

# Developing a conceptual framework for the early adoption of healthcare technologies in hospitals

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The [2019 Topol Review](#) for the UK National Health Service (NHS) outlined a vision for a digital future for healthcare, including the development of on-site innovation hubs in hospitals<sup>1</sup>. These spaces are intended to improve patient care through innovation collaborations.

At The Digital Research, Innovation and Virtual Environments ([DRIVE](#)) centre at Great Ormond Street Hospital for children, ideas for new technologies are submitted to the innovation hub each month. These ideas are triaged by an inter-disciplinary group of hospital staff, with a goal to break down silos and develop these technologies in a real-world context. We are interested to adopt more new healthcare technologies and to encourage a culture of innovation where ideas are valued and worked on collaboratively. However, initial proposals received for review by innovation hubs, like ours, vary in quality. This makes it difficult to decide which technologies should be selected first without a more thorough assessment, which might take between several months to years to complete.

New technologies in healthcare should be safe, reliable and provide benefits to patients. Theoretical frameworks and methods can be adapted and deployed to assess these new technologies. There are several theories on technology acceptance within the fields of Computer Science, and Human Computer Interaction (HCI) which pertain to the ease of use and usefulness of technologies; these theories have evolved with new technologies<sup>2</sup>. This well-established body of theoretical knowledge is well applied to research but is less commonly translated into mainstream practice in hospitals. There also exist national guidelines from organisations including Healthcare Information and Management Systems Society (HIMSS), National Institute for Clinical Excellence (NICE) and NHS Transformation, which orchestrate the adoption of new technologies. Most recently, the NHS Digital Technology Assessment Criteria (DTAC) has received praise amongst the Digital Health and MedTech community for ensuring that digital technologies meet baseline standards.

National guidelines are designed to facilitate full-scale deployments, particularly at the procurement stage. However, these theories and frameworks are less suited to rapid explorations of emerging technologies, such as new-to-market devices, chatbots, engines and software in Artificial Intelligence (AI) and Machine Learning (ML), Augmented Reality (AR), Virtual Reality (VR), Touchless Computing, Internet of Things (IoT) and predictive analytics<sup>3,4</sup>. These guidelines and theories rarely prioritise early interest from healthcare staff and patients<sup>5,6</sup>, and so a different approach is needed, one that is agile, user experience (UX) focussed and embraces human-centred interactions<sup>5,7,8</sup>.

During the COVID-19 pandemic, we took a pragmatic and empathetic approach to new human-computer interactions by conducting Clinical UX studies of rapid technology adoption. As part of this we listened to healthcare staff as they recounted firsthand experiences of rapid technology adoption practices.

51 We believe that lessons from the adoption of healthcare technologies during COVID-19 can  
 52 be applied to other emerging technology implementations. For this, we propose a new ‘active  
 53 discourse’ framework: A framework for the early exploration and adoption of emerging healthcare  
 54 (ARC) technologies that uses a rapid debriefing technique to learn about deploying technologies  
 55 such as providing remote care, and speech recognition software (Figure 1). Over three phases, the  
 56 ARC framework introduces staff to emerging technologies and concepts, builds capability and core  
 57 competencies to use new technologies, and redesigns interactions and workflows to create new  
 58 technology enabled user experiences (Table 1). As part of rapid debriefing, it also asks: what did  
 59 you expect to happen (when interacting with this new technology); what happened; what were the  
 60 differences between expectation and reality; and what lessons can be learnt from this?

61 Our ARC framework differs from other national frameworks for technology adoption, as it  
 62 has been tailored to first experiences from healthcare staff and patients with new technologies. An  
 63 accompanying checklist of ten questions (Table 1) serves as a practical tool to guide the  
 64 development of an initial proposal for a technology and should make proposals comparable for  
 65 decision makers. This should help streamline the process to decide which technologies should be  
 66 first explored, resourced, and progressed within a hospital environment.

67 Our framework is not intended to replace high level guidelines, but to complement existing  
 68 processes, by serving to improve applications for clinical trials and other formal assessments, such  
 69 as by NHS DTAC or the NICE Evidence Standards Framework (ESF). We are currently  
 70 undertaking a Delphi study as a validation step, with the intention to improve and draw consensus  
 71 on this conceptual framework and accompanying checklist. We have already reached consensus  
 72 on the broader conceptual framework in our first Delphi round of twenty-three expert panellists and  
 73 we look to learn from a wider, diverse, and global network of peers in the final part of this process.

74 We hope that this framework will allow healthcare technology decision-makers to assess  
 75 the potential benefit for a given technology by using a transparent, reproducible, and practical tool  
 76 that gives prominence to the early user experiences of healthcare staff, delivering both safer and  
 77 kinder patient care.

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79 **Figure legends**

80 **Figure 1: The ARC framework**

81 Venn diagram showing the core constructs for the ARC framework.

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84 **Table 1. Framework phases for ARC**

Phase	Purpose	Steps
Imagine	To introduce staff to emerging technologies and concepts, using demonstrations to image new interactions	<ol style="list-style-type: none"> <li>1. Create a space to trial the new technology away from patient care areas.</li> <li>2. Provide clear directives from hospital leadership to support this type of technology.</li> <li>3. Invite a wide and inclusive stakeholder group as part of this introductory phase.</li> <li>4. Use interactive demonstrations to introduce a new technology to show how it works.</li> </ol>

		<ol style="list-style-type: none"> <li>5. Use practical design scenarios and examples in everyday life when demonstrating a new technology.</li> <li>6. Encourage independent exploration of this new technology.</li> <li>7. Address common worries about a new technology.</li> <li>8. Involve experts in industry and academia such as through an industry launch event for new technology.</li> <li>9. To develop an interest in a given technology, assign a clinical champion with knowledge and skills in digital health.</li> </ol>
Educate	To establish core competencies and training needs that build capability using a progressive learning path that takes a user from novice to expert.	<ol style="list-style-type: none"> <li>1. Create a digital competency pathway.</li> <li>2. Think about ways to nurture digital literacy in a way that leaves no one behind.</li> <li>3. Use a progressive learning path to incrementally improve skills.</li> <li>4. Be clear about the intended use case for a new technology.</li> <li>5. Conduct in person live training or onboarding for new technologies.</li> <li>6. Create easy to access FAQs, bite sized learning and online demonstrations.</li> <li>7. Run educational workshops for more complicated technologies.</li> <li>8. Provide clear details of who is providing support and how to access it.</li> <li>9. Ensure equitable access to equipment.</li> <li>10. Capture early feedback on first impressions of using a new technology.</li> <li>11. Involve experts in digital education, such as local and national networks in digital education</li> </ol>
Validate	To redesign interactions and workflows in clinical spaces with clinical teams (real or emulated) to create new technology enabled user experiences.	<ol style="list-style-type: none"> <li>1. The technology redesign process should include time in clinical spaces (the user environment) with clinical teams.</li> <li>2. Where clinical spaces cannot be accessed directly, consider redesigning it in a simulated training space.</li> <li>3. Emulate a clinical workflow to consider infrastructure, patient safety and interaction design needs.</li> <li>4. Evaluate functionality and features of a new technology including those which can be personalised.</li> <li>5. Consider what will happen if a technology doesn't work, and the back-up plan, to increase confidence in a new technology.</li> <li>6. Where it is appropriate, simulate real world use cases in a fun way.</li> <li>7. Show demonstrable positive benefits with a small-scale deployment.</li> <li>8. Show data driven benefits of using this new technology.</li> <li>9. Provide some trouble shooting resources and live support in clinical spaces.</li> <li>10. Carry out a structured debrief with staff to capture early experiences of using a new technology.</li> <li>11. Involve experts in digital innovation, clinical simulation, or improvement science, such as a clinical simulation team</li> </ol>
Score	To decide to accept, adapt or reject further resourcing this proposed technology for a specified use case, guided by a ten-point checklist	<ol style="list-style-type: none"> <li>1. Technology value proposition: what we are looking to gain by using this technology?</li> <li>2. Use case: who will use this technology? What will it be used for? Why will it be used? When will it be used, how often? Where will it be used? How will staff get access to technology?</li> <li>3. User environment: what considerations to the physical hospital space and ICT Infrastructure are needed for this technology to work?</li> <li>4. Ease of use: describe the education and training needs, based on early UX?</li> <li>5. Does this technology work in the hospital setting, based on early UX and usefulness?</li> </ol>

		<p>6. Is this a technology that healthcare staff want to use again, based on feedback from end users?</p> <p>7. Patient care: is this technology safe and human centered? How will patient care be improved through using this technology and assessments of risk?</p> <p>8. What do patients think about this technology? Have you asked for feedback from advisory groups in digital health?</p> <p>9. Are hospital staff already using a similar technology? Include a competitor analysis.</p> <p>10. What are the high value, measurable benefits from using this technology? Have you taken a data driven approach to this?</p>
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## 90 **Competing interests**

91 Authors declare no competing interests.

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