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From development to exploitation of digital health solutions: Lessons learnt through multidisciplinary research and consultancy.

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Abstract

Purpose This viewpoint paper provides an overview of lessons learnt throughout the whole cycle of development to exploitation of digital solutions in health and wellbeing settings. We aim to address learnings that can be applied to all digital health technologies, including assistive technologies, apps, wearables, medical devices and serious games.

Design Based on the knowledge and experiences of working within a multidisciplinary team, we discuss lessons learnt through research and consultancy projects in digital health, and translate these into pragmatic suggestions and recommendations.

Findings Firstly, the importance of collaborating and co-creating with multidisciplinary stakeholders and end-users throughout the whole project lifecycle is emphasized. Secondly, digital health solutions are not a means to an end, nor a panacea; decisions should be evidence-based and needs-driven. Thirdly, whenever possible, research designs and tools need to be more adaptive and personalised. Fourthly, the use of a mixed-method system approach and continuous evaluation throughout the project's lifecycle is recommended to build up the evidence-base. Fifthly, to ensure successful exploitation and implementation, a business case and timely bottom-up approach is recommended. Finally, to prevent research waste, it is our shared responsibility to collaborate with existing consortia and create awareness of existing solutions and approaches.

Originality/Value In conclusion, collaborating in the field of digital health offered insights into how to be more purposeful and effective in development, evaluation and exploitation of digital health solutions. Moving this diverse and dynamic field forward is challenging but will contribute to greater long-term impact on society.

Keywords mHealth, digital health, multidisciplinary, technology, health care, innovation

Article classification Opinion Piece – Viewpoint

Introduction

This viewpoint paper provides an overview of our key learnings from development to exploitation of digital health solutions. Using the knowledge and experiences of our multidisciplinary research team, we translate these learnings into pragmatic suggestions and recommendations for other colleagues working in this field. We aim to describe learnings that are applicable to all digital health solutions, including assistive technologies, apps, wearables, medical devices and serious games.

1. *Involve, collaborate and co-create with multidisciplinary stakeholders and end-users from start to finish; set out expectations from the start.*

Throughout the whole lifecycle of developing, evaluating, implementing and exploiting digital health solutions, a multidisciplinary approach is required. Due to the complex nature of wellbeing and disease, health care delivery and systems, the possibilities of technology and new data they generate, and the complexity of how people use and interact with technology, working in silos is unlikely to result in adopted solutions that benefit society as a whole. As such, a multidisciplinary approach is crucial because everyone brings their own knowledge, experience, expertise and perspectives needed to address the diverse challenges in digital health (Aboelela *et al*., 2007; Payton *et al*., 2011). Perspectives from multiple disciplines and end-users (including citizens and patients) will help to identify and assess end-user, societal and/or business market needs; solution desirability and usefulness; user-friendliness, validity, effectiveness of the solution as well as its socio-economic viability and value. To gather input from end-users, researchers and designers in a cost effective and efficient manner, we recommend following an iterative rather than linear process (Holliday *et al*., 2015). An example of such a iterative approach comes from the use of co-creative methods which harness and encourage the collective creativity of multiple stakeholders (Sanders and Stappers, 2008). Actively involving and engaging end-users from an early stage onwards is an important requirement for successful funding in many countries, including the United Kingdom. Numerous tools and guidance have been developed to support teams to implement such methodologies (Anastácio, Z., Bernard, S., Carvalho, et al, 2019; Sanders and Stappers, 2012).

However, working with different disciplines and stakeholders also brings its own challenges, including understanding each other's fields, language, communication, perspectives and priorities (Schwartz *et al*., 2016). Amongst others, successful partnerships require mutual trust and confidence, which may be facilitated by non-disclosure and collaboration agreements. Such agreements set out expectations, needs and wishes of different parties, which should ideally be agreed before or at the funding application stage to reduce the risk of project delays or disagreements along the way. Such agreements should cover shared intellectual property, scientific publication and dissemination policies and setting out ways of collaborating. To facilitate communication, we recommend avoiding jargon and supporting text and words by visual illustrations and practical examples; asking for clarification or examples where required.

2. *Digital health solutions are not a means to an end, nor a panacea; decisions should be evidence-based and needs-driven.*

Our society is constantly changing and people are increasingly expected to process, shift, adjust and perform better with the fast pace of technological development

integrated in their day-to-day life. The recent Covid-19 crisis may force us to reconsider how we seek evidence for our digital solutions, and indeed Governments have had to promote the rapid evaluation of digital health products (Public Health England, 2020) to support quicker development and adoption. Despite this we must ensure technologies developed meet user need. In 1979, the architect Cedric Price gave a lecture with the thought-provoking title "Technology is the Answer, but what was the Question?" which still seems relevant today (Unterrainer, 2016). We recommend determining whether the envisaged digital solution addresses user or societal needs in a more effective or desirable way than existing or non-digital solutions. Failing to do so can result in numerous technologies that do not meet the end-user needs (Schwartz *et al*., 2016). There is a risk that such technologies are not cost-effective and are not adopted in the long-term. Therefore, we recommend to keep an open mind when addressing needs of different end-users, and conduct a Strengths, Weaknesses, Opportunities and Threats analysis of the proposed solution. More so in health care than for wellbeing purposes, benefits on health outcomes need to be clearly demonstrated before the health system is likely to embrace these innovative solutions (Milewa, 2006).

The ideal digital health solution should be needs driven and both evidence and theory based (e.g. making use of the Behaviour Change Wheel; Michie *et al*., 2014, Technology Acceptance Model; Lee *et al*., 2003) so that relevant theories can be translated into effective design elements. These solutions will have the highest chances for adoption in a health setting, and be fit for purpose. Besides being user-friendly, they should adhere to relevant privacy and security standards. When considering medical devices for adoption, the solution should be approved by the relevant administration, for example, CE marking in the European Union or the Food and Drug Administration (FDA) in the United States. Publishing validation or evaluation studies of the solution will demonstrate credibility to the medical and health community as does a health economic evaluation.

3. *One-size does not fit all – Digital health solutions and research designs need to be more adaptive and personalized where possible.*

Every individual is different and has different needs. We need to tailor solutions to the specific end user(s) and personalise (some) features to increase engagement with a digital solution and improve effectiveness, health and wellbeing (Hekler *et al*., 2016). However, there is a balance to be made to ensure the eventual solution does not result in a highly exclusive bespoke solution that is not representative of the needs of the widest population; a solution impeded by user stigma and low adoption levels. This includes paying attention to the socio-demographic, cognitive and health characteristics of the end users (e.g. age, gender, digital literacy, disease severity), their skills and preferences. If the technology aims to improve wellbeing or health, we should also consider which intervention component or delivery method is most likely to be effective.

There is a tension between research and technology development. Technology is developing at a very fast pace. However, evaluation of new technologies usually takes several years; involving concept development, usability, feasibility and pilot studies and randomized controlled trials. While trials can still prove the general concept, the digital solution is often out of date when results of a randomized controlled trial become available (Patrick *et al*., 2016). It would be less costly to "fail often, fail fast" and make adaptations or change an approach rather than remaining

focused on the current solution (Norman, 2013). Using the Multiphase Optimization Strategy (MOST) framework is one approach that may help researchers doing so (Collins, 2018). Besides traditional approaches such as randomized controlled trial with one or more intervention groups and control groups, we should consider more adaptive and flexible research designs and methods that go hand in hand with the dynamic nature of technological change, such as those receiving increased attention due to the Covid-19 pandemic (Public Health, 2020).

A research team consisting different expertise (e.g., computing, epidemiology, design, psychology) will be more likely to select and apply the most suitable study designs, methods and practices (Calvo *et al*., 2018; Collins, 2018), and gain holistic research insights.

4. *Focus on the use of a mixed-method system approach and continuous evaluation throughout the project's lifecycle to build up the evidence-base around digital health care tools.*

A variety of data collection methods can be used to get an evidence-base for digital health solutions. Questionnaire data can indicate to what extent someone is effectively engaged with the digital health solution, i.e. to what degree someone is engaged and reaches the intended outcomes (Yardley *et al*., 2016). Focus groups and interviews can provide more in-depth information concerning the level of engagement or reasons on attrition, and inform end-user requirement needs for digital solutions. Gathering real-time information, e.g. through Ecological Momentary Assessment, can offer additional insight and enhance ecological validity (Vandelanotte *et al*., 2017).

Metrics that are collected at the back-end of a digital health solution may help identify relevant usage patterns. Metrics are objective and can be collected at a larger scale resulting in a rich source of data. For example, metrics can demonstrate that certain elements of a digital health solution (e.g. an app) are more often used and seem highly popular while others are less intensively used. This may indicate room for improvement concerning its design. Moreover, specific usage patterns may be related to effectiveness, which may help identify for whom the digital intervention works best. However, there are multiple unknowns regarding use of metrics when evaluating digital health solutions, so it is worthwhile to explore this with different disciplines. Overall, we recommend a mixed method approach as this will enable the involved stakeholders to not only focus on generated health or well-being outcomes but also draw conclusions concerning more process-oriented outcomes such user-friendliness of the technology at hand (Johnson et al., 2007).

5. *Make a business case as part of your project to ensure exploitation and timely involve ambassadors from a bottom-up approach to elevate the chances of successful implementation.*

Often, resources invested in academia-led research and innovation projects may not lead to the development of a commercially successful product, and thus less is known about successful implementation and exploitation strategies (Murray *et al*., 2016; Goldzweig *et al*., 2009). This means that the digital solution does not always evolve further and successfully reach the end-users. We recommend to involve business experts or modellers early on in the project. They can support making a business case to identify and secure further funding later on. Increased uptake will allow further insights into the strengths and weaknesses of the digital solution to be explored and

identify its unique contribution to the field. The long-term uptake of the digital health solution will be supported where SMEs or enterprise hubs are involved. Whereas digital solutions have been traditionally funded from public resources, academics have become more aware of the advantages of considering commercial, consumer solutions (Granja *et al*., 2018; Ward *et al*., 2016) and the benefits of creating spin-out companies and (social) enterprises resulting in more sustainable and scalable digital health solutions.

Implementation of digital solutions is often challenging, especially in the healthcare context where procedures and policies are generally well-established. There may be organisational resistance to change. Given the dynamic nature of technological change, we expect that healthcare organizations will be asked to cope with change more dynamically and flexibly. The structure provided by the non-adoption, abandonment, scale-up, spread, and sustainability (NASSS) framework (Granja *et al*., 2018) may help to consider the domains of the condition, technology, value proposition as well as the adoption system (i.e. staff, patient and lay caregivers) from the beginning, and thereby enhance the likelihood of successful implementation. We recommend working with ambassadors and giving people enough time and training to adapt to new ways of working. The involvement of healthcare stakeholders in the development of digital solutions will ensure their needs are also being met. This will lead to staff who are more willing, and able, to adopt and accept digital solutions within their current practice (Greenhalgh *et al*., 2017).

6. *To prevent research waste, it is our shared responsibility to not reinvent the wheel but to collaborate with existing consortia and create awareness of existing solutions and approaches.*

Developing new digital health solutions should start with creating awareness of which technology already exists and whether it is effective, and with identifying gaps in knowledge or approaches. Describing (complex) interventions is crucial for implementation and replication purposes (Craig *et al*., 2008). There are few databases available where an overview of digital health solutions is presented. In the field of serious gaming, different peer-reviewed journals (e.g., Games for Health) have tried to harmonize the description of games by asking authors who submit a manuscript to fill in a predefined format description of the game at stake. In the field of psychology, the lack of a clear overview of the status quo and its evidence led to the initiation of a project (Michie *et al*., 2017) using machine learning to synthesize available digital behaviour change solutions and its evidence. Open-access policies give people access to research results, but access to the digital solution itself is usually unavailable, and the description of the technology is often not fully comprehensive. Such scientific output is also not fully inclusive as it is not targeted to the lay audience for which most solutions have been developed. This results in continuing unawareness of what is out there and evaluated among relevant stakeholders.

Apart from stimulating a uniform description of digital solutions to improve comparability with other solutions, quality ratings by experts, public members and the end-users should be included. Having more knowledge about what is already out there will prevent involved stakeholders from starting initiatives that are similar or just-as-good as existing ones. Too often, much time and money is invested in developing digital solutions that already exist or closely resemble existing initiatives. We recommend to redesign or repurpose current existing solutions into a better digital health solution with consideration of past lessons learnt (Ghezzi, 2017). Moreover,

involving engineers and technological experts who have experience with digital solutions can help to realize re-usage of existing technologies and frameworks so that that value for money will be guaranteed.

Conclusions

We share our insights gained from working in the field of digital health to help identify how to be more purposeful and effective in development, evaluation and exploitation of digital health solutions. Alongside the six key learnings described here, other factors such as data protection and security, cost-effectiveness, ethics and safety and transfer to real-world behaviour need to be considered when working in the field of digital health. Moving this diverse and dynamic field forward is challenging but will contribute to greater long-term impact on society.

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