

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

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

4

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49 Abstract

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

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

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

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

74
75 **Keywords** mHealth, digital health, multidisciplinary, technology, health care,
76 innovation

77 **Article classification** Opinion Piece – Viewpoint

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92 Introduction

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

99
 100 *1. Involve, collaborate and co-create with multidisciplinary stakeholders and*
 101 *end-users from start to finish; set out expectations from the start.*

102
 103 Throughout the whole lifecycle of developing, evaluating, implementing and
 104 exploiting digital health solutions, a multidisciplinary approach is required. Due to the
 105 complex nature of wellbeing and disease, health care delivery and systems, the
 106 possibilities of technology and new data they generate, and the complexity of how
 107 people use and interact with technology, working in silos is unlikely to result in
 108 adopted solutions that benefit society as a whole. As such, a multidisciplinary
 109 approach is crucial because everyone brings their own knowledge, experience,
 110 expertise and perspectives needed to address the diverse challenges in digital health
 111 (Aboelela *et al.*, 2007; Payton *et al.*, 2011). Perspectives from multiple disciplines and
 112 end-users (including citizens and patients) will help to identify and assess end-user,
 113 societal and/or business market needs; solution desirability and usefulness; user-
 114 friendliness, validity, effectiveness of the solution as well as its socio-economic
 115 viability and value. To gather input from end-users, researchers and designers in a
 116 cost effective and efficient manner, we recommend following an iterative rather than
 117 linear process (Holliday *et al.*, 2015). An example of such a iterative approach comes
 118 from the use of co-creative methods which harness and encourage the collective
 119 creativity of multiple stakeholders (Sanders and Stappers, 2008). Actively involving
 120 and engaging end-users from an early stage onwards is an important requirement for
 121 successful funding in many countries, including the United Kingdom. Numerous tools
 122 and guidance have been developed to support teams to implement such methodologies
 123 (Anastácio, Z., Bernard, S., Carvalho, et al, 2019; Sanders and Stappers, 2012).

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

136
 137 *2. Digital health solutions are not a means to an end, nor a panacea; decisions*
 138 *should be evidence-based and needs-driven.*

139
 140 Our society is constantly changing and people are increasingly expected to process,
 141 shift, adjust and perform better with the fast pace of technological development

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

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

170

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

173

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

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

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

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

203

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

207

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

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

229

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

233

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

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

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

263

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

267

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

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

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

295

296 Conclusions

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

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