4,6,7; ProviderCCG_INT6,16,18,19; CharityPPIE_INT2,3,6,8,10,11,13; Private_INT2,3). Initiatives should be evaluated against progress and delivery on clear remits and roles (as with AHSNs and Vanguards).
- *Organisational leadership could work to facilitate more cross-organisational representation on initiatives' committees (e.g. steering committees, advisory groups, executive boards)* (CharityPPIE_INT2,3,13; workshop: networks, private sector), *support collaborative projects to nurture a shared vision of success* (Policymaker_INT3; Private_INT8; ProviderCCG_INT7,18) *considering prospects for shared posts, secondments, and placements* (Policymaker_INT3; Private_INT7,8,18), *and appoint individuals with information and relationship brokerage roles into initiative structures* (workshops: academics, providers/commissioners). Patient and public contributions should be considered based on a principled strategy supporting meaningful

involvement (CV7-9; CharityPPIE_INT2,6,7,10,12-14; Private_INT2; Academics_INT7; Policymaker_INT8; charities/PPIE workshop).

6. Interdependencies between factors influencing an innovating healthcare system

Although we have chosen to in this article focus on three specific factors needed to support an innovating healthcare system (i.e. the themes of skills, capabilities, and leadership; motivations and accountabilities; and relationships and networks for coordinated co-operation), it is important to flag that in supporting innovation throughout the healthcare pathway, these factors, as well as others (i.e. funding, commissioning, and procurement; information and evidence; and public and patient involvement and engagement) interact.

This interaction between diverse influencing factors is central to the innovation systems and sociotechnical systems lenses on innovating healthcare systems outlined earlier. To illustrate with a few examples from the case vignette elements of our research:

- Earlier, we discussed how the adoption of high-sensitivity troponin assays to detect heart disorders was facilitated by a compelling business case on clinical value and financial savings. Developing that business case could only happen once sufficient information and evidence were collected from trials and testing of the innovation in a real-world setting. Interested clinicians needed to develop the skills, capabilities, and leadership to embed the assays into existing diagnostic pathways and into the working relationships that underpinned those pathways (CV1).
- Similarly, in another case example, that of remote cardiac monitoring devices (systems in patients' homes, which monitor the performance of devices such as implantable cardioverter defibrillators, to make sure that they are working properly), the innovators' efforts to demonstrate the value of the device to clinicians led to the building of supportive relationships and networks for uptake by cardiac centres. Innovators were able to demonstrate the innovation's value to frontline staff who were initially sceptical about the claimed benefits, believing the device would result in higher workloads. Implementation testing and implementation support showed that the device in fact reduced the need for face-to-face appointments with patients and equipped clinicians with the capabilities to engage with remote monitoring, which motivated them to engage with efforts to support adoption (CV2).
- In the case of UroLift, a minimally-invasive surgical technique for enlarged prostate treatment, the innovators invested in improving the product through testing in the UK and USA, and developing relationships with multiple stakeholders including patients, clinicians, payers, and healthcare administrators, which later facilitated adoption. A positive NICE recommendation provided the information and evidence and regulatory impetus needed to ensure funding support through the national NHS England Innovation and Technology Tariff, and AHSNs helped broker networks that supported adoption by healthcare providers (CV4), together with the financial incentives provided through the tariff.
- A new and innovative NHS Blood Donor Chair was developed in response to issues faced when using the previous version of the donor chair, including poor patient experience and process disruption due to fainting. The new chair reduces the risk of fainting, improves patient comfort, and is also easier to transport and

clean which all acted as motivators to adopt the product. The NHS National Innovation Centre acted as an uptake brokering body, engaging both the payer (NHS Blood and Transplant) and patients to ensure the development of a product that met the needs of the service and of patients. The existence of a centralised buyer (i.e. NHS Blood and Transplant) helped ensure financial viability and coordinated and timely diffusion of the innovation in the healthcare system (CV9).

7. In reflection: our contribution to the evidence base and implications for future research, policy, and practice

We have illustrated the complexity of factors that influence the ability of a healthcare system to support the development and uptake of promising innovations.

Innovation literature in the health services field has been studied from complexity science, implementation science, and social theory perspectives such as structuration theory, normalisation process theory, and actor-network theory (cf. Greenhalgh and Papoutsi 2019; Shaw et al. 2017). As mentioned, amongst the health service-centric innovation literature, most studies focus on the organisational level. Our study contributes to the relative scarcity of *solutions-focused* literature on the role of innovating in healthcare improvement that considers the *systems-level* support needed for the maturation and translation of innovations into benefits for the wider health service and for patients, to support system transformation and transitions to sustainability. We also identify practical and concrete, evidence-based actions that decision-makers can consider in efforts to improve the support system for innovating in healthcare (especially as it relates to skills, capabilities, leadership arrangements, motivations, accountabilities, and networked arrangements in the innovating healthcare system). Such practical action-focused evidence is essential for translating relatively-abstract concepts that are found in some of the academic literature into reality ‘on the ground’.

Several points stand out in terms of the implications of our findings for policy and practice, and in terms of contributions to the wider literature. We also identify some areas in need of further research.

We highlight that efforts to ensure sustainable innovating healthcare systems require attention to multiple aspects of the system simultaneously, including to behavioural and cultural levers, as much as to the more commonly targeted financial and structural interventions. We have seen substantial enthusiasm for building relationships for an improving healthcare system in the NHS. Innovation takes place primarily within organisational settings and some organisations are more active innovation-wise than others. But without coordination and support infrastructure at the regional, national, and sectoral system levels, and an infrastructure to incentivise and connect organisations to help share learning, organisations can become excessively inward-looking and inert. They can become focused on short-term financial outcomes and fire-fighting, which are not conducive to reaping benefits from innovation. This makes better evidence on how to create an innovating healthcare *system* (of the nature that we have sought to contribute to) all the more important.

Each setting combines different types of factors that influence innovation in unique habitats. When innovation happens, habitual ways of working become unlocked. The cause of this varies: for example, it can include external shocks; effective patient advocacy;

new and compelling evidence of what is feasible; a charismatic champion mobilising the case for change. However, successful innovation requires more than this moment of openness in a specific setting. It also requires that making sense to stakeholders in both the organisation and in the wider system (e.g. in policy circles, amongst service-users) in a way that can support embeddedness of change. Sustainable change from innovation happens when new possibilities are aligned with clinical and economic system priorities in manageable and absorbable ways. Our research helps us understand better what innovators do when they are trying to improve healthcare, and case studies highlight what happens when new innovations seek to deliver change. From this it is clear that innovation draws upon: the macroscopic conditions of policy, regulation, professional identity, and resource allocation; the meso-level structures of networks, various communication fora, regional entities, and the immediate patient needs, organisational priorities, and clinical settings.

Our research also emphasised the importance of nurturing both social and technical skills throughout career pathways (in medical education and continuing professional development). Learning from the quality improvement space suggests that required skills are often difficult to identify (Aveling et al. 2012), and investment in technical skills alone does not necessarily lead to sustainable change. A skills audit prior to considering the adoption of an intervention may be helpful in targeting the capability-building effort (Bibby 2014).

We also outlined practical actions for embedding accountability for innovation, but not mandates, into the healthcare system—through more robust ‘adopt or explain why not’ practices, linkages to regulatory regimes, and clear accountabilities in formal innovation roles in healthcare provider organisations. Wider insights from the literature, although they suggest the need for accountabilities to accompany incentives, also suggest caution before adopting targets as formal incentives. Although targets can initiate compliance, they may not always lead to the shift of staff culture and buy-in needed to support innovations (Albury et al. 2018). Targets are also often short-term, which reduces the incentives for commissioners to invest in long-term innovation projects (Collins 2018) and can have detrimental effects (Mannion and Braithwaite 2012). Thus, commissioners should support the creation of useful, long-term incentives and accountabilities that prioritise the sustainability of innovations over their immediate impacts and outcomes (Albury et al. 2018).

Our study identified six key factors influencing an innovating healthcare system and this article has focused on three. As indicated by both innovations systems thinking and sociotechnical systems thinking, and supported by our empirical evidence, the different factors influencing an innovating healthcare system need to be considered together in policy design and implementation, given that they are interdependent in their influence on framing an effective innovating healthcare system.

However, this also begs the question of whether the simultaneous pursuit of multiple policy actions that can support the six key factors is feasible or whether it would lead to policy fragmentation. We would argue that policy fragmentation occurs precisely when policy design is considered in a piecemeal fashion, rather than in light of the interdependencies between different determinants of success and without consideration of how policy actions can be implemented while supporting adaptation to a given organisational context. However, specific actions to be taken at any one point in time, to support effective and well-rounded policy, depend on the ‘baseline’ state of the healthcare system and on emerging priorities. For example, if a healthcare system has invested substantially in funding or in creating structural networks for innovation, but

neglected investments in the accountability regimes or in skills for the uptake of innovations, then the latter can emerge as priorities for action in the policy mix. In addition, the interdependencies between individual actions and whether one has to be in place before another can unfold will in part depend on how policymakers and wider stakeholders choose to pursue specific combinations of actions. For example, prioritising investments into funding schemes for adoption of innovations is likely to be interdependent with the national evidence and data infrastructure and consensus processes for identifying key areas of innovation need and demand.

We also recognise that implementation of a package of actions needs to unfold in an organised and staged manner, ensuring that required oversight infrastructure and appropriate operational management (i.e. not only strategic oversight and governance) is in place, alongside a clear delegation of roles and responsibilities for implementation. Some actions are also likely to be easier to implement than others. A rounded and feasible policy package inevitably needs to balance shorter-term quicker wins with medium- or long-term benefits. For example, establishing a training programme for the private sector on how to effectively engage with the health service or raising awareness about existing funding schemes and resources to support the development and adoption of innovation should be balanced with medium or longer term interventions such as embedding cultural change in attitudes to innovation through evolution of the medical education curriculum or through structuring job-posts to include more dedicated time-allowances for healthcare staff to engage with innovation. The particular challenges of driving cultural change may in part explain why transformation efforts are often applied to areas that are somewhat easier to influence or implement in the shorter term (e.g. creating a new initiative or network, a pilot scheme, a funding scheme). However, these may be disconnected from longer term transformation. Further understanding the levers of cultural change as they pertain to innovating healthcare systems would benefit from additional research that digs deep into cause and effect relationships of implementing policies that target such change, including through ethnographic studies.

Although our research drew on empirical evidence from the healthcare system in England, the six key factors influencing innovation that we introduced earlier in the article, and the overall messages pertaining the complex sociotechnical nature of innovating healthcare systems and to efforts to build them are likely to apply to other contexts as well. However, the precise nature of priorities and the nature of actions to be taken will vary in light of factors such as the innovation performance of a healthcare system at any one point in time, payment models, and population needs. For example, appropriate funding of innovation will always matter but, who pays will depend on how a healthcare system is financed (e.g. public or private; taxation based, insurance based, out of pocket fees) and on how centralised payment decisions are, which will influence what role the market plays. And the extent to which funding is a priority will depend in part on the overall scale of healthcare system financing. The nature of financing and the role of the market also influence the diversity of innovation portfolios on offer in any one context, as well as influencing issues of equitable access. Similarly, the availability of appropriate skills, capabilities, and leadership for innovation matters irrespective of geographical context. But some countries or regions may invest more heavily in skills for developing innovations (depending on the state of their knowledge and innovation economy) and others more in the uptake of innovations developed elsewhere. Patient and public involvement will always matter in terms of both advocacy efforts and informing innovation needs, but the

extent to which it is prominent in the innovation and healthcare policy debate will depend on wider socio-political forces. Similarly, the extent to which healthcare innovation is pursued as an industrial policy issue versus a healthcare improvement issue will be influenced by the political pressures framing healthcare policy, by the performance of the healthcare system, and by the state of the research and innovation base in an economy.

We also mentioned earlier that industrial strategy and economic competitiveness perspectives on innovation are researched more extensively than healthcare services research perspectives on innovation. These perspectives on innovation are not necessarily mutually exclusive, but the challenge for policymakers, innovation practitioners as well as for the research community is to understand how to act in an environment with many legitimate but possibly conflicting interests, and how to steer a system towards defined public goals. This includes supporting transformation processes that do not excessively disrupt everyday care delivery, but can support both shorter term incremental clinical innovation and a longer term vision for more radical transformation (and more radically-transformative innovations, once requisite infrastructure and systems and safeguards are in place). From a research perspective, this implies a need to study innovating in healthcare from a more multidisciplinary perspective that considers the entire pathway—from development through to adoption and spread. This requires bridging siloed thinking between management science perspectives, organisational studies, industrial economics, science and technology studies, socio-technical perspectives, complexity theory, social theory and implementation science, and improvement research. It also requires closer collaboration between innovation and quality improvement scholars as well as between innovation policymakers and improvement policymakers, given that innovation serves a health services improvement function, and that innovation science and improvement science share many common challenges and opportunities (Marjanovic et al. 2017; Horton et al. 2018). The pace of innovating and translation also requires further attention. Webster (2017) offer useful insights in the context of responsible research and innovation approaches, arguing that the policy focus should not be only on accelerating access, but on doing so responsibly, considering organisational, institutional, and stakeholder readiness.

Our analysis illustrates how social and systemic factors that interact with physical technologies (i.e. with the innovations themselves) have evolved over time in England in response to technological advances and demand forces, and also as a result of policy and institutional developments and their associated programmes and initiatives that have emerged. Many of the individual innovations covered in our case examples began as part of niche experiments. However, it is deliberately introduced national and regional support infrastructures targeting multiple influencing factors that are enabling the evolution of the innovating healthcare system more widely, across diverse innovation types. Further research is needed to understand how different drivers in the social elements of the sociotechnical innovating healthcare system can reinforce or undermine each other and what this implies for how governance and oversight institutions in the policy sphere interact.

We have also sought to contribute to advancing the applications of sociotechnical systems thinking to major social transformation challenges. To date, much sociotechnical systems thinking has been applied to and evolved from learning about specific types of innovations as the core focal point. We consider instead what fundamental features of the social system need to be in place to allow for a thriving and sustainable innovating healthcare system. Indeed,

individuals consulted for our research engaged with many diverse types of innovations (medicines, devices and diagnostics, service, and digital innovations) and the major bottlenecks, challenges, and enabling levers for innovating effectively seemed to apply across different innovation types. Undoubtedly, some unique determinants also exist. For example, digital technology platforms come with unique information security and interoperability determinants of uptake and spread, and the regulatory landscape for apps and digital innovations is arguably less mature than that related to pharmaceutical innovation.

Our research also has implications for policymakers supporting the transition of healthcare systems towards more integrated care models with closer linkages between primary, acute, community, and social care, as is the case with the healthcare system in England. Decision-makers need to identify needs across care pathway(s) and support the development and uptake of combinations of solutions that can yield the required improvement in quality and cost for the system as a whole (especially as an innovation may, for example, decrease costs in acute care but displace them to primary care). This requires political and policy structures that invest heavily in cooperation rather than siloed working that pursue depoliticised strategies for health system sustainability to support long-term shared visions, with some pragmatic attention to quick wins. Further research is needed on how this can be achieved in practice, but we have outlined some developments in England (such as cross-departmental government initiatives and accountability and regulatory regimes that consider whole system effects from innovation uptake) that could support this aim.

Given the complex dynamics associated with change, highlighted in sociotechnical analysis, further research is also needed to understand the implementation requirements and success criteria for healthcare innovation policy initiatives. Accompanying this is a need for more sophisticated metrics and evaluation. Indicators of success will need to go beyond traditional input or output measures such as investments in R&D, patents or contributions to GDP (Archibugi & Planta 1996; Gault 2013) to consider uptake and impacts on patients and the health service, as well as indicators of system-level capacity along multiple dimensions (and the six drivers we have outlined in this article) that influence the process of translating innovations into impacts on patients, the health service, and the economy.

Acknowledgements

The authors declare their contribution to this study and approval of the final manuscript. We thank everyone who contributed their expertise and insights to this research through interviews, workshops, and the survey, including healthcare professionals, academic researchers, patient and public representatives, charity representatives, policymakers, innovation and improvement network representatives, and private sector communities. We are also grateful for the support of the National Institute for Health Research Policy Research Programme, and appreciate the engagement with our work by the Department of Health and Social Care, the Office for Life Sciences, and NHS England who were part of a study working group. We are grateful for the collegiality of the University of Manchester colleagues and RAND Europe alumni and for their input into various work streams for this project (not all of which are reported on in this article). Specifically, we would like to thank Prof. Ruth McDonald, Prof. Matt Sutton, Dr Rachel Meacock, Talitha Dubow, Dr Megan Sim, Emma Harte, Calum MacLure, Jennie Corbett, Dr Sarah Parks, Carla Cox, Ioana Ghiga, Dr Molly Morgan Jones, and Dr Katerina Galai. Finally, the authors also thank Prof. Graham Martin for his advice. The views expressed in this article are those of the authors and not

necessarily those of NHS England, the NIHR, the Department of Health and Social Care, or the Office for Life Sciences.

Supplementary data

Supplementary data is available at *Science and Public Policy* online.

Funding

This project was funded by the National Institute for Health Research (NIHR) Policy Research Programme (PR-R7-1113-22001). The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care.

Conflict of interest statement. None declared.

References

- Accelerated Access Review (2016) *Accelerated Access Review: Final Report. Review of Innovative Medicines and Medical Technologies. An Independently Chaired Report, Supported by the Wellcome Trust.* London: GOV.uk <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/565072/AAR_final.pdf> accessed 12 Jun 2019.
- Aitaoto, N., Tsark, J., and Braun, K. L. (2009) 'Sustainability of the Pacific Diabetes Today Coalitions', *Preventing Chronic Disease*, 6/4: 1–8
- Albury, D., Beresford, T., Dew, S. et al. (2018) *Against the Odds: Successfully Scaling Innovation in the NHS.* London: Innovation Unit & The Health Foundation <<https://www.health.org.uk/publication/against-odds-successfully-scaling-innovation-nhs>> accessed 12 Jun 2019.
- Archibugi, D., and Planta, M. (1996) 'Measuring Technological Change Through Patents and Innovation Surveys', *Technovation*, 16/9: 451–519.
- Aveling, E. L., Martin, G., Armstrong, N. et al. (2012) 'Quality Improvement Through Clinical Communities: Eight Lessons for Practice', *Journal of Health Organization and Management*, 26/2: 158–74.
- Bason, C. (2018) *Leading Public Sector Innovation. Co-Creating for a Better Society*, 2nd edn. Bristol: Policy Press.
- Bibby, J. (2014) 'Four Lessons for Running Impactful Collaboratives in Health Care' <<https://www.health.org.uk/blogs/four-lessons-for-running-impactful-collaboratives-in-health-care>> accessed 31 Jul 2019.
- Bowling, A. (2002) *Research Methods in Health: Investigating Health and Health Services*, 2nd edn. Buckingham: Open University Press.
- Bell, J. (2017) *Life Sciences Industrial Strategy – A Report to the Government from the Life Sciences Sector.* London: Office for Life Sciences <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/650447/LifeSciencesIndustrialStrategy_acc2.pdf> accessed 24 Mar 2019.
- Berkhout, F., Smith, A., and Stirling, A. (2004) 'Socio-Technological Regimes and Transition Contexts'. In: E., Boelie, F. W., Geels, and K., Green (eds) *System Innovation and the Transition to Sustainability*, pp. 48–75. Cheltenham: Edward Elgar.
- Black, S. E., and Lynch, L. M. (2004) 'What's Driving the New Economy?: The Benefits of Workplace Innovation', *The Economic Journal*, 114/493: F97–116.
- Blasinsky, M., Goldman, H. H., and Ünützer, J. (2006) 'Project IMPACT: A Report on Barriers and Facilitators to Sustainability', *Administration and Policy in Mental Health*, 33/6: 718–29.
- Braun, V., and Clarke, V. (2006) 'Using Thematic Analysis in Psychology', *Qualitative Research in Psychology*, 3/2: 77–101.
- Broerse, J. E. W., and Grin, J., eds (2017) *Toward Sustainable Transitions in Healthcare Systems.* London: Routledge.
- Castle-Clarke, S., Edwards, N., and Buckingham, H. (2017) *Falling Short: Why the NHS Is Still Struggling to Make the Most of New Innovations. Briefing.* London: Nuffield Trust <https://www.nuffieldtrust.org.uk/files/2017-12/1513183510_nt-innovation-briefing-scc-web-2.pdf> accessed 12 Jun 2019.

- Chataway, J., Tait, J., and Wield, D. (2006) 'The Governance of Agro- and Pharmaceutical Biotechnology Innovation: Public Policy and Industrial Strategy', *Technology Analysis & Strategic Management*, 18/2: 169–85.
- , Brusoni, S., Cacciatori, E. et al. (2007) 'The International AIDS Vaccine Initiative (IAVI) in a Changing Landscape of Vaccine Development: A Public/Private Partnership as Knowledge Broker and Integrator', *The European Journal of Development Research*, 19/1: 100–17.
- , Fry, C., Marjanovic, S., and Yaqub, O. (2012) 'Public-Private Collaborations and Partnerships in Stratified Medicine: Making Sense of New Interactions', *New Biotechnology*, 29/6: 732–40.
- Cohen, W. M., and Levinthal, D. A. (1990) 'Absorptive Capacity: A New Perspective on Learning and Innovation', *Administrative Science Quarterly, Special Issue: Technology, Organizations, and Innovation*, 35/1: 128–52.
- Collins, B. (2018) *Adoption and Spread of Innovation in the NHS*. London: The King's Fund <<http://www.ahsnetwork.com/wp-content/uploads/2014/12/Final-AHSN-The-Kings-Fund-report.pdf>> accessed 12 Jun 2019.
- Consoli, D., and Mina, A. (2009) 'An Evolutionary Perspective on Health Innovation Systems', *Journal of Evolutionary Economics*, 19: 297.
- Cox, A., Spiegelhalter, K., Marangozov, R. et al. (2018) *NHS Innovation Accelerator Evaluation*. Brighton: Institute for Employment Studies <https://www.employment-studies.co.uk/system/files/resources/files/nia0318-NHS_Innovation_Accelerator_Evaluation.pdf> accessed 12 Jun 2019.
- David, P. A. (1994) 'Why Are Institutions the "Carriers of History"? Path Dependence and the Evolution of Conventions, Organizations and Institutions', *Structural Change and Economic Dynamics*, 5/2: 205–20.
- de la Maisonneuve, C., and Oliveira Martins, J. (2014) 'The Future of Health and Long-term Care Spending', *OECD Journal: Economic Studies*, 2014: 61–96.
- Deloitte (2019) *2019 Global Health Care Outlook. Shaping the Future*. London: Deloitte <<https://www2.deloitte.com/global/en/pages/life-sciences-and-healthcare/articles/global-health-care-sector-outlook.html>> accessed 12 Jun 2019.
- Department of Health (2018) 'The Government's Revised Mandate to NHS England for 2017–18. A Mandate from the Government to NHS England: April 2017 to March 2018'. Presented to Parliament Pursuant to Section 13A(1) of the National Health Service Act 2006, London, Department of Health <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/692140/NHSE_Mandate_2017-18_revised.pdf> accessed 30 Mar 2019.
- DG for Economic and Financial Affairs (2018) 'The 2018 Ageing Report. Economic & Budgetary Projections for the 28 EU Member States (2016–2070)'. *Institutional Paper*, 079, May 2018 <https://ec.europa.eu/info/sites/info/files/economy-finance/ip079_en.pdf> accessed 12 Jun 2019.
- Dopson, S., Fitzgerald, L., Ferlie, E. et al. (2002) 'No Magic Targets! Changing Clinical Practice to Become More Evidence Based', *Health Care Management Review*, 27/3: 35–47.
- Dosi, G. (1995) 'Hierarchies, Market and Power: Some Foundational Issues on the Nature of Contemporary Economic Organization', *Industrial and Corporate Change*, 4/1: 1–19.
- Evaschick, C., and Ory, M. (2003) 'Organizational Characteristics of Successful Innovative Health Care Programs Sustained over Time', *Family & Community Health*, 26/3: 177–93.
- Freeman, C. (2008) *Systems of Innovation*. Cheltenham: Edward Elgar Publishing.
- Fuensschilling, L., and Truffer, B. (2014) 'The Structuration of Socio-technical Regimes—Conceptual Foundations from Institutional Theory', *Research Policy*, 43/4: 772–91.
- Gault, F. (2013), 'Innovation Indicators and Measurement: An Overview'. In: F., Gault (ed.) *Handbook of Innovation Indicators and Measurement*, pp. 3–37. Cheltenham/Northampton, MA: Edward Elgar.
- Geels, F. W. (2004) 'From Sectoral Systems of Innovation to Socio-technical Systems: Insights About Dynamics of Change from Sociology and Institutional Theory', *Research Policy*, 33/6–7: 897–920.
- , and Schot, J. (2007) 'Typology of Sociotechnical Transition Pathways', *Research Policy*, 36/3: 399–417.
- (2011) 'The Multi-level Perspective on Sustainability Transitions: Responses to Seven Criticisms', *Environmental Innovation and Societal Transitions*, 1/1: 24–40.
- Goetz, M. B., Hoang, T., Henry, S. R. et al. (2009) 'Evaluation of the Sustainability of an Intervention to Increase HIV Testing', *Journal of General Internal Medicine*, 24/12: 1275–80.
- Grant, M., and Booth, A. (2009) 'A Typology of Reviews: An Analysis of 14 Review Types and Associated Methodologies', *Health Information & Libraries Journal*, 26/1: 91–108.
- Greenhalgh, T., Robert, G., Macfarlane, F. et al. (2004) 'Diffusion of Innovations in Service Organisations: Systematic Review and Recommendations', *Milbank Quarterly*, 82/4: 581–629.
- , and Papoutsis, C. (2019) 'Spreading and Scaling Up Innovation and Improvement', *The BMJ*, 365: l2068.
- Horton, T., Illingworth, J., and Warburton, W. (2018) 'The Spread Challenge: How to Support the Successful Uptake of Innovations and Improvements in Health Care' <<https://www.health.org.uk/sites/default/files/upload/publications/2018/The-spread-challenge.pdf>> accessed 31 Jul 2019.
- Kislov, R., Hyde, P., and McDonald, R. (2017) 'New Game, Old Rules? Mechanisms and Consequences of Legitimation in Boundary Spanning Activities', *Organization Studies*, 38/10: 1421–44.
- Kyratsis, Y., Ahmad, R., Hatzaras, K. et al. (2014) 'Making Sense of Evidence in Management Decisions: The Role of Research-based Knowledge on Innovation Adoption and Implementation in Health Care'. *Health Services and Delivery Research*. Southampton: NIHR Journals Library <<http://www.ncbi.nlm.nih.gov/books/NBK259620/>> accessed 12 Jun 2019.
- Lord Carter of Coles (2016) *Operational Productivity and Performance in English NHS Acute Hospitals: Unwarranted Variations*. London: Department of Health <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/499229/Operational_productivity_A.pdf> accessed 24 Mar 2019.
- Lundvall, B.-A. (1992) *National Innovation System: Towards a Theory of Innovation and Interactive Learning*. London: Pinter.
- Malerba, F., and Orsenigo, L. (2002) 'Innovation and Market Structure in the Dynamics of the Pharmaceutical Industry and Biotechnology: Towards a History-Friendly Mode', *Industrial and Corporate Change*, 11/4: 667–703.
- Mannion, R., and Braithwaite, J. (2012) 'Unintended Consequences of Performance Measurement in Healthcare: 20 Salutary Lessons from the English National Health Service', *Internal Medicine Journal*, 42/5: 569–74.
- Marjanovic, S., Sim, M., Dubow, T. et al. (2017) *Innovation As a Driver of Quality and Productivity in UK Healthcare. Creating and Connecting Receptive Places: Emerging Insights Report*. Santa Monica, CA/Cambridge: RAND Corporation <https://www.rand.org/pubs/research_reports/RR1845.html> accessed 12 Jun 2019.
- Martin, G. P., Weaver, S., Currie, G. et al. (2012) 'Innovation Sustainability in Challenging Health-Care Contexts: Embedding Clinically Led Change in Routine Practice', *Health Services Management Research*, 25/4: 190–9.
- Mason, M. (2018) 'Cardiology Innovations and Advances Within the NHS' <<https://www.rbht.nhs.uk/blog/cardiology-innovations-and-advances-with-in-nhs>> accessed 12 Jun 2019.
- NHS England (2018a) 'Medical Cannabis (and Cannabis Oils)' <<https://www.nhs.uk/conditions/medical-cannabis/>> accessed 30 Jul 2019.
- (2018b) 'Innovation and Technology Payment (ITP) 2018/19' <<https://www.england.nhs.uk/ourwork/innovation/innovation-and-technology-payment-201819/>> accessed 30 Jul 2019.
- (2018c) 'NHS Continuing Healthcare and NHS-Funded Nursing Care 2017-18' <<https://www.england.nhs.uk/statistics/statistical-work-areas/nhs-chc-fnc/2017-18/>> accessed 24 Mar 2019.
- (2019) *The NHS Long Term Plan*. Leeds: NHS England <<https://www.longtermplan.nhs.uk/wp-content/uploads/2019/01/nhs-long-term-plan.pdf>> accessed 12 Jun 2019.
- NHS England (n.d.) 'NHS Test Beds programme' <<https://www.england.nhs.uk/ourwork/innovation/test-beds/>> accessed 30 Jul 2019.
- NHS Digital (2017) *NICE Technology Appraisals in the NHS in England (Innovation Scorecard): To December 2016*. Leeds: Health & Social Care Information Centre <<https://files.digital.nhs.uk/publication/a/e/nice-tech-apps-eng-jul17-inno-scor-rep.pdf>> accessed 24 Mar 2019.

- NHS Innovation Accelerator (2018) *NHS Innovation Accelerator. Understanding How and Why the NHS Adopts Innovation*. London: NHS Innovation Accelerator <<https://nhsaccelerator.com/wp-content/uploads/2018/11/NHS-Innovation-Accelerator-Understanding-how-and-why-the-NHS-adopts-innovation.pdf>> accessed 12 Jun 2019.
- NICE (2013) *Intraoperative Tests (RD-100i OSNA System and Metasin Test) for Detecting Sentinel Lymph Node Metastases in Breast Cancer*. London: National Institute for Health and Care Excellence <<https://www.nice.org.uk/guidance/dg8/chapter/6-considerations>> accessed 24 Mar 2019.
- Nelson, R. R. (1993) *National Innovation Systems. A Comparative Analysis*. Oxford: Oxford University Press.
- Nolte, E. (2018) *How Do We Ensure That Innovation in Health Service Delivery and Organization is Implemented, Sustained and Spread?*. Denmark: World Health Organisation <http://www.euro.who.int/_data/assets/pdf_file/0004/380731/pb-tallinn-03-eng.pdf?ua=1> accessed 2 Aug 2019.
- O'Dowd, A. (2018) 'Doctors Question Hancock's Idea of GP Video Consultations for All', *BMJ Open*, 362: k3934.
- Plsek, P. (2003) *Complexity and the Adoption of Innovation in Health Care. Accelerating Quality Improvement in Health Care Strategies to Speed the Diffusion of Evidence-Based Innovations*. Washington, D.C.: National Institute for Health Care Management Foundation/National Committee for Quality Health Care <<https://www.nihcm.org/pdf/Plsek.pdf>> accessed 12 Jun 2019.
- Pope, C., and Mays, N. (2006) 'Synthesising Qualitative Research'. In: C., Pope, and N., Mays (eds) *Qualitative Research in Health Care*, pp. 142–52. Malden, MA: Blackwell Publishing Ltd.
- Proksch, D., Busch-Casler, J., Haberstroh, M. M., and Pinkwart, A. (2019) 'National Health Innovation Systems: Clustering the OECD Countries by Innovative Output in Healthcare Using a Multi Indicator Approach', *Research Policy*, 48/1: 169–79.
- Robert, G., Greenhalgh, T., MacFarlane, F., and Peacock, R. (2009) *Organisational Factors Influencing Technology Adoption and Assimilation in the NHS: A Systematic Literature Review. Report for the National Institute for Health Research Service Delivery and Organisation Programme*. London: King's College London <http://www.netscc.ac.uk/hsdr/files/project/SDO_FR_08-1819-223_V01.pdf> accessed 12 Jun 2019.
- Rollins, A. L., Salyers, M. P., Tsai, J., and Lydick, J. M. (2010) 'Staff Turnover in Statewide Implementation of ACT: Relationship with ACT Fidelity and Other Team Characteristics', *Administration and Policy in Mental Health*, 37/5: 417–26.
- Schot, J., and Steinmueller, W. E. (2017) *Three Frames for Innovation Policy: R&D, Systems of Innovation and Transformative Change*. Brighton: University of Sussex <<http://www.johanschot.com/wordpress/wp-content/uploads/2016/09/Latest-April-2018-3-Frames-Paper-fro-Web-Proofed-v8RK-SENT-Schot-Steinmueller-Framings-of-STI-Policy-Secondsubmission2-copy-2.pdf>> accessed 12 Jun 2019.
- Shaw, J., Shaw, S., Wherton, J. et al. (2017) 'Studying Scale-up and Spread as Social Practice: Theoretical Introduction and Empirical Case Study', *Journal of Medical Internet Research*, 19: e244.
- Teece, D. J., Pisano, G., and Shuen, A. (1997) 'Dynamic Capabilities and Strategic Management', *Strategic Management Journal*, 18/7: 509–33.
- The AHSN Network (2018) 'Innovation and Technology Tariff (ITT)' <<https://www.ahsnnetwork.com/supporting-innovation/innovation-technology-payment-itp/innovation-technology-tariff>> accessed 30 Jul 2019.
- Von Hippel, E. (1994) "'Sticky Information" and the Locus of Problem Solving: Implications for Innovation', *Management Science*, 40/4: 429–39.
- Ward, D., and Chijoko, L. (2018) *Spending on and Availability of Health Care Resources: How Does the UK Compare to Other Countries?*. London: The King's Fund <<https://www.kingsfund.org.uk/publications/spending-and-availability-health-care-resources>> accessed 12 Jun 2019.
- Webster, A. (2017) 'Regenerative Medicine and Responsible Research and Innovation: Proposals for a Responsible Acceleration to the Clinic', *Regenerative Medicine*, 12/7: 853–64.
- Wisdom, J. P., Chor, K. H. B., Hoagwood, K. E., and Horwitz, S. M. (2014) 'Innovation Adoption: A Review of Theories and Constructs', *Administration and Policy in Mental Health*, 41/4: 480–502.
- Wright, D. B. (2009) 'Care in the Country: A Historical Case Study of Long-term Sustainability in 4 Rural Health Centers', *American Journal of Public Health*, 99/9: 1612–8.