Digital Innovation in Outpatient Healthcare Delivery Services: A Common Methodology to Introduce IoT Technologies in Two Use-cases

Salomé Azevedo[1,2][a] and Ana Rita Londral[1][b]
[1]*Value for Health CoLAB, NOVA Medical School, Lisbon, Portugal*
[2]*Department of Engineering and Management, Instituto Superior Técnico, Lisbon, Portugal*

Keywords: eHealth, Healthcare Pathways, Outpatient, IoT, Patient-centered Design.

Abstract: The introduction of digital innovation in established healthcare pathways needs collaborative work among technology providers and clinical teams. Further, the involvement of patients is a key-factor as a highly-impact resource in the design of effective services and sustainable innovation in Healthcare. This paper presents two use-cases where a common methodology is being applied in two different hospitals, to digitize outpatient healthcare pathways using IoT technologies for remote monitoring patients at home. The methodology is driven by principles of user-centered design and focused on outpatient outcomes measurement. It is described in three steps: "as-is" process design, process mapping for the new service and deployment strategy. From context requirements to results evaluation, clinical teams and patients are actively involved in the service design.

1 INTRODUCTION

In the last decades, the development of digital technology innovations brought unprecedented opportunities to outpatient healthcare delivery and to empower citizens in managing their own health. Sensors, mobile devices, Internet connection and artificial intelligence algorithms have become more accessible to the Healthcare systems and to the citizens, and have enormous potential in reducing inpatient costs that have been continuously increasing, worldwide. However, these technologies are still a remote reality for most of the healthcare delivery processes. Among the main identified reasons for this slow adoption are factors that influence the acceptance of these technologies and resistance by medical staff and patients. From previous research, it is known that the strategy used for managing change is a key indicator of success or failure (Safi et al., 2018). Interestingly, recent studies indicate that the role of patients (demand-side) is limited and that the healthcare providers (supply side) play a more important role in driving variation and growth of healthcare utilization and expenditure in advanced economies (Krämer and Schreyögg, 2019). If that is the case, a shift from a single-disciplinary approach to a multidisciplinary collaboration, that tackles real-world medical challenges and considers the main expectations, capabilities and priorities of patients and clinical teams, is needed for scaling-up digital innovations in Healthcare (Kostkova, 2015) (Spanakis et al., 2016) (Garavand et al., 2016).

In this paper, we present the methodology employed in two different healthcare services for the real-time deployment of IoT technologies in outpatient healthcare pathways: (i) follow-up of patients in the 1st month post-surgery, from the Cardiothoracic service in a Portuguese public hospital; and (ii) monitoring elderly patients that are enrolled in a Homecare nursing program, delivered by a Portuguese private hospital. Both use-cases that are reported in this paper are being deployed in real contexts of healthcare services and include the collaboration of patients and clinical teams with technology developers, to incorporate the IoT technology in the already established healthcare pathways.

We describe a patient-centered methodology that is being proposed to evaluate the value of a new service for outpatient healthcare with the use of IoT devices to collect and monitor clinical and patient-reported outcomes. This work follows the framework of Value-Based Healthcare, with a focus on the collection of patient-centered outcomes during the outpatient period (Åkerman and Stowell, 2015).

[a] https://orcid.org/0000-0003-1234-9464
[b] https://orcid.org/0000-0002-8002-6790

Azevedo, S. and Londral, A.
Digital Innovation in Outpatient Healthcare Delivery Services: A Common Methodology to Introduce IoT Technologies in Two Use-cases.
DOI: 10.5220/0009394908210826
In *Proceedings of the 13th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2020) - Volume 5: HEALTHINF*, pages 821-826
ISBN: 978-989-758-398-8; ISSN: 2184-4305

2 USE CASES

This paper describes the implementation of a service for outpatient outcomes monitoring in two different hospital contexts:

2.1 Follow-up Service in Cardiothoracic Surgery Service in a Public Hospital

A pilot is running to monitor patients from home, in the first month after cardiothoracic surgery. The main objective of this telemonitoring service is to early detect complications and increase patients experience of safety. Clinical and patient-reported outcomes are collected daily by the patient and reported to the clinical staff that contacts the patient in case of an alarm event is detected. After running a pilot with two patients that were exposed to cardiothoracic surgery, the technology and process design were adjusted, based on patients and clinical staff feedback. The pilot moved now to its second-stage: to follow-up 80 randomly selected patients that are discharged in this service.

Outcomes that are collected are: blood pressure, weight, steps, 5 questions in a mobile app and a self-picture of the surgical wound.

2.2 Homecare Nursing Service for Elderly Population in a Private Hospital

This use case relates to the implementation of a pilot from an European project H2020-ACTIVAGE. A group of 50 elderly patients (age over 65 years old) and their caregivers, followed in a homecare nursing service, were selected to use IoT devices to remotely monitor outcomes and communicate these with the nursing team. At current stage, the requirements and process design were already defined to start the pilot.

Outcomes that will be collected are: glucose level, blood pressure, weight, steps and simple patient-reported outcomes that are answered through a mobile app.

3 METHODOLOGY

As both services were deployed in two real-life pilot sites, we followed a case study approach in order to identify technical, organizational, and sustainability perils and to collect the generated knowledge during the deployment of the services, according to (Yin, 1994).

In the healthcare context, the process of creating or re-engineering a healthcare service that meets the several needs from the different stakeholders involved poses a high risk in guaranteeing that the end-user (the patient) is the main beneficiary of the service. Therefore, we applied the User-centred design (UCD) methodology to achieve higher levels of effectiveness, efficiency, and satisfaction (Dabbs et al., 2009; Årsand et al., 2008). Some key principles of UCD were applied, such as an iterative and incremental development process, involvement of end-users, explained design options, real life context evaluation and effective multidisciplinary teams development process (Gulliksen et al., 2003).

The UCD process was divided in three main stages:

1. **Environment Analysis:** Documentary analysis to collect the information about the *as-is* situation of outpatient services in both hospitals. This stage comprised several activities, such as: identification of stakeholder groups profiles, their motivations and needs, their interests, influence and importance.
2. **Digitizing the Healthcare Outpatient Pathway:** The following step consisted in transforming stakeholders' needs into requirements. Firstly, the real needs and the perceived and expressed needs were identified through semi-structured interviews. Secondly, the listed requirements were analysed and negotiated. In this negotiation stage, for each requirement it was discussed the feasibility to meet the need, regarding time and complexity, and available resources.
3. **Deployment Strategy:** In both case studies, we applied the same deployment strategy. Due to the lack of literature found in discussion of deployment effects of health-related IoT-based technology in real-life settings, this paper reports the activities supporting the implementation of the new outpatient care services.

4 SERVICE DESIGN OF OUTPATIENT HEALTHCARE

Digitizing the outpatient healthcare pathway is only possible through collaborative and multidisciplinary work, where the assessment of the community and its members experience plays a crucial role in the adoption and evaluation of a new project or program (European Commission, 1993) (Vermeulen et al., 2014). This approach was used to enhance participation and

transparency through a logically ordered series of actions designed to solve problems previously identified by the involved stakeholders.

The role of the patient in product innovation and development process has been neglected for most of the healthcare industry life cycle (Garrido et al., 2016). However, in the last years, a lot of effort from academia and patient's advocates has been conducted to use the patient as a highly-impact resource in the design of effective products and services in the healthcare sector. The UCD methodologies are validated tools to cope with this lapse and empower patients and their caregivers to be part of this development. In the context of both use cases described in this paper, the two main characteristics (among the others) of this systematic methodology are: (i) the participation of patients, caregivers and the clinical team in the digitization of the outpatient pathway and (ii) the seek of consensus among technology providers, healthcare providers and the patients. Figure 1 illustrates the co-creation framework that was used for this work.

In this section, we briefly describe the three steps that were developed to implement the deployment strategy.

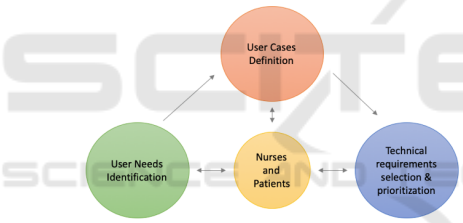

Figure 1: The co-creation framework used for the digital innovation in outpatient healthcare services.

4.1 Step 1: Design the Process *as-is*

We first selected the following tools to collect enough information to report the technical requirements:

1. **Environmental Analysis through Semi-structured Individual Interviews.** With the goal of understanding the context of both home care delivery initiatives, we conducted several interviews to different stakeholders in order to understand their needs and motivations, their relevance and importance in the definition of the outpatient pathway. The main relevant stakeholders identified were: assisted persons (patients), formal caregivers (individuals hired by the assisted persons to provide assistance at home), informal caregivers (patient's relatives), healthcare professionals (nurses and surgeons), healthcare providers (hospitals), technology providers (organizations that develop and provide solutions), technology transfer supporter (organizations/institutions that guarantee that the technological intervention adds value to the healthcare service, satisfies the most relevant needs of the different stakeholders, and is cost-effective). The group profiles were described by identifying the motivations, goals, and benefits with the proposed new system. According to the impact that the solution could have for the each stakeholder, we classified each in terms of importance and influence.
2. **Previous Experience Analysis through Structured Individual Interviews.** For the most relevant stakeholders identified for each of the use-cases, we investigated on previous experiences with technology in their practices (advantages, disadvantages and opportunities). To gather qualitative insights about operational opportunities and constraints, we interviewed different representatives from each stakeholder group about their attitudes, believes and values of the proposed project.
3. **Use Case Scenarios Definition from Visits to the Real Life Context.** To avoid conflicts in design due to lack of accountability of real-life constraints of the system and its actors, the team visited both hospitals, talked to patients and visited some homes. The visit to the hospitals enabled the understanding of the environment in which the healthcare professionals provide care and how the interaction with patients occurs. The visit to patients' homes enabled the understanding of the context of how nurses provide care outside hospital facilities.

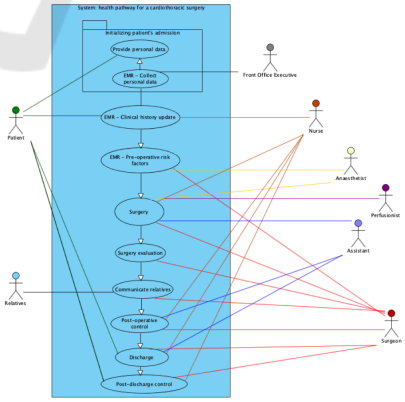

Figure 2: Use Case Diagram to identify, clarify, and organize system requirements.

4. **Process Characterization.** The output from previous steps enabled us to create the model of the current process ("as-is"-model) following existing best-practice solutions (Im et al., 1997). Visual

Paradigm software was used to characterize each step/operation and its dependencies with the rest of the environment. For each operation, information regarding resources, time, cost and clinical constraints was provided by the healthcare provider and its professionals. Through meeting with nurses and surgeons several iterations to the *as-is* model took place until a consensus to the final process was achieved (Figure 3).

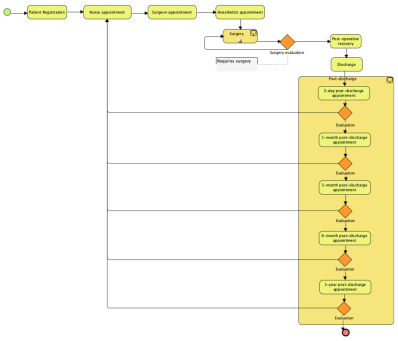

Figure 3: Mapped process of the health pathway of a patient submitted to cardio-thoracic surgery.

4.2 Step 2: Mapping the Process with a Focus on Patient-centered Care

The design of the technological solution to be integrated in both home care delivery initiatives was developed with the contributions from both demand and supply side were involved. To reach a consensus in the prioritization of the needs to be coped by the new system we conducted a focus group with clinical teams. We presented the general process to the stakeholders in individual meetings and identified opportunities to integrate technology that would cope with the experienced needs.

Transforming the perceived and expressed needs into retained and specified needs, we conducted several meeting to negotiate the requirements that could be solved by the service and technology proposed, respect the time and the resources available. The list of requirements was validated by all stakeholders. Five different types of requirements were identified: functional, security, usability and humanity, maintainability and support, and performance. The stakeholders' list and the real needs identified were used to summarize and describe the different scenarios underlying the outpatient pathway (Table 1).

The main focus of the "to-be"-model (Figure 4) was to enhance the performance of home care service by improving the patient engagement and experience, and by informing healthcare professionals with relevant, real-time data on patient's recovery, health status, and quality of life. For this goal, we also worked on the outcomes reports to provide this information in an appropriate format so patients and caregivers get more engaged in the follow-up and recovery process. Reporting design is an important issue related to human-computer interaction that directly affects acceptance and engagement of both patients and healthcare providers.

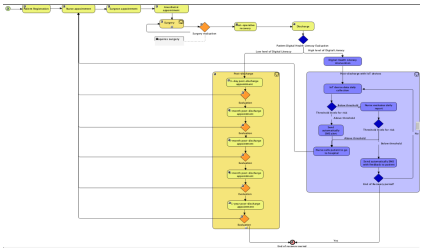

Figure 4: Mapped process of the health pathway of a patient submitted to cardio-thoracic surgery and opportunities to use IoT-based health-related devices.

4.3 Step 3: Deployment of IoT-based Technology to Monitor Outpatient Pathway

The use cases created are being implemented in a pilot to validate the described methodology. In order to be able to test the level of adoption of the "to-be"-model of outpatient, we selected devices with high usability concerns and taking into account the requirements previously defined. A monitoring web platform allows to control users' engagement, operational data-related problems and the outcomes collected by each monitored patient.

The deployment strategy that is being implemented is iterative: we started to monitor a single patient with good level of digital literacy for one month, then incorporated lessons learned and we are now following a group of five randomly selected patients, before widely running the pilot.

In the cardiothoracic surgery use case, at the day of discharge from hospital, patients receive instructions to use the IoT-based kit. For 30 days, the patient is instructed to follow the same procedure every morning: use a mobile app to follow the tasks of weighting, measuring blood pressure, taking a picture of the surgical wound, and answering five questions regarding patient reported outcomes. A report with the collected outcomes from the patient is digitally sent to the clinical team who contacts the patient in case of any abnormality detection.

For the referred first patient, a weekly contact/meeting with nurses and surgeons was followed to refine the process. After 1 month, the patient re-

Table 1: Use Case Scenarios selected for the private Homecare Nurse Service.

Use Case Scenarios List	
Title	Description
Daily activity monitoring	Nurse needs to monitor activities of the person's daily living, such as walking speed, mobility function, number of falls and/or risk of fall, fine motor control, measure hand grip strength, calligraphy assessment, ability to speak, and speech articulation. The nurse evaluates these outcomes when he/she visits the patient. In order to have a more accurate evaluation of the outcomes, the nurse asks each stakeholder (informal and/or formal caregiver and patient) this information, at different times throughout the clinical appointment. Patients usually do not have the right perception of their level of mobility function or risk of fall.
Health parameter monitoring	Caregivers and patients are told to register daily different health parameters: blood pressure, pulse/heart rate, temperature, pain level, weight, glycaemia and skin status for prevention and follow-up of disease complications. When nurse visits the patient, he/she asks for the records registered by the informal/formal caregivers and repeats the record of the patients' health parameters to validate. When appropriate, the nurse also takes a picture of the wound status to have a better perception of the wound recovery progression.
Notification of abnormal situation	Formal and informal caregivers notice an abnormal activity, including health parameters monitored that are outside of normal range and low activity perceived. They contact nurses and report the situation. When this happens the Nurse-Chief makes more questions to better understand the situation and allocates an urgent visit from a nurse to the patient's house.

turned to the hospital and delivered the equipment. System Usability Scale (Martins et al., 2015) and semi-structured interviews to the patient and nurses were used to test acceptance and optimize the outcomes reporting tools.

5 DISCUSSION AND CONCLUSIONS

In this paper, we propose a methodology to design outpatient healthcare services, by deployment of IoT technologies. Due to increasing Elderly population demands in the Healthcare systems and the increased treatment options, the sustainability of Healthcare is threatened in the advanced economies. Digital innovation brings opportunities to empower patients to actively participate in the process of care, to engage in the process of collecting and reporting outcomes, in order to prevent healthcare complications that represent a burden to the Health systems. These opportunities are being exploited in various studies focused either in technology development and clinical services (Acheampong and Vimarlund, 2016).

The methodology that we present is based on UCD and takes into account the real-time implementation of digital innovation, i.e. a new process is mapped to be successfully integrated in the existent running process. This work compares with other recently published studies (e.g. (Hobson et al., 2018) (Backman et al., 2018), in the way that the methodology presented brings an innovative perspective process mapping and service design that is centered on the patient and its outcomes collection points and not on hospital resources or technology design. This patient-outcomes perspective aims at developing tools to implement value-based healthcare frameworks considering the real-life challenges.

The two use-cases described are actually running. Results from the pilots will be published in future work. Costs driven from this digital innovation will be integrated in the overall outcomes analysis, as an important part for the study of scaling-up requirements.

ACKNOWLEDGEMENTS

The devices and 4G transmission for the pilot in Hospital de Santa Marta (Lisbon, Portugal) was supported by Fraunhofer Portugal and Vodafone Portugal. The pilot in the CUF Infante Santo hospital (Lisbon, Portugal) was supported by EU project H2020 ACTIVAGE ID732679.

REFERENCES

Acheampong, F. and Vimarlund, V. (2016). Innovating healthcare through remote monitoring: Effects and business model. *International Journal of Information System Modeling and Design (IJISMD)*, 7(1):49–66.

Åkerman, C. and Stowell, C. (2015). Measuring outcomes: the key to value-based health care. *Harvard Business Webinar*.

Årsand, E., Tufano, J. T., Ralston, J. D., and Hjortdahl, P. (2008). Designing mobile dietary management support technologies for people with diabetes. *Journal of telemedicine and telecare*, 14(7):329–332.

Backman, C., Harley, A., Peyton, L., Kuziemsky, C., Mercer, J., Monahan, M. A., Schmidt, S., Singh, H., and Gravelle, D. (2018). Development of a path to home mobile app for the geriatric rehabilitation program at bruyère continuing care: Protocol for user-centered design and feasibility testing studies. *JMIR research protocols*, 7(9):e11031.

Dabbs, A. D. V., Myers, B. A., Mc Curry, K. R., Dunbar-Jacob, J., Hawkins, R. P., Begey, A., and Dew, M. A. (2009). User-centered design and interactive health technologies for patients. *Computers, informatics, nursing: CIN*, 27(3):175.

European Commission, E. (1993). Cycle Management: Integrated approach and logical framework. Technical report, European Commission, Brussels.

Garavand, A., Mohseni, M., Asadi, H., Etemadi, M., Moradi-Joo, M., and Moosavi, A. (2016). Factors influencing the adoption of health information technologies: a systematic review. *Electronic physician*, 8(8):2713.

Garrido, T., Raymond, B., and Wheatley, B. (2016). Lessons from more than a decade in patient portals. *Health Affairs Blog*, 2016.

Gulliksen, J., Göransson, B., Boivie, I., Blomkvist, S., Persson, J., and Åsa Cajander (2003). Key principles for user-centred systems design. *Behaviour & Information Technology*, 22(6):397–409.

Hobson, E. V., Baird, W. O., Partridge, R., Cooper, C. L., Mawson, S., Quinn, A., Shaw, P. J., Walsh, T., Wolstenholme, D., and Mcdermott, C. J. (2018). The tim system: developing a novel telehealth service to improve access to specialist care in motor neurone disease using user-centered design. *Amyotrophic Lateral Sclerosis and Frontotemporal Degeneration*, 19(5-6):351–361.

Im, I., El Sawy, O., and Hars, A. (1997). Business process reengineering: Do software tools matter.

Kostkova, P. (2015). Grand challenges in digital health. *Frontiers in Public Health*, 3:134.

Krämer, J. and Schreyögg, J. (2019). Demand-side determinants of rising hospital admissions in germany: the role of ageing. *The European Journal of Health Economics*, pages 1–14.

Martins, A. I., Rosa, A. F., Queirós, A., Silva, A., and Rocha, N. P. (2015). European portuguese validation of the system usability scale (sus). *Procedia Computer Science*, 67:293–300.

Safi, S., Thiessen, T., and Schmailzl, K. J. (2018). Acceptance and resistance of new digital technologies in medicine: Qualitative study. *JMIR Res Protoc*, 7(12):e11072.

Spanakis, E. G., Santana, S., Tsiknakis, M., Marias, K., Sakkalis, V., Teixeira, A., Janssen, J. H., de Jong, H., and Tziraki, C. (2016). Technology-based innovations to foster personalized healthy lifestyles and well-being: A targeted review. *J Med Internet Res*, 18(6):e128.

Vermeulen, J., Verwey, R., Hochstenbach, L. M., van der Weegen, S., Man, Y. P., and de Witte, L. P. (2014). Experiences of multidisciplinary development team members during user-centered design of telecare products and services: A qualitative study. *J Med Internet Res*, 16(5):e124.

Yin, R. K. (1994). Discovering the future of the case study. method in evaluation research. *Evaluation practice*, 15(3):283–290.