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Applying Team Science to Collaborative Digital Health Research: Learnings from the Wearable Clinic

Niels PEEK[a,1], Charlotte STOCKTON-POWDRELL[a,] Alexander CASSON[b], Matthew SPERRIN[a], Bijan PARSIA[c], Andrea MANCA[d], Cynthia IGLESIAS[d], Ibrahim HABLI[e], Lamiece HASSAN[f], Steven ANTROBUS[a] and Matthew MACHIN[a]
[a] *Division of Informatics, Imaging and Data Sciences, University of Manchester, UK*
[b] *Department of Electrical & Electronic Engineering, University of Manchester, UK*
[c] *Department of Computer Science, University of Manchester, UK*
[d] *Centre for Health Economics, University of York, UK*
[e] *Department of Computer Science, University of York, UK*
[f] *Division of Psychology and Mental Health, University of Manchester, UK*
ORCiD ID: Niels Peek https://orcid.org/0000-0002-6393-9969

Abstract. Collaboration across disciplinary boundaries is vital to address the complex challenges and opportunities in Digital Health. We present findings and experiences of applying the principles of Team Science to a digital health research project called 'The Wearable Clinic'. Challenges faced were a lack of shared understanding of key terminology and concepts, and differences in publication cultures between disciplines. We also encountered more profound discrepancies, relating to definitions of "success" in a research project. We recommend that collaborative digital health research projects select a formal Team Science methodology from the outset.

Keywords. Team science, interdisciplinary, multidisciplinary, collaboration, digital health

1. Introduction

Digital Health is a field with complex challenges and opportunities that can rarely be addressed with expertise from a single discipline. In most Digital Health projects, expertise in computer science, engineering, and informatics has to combined with knowledge from the health and medical sciences, as well as with insights from the behavioural and social sciences. Furthermore, often the viewpoints from multiple stakeholders (e.g., patients, clinicians, and policy makers) must be taken into account.

Collaborative research is any form or research where researchers or practitioners from more than one discipline engage in scientific inquiry. Team science is a form of collaborative research where researchers work together on complex problems by applying and actively integrating conceptual and methodological approaches from

[1] Corresponding Author: Niels Peek, email: niels.peek@manchester.ac.uk.

multiple disciplines and professions [1,2]. It is still a relatively new field, although it has witnessed an increase in interest in recent years [1,4].

In this paper we present experiences with applying the principles of Team Science to a recent digital health research project (called 'The Wearable Clinic') conducted at the Universities of Manchester and York in the UK [5]. Mindful of the complex challenges faced in the project, we assembled a highly multidisciplinary research team and applied Team Science approaches to our working procedures. We describe our main findings and experiences with these approaches, specifically highlighting challenges faced.

2. Methods

The Wearable Clinic project aimed create of new forms of collaborative management of long-term conditions, enabled through dynamic personal care plans that adapt to the changing state of the individual and the world around them. This requires integration of self-care data, clinical data, and care-service information. Our long-term goal was to extend care services into the rhythms of daily life, and empower patients to become managers of their own care through mobile and wearable technologies.

At the start of the project four types of deliverables were planned:

1. Two realistic use cases, developed in close collaboration with key stakeholders (patients and clinicians);
2. Software "demonstrators" for each of the use cases that followed a participatory approach for development;
3. Pilot studies with patients providing evidence of feasibility for each use case;
4. High-quality academic journal and conference papers, created collaboratively within the team.

In addition, there was an important "softer" success criterion: multidisciplinary collaboration across the research team to generate new ideas and achieve forms of innovation that would not happen within the boundaries of unidisciplinary research. It became apparent that expertise would be required from several different fields and that collaborative, Team Science approaches were therefore needed for the project to have a good chance of being successful. We applied these Team Science approaches to formation and organisation of the research team and to producing each of the four types of deliverables listed above.

3. Results

3.1. Formation and Organisation of the Research Team

The project involved 3 technical workstreams (in electrical engineering, statistics, and ontology engineering), 2 cross-cutting workstreams (focused on use case development and software development), and a translational workstream (aimed at preparing Wearable Clinics for real-world deployment through stakeholder involvement, early health economic assessment, and safety assurance). The project team comprised 19 members with research expertise ranging from engineering and computer science to medical statistics, health informatics, health economics, and patient involvement. In addition the team included a project manager, patients with long-term health conditions,

and clinicians. Some members of the team had significant experience working on digital health research projects, but others had no experience of digital health projects at all.

3.2. Use Case Development

A key collaborative effort was the development of two extensive use cases, for severe mental illness (SMI) and for chronic kidney disease (CKD). The SMI use case was focused on symptom monitoring via a smartphone app and GPS tracking as a proxy of social functioning. An adaptive sampling algorithm was developed to optimise the frequency with which the symptom questions were asked. The CKD use case focused on ambulatory blood pressure monitoring (ABPM). Typically, ABPM requires patients to wear a blood pressure cuff for a 24-hour period with blood pressure readings being taken at regular intervals (usually every hour) without any contextual or behavioural information. We used an activity monitor to prompt participants to take a blood pressure reading at an optimal time when they had been sedentary for at least 5 minutes.

Each use case was led by a clinician with specialist knowledge of the relevant health condition. A patient contributor with lived experience of the condition was also assigned to work on the development of each use case. Each use case was therefore a combination of clinical knowledge, patient experience and technical domain-specific knowledge from the workstreams involved. The development of the use cases was highly iterative, starting with an abstract flowchart that illustrated how Wearable Clinic functions could be integrated into relevant clinical pathways.

3.3. Software Demonstrators

We delivered software demonstrators for both use cases. The SMI demonstrator was built on an existing smartphone app to which GPS tracking and the adaptive sampling algorithm were added. For the CKD use case a wrist-worn accelerometer was used to detect when participants had been sedentary for at least 5 minutes. An app was developed that linked with the accelerometer and prompted users to take a blood pressure reading at the correct time. We intended to integrate with an instrumented blood pressure cuff so that we could initiate a reading and collect results directly from the app but unfortunately we were unable to find a manufacturer who was willing to provide the necessary functionality to do this.

3.4. Pilot Studies

Our plans to undertake pilot studies were severely disrupted by the COVID-19 pandemic. It wasn't possible to get access to patients at the time we were running the pilot studies. Therefore we only undertook some pilot testing with members of the research team. This could be considered "pre-feasibility" and further pilot work would be needed with patients in future in order to establish feasibility for the target patient groups.

3.5. Academic Outputs

To facilitate multidisciplinary working in the creation of the research outputs, a publication policy was developed early in the project which encouraged authors to always involve at least one co-author from another workstream. In addition, we asked

authors to invite clinical and patient collaborators to become co-authors if they made a relevant contribution.

To date we have published 19 journal articles and 7 conference papers, and organised 2 conference workshops and 1 conference panel. The large majority of outputs (27 out of 29) include authors from at least 2 workstreams, and several include authors from all workstreams. Some papers included clinical co-authors but none had patient collaborators as co-authors. Their input was acknowledged in many papers though.

3.6. Challenges Faced

Throughout the project, we found that people from different areas of expertise used the same term to mean different things. For example, our software developments used the term "prototype" for a visual representation of a user interface developed using a rapid prototyping tool, while electrical engineering colleagues used the term "prototype" in a more generic manner to refer to a basic functional system or piece of technology that would require further development. This is clearly a potential source of confusion and misunderstandings. To address terminology misunderstandings, we produced a glossary of terms that were commonly used throughout the project. In addition, we encouraged all members of the team to ask for clarity whenever they felt that there was an opportunity for misunderstanding; this became more routine as the project progressed.

At a more fundamental level, we observed different views about what constituted "success" for the project. For instance, patients and clinicians sometimes had different views of what a technology based solution should achieve.

Our project publication policy encouraged collaboration across disciplines. However, the different publication cultures in different fields were sometimes a barrier to do this. In some fields co-authors need to make a substantial intellectual contribution otherwise they wouldn't be included. In other fields there is a more inclusive approach making sure that everyone is "involved". As a result it was not always possible to follow a uniform publication policy across the entire project.

4. Discussion

In this paper, we have summarised the challenges associated with multidisciplinary collaboration that we faced in a digita health project. Important challenges were language and terminology, cross-workstream collaboration, definitions of "success", and collaborative creation of research outputs.

Team Science is a relatively new field and there are few publications considering the application of Team Science to Digital Health. A qualitative analysis of 166 machine learning for health papers found that clinicians were involved in minority of publications (34.9%) [6]. A recent scoping review described the prevalence and nature of clinical expert involvement in the development, evaluation, and implementation of predictive clinical decision support systems [7]. It found that clinical expert involvement is most prevalent when system specifications are made or when system implementations are evaluated. We are not aware of any publications that make specific recommendations for how to apply Team Science to Digital Health projects.

The Wearable Clinic was a complex collaborative digital health research project. We recognised early on that Team Science approaches were required, but chose to follow a pragmatic rather than a theory-driven approach. With hindsight, it would have been

better to select a formal Team Science methodology at the start of the project. This would have helped to provide clarity to all team members on how the team would work together, and helped to monitor multidisciplinary collaboration throughout the project. Another important limitation is that these are learnings from a single project and the experiences with other projects, teams and areas of digital health may be different.

5. Conclusions

The complexity of Digital Health projects often requires collaboration between researchers from different disciplines as well as active involvement from clinicians, patients, and other stakeholders. This presents numerous challenges such as the need to build the right team, reaching a shared understanding of key concepts within that team, and achieving a cohesive approach to pursue common objectives across functionally diverse areas. Applying Team Science principles is a potential way to address these challenges. In the Wearable Clinic, we were able to improve multidisciplinary collaboration and to achieve project deliverables by applying a pragmatic Team Science approach. We recommend that collaborative digital health research projects select a formal Team Science methodology from the outset, provide training to their team members in collaborative research, develop a shared understanding of key concepts and terminology, and carefully consider how to engage with clinicians and patients.

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