

# Three Living Labs in Denmark: Challenges with Co-design and Implementation of Health IT

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## Abstract

*Living labs are increasingly used as an approach for facilitating innovation and testing emerging information technologies. In this paper we analyse three large-scale technology design projects in Danish healthcare where co-design and implementation activities were organised in living labs. We describe some of the critical challenges that we experienced from transitioning technology prototypes and co-design activities into becoming part of the daily lives of patients, citizens and healthcare practitioners. The main challenges relate to creating and sustaining new work practices, scaling the number of participants, and facilitating the transition between everyday life and living lab behaviour.*

## Keywords:

Living lab, Co-design, Implementation, Health information technology, Innovation.

## Introduction

Information Technology (IT) offers continuously new opportunities for supporting health and has been pointed out as a driver for healthcare innovation [1]. However, the socio-technical aspects of healthcare systems are complex, and research stresses the importance of engaging key actors in the co-design and implementation of future technology to bridge knowledge gaps in requirements analysis and design for functional support and quality in use [2]. Living laboratories, in short living labs, is an increasingly used approach for facilitating co-design of emerging health technology across multiple actors including engineers, researchers and end-users. Living labs are technological installations set-up in (semi) naturalistic settings over a medium- or long-term period providing an infrastructure for transitioning design to implementation. As such, living labs complement usability labs, which have been proven successful for quick findings of many usability issues but often miss aspects related to in-situ use of the technology [3; 4]. Living labs offer a way for exploring and continuing design along with implementation in cooperation with future users [5]. This focus on continued co-design goes hand in hand with a new wave of studies and

critical voices that suggest considering ‘success’ in technology co-design projects to be more focused on the post-project impact among users and participating stakeholders like software companies, funding agencies and the wider society [6]. However, integrating co-design of future health technology in living environments for health care is a complex intervention and a fundamental challenge for the design and innovation community. Yet, as highlighted by Bygholm and Kanstrup [7] the living lab literature is in general characterised by prescriptive examples with limited insights and reflections on challenges for setting up and managing living labs to meet the intentions of long-term participatory technology innovation. Examples of reported challenges are motivation of users during the lab period [8], facilitating innovations among various stakeholders [9], and the importance of maturing the technical set-up [8].

In this paper we analyse some of the major challenges that we have encountered first-hand as researchers in three large-scale health IT design projects where co-design activities were organised in living labs. The remaining of this paper provides first, background on co-design in living environments. Second, we present the three living labs and their challenges. Third, we conclude on core challenges across the three cases and consider perspectives for research in co-design and implementation in living health environments.

## Co-design in Living Environments

The attention on moving design activities into use settings to bridge the gap between technology innovation and use practice is not entirely new but found as a key methodologically focus in studies that aim at diffusion and adoption of innovation [10, 11]. However, as presented by [12] co-design research is predominantly focused on early stages of requirements analysis also known as ‘the fuzzy front end of design’ because of the initial unclear conceptual understanding of the product being developed. Living labs offer an attention for organising long-term participation around design, development, implementation and use. However, the approach is unclear, or diverse. As stated by Bannon and Ehn [13], examinations of what actually goes on in living labs are scarce.

Hence, research on co-design and implementation in living labs is relevant.

The use of the term living lab is broad and makes the concept difficult to grasp. Some living labs aim to be real world test beds setting up a “wireless playground” for “ordinary people on the street” like in the European OPIUM networks of living labs [14] or in small rural villages like Wray Living Lab [15]. Other living labs are controlled environments set-up in test centres furnished like a “real home” and inhabited by volunteer participants in the AwareHome at Georgia Tech [16] and the PlaceLab at MIT [17]. Yet other labs are a mix of naturalistic environments and controlled set-ups in family homes like the SMEDL lab [8] and local stores in a city like Living Lab Skagen [18]. Methodological concerns in the living lab literature are often related to the dilemmas of how artificial to make the naturalistic setting – how to find the balance between controlled research and keeping sense of the real-life practice [8]. Open innovation is an often-used term [9, 19] presenting the ideals of living labs as platforms facilitating innovative co-operation among stakeholders. In the naturalistic end of the scale, labs present the aim of making an e-Infrastructure that facilitate citizens’ participation as the central objective and challenge of living labs [14]. In contrast, artificial labs present the opportunity for detailed documentation and systematic test of technological installations as the core objective [16, 17]. Mixed labs are occupied with setting the stage for co-operations among designers and users [8, 18]. Data collection in living labs often includes a mix of unobtrusive and obtrusive methods like data-logs, observations, users’ self-documentation, interviews, and workshops [20]. Only few living lab studies goes at length in describing how the innovation is facilitated and the challenges that arise with regards to e.g. long-term user involvement [8].

### Three Living Labs in Danish Healthcare

To detail our understanding of co-design and implementation in living labs for future health IT we analyse three living labs with attention on identifying core challenges within and across the cases.

#### Lab 1: Technology supported senior networks

In a first living lab, the aim is to support and create new networks between senior citizens based on ideas of sharing and helping each other. The living lab is part of a project Give&Take (2014-2017) (<http://givetake.eu>) developed in the framework of a European project with partners in Denmark, Portugal and Austria. The aim was to co-design digital mediated sharing within senior communities (e.g. IT-volunteers from the library, or a walking group). The platform developed in the project allows senior citizens to reciprocally exchange services and resources. The platform is designed to support existing and often loosely coupled communities in order to strengthen and sustain. At the same time the idea is that the communities through the platform stays connected to a ‘coordinator’ like a health counsellor, social worker or the like who initiated or helped establish the community, who can then remotely follow the group (after the

initiation) on the platform and here inspire the group with other offers and possible activities - and only reach out with a helping hand when needed. The platform is for vulnerable communities that need support for networking. It was developed during the project’s first year, based on the outcome of a series of dialogue meetings and later workshops. Here 50-60 senior citizens and employees working with senior communities explored together with researchers, the municipality and private partners what sharing is in senior communities and how it could be supported by a digital platform.

Around nine small living labs were established after the co-design workshops, where a finished trial version of the platform was tried out to explore whether and how it could support and optimise sharing and exchange among members of a senior community. The Living labs were established by creating arrangement with different senior communities and the connected institutions (municipality) or organisations (e.g. DanAge). It was communities like a walking group, a group of IT volunteers, and a food club for men. The third living lab lasted throughout the last part of the project, while the rest only ran for a couple of months. Researchers and municipality representatives took part in the communities’ activities – in some of the communities on a weekly basis for 4-5 months – to observe the communities as well as to introduce the technology and create small experiments for the exploration of the technology. The living labs became a space for rehearsing new practices both for the citizens in the communities and for the ‘coordinators’ from the municipalities, etc. [21] – and the aim was to make this practice viable and sustainable after the end of the project. This became challenging especially in relation to the coordinators.

One thing was to try out and evaluate the digital platform in the living lab, but the rehearsals of new practices turned out to be very challenging especially in the transition from ‘rehearsing new practices’ to ‘make the new practices viable and sustainable’ beyond the project and the engagement of the researchers. The researchers realised that their participation in the community was not just researchers intervening and observing the group’s use of the platform. Their participation became a rehearsing of the coordinator’s new practices. The introduction to and support with the platform - and the interaction with the community through the platform were all different ways of trying out what the coordinator role could be like and what would be required of the coordinator in relation to creating a community supported by a digital sharing platform. Though, the researchers’ number of hours of presence in the meetings, home visits and on the platform was not realistic and ideal for a coordinator. Especially due to the idea that the digital platform should support self-organising groups – coordinators were only meant to remotely follow the group and only reach out with a helping hand when needed.

The question the project wanted to explore was how the platform could be valuable in the ‘coordinators’ daily work? What kind of support and what kind of functions on the platform and information (or data) would they need? Though, the initial part of introducing the platform, etc. took a great amount of time. It was necessary for the implementation, but it made difficult to explore these questions. After the project

and the researchers left the living labs, 2-3 of the communities continued using the platform. In one of the cases, the coordinator also continued to a lesser degree. Without the framing of project, it was no longer an articulated part of the coordinators' work. At the same time, the platform was not robust enough to be sold to the municipalities, social housing associations, etc. - it required further development. The platform is therefore not available to new communities (if the coordinators would like to share it), while at the same time the existing communities cannot get IT support from either a 'Give&Take team' or the coordinators. The aim of creating viable and sustainable practices becomes difficult especially when the mediating platform is still unstable and the organisations are not committed to it (after the project), which raises question on how to navigate in these living labs with new technology and practices when the aim is to support social aspects (to create new or stronger communities), if one or more of the actors that take part in mediating the social practice are uncertain or unstable.

Summing up, central challenges in the Living Lab 1 was:

- Challenges with transition: The process from rehearsing to real-life practice was difficult and unclear since the living lab is only a minor part of the coordinators work and the practices were not merged with or adapted to the existing practices of e.g. the Health centre.
- Challenges with resources: Lack of time and resources after the project ended made it difficult to sustain the new digital (and social) practices.
- Challenges with commitment: Commitment from all partners to engage in the temporary practice in the Living Lab was a challenge. The ambition that citizens adapt to the new practice is difficult when the other partners only commit to the practice within the timeframe of the living lab.

## Lab 2: e-Health for Heart Patients

In a second living lab, the aim is to improve remote communication between patients with an advanced pacemaker and clinicians. The living lab is part of a large R&D project called SCAUT (<http://scaut.dk>) that runs from 2014-2018, supported by the Innovation Fund Denmark (#72-2014-1) with a consortium of two industry and two public partners including The Heart Centre at Rigshospitalet in Copenhagen Denmark. The project began with IT design researchers doing fieldwork studies and co-design activities in the clinic and in patients' homes. Six months into the project, a first prototype of a patient mobile app and a web application for clinicians was developed and deployed among 20 cardiac device patients who were invited to take part in the living lab. The patients could use the app to record symptoms and describe their context in audio while clinicians at the Heart Centre could use the patient-generated data for decision-making and for providing feedback to patients. Satisfaction was quite high among patients, since it supported better contact with the clinic than without the app. Many patients explained that it made them feel safer and more informed. The

clinicians, on the other hand, were at times dissatisfied due to some features, such as a symptom diary, introduced more work [22]. Nurses and bio technicians explained that although the system supported provision of better care it also generated new accountabilities and tasks that there was no time for. And since the prototype was only used in follow-ups with 20 patients, and not the 3.500 cardiac device patients at the Heart Centre, it became a general concern that the system could not scale. For the prototype to work, the design researchers now had to focus on re-designing the functionality so that it provided value for patients and clinicians at the same time [22]. The question was therefore: How to adapt the prototype so that it could become useful for the actual, large-scale remote monitoring work? To answer this question, the design researchers decided to do two things: Increase the efforts in re-designing the features that were not adding value in the clinic and increase the number of participating patients to ensure evaluation against real-life, large-scale remote monitoring work.

Over the course of two years, the design researchers succeeded to onboard more than 200 patients and a total of nine clinicians as well as adapting the prototype to become more useful for clinicians. The scaling up of user involvement and co-design in the living lab was, although, a very difficult undertaking: Small technical issues for a few users are now large critical issues for many users; A few good ideas and design inputs for changes in the prototype are now hundreds of ideas and inputs for adaption; High user engagement is now high, medium or no user engagement; Good personal relations with a few users is now good, little or no personal contact with many users.

Technical/practical issues as well as design issues multiply and increase when scaling up. For example, it became a time-consuming task in itself to support patients in understanding and using the prototype. Other important tasks that arose was keeping track of and reporting back to participants as well as coordinating when and how to contact them. The ability to remember and differentiate among participants, their expectations, and the degree to which they wish to engage became an issue. More time was needed to monitor use of the system along with reaching out over the telephone to users and non-users to learn about the reasons and discuss ways for improvement.

Summing up, central challenges in the Living Lab 2 was:

- Challenges with scaling: The co-design with 200 users was difficult and identified a need for resources and approaches for co-design in large scale living labs.
- Challenges with technical issues: Small technical problems for a few users became large-scale technical issues for the 200 users and required strong focus on a mature and reliable prototype.
- Challenges with practical issues: Practical tasks like coordinating user communication, keeping track of users and the use etc. became a central (underestimated) task in the living lab.

### Lab 3: Welfare Technology in Nursing Homes

LabX was the overall name for an umbrella of living labs set up in North Denmark to explore living labs for innovation of healthcare technologies in the care of elderly, chronically ill and handicapped persons. The project was supported by the European Regional Development Fund and the overall goal was to foster collaboration between municipalities, industry and knowledge institutions in order to stimulate economic growth for the industrial partners, achieve efficiency and cost reduction in the public sector and better serve the citizen. Six municipalities and eleven small- and medium-sized technology enterprises participated in the project together with a number of nursing homes, a university college, a vocational education, and researchers from Aalborg University. Thirteen living labs were initiated but only eight living labs were succeeded on a basis where data quality allowed for analysis. A variety of technologies were explored. Some technologies were aimed at staff only, but most technology were intended to support both residents and staff. Technology included digital fences based on sensors and Bluetooth bracelets to sound alarms of residents left the nursing home. Bluetooth bracelets with accelerometers to send alarms if residents have a fall. Sensor screens to stimulate residents via digital art. Automatic toilets, intelligent beds, intelligent laundry based on RFID chips, a machine to help residents into and out of compression stockings. Seven of the eight nursing homes were intended for elderly people and one was for young adults with physical disabilities. In all cases living labs were set up for a three-month period beginning with a contract between participating nursing homes and technology enterprises regarding the purpose of the lab.

The living labs started with the technical installation and short training of super-users, i.e. selected staff trained to use the technology and record data. A living lab coordinator visited the labs on a frequent basis to collect data and support the coordination of activity. However, the initial idea was to install the technology and then observe the use. This approach resulted in a low use of co-design methods facilitating interaction among the various stakeholders in the living labs. Instead data collection was based on individual interviews and observations with staff, management, municipality and residents. Only in one lab a co-design workshop was organised. The participation of the nursing home residents was limited.

The ambition to set-up a living lab and then observe the lived life with the new technology was based on the assumption that a living lab (in contrast to a simulation or usability lab) is close to a naturalistic environment because of the long-term installation and use in a living environment. However, though the labs lasted for three months the results repeat existing concerns from the living lab literature on missing long-term perspectives – start-up-problems continued throughout the labs with only one exception. An example is the living lab with the intelligent beds, which started with a massive amount of alarms send from the beds. Alarms make a high sound in the hallways. As described by the care workers in interviews this was ‘very disturbing’ and the beds were all turned off within the first 24 hours. After a couple of weeks

where the producer worked with the technical installation the beds were re-installed and used for three months. However, problems with false alarms and missing alarms continued due to a weak technical infrastructure between the beds and the nursing home’s existing network. Some alarms reached the mobile phones of the care workers, and some alarms did not. The technical problems moved attention from daily living in the lab. As expressed by the manager: ‘It is frustrating because I thought that the focus was different, to use the bed in our care, and then the bed was not in focus at all, it was the alarms and the paging system that got all attention’. Similar technical problems stealing the attention from the ‘real-life’ was observed in other labs [23].

A consequence of assuming that living labs are close to real life living is the assumption that life in living labs is business as usual – technology can be installed and life can continue as usual and likewise, technology can be removed after three months and life can continue as before. Assuming business as usual means to assume that people who live and work in labs know what to do, i.e. that they are familiar with the environment (since it is their daily environment) and know how to do their daily tasks (as usual). However, in these labs the roles and activities were mostly unclear to most of the participants. Are care assistants and residents allowed to unplug technology if it keeps firing alarms? In other words, are care workers testers who must work with and report errors? Are they innovators who must come-up with solutions and engage in technology development? Or are they simply expected to behave as care workers and residents and do business as usual? In general, the labs identified a need to define lab behaviour

Summing up, central challenges in the Living Lab 3 was:

- Challenges with participation: The interaction between the multiple stakeholders in the living labs was low and mostly non-existing and the participation of the elderly users was very limited. This identified that co-design activities need to be methodological designed as part of a living lab set-up.
- Challenges with exploring the real-life: Technical problems were stealing resources and attention throughout most of the living labs and identified a need to define and develop approaches for innovation in real-life health settings.
- Challenges with lab behaviour: unclear roles and lab behaviour caused conflicts and misunderstandings and identified a need to define roles, tasks and scripts for living lab.

### Conclusion

In this paper, we have analysed and identified nine challenges within three health IT living labs in Denmark; Transition, resources, commitment, scale, technical issues, practical issues, participation, real-life and lab behaviour. Each of these challenges are interrelated. In lab 1, the transitioning from design to implementation and use was very challenging since it hinges on organisational commitment and securing re-

sources for continuing stabilisation of the IT platform after the living lab. In lab 2, large-scale user participation accentuated the technical issues and practical issues in the ability to facilitate transition from design to use – technical and practical issues affected the lab participants commitment and experience. In lab 3, the tension between real-life and lab behaviour became a challenge, primarily due to unclear roles and little interaction among stakeholders. Thus, a general conclusion from the analysis is, that examinations of living lab challenges are needed to further advance approaches for health IT innovation in living environments. An examination of the challenges across the three examined living labs in this paper indicate that the living lab approach is indeed a socio-technical challenge calling attention to the need to facilitate the complex interrelation between technology, humans, organisational structure and tasks when innovating new technology supported health practices [24].

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