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TITLE: Living Labs' roles in digital health innovation – an empirical study on Norwegian Living Labs and start-ups

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Abstract

The purpose of this master thesis is to clarify the roles of Living Labs and means of collaboration with companies in the digital health context. Interviews with three Living Labs and seven start-ups were organized to develop an in-depth understanding of this phenomenon from the perspective of both parties. Specific attention was paid to their practices and methods of user involvement for developing digital solutions.

Our findings have confirmed the Living Lab's role as a facilitator and its importance in the innovation system for integrating and orchestrating the network of players, including public sectors, institutes, companies, organizations, healthcare professionals and patients, etc. This study has also confirmed the user inclusion during the innovation process within both Living Labs and start-ups, although the actual practices and methods vary. However, the diversity of theory and practices have resulted in an intricate and scatted landscape for the systemic Living Lab research. The findings show the late engagement between Living Labs and start-ups during the innovation process, which could be an area for future improvement.

We suggest that both Living Labs and start-ups establish the earlier and more robust connection to utilize the potential from collaboration fully, and further studies on this topic are essential as well. There is still a big gap for users to become co-creators in the innovation process. More studies on the methods and tools for effective user involvement and co-creation are required. Future research could consider some combined research methods to generate data from a larger group of innovators/players or conduct some long-term research to evaluate the impact of collaborative actions on the innovation outcome.

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4Ps	Public-private-people partnerships
CSR	Corporate Social Responsibility
DPIA	Data Privacy Impact Assessment
ENoLL	European Network of Living Labs
EU	European Union
GDPR	General Data Protection Regulation
HVL	Western Norway University of Applied Sciences
ICT	Information and communications technology
IP	Intellectual Property
IT	Information technology
NDE	Norwegian Directorate of e-Health
NHN	Norwegian Health Network
NSCC	Norwegian Smart Care Cluster
NSCL	Norwegian Smart Care Lab
NTNU	Norwegian University of Science and Technology
R&D	Research & Development
RCN	Research Council of Norway
RI	Responsible Innovation
RRI	Responsible Research and Innovation
SIVA	Industrial Development Corporation of Norway
SMEs	Small and mid-size enterprises
SSHF	Hospital of Southern Norway
TEP	Test and experimentation platforms
TTO	Technology Transfer Office
UiA	University of Agder
UiS	University of Stavanger
UiT	The University of Tromsø
VR	Virtual Reality

1. Introduction

Globalization has made this world more connected than ever. Technological development is the result of innovation, and on the other hand, is the fundamental driver of change. Organizations and companies have been shifting away from the traditional way of 'self-reliance' innovation model to the open innovation model with extensive collaborations and interactions with external experts during the innovation process (Chesbrough, 2003a; Chesbrough & Appleyard, 2007; Chesbrough & Crowther, 2006; Koza & Lewin, 2000; Pénin, Hussler, & Burger-Helmchen, 2011). The mobility of knowledge increases rapidly. Organizations and companies must have the 'dynamic ability' to integrate their expertise in the changing environment (Lichtenthaler & Lichtenthaler, 2009), and establish a 'broader inclusion' of players in the arena (Adner, 2006, 2017; Adner & Kapoor, 2010; Bessant, Iakovleva, & Oftedal, 2019b).

The Living Lab concept is growing beyond the research territory and small sectors to a more sophisticated 'socio-spatial' milieu (Marsh, Molinari, & Trapani, 2013; Puerari et al., 2018). The Living lab as one newer phenomenon in innovation has gained popularity with organizations. We see a wider variety of Living Labs in different fields. Researchers have been striving to identify the relationship of components inside the Living Lab network, strategies, practices (Leminen, 2015; Leminen, Mika, & Nyström, 2014; Leminen, Nyström, Westerlund, & Kortelainen, 2016; Leminen & Westerlund, 2014, 2017; Leminen, Westerlund, & Nyström, 2012; Mulder, 2012; Mulder & Stappers, 2009; van Geenhuizen, 2018; Westerlund, Leminen, & Habib, 2018), and effective methodologies for fostering innovation via Living Lab approaches (Georges, Schuurman, Baccarne, & Coorevits, 2015; Mulder, 2012; Mulder & Stappers, 2009; Ståhlbröst, 2008).

Researchers have proposed to view Living Labs as a dynamic concept that incorporates different dimensions like methodology, system, environment, organization, and extend from the current research context to the 'social-spatial' settings (Bergvall-Kareborn & Stahlbrost, 2009; Puerari et al., 2018). Responsible Research and Innovation (RRI) has also offered principles to ensure sufficient integration of the societal values throughout the innovation process (Iakovleva, Oftedal, & Bessant, 2019a; Oftedal & Foss, 2019; Stilgoe, Owen, & Macnaghten, 2013; Von Schomberg, 2012). Studies have extended from confirming the importance of including stakeholders to the exploration of the more profound understanding of

users, ways of engagement, and their effectiveness (Iakovleva, Oftedal, & Bessant, 2019b; Oftedal, Iakovleva, & Bessant, 2019; Pedro, Salomé, & Helena, 2019). And, companies turn to Living Labs for engaging users and other players into the development of digital solutions (Elizabeth et al., 2019; Kanstrup, Bjerge, & Kristensen, 2010; Mulder, 2012; Nishdia, Kitamura, Yamamoto, Takahashi, & Mizoguchi, 2017; Santonen & Julin, 2018a, 2018b, 2019; Vaziri et al., 2016; Wu et al., 2014).

This Living Lab approach is especially popular with start-ups and small and mid-size enterprises (SMEs) who generally have resource constraints and needs for the indication of products' business potential before launch (Eriksson, Niitamo, Kulkki, & Hribernik, 2006). Prior studies show that it can stimulate open innovation, multi-player collaboration, user contribution in start-ups and SMEs; it also speeds up the innovation process and scale-up in the market (Niitamo, Westerlund, & Leminen, 2012; Schuurman, De Marez, & Ballon, 2016).

In the context of the healthcare industry, digital technology is considered as the future solution for improving the quality and efficiency of this patient-centered innovation process (Bessant et al., 2019b). The Norwegian government has its plan for building an 'innovative and sustainable Norway' (Regjeringen, 2008, 2011), with e-health as one fundamental approach for steering the collaboration among the public authorities, institutes, health providers, technology providers, individuals, etc. (eHelse, 2016).

However, there is a call for more theoretical and empirical Living Lab research development (Greve, 2020). Prior literature has been stressing on the importance of Living Labs (Ballon, Pierson, & Delaere, 2005; Følstad, 2008; Leminen et al., 2016; Leminen, Westerlund, & Nyström, 2012; Niitamo, Kulkki, Eriksson, & Hribernik, 2006), but not enough on the methods and tools used (Leminen & Westerlund, 2017; Ståhlbröst, 2008). Studies focused on the 'what' questions but did not explain much on the 'how' part (Leminen, 2015; Leminen et al., 2016; Schuurman, De Marez, & Ballon, 2015). When we look at the healthcare industry, particularly the need for more theoretical and empirical studies is even stronger.

This thesis attempts to address some gaps in Living Lab studies with research conducted in the Norwegian digital health context. We approach Living Labs and start-ups, aiming to test and evaluate some Living Lab assumptions from earlier studies and clarify the current models of collaboration and methods inside Living Labs in the Norwegian digital health industry. By presenting our findings, we hope to contribute to both theoretical and empirical research of the Living Lab concept, as well as some insights on the Norwegian Living Lab development.

1.1 Research Questions

We begin with the main research question: what is the Living Lab's role in the collaboration within the innovation system of digital health? We aim to clarify the conceptualization of Living Lab as a boundary space for innovation through theoretical and empirical investigations. We first explore the literature and identify some common conceptions regarding the Living Lab's origin, definitions, types, characteristics, with a critical review of its literature development.

We proceed further into Living Labs' actual work, by asking the 'why' and 'how' questions to unfold more in-depth knowledge about this phenomenon. Here are the three sub-questions that we intend to clarify with this study:

1. How do Living Labs collaborate with companies like start-ups?
2. How do start-ups engage with users in Living Labs?
3. How do Living Labs facilitate user involvement for innovation?

Answering these questions helps us to develop an understanding of the design and structure for Living Labs' activities, the collaboration models and the underlying components influencing them. The basic idea is to identify the methodologies and basis for evaluating the findings. With the empirical data, we inspect Living Labs' patterns of interaction and collaboration for innovation with start-ups, users' roles during this innovation process, and the approach for user involvement from real experiences. We investigate the degree of user involvement in Living Labs, also check whether and how they carry out the 'user-centric' and 'co-creation' approaches as the literature suggests (Eriksson et al., 2006; Westerlund & Leminen, 2011), as well as Living Labs themselves promote.

Meanwhile, we approach from the start-ups' perspectives on their innovation journey in the field. We explore start-ups' collaboration with Living Labs: what, why, when (at which stage of innovation), and how. We investigate their experiences of innovation development with the help of Living Labs, as well as their perceptions of Living Labs' facilitation. By viewing the innovation process a whole, we pursue to shed more light on start-ups' work outside Living Labs, trying to get insights about their experiences beyond the Living Lab engagement. We measure the direct and indirect influence on start-ups from Living Labs, in terms of the support in product/service development, facilitation of user involvement, and innovation network

building. The information could be useful to reflect the effectiveness of collaboration between Living Labs and start-ups.

By putting the pieces of puzzles together, we attempt to map out a bigger picture of things happening within Living Labs. We hope this information can contribute to the currently underdeveloped studies on Living Labs, for example, the collaboration between Living Labs and start-ups, the status and methods of user involvement in Living Labs, and assist in verifying claims about the benefits of using Living Labs for companies (Følstad, 2008; Niitamo et al., 2012).

1.2 Structure of the Thesis

This master thesis consists of six sections with the associated subsections. We start with an introduction to the research questions, followed by the theoretical framework. We describe the context of this study before moving to the methodology section, where we explain the research design, data collection, and analysis. After that, we present the empirical findings with explanations to answer the research questions. We then proceed to the discussion section to compare against the theories found earlier and conclude our results with some theoretical and practical implications.

2. Theoretical Framework

2.1.1 What is Living Lab?

'Living Lab' is a relatively new concept that appeared in recent decades. There are various definitions of Living Labs, which have led to numerous discussions among researchers (Leminen, 2015; Leminen et al., 2016; Schuurman et al., 2015). Leminen (2015) calls it a 'buzzword in the innovation domain' since there is no such single widely accepted definition of the Living Lab. Westerlund and Leminen (2014) list words used to describe a Living Lab: innovation system, regional system, ecosystem, network, a combined approach, develop a project, methodology, environment, and so on.

One definition of the Living Lab from the earlier researchers Eriksson, Niitamo, and Kulkki (2005) is: "an R&D methodology where innovations, such as services, products or application enhancements, are created and validated in collaborative multi-contextual empirical real-world environments" (p. 5). Users are not merely testing objects but essential sources of innovation to include in the innovation process. This human-centered view brings the societal factors into the technological development, and such an integration of knowledge and experience improves the magnitude of innovation (Eriksson et al., 2005; Eriksson et al., 2006).

The European Commission project CoreLabs (2007) states the Living Lab as "a system enabling people, users/buyers of services and products, to take active roles as contributors and co-creators in the research, development and innovation process" (p. 9). They emphasize that a Living Lab's primary role is to engage and empower users during the process of value creation towards common objectives with its partners and customers.

Westerlund and Leminen (2011) describe Living Labs as:

> Physical regions or virtual realities, or interaction spaces, in which stakeholders from public-private-people partnerships (4Ps) of companies, public agencies, universities, users, and other stakeholders, all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts. (p. 20)

Leminen, Westerlund, and Nyström (2012) call the Living Lab: "a network that integrates both user-centered research and open innovation" (p. 6). The Living Lab focuses on collaboration among stakeholders through integrated research. Participants work jointly from the early idea stage to product prototyping, testing and then validating phases, which shows a much closer tie and deeper involvement compared to the traditional innovation process (Leminen et al., 2016; Leminen, Westerlund, & Nyström, 2012; Rits et al., 2015).

In the absence of a single definition (Almirall Mezquita, 2009; Bergvall-Kareborn & Stahlbrost, 2009; Leminen, 2015), there is a wide range of Living Labs and associated methodologies developed by various studies (Leminen, 2015; Leminen et al., 2016; Leminen, Westerlund, & Nyström, 2012; Schuurman, De Moor, De Marez, & Evens, 2011). Different Living Labs initiatives employ different parts of the meanings, develop varying infrastructures and activities, subsequently apply different methods (Følstad, 2008).

2.1.2 The Origins and Development of the Concepts

To understand the theoretical development of the Living Lab concepts, we reviewed the history and previous works of researchers. Back in the early 1990s, Professor Bajgier and his colleagues at the Drexel University and the University of North Texas of the USA introduced this 'Living Laboratory' concept. Students joined real-world projects in the city neighborhood, as a part of the 'learning-through-doing' exercise (Bajgier, Maragah, Saccucci, Verzilli, & Prybutok, 1991). Professor William Mitchell implemented the concept with a 'user-centric' method in his project in the Massachusetts Institute of Technology. People were invited to live in the future homes for several days for researchers to monitor and validate their use of home technologies. The emphasis on 'real-life' setting attracted attention (Dutilleul, Birrer, & Mensink, 2010; Eriksson et al., 2005; Leminen, Westerlund, & Nyström, 2012).

The development of Living Labs in Europe has progressed rapidly since the 21st century. Markopoulos and Rauterberg (2000) coined the term 'LivingLab', an infrastructure for collaborative research on future home technology in an 'ecologically valid' method, with future computer technology playing an important role. The study also gradually expanded beyond the future home field to others.

Many early studies are related to the industry of Information and communications technology (ICT), due to the flourishing IT sector at the beginning of this millennium (Ballon et al., 2005; Eriksson et al., 2005; Følstad, 2008; Niitamo et al., 2006). Ballon et al. (2005) introduce the framework of 'test and experimentation platforms' (TEPs), a systematic establishment for taking technology to the market through 'joint innovation'. There are six concept categories, namely prototyping platforms, testbeds, field trials, living labs, market pilots and societal pilots. Each has different characteristics. Ballon et al. (2005) examine 18 innovation cases in Europe by matching them with the six categories, using the Living Lab as a separate category, which is an 'experimentation environment' for developing technologies in real-life contexts and including (end) users as 'co-producers'. Living Labs are described as one key new concept for the open innovation platform, with early engagement of users that helps to generate 'context-specific' insights and understandings of the potential economic and societal impacts brought by innovation (Ballon et al., 2005). Here comes the early conceptual connection between Living Lab and open innovation, the other mainstream theory (Chesbrough, 2003a; Chesbrough & Appleyard, 2007; Chesbrough & Crowther, 2006; Frissen & Lieshout, 2004).

Eriksson et al. (2005); (Eriksson et al., 2006) refer to the Living Lab as a 'multi-contextual R&D methodology', where innovation conducts in an empirical and multi-contextual real-life environment. They compare the 'user-centric' approach against the traditional 'technology-centric' approach, claiming that the critical difference lies in the user interaction. The innovation process is the integration of three components: society, market and enabling technology, whereby users interact with innovators in the 'co-design' process (Eriksson et al., 2006). Users are not merely passive testing objects for products' usability or functionality, but active providers of ideas and evaluation. The Living Lab is used as a collaborative framework for user and stakeholder involvement during the innovation process. This concept has been widely acknowledged by researchers (Følstad, 2008; Schuurman et al., 2015).

In November 2006, the 'European Network of Living Labs' (ENoLL) was launched under the Finnish Presidency of the Council of The European Union, to serve as a pan-Europe platform for collaboration and co-creation in innovation (ENoLL, 2020). The initial members were 20 Living Labs from 15 European countries. This formal organization has boosted Living Labs' growth, especially in Europe. Today, ENoLL has had its 13th wave of member intake, with over 150 Living Labs members across continents, and more than 440 members historically. ENoLL's expectations on Living Labs can be reflected from their definition of the Living Lab, that is: "the user-centered, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real-life communities and settings" (ENoLL, 2020).

ENoLL services as a focal point for Living Labs, researchers, citizens, firms and organizations to actively contribute and utilize the joint value from co-creation in innovation. This platform established and enhanced the international collaboration over innovation development across regions, and ENoLL's members have contributed to the literature and empirical studies in Living Labs from various industries (Dutilleul et al., 2010; ENoLL, 2020). The development of Living Labs has thrived since then, with Europe as the dominant region and increasing international attention (ENoLL, 2020; Leminen, Westerlund, & Nyström, 2012; Schuurman et al., 2015).

2.1.3 Types of Living Labs

Over the decades, various types of Living Labs have been formed based on different understandings. Identifying its type is then the first step of studying a Living Lab. Ballon et al. (2005) define Living Labs as "experimentation environments in which technology is given shape in real-life contexts and in which (end) users are considered co-producers" (p. 15). The fundamental idea is about constructing a close-to-natural environment that supports the development of 'context-specific innovation' through triggering and integrating the societal effect on users (Ballon et al., 2005).

Later on, Dutilleul et al. (2010) summarize the five different dimensions of Living Labs as:

> (1) An innovation system with organized and structured multi-disciplinary networks for interaction and collaboration; (2) Real-life or 'in vivo' monitoring of a social setting involving technological experimentation; (3) A technique for involving users into the product development process; (4) Organizations which facilitate the network, maintain and develop infrastructure and offering relevant services; (5) The European movement. (p. 64)

Their study focuses on the first three types, where the Living Lab is articulated as physical, organizational set-up, the intangible innovation system/approach, or a movement. Each has its agenda of development. The Living Lab provides innovators 'contact' with private or public institutions, small or large firms. Public institutions are often involved in funding and governance purposes. The multi-actor and cross-region collaboration improve efficiency, enhance knowledge sharing, and avoid lock-in. In the real-life settings, the Living Lab stresses on the 'ethical involvement with users' by ensuring users' rights and interests during the experiment. This approach involves users in the innovation process by examining the 'rationales' of engagement, tackling the 'cognitive and motivational challenges', and the ensure the quality of collaboration (Dutilleul et al., 2010).

One commonly referred theory is from Leminen (2013); Leminen et al. (2012), who categorize Living Labs into four types according to the driving role of participants in the Living Lab: *utilizer-driven, enabler-driven, provider-driven and user-driven* (Figure 1).

Utilizers refer to companies that launch and utilize Living Labs to develop their products. Thus, utilizer-driven Living Labs are formed around the utilizers, focusing on certain R&D activities. And companies collect user information via Living Labs. This type of Living Labs is generally

short-term because companies are mainly efficiency-orientated, meaning they want to validate the results quickly before moving to the next step or the market. Enablers are public sectors, governmental and non-governmental organizations, which often initiate and support Living Labs as the strategic development for specific regions or projects. Information and co-created knowledge are shared among the participants. The work is to fulfill regional or societal needs, reflecting the long-term vision of enablers. And participation from companies is limited here. The third one is provider-driven Living Labs, which are initiated by 'developer organizations' such as universities, research institutes. The work is often built around a single project and operated by the network aiming to generate and promote knowledge during the process. The last one is user-driven Living Labs, which are founded by user groups like local communities, seeking to fix their real-life problems via collaborative efforts. This kind of Living Labs are rather informal and no longer common nowadays (Leminen, 2013).

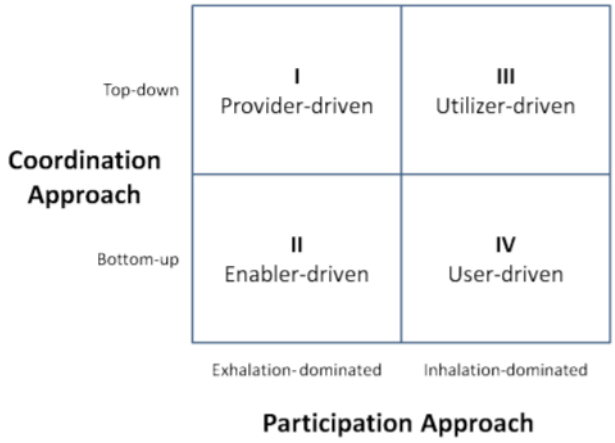

Figure 1.A matrix of innovation mechanisms in living lab networks.

(Source: Leminen, 2013, p.11)

This classification helps participants and external parties gain the necessary knowledge about the driving roles of Living Labs, structure, purpose, logic of value-creation and the potential outcome. Actors can also match themselves to the right Living Labs based on their objectives and situation more effectively (Leminen, Westerlund, & Nyström, 2012).

Researchers continue to develop the theory about Living Labs by exploring the innovation tools used. Leminen and Westerlund (2017) present a 'two-dimensional framework' based on the types of the innovation process and use of tools (Figure 2): innovation activities are linear (predefined) or iterative (non-linear); tools are standardized or customized; and there are four

ways of using the tools in Living Labs: *linearizers, iterators, tailors, and mass customizers*. Linearizers follow a predefined innovation process and use standard tools at each step. Iterators also try to use the standard tools, but they adapt the innovation process according to the actual experiences and situation. Mass customizers follow the linear innovation process with customized tools according to usage. Tailors are the most flexible ones who customize both innovation processes and tools based on their needs. Leminen and Westerlund (2017) give some examples of the tools used, such as open communication and ideation tools for collecting, evaluating and disseminating contributions, and monitoring tools for tracking the input from the activity or individual, which are very different from the traditional project management tools.

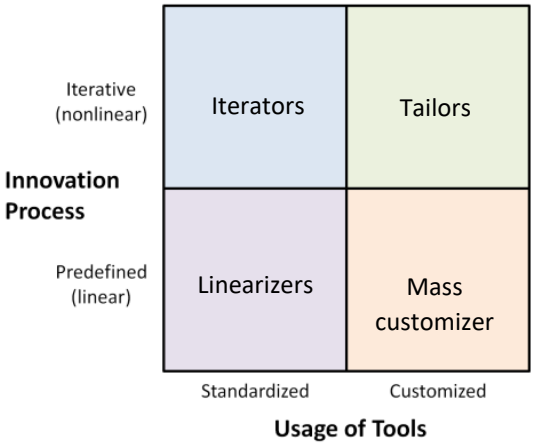

Figure 2.A framework for categorizing living labs based on their innovation process and tools

(Source: Leminen & Westerlund, 2017, p. 19)

This conceptual framework can assist Living Labs and outsiders in developing an overview of their innovation activities and usage of tools. Standardized tools simplify the innovation process and save cost for Living Labs but possibly reduced passion with the activities and lead to incremental innovation; on the other hand, the non-linear and customized tools can help bring in new opportunities and boost outcomes for radical innovation (Leminen & Westerlund, 2017; Leminen, Westerlund, & Kortelainen, 2012). This framework is a helpful tool for understanding and explaining the models of collaboration between Living Labs and companies.

Instead of dividing Living Labs and the methods into distinct types, another group of researchers holds an integrated view. Bergvall-Kareborn and Stahlbrost (2009) argue that the three types definitions, respectively environment (Ballon et al., 2005; Schaffers et al., 2007), methodology (Eriksson et al., 2005) and system (CoreLabs, 2007) are not contradictory but

complementary, depending on which one is the theme selected. The roles do not have to be exclusive to each other but can enrich each other. Puerari et al. (2018) stress that what the different definitions have in common is the idea of the Living Lab as a multi-stakeholder platform using methodologies and tools for co-creation of innovative products/services with users in a real-life context (Puerari et al., 2018).

The lack of consensus in Living Labs can slow down the development of Living Labs, especially when it comes to a broader level collaboration, same for the literature studies. Besides, it is a resource-and-time consuming process for researchers and innovators to contribute to the theoretical and empirical development in the various types of Living Labs. Even within the same definition of Living Lab, there can be a great deal of variety in terms of actual types. Since we cannot have a single description of the Living Lab, it is then essential to establish a good understanding of the common types of Living Labs as a base to explore the corresponding characteristics and activities (Leminen, 2015).

2.1.4 Characteristics of Living Labs

It is difficult to characterize Living Labs as their types vary. Each type has its characteristics stretching into different dimensions. It is essential to understand these characteristics and the possible converging trends before moving to further exploration of Living Lab practices. We go through prior studies trying to find out some common and key attributes of Living Labs.

Leminen et al. (2012) argue that one of the most notable characteristics of Living Labs is that they are open-innovation networks, offering a ‘think-tank’ and platform to help companies to carry out innovation activities. Collaboration happens inside companies and other relevant parties like the public, end-users, the value chain, etc. Different parties work together voluntarily. Each party has a role, but naturally, some are more active than the others. The driving role of the Living Lab is the most active actor and the decisive component in shaping its characteristics in terms of objectives, structures, activities, and development outcome (Leminen et al., 2016; Leminen, Westerlund, & Nyström, 2012; Ståhlbröst & Bergvall-Kåreborn, 2011).

Ballon et al. (2005) argue that the Living Lab is characterized by its level of openness, which decides the degree of involving the external parties like the public, partners and users into the product/service development process. Følstad (2008) talks about the ‘characterizing purposes’

of Living Labs in the ICT industry, saying there are the ‘common purposes’ and ‘diverging perspectives’, which can differentiate Living Lab practices.

Another group of researchers, Niitamo et al. (2006, pp. 3, 4) list the must-have practices and characteristics of a successful Living Lab:

1. Cooperation with technology and application providers (both large players and SMEs).
2. Technology availability: access to state-of-the-art technology is the key to optimize the results generated.
3. Vertical co-operation within the value chain: the ability to interact with users is what distinguishes the Living Lab approach from the other traditional supplier-customer partnerships.
4. Openness and neutrality: the ability to include a large variety of companies and organizations in many segments of society.
5. Public involvement: the use of Living Labs by the public sectors to improve and reform their societal processes.
6. User involvement: involve users in the technology creation process.
7. Research involvement: the ability to transform and transfer the knowledge created in Living Labs into new areas of research.

They view the innovation process in the Living Labs as self-managed and stress on the importance of communication and sharing of knowledge generated, and the ‘vertical co-operation’ along the value chain (Niitamo et al., 2006). Living Labs are expected to be the open space and force for integrating the scattered innovation activities within organizations with a collaborative framework for learning. There is also the call for the involvement, utilization and governance from European public organizations, which is often the one overseeing innovation systems (Niitamo et al., 2006).

Leminen et al. (2012) derive the critical characteristics of Living Labs from their various types and definitions: the real-life environments; the 4Ps; the importance of users; the difference from testbeds, field trials or others; the involvement and collaboration of stakeholders. Later on, they stress on Living labs’ character as a real-life milieu for the collaboration between users and relevant stakeholders (Leminen, Nyström, & Westerlund, 2015).

Another claim is that Living Labs should reflect the ‘systemic character of innovation’ to act as the ‘innovation catalysts’ for cross-border collaboration (Schaffers & Turkama, 2012).

Living Labs as an open innovation platform should mitigate the institutional barriers for the interconnection of actors in the innovation system.

There are several advantages associated with those characteristics. Living Labs solve problems for users by addressing their needs and desire, and improve user value with the collaboration (Almirall & Casadesus-Masanell, 2010). A well-managed value chain for technology innovation in the market also provides companies and organizations with financial benefits (Eriksson et al., 2006). Leminen (2015) summarizes the advantages of Living Labs from three areas, namely innovation, context and business opportunities, from various aspects and steps of the innovation process. Companies receive benefits through the effective and user-driven process, innovation performance, eventually, financial gains from selling products that suit the needs (Leminen et al., 2015). Users get to participate the product development process and benefit from having solutions meeting their needs. Organizers of Living Labs also achieve their targets by having those activities.

The views on Living Labs tend to emphasize the positive effect of Living Labs but often neglect the drawbacks; meanwhile, the reality is that many Living Labs are rather short-lived, with some only have one single project before the closure (Ståhlbröst, 2012). Some struggle about maintaining a sustainable operation due to issues like funding and the estimation is that around 35-40% of the Living Labs with ENoLL benchmark were inactive by the year 2015 (Schuurman et al., 2015). It reminds us that more balanced theoretical and empirical studies and views essential in the future.

Ballon and Schuurman (2015) point out that the most powerful way of characterizing living labs is to investigate actual experiences and the method of evolving in the long run. Therefore, researchers should look into an enormous variety of activities carried under or not under the name of Living Labs to probe how they organize (Schuurman, 2015). It is also a practical guideline for researchers to conduct empirical studies given the heterogeneity of Living Labs.

To wrap up, we notice some commonly agreed characteristics among researchers: openness, real-life setting, stakeholder engagement, user involvement, technology employment, etc. These characteristics are reflected throughout the innovation and can be used as a measurement to assess Living Labs' practices and performance. With a thorough understanding of the types and characteristics of in different Living Lab, companies can efficiently identify the stakeholders and their roles in the innovation, set up the optimal mode of collaboration, gain access to the network and market, as well as predict the potential outcome (Leminen,

Westerlund, & Nyström, 2012). At the same time, the variation in characteristics and types of Living Lab are causing the diversity in Living Lab strategies and approaches. The lack of universal understanding hinders the Living Lab's operation running a more efficient level (Eriksson et al., 2005).

2.2 The Innovation Process and Users

In this section, we temporarily shift the focus from the Living Lab itself to a broader topic, the innovation process. We have seen this term 'innovation process', which is about the nature of Living Labs' work, being mentioned numerous times since the beginning of the Living Lab discussion. We have also noted 'users' are emphasized as a critical element during this process and often the ultimate receiver of the outcome (Ballon et al., 2005; CoreLabs, 2007; Dutilleul et al., 2010; Eriksson et al., 2005; Eriksson et al., 2006; Leminen, 2015; Leminen & Westerlund, 2017; Niitamo et al., 2006; Rits et al., 2015; Westerlund & Leminen, 2011). Therefore, before we proceed to the practices within the Living Lab, we have to explore the relevant schools of literature on a broader horizon, to derive a multidisciplinary understanding of the relationship and reasons for Living Labs' and users' roles, and more importantly to disclose possible methods for implementing the plans.

2.2.1 The Innovation Process

When we evaluate innovation, it is crucial that we do not simply look at the outcome - what kind of product or service to produce, but also equally look at the process - the what and how that makes it happen (Bessant & Tidd, 2007). Successful innovation usually adopts certain structures, techniques, and methods along the journey (Bessant & Tidd, 2007), while the incompetence of companies in managing their resource during the innovation process could lead to failure or slowing down of the growth (Cooper, 2009). There have been numerous studies on the innovation process, discussing types of innovation, innovation management, the success factors, components and steps during the process and so on (Cooper, 2008; Cooper & Kleinschmidt, 1987, 1993; Page, 1993; Tidd, 2001; Tidd & Bodley, 2002; Vanhaverbeke, 2013). Researchers have suggested various innovation process models (Page, 1993; Tidd & Bodley, 2002).

The focus of our thesis here is not about the in-depth analysis of every single step or factor in the innovation process. Thus, we adopt one commonly accepted and simplified 4-stage model based on the work from Bessant and Tidd (2007); Tidd and Bodley (2002); Unger (2003). Figure 3 is this simplified model - concept, design, testing, launch, for illustration purposes. The flow of the innovation process runs from the initial concept stage to product design, testing of prototypes, and then the final product launch.

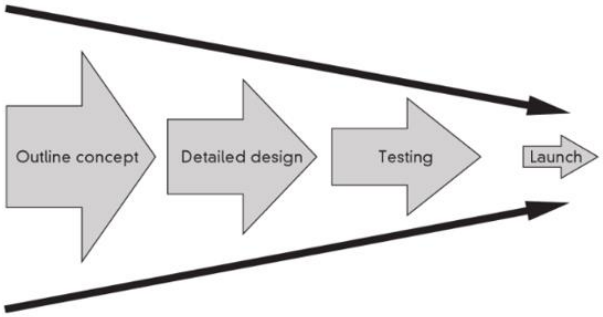

Figure 3.The New Product Development Funnel

(Source: Bessant & Tidd, 2007, p. 423)

Concept generation is an important but often overlooked 'pre-development homework' and its key idea roots in users' needs (Cooper & Kleinschmidt, 1993). During this stage, innovators define the target market, product idea and strategy. They approach customers to uncover their preferences and needs regarding users' knowledge as the sources of development and conduct analyses to learn about market competitiveness and future trends (Bessant & Tidd, 2007). After the concept stage, innovators move to the design stage, where they formulate the specification and detailed product design, and subsequently develop a product prototype (Tidd & Bodley, 2002; Unger, 2003). Testing can be in-house testing, external field trial, or others, helping to evaluate and validate the product, test the market, and solve specific problems (Tidd & Bodley, 2002). When the product is ready, it proceeds to full production and launches into the market. It is never a comfortable journey. And there are so many factors impacting the outcome of innovation.

Some several critical success factors are named for new product development processes, including product advantage to users, market knowledge, product definition, risk assessment, project management, resources, quality of execution, and management support (Tidd & Bodley, 2002). The first three factors closely link to users' needs. Thus, it is crucial to develop a

thorough understanding of users and their needs since the beginning and follow through the process.

Researchers claim that the pre-development actions, also called the 'up-front phases' are the key to success because the execution of these activities decides the success of innovation outcomes (Cooper & Kleinschmidt, 1995). Here are the five main types of up-front phase activities: initial screening for ideas; preliminary market assessment; preliminary technical assessment; the detailed market study; the business and financial analysis (Cooper & Kleinschmidt, 1995, p. 329). Good up-front phases generate 'sharp and early' product concepts and explicit target market information, based on solid knowledge and facts from the end market. Eventually, all these contribute to performance - profitability and market share (Cooper & Kleinschmidt, 1987, 1995).

The critical early activities in innovation, however, is often the weakest in the innovation process (Cooper, 1990; Cooper & Kleinschmidt, 1993). A vast amount of 'uncertainties' exist during this 'fuzzy front-end' (Brun & Saetre, 2008; Khurana & Rosenthal, 1997; Moenaert, De Meyer, Souder, & Deschoolmeester, 1995). Uncertainties are "the difference between the amount of information required to perform a particular task, and the amount of information already possessed by the organization" (Galbraith, 1973; Moenaert & Souder, 1990, p. 244). During the innovation process, the uncertainties refer to the lack of information about user needs, market trends, technological requirements, resources, competitors, the value chain, and so on (Khurana & Rosenthal, 1997). Moenaert et al. (1995) show that most information is acquired during the planning stage, and the rest of the stages are the execution of the strategies developed from there. Innovation is a process for uncertainty reduction, and this step is generally tougher for innovation with radical technologies. Successful ones manage to reduce as much uncertainties as possible during the pre-development stage. Whether companies can acquire the information related to technological strategy earlier than competitors is critical in deciding the success or failure of the projects. The more uncertainties that companies manage to reduce, the higher chance of success they will have (Moenaert et al., 1995).

Uncertainty-reducing activities in the frond-end contribute to integrate the elements, including product portfolios, innovation strategies and business plans for effective decisions. Without front-end activities, the foundation of successful innovation is at risk (Moenaert & Souder, 1990). Khurana and Rosenthal (1997) suggest that the best solution is to adopt an overall system view with a thorough assessment of the front-end stage. As what Cooper (1990) has

argued that the companies' orientation in innovation often has more 'tech push' than 'market pull', which means the more significant part of the 'impetus' of change is from technology but not the market. The concept of a flexible innovation management model is a solution for companies to integrate innovation with their systems and market-oriented activities effectively.

Cooper proposes the widely-adopted Stage-Gate Model (1990, 2008), which recognizes the new product innovation as a process of a series of stages and gates. The major stages of full new product development are idea scooping, building the business case, development, testing & validation, and launch. After each stage, there is a gate meaning a decision-making point, with gatekeepers conducting quality control. This Stage-Gate model clearly states the definitions, activities and criteria of each stage/gate. The philosophy is that 'innovation is manageable', and the way of improving the outcome is to focus on the effective management of the process (Cooper, 1990). The idea of this model is for firms to have a guidebook for cross-checking their work, applying the methodology, evaluating market needs, aligning their strategies with the market situation, and eventually producing quality and innovative deliverables. Cooper has been continuously developing and upgrading this model to a more flexible process, allowing companies to customize their own process as reflected in Figure 4 (Cooper, 2008).

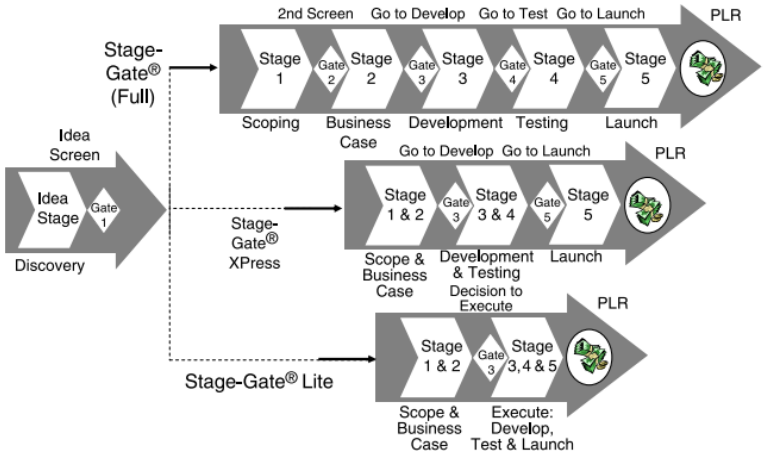

Figure 4.An Overview of a Typical Stage-Gates System

(Source: Cooper, 2008, p. 223)

The Stage-Gate Model has generally made a positive impact on new product development and has been shaping innovation development as a widely implemented template for projects (Cooper, 2011; Lenfle & Loch, 2010). At the same time, it has received several criticisms, mainly arguing that it is too linear, bureaucratic, non-adaptive for complex or innovative projects and promoting 'one size fits all' (Becker, 2006; Cooper, 2014). Although Cooper

(2014) argues that many issues actually happen during the implementation stage, he subsequently proposes the 'The Next Generation Idea-to-Launch System' also called the 'The Triple-A System' referring to adaptive and flexible, agile, and accelerated. The meaning is self-explanatory, and the purpose is to make the innovation process more adaptive, agile, leaner, and efficient. More emphasis is placed on the fuzzy front end, to enable the system to capture the unknowns and risks as early as possible (Cooper, 2014).

This system integrates the key elements of the Agile Manifesto from the software industry, promoting the thinking which is about to reduce the formalities from start to finish of product development, focus on customers throughout the development process, enhance communications and interaction with customers, fast response to change and freedom for an adjustment (Barlow et al., 2011; Beck et al., 2001; Cooper, 2014).

Later on, Cooper and Sommer (2016) suggest another upgraded version, which is the integrated Agile–Stage-Gate Hybrid Model, including the following key features: be more responsive to changing customer needs especially in the fluid market; set up the proactive and effective voice-of-customer; directly deal with the issues with resourcing; improve productivity by reducing cycle time. The agile approach builds on rapid and frequent design-build-test iterations, continuous feedback and interaction with actual customers and continually changes to needs (Cooper & Sommer, 2016).

The innovation process is a dynamic journey, with numerous factors influencing the outcome. Many innovators have failed. Researchers have analyzed it from different dimensions, providing analyses, frameworks and suggestions for innovators to move forward by converting ideas into strategic actions and ultimately the output (Cooper & Kleinschmidt, 1995; Francis & Bessant, 2005; Khurana & Rosenthal, 1997; Page, 1993; Tidd, 2001; Tidd & Bessant, 2014).

The concept of the innovation process and management has evolved over the years, from a rigid model for traditional product development to a more inclusive and flexible model to suit the rapid-changing needs from the modern innovative technology development. Customers/users are turning from the passive and often neglected roles to active participants of the innovation process. Through the interaction and adaptive responses to the customers' needs, companies improved their efficiency, quality of work, and eventually performance in the market. The theories also proposed some methods such as the project matrix, context-based and risk-based contingency approach, visual tools for project management and so on (Cooper & Sommer, 2016). However, even with more agile elements included, they are still generally

company-oriented and process-focused, and users are not thoroughly explored or proactively taking part in the process.

Therefore, we take an innovation process perspective as a starting point for analyzing the innovation activities carried out by companies and Living Labs. It will serve as an embedded and fundamental concept in the following section, where we assess the Living Lab and its conceptual building blocks.

2.2.2 User Innovation

Having discussed the importance of users in the earlier sections, we should also re-visit this term from its theoretical aspect, to uncover the roles of users in innovation, which is not a new discussion. Users are "firms or individuals consumers that expect to benefit from using a product or service" (von Hippel, 2005b, p. 3). In earlier studies, von Hippel (1986) highlights the importance of users, especially the power of 'lead users', a group of users who provide information about needs and ideas for new product development. 'User innovation', as a phenomenon, is discussed later.

Empirical works show that 'user innovators' contribute to most of the important innovations in various industries like chemical, semi-conductors, scientific instruments and medical, etc. (von Hippel, 1988). It is a complicated process to find out information about users' needs and requirements. During the initial 'trial-and-error' period, firms use tool-kits to capture user inputs, explore the possible outcome of user-based design, and to produce the 'mass-customized' products meeting the needs of users (Thomke & von Hippel, 2002; von Hippel, 1998, 2005a).

Decades later, the user innovation concepts have evolved and streamlined into the 'user-centered innovation', in contrast with the traditional 'manufacturer-centric innovation' (von Hippel, 2005b). The relationship between manufacturers and users are thus not merely selling and buying, but a 'functional' link that enables manufacturers to develop the right products and services for users to benefit from directly (von Hippel, 2005a). Empirical works have shown the heterogeneity in user needs that they want 'customized' solutions and have a high willingness to pay; besides, users' innovative ability is growing with the help of modern technology (von Hippel, 2005b).

The collaboration of different users, organizations, companies, and consumers is the resource of creativity and it is to bring users' knowledge into the process but not simply to treat them as testing objects like in the traditional settings (Eriksson et al., 2005). User involvement is essential in building the innovation system, as "innovation is created by humans, not by systems" (Eriksson et al., 2005, p. 2). The inclusion of more actors is the requirement from the shift of the traditional innovation model to the open innovation approach (Chesbrough, 2003; Vanhaverbeke, 2006). The 'rationale' for user involvement in the innovation process is that understanding users and their needs can help to mitigate risks after the market introduction and lower the threshold for market acceptance (Ballon et al., 2005).

Users' current and potential needs are explored, and they co-create with innovators in innovation. More companies, institutes, communities and public sectors create joint efforts in terms of sharing resources and knowledge for generating solutions and opportunities. User-centric innovation provides the 'commercial value' for companies by validating the product, mitigating the potential risk of launching into the market, increasing the possible financial return, as well as creating awareness to potential user groups (Leminen, Westerlund, & Nyström, 2012). Therefore, users can take part in the innovation activities actively with the assistant of rapidly growing technologies especially ICT, that enhances the convenience and efficiency in facilitating the process. As for innovators like companies and organizations, it is a strategic move as well as a logical choice to adapt to this shift from the manufacturer-focus and technologic-centric development to the user-centric innovation system, making it a win-win solution for both.

2.3 User Involvement in the Two Theories - Open Innovation & Responsible Innovation

We have examined the path of evolvement from the traditional innovation system to the futuristic user-centric innovation by taking the perspective of the innovation process. One crucial topic still awaits discussion is the user involvement in the innovation process and its application in Living Labs for this study. We have searched in previous studies and decided to explore more research avenues by looking into the two main-stream theories - Open Innovation and Responsible Innovation (RI), also using them as the building blocks for examining user's involvement in the innovation process inside Living Labs.

As reflected in the prior works, we encounter terms such as open innovation, user innovation, user-centric approach or user involvement discussed together in several studies (Kanstrup et al., 2010; Leminen, Turunen, & Westerlund, 2015; Logghe & Schuurman, 2017; Niitamo et al., 2012; Schuurman, De Marez, & Ballon, 2013; Schuurman et al., 2011). Leminen et al. (2012) conceptualize Living Lab as the integration of open innovation and user-centered innovation. At the same time, RI, another emerging concept, is often associated with discussions on innovation (Bessant, Iakovleva, & Oftedal, 2019a; Iakovleva et al., 2019a; Iakovleva et al., 2019b; Oftedal & Foss, 2019; Oftedal, Foss, & Iakovleva, 2019).

2.3.1 Open Innovation

We start with open innovation, a model which often credits to Henry Chesbrough (Chesbrough, 2003a, 2003b; Chesbrough & Appleyard, 2007; Laursen & Salter, 2006). Chesbrough, Vanhaverbeke, and West (2006) describe open innovation as:

> The use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology. (p. 1)

Vanhaverbeke and Roijakkers (2013) outline open innovation as an ‘inside-out’ or ‘outside-in innovation’. The principal idea is to break the wall between the firm and external environment as in the closed innovation model and move to the open innovation model by enabling knowledge inflow and outflow (Chesbrough, 2003a). Through the knowledge exchange process, companies enhance their competence and accelerate the innovation process by acquiring external knowledge; or they export their knowledge to others in the environment. Innovations can travel easily (Chesbrough, 2003b). Companies or other players, even though they are not the developers, can still benefit from the innovation result in this open environment (Vanhaverbeke, 2013).

Application of the open innovation concept has gradually extended from new product development to more situations like business models, open service innovation, as well as a broader scope of industries (Chesbrough et al., 2006; Vanhaverbeke, 2013).

Chesbrough and Brunswicker (2014) classify the main activities for inbound and outbound open innovation activities, mentioning that inbound practices are more common. The major inbound activities ranked by popularity: co-creation with customers; informal networking with other organizations; funding of research projects by outside researchers; government-sponsored R&D projects; contracting external R&D service providers, etc. The main outbound activities: joint venture partnership; selling of market-ready products to other firms; participating in public standardization programs; corporate incubators and venturing; selling of patent or licensing of Intellectual Property (IP). Companies and the external environment can exchange knowledge and resources much freely and efficiently according to their needs. And, such an exchange can take place in different stages of the innovation, from the very early stage of ideas to the finished product in the market like IP and licensing.

The principle of openness breaks the previous boundary between companies and the external environment in innovation, and subsequently extend the value creation to outside the company (Chesbrough, 2003a). For companies, one basic idea is the integration of open innovation practices into their corporate strategies, to fully realize the benefits (Vanhaverbeke & Roijakkers, 2013). Companies have been adopting this concept as a strategy for minimizing the potential risk and optimizing their growth (Chesbrough & Crowther, 2006). With a strong link to the corporate growth targets, companies can take the initiatives to source knowledge to boost their internal competence and innovation capabilities, as well as to benefit from the knowledge exporting (Chesbrough & Crowther, 2006; Chesbrough et al., 2006). Small firms often cannot fully benefit from the open innovation environment due to restrictions from their limited resource (Leminen & Westerlund, 2012).

There has been empirical research to test the relationship between open innovation and Living Lab. Schuurman et al. (2013) examined the degree of knowledge spillover between Living Labs and the three types of open innovation processes, namely exploration, exploitation and retention, the concept from Lichtenthaler and Lichtenthaler (2009). Findings from the case studies show that Living Labs are especially useful for knowledge exploration, more than exploitation, while retention has not much been explored yet. The Living Lab approach is adopted to connect the open innovation environment and users' capacities for innovation via co-creation. Schuurman et al. (2015) in the review of Living Lab literature development, confirm the same relationship from theoretical analyses.

The initiatives from the arising 'open strategy' stimulate the collaboration and value creation among players in the network (Chesbrough & Appleyard, 2007). They lay the groundwork for the Living Lab to act as 'an open innovation platform' and a system that integrates open innovation and user-centered research (Ballon et al., 2005; Følstad, 2008; Leminen, Westerlund, & Nyström, 2012). The Living Lab is proposed as both an open and user-centric environment and methodology for innovation (Bergvall-Kareborn & Stahlbrost, 2009). It is the "potential bridge between open innovation and user innovation" (Schuurman et al., 2013, p. 29), and a way to transform organizations to follow an open-innovation model and user innovation (Leminen, Westerlund, & Nyström, 2012).

Open innovation applications have helped Living Labs to explore the optimal way of innovation, by adopting strategies, integrating their expertise with the environment, and lay the foundation for user involvement inside Living Labs. However, the theory stays mainly on the strategic level as there is no explicit information about how exactly the activities should be carried out and evaluated. It is subject to Living Labs' interpretation and implementation, which makes it challenging to evaluate. Meanwhile, we must also bear in mind that there are some particular types of open innovation processes, like ready-product selling, licensing agreement, and IP selling/buying as mentioned above. They are forms of accessing knowledge but do not involve any co-creation with external parties (Chesbrough, 2003a; Schuurman et al., 2015).

2.3.2 Responsible Innovation

In this section, we explore the second important building block RI, and its impact on the Living Lab development. We first examine RI, which has a focus on stakeholder engagement, as an intrinsically motived discussion on the quality of innovation, then incorporate it as a guideline the user and stakeholder involvement in Living Labs.

The call for responsibilities

Knowledge production has generated a huge impact on society in various dimensions. However, the development is often unbalanced and associated with consequences. In the global pharmaceutical industry, there is the '90/10 gap', meaning 90% of the pharmaceutical research is only target at the common diseases from the wealthiest 10% of the population (Owen, Heintz, & Bessant, 2013). The facial-recognition technology is a controversial innovation that has

attracted enormous attention as the future trend, but have also stirred vast debates over potential issues like breaching of human rights in actual usage (Greene, 2020). We can find examples in different industries (Fisher & Mahajan, 2006), and there come imperative calls for innovation to happen in more responsible ways.

The United Nations General Assembly (2015) in its report "Transforming our world: The 2030 Agenda for Sustainable Development", highlights the responsibilities of innovation for more inclusive and sustainable social and technological development among nations. Innovation is used as a means to foster sustainable development, improve economic growth while reducing the adverse effects on the society and environment. The focus is to build the infrastructure that promotes their policies at the national and regional levels.

While the regulatory approaches are on the macro level, researchers have also discussed the micro-level practices like the 'moral responsibilities' during the innovation process. Douglas (2003) argues that scientists have to take the 'general responsibilities' by thinking for the 'consequences' of the knowledge production on other things like environmental health and human wellbeing instead of conduct it in an isolation setting.

RRI has attracted considerable attention and studies over the past two decades, and its primary purpose is to deal with the societal sustainability challenges during the scientific and technological development (Bessant et al., 2019b; Iakovleva et al., 2019b).

von Schomberg (2011) defines RRI as:

> A transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society). (p. 73)

Responsibility is taken as an 'add-on or extension' to the regular innovation conceptions (Blok & Lemmens, 2015). RRI has then been employed to integrate the societal and technical considerations into the governing of scientific innovation development; meanwhile, researchers and practitioners are trying to figure out the operational implications and requirements (Owen, Heintz, et al., 2013). One example is the STIR project, where a group of researchers conducts studies to investigate the empirical expectations and validate the effectiveness of the techniques from being responsible for innovation (STIR, 2020).

Von Schomberg (2012) state that RRI is a multidisciplinary approach used by innovators for co-creating 'societal-desirable products' in an inclusive innovation environment with stakeholders; and early engagement of users and stakeholders at a broader level is the key. He suggests some methods such as imposing codes of conduct, ensuring market accountabilities via, standards, certifications, and ethical principles, establishing communication channels with stakeholders, balancing 'technology push' & 'policy pull', etc. (Von Schomberg, 2012).

Some researchers have also pointed out that RRI may share some ideas with Corporate Social Responsibility (CSR), which refer to as 'philanthropy' (Oftedal et al., 2019; Cutlip, Center, & Broom, 1994). The initial purpose of using CSR is to build companies' corporate images by complying with the governmental requirements, companies' motivation of having CSR is from external, and the 'commercial incentives' is missing (Laudal, 2011).

RI and four-dimensional framework

Researchers are now moving towards a more streamlined concept of RI, focusing explicitly on innovation itself and its responsible characters' (Blok & Lemmens, 2015; von Schomberg, 2011). RI is a "collective commitment of care for the future through responsive stewardship of science and innovation in the present" (Owen, Heintz, et al., 2013, p. 37). It is a collective effort of innovation governance approaches and stakeholder participation for delivering innovation with societal benefits (Lubberink, Blok, Van Ophem, & Omta, 2017). The ambition behind for adopting RI is to connect the innovation practice with the promised future to the society at large (Bessant et al., 2019b). In short, it is 'innovation with society and innovation for society' (Lubberink et al., 2017, p. 2; Owen, Macnaghten, & Stilgoe, 2012).

The driver of RI is the engagement with users and stakeholders towards solving the societal challenges, and the stakeholders can be policymakers, experts, politicians, the general public, etc. (Iakovleva et al., 2019a).

To address the societal concern within the innovation process under different contexts, Stilgoe et al. (2013) suggest a four-dimensional RI framework: *anticipation, reflexivity, inclusion, and responsiveness*.

Anticipation is to analyze potential opportunities and outcomes with systemic thinking. The timing of public engagement is crucial as it has to happen at a stage that is early enough to

influence the critical decisions before the process is locked by other constraints (Rogers-Hayden & Pidgeon, 2007).

Reflexivity means reflecting own commitments, values, and assumptions, being able to see their limits of knowledge and issues (Stilgoe et al., 2013, p. 1571). Therefore, the institutions and firms should be able to acknowledge and help to set up a resilient system where the knowledge and interests of other actors are captured.

Inclusion is to listen to the voices from the public and stakeholders via different channels and methods (Stilgoe et al., 2013). It is a continuous process throughout the innovation period. It is not only the extensiveness of how many parties are included, but more importantly, it is the degree of involvement in terms of how early it happens and how much attention is given, in other words, the quality of inclusion (Callon, Lascoumes, & Barthe, 2009).

Responsiveness is about the capability to respond to stakeholders and public values in the changing environment (Stilgoe et al., 2013, p. 1572). Mechanisms must be adopted to ensure the innovation is responsive to the changing circumstances and make new moves.

RI is driven by engagement with relevant stakeholders in the early stage of the innovation process, with inclusion as the starting point and a key element (Iakovleva et al., 2019a). Without inclusion, the other three will not be able to proceed. A lack of early involvement of stakeholders will eventually result in a lack of anticipation (Silva, Bitencourt, Faccin, & Iakovleva, 2019). With the extensive and early inclusion, future-oriented and systemic anticipation is to generate positive impacts and results of innovation. The innovators also gradually develop the capability for better reflexive thinking and responsive actions to take care of the societal and ethical needs of users as well as stakeholders' opinions. These four dimensions provide an integrated assessment for different approaches in the implementation of responsible innovation practices (Lubberink et al., 2017), with continuous dialogues and knowledge sharing with stakeholders throughout the entire innovation journey to achieve the balanced views and results (Iakovleva et al., 2019a; Silva et al., 2019).

RI demonstrate the guideline for addressing societal concerns in terms of the anticipation, reflexivity, inclusion, and responsiveness (Owen et al., 2013) Stakeholder engagement is crucial to RI. Still, there is plenty of unknowns about the inclusion process – what happens and how, including those emphasized as co-creators (Silva et al., 2019). Empirical studies show that innovators only included multiple stakeholders during the late stage of their innovation

process, and there is little coverage on stakeholders as the co-creator (Silva et al., 2019). The level of stakeholder influence in the innovation process is somewhat limited. Besides, researchers have already pointed out that inclusion is only one of the many aspects of RI. However, it is an essential and often the first dimension, but more in-depth investigation of the other dimensions is necessary as well (Silva, Bitencourt, Faccin, Iakovleva, & Bessant, 2020).

RI Methodologies

Researchers attempt to figure out methodologies used to put RI into practice. Stahl et al. (2017) suggest the RRI Maturity Model measures the level of RRI alignment for organizations like companies, moving from unawareness, reactive, defined, proactive to strategic incorporation of RRI into their innovation work. They collect some information about actions done by companies towards RRI maturity through case studies. There are social inclusion and ethic analysis of the project, risk analysis of the future impact, integrate the user-oriented motivation into the organization goal, training for staff, engagement of stakeholders, gender equality and diversity implementation, the annual action plan for sustainability, etc. (Stahl et al., 2017).

Researchers also discuss the methodology aspect of the RI framework. For anticipation, the methodologies can be technology assessment, horizon scanning, scenario development, and foresight, to reflect the potential impacts of innovation (Owen et al., 2012; Owen, Stilgoe, et al., 2013).

For the systemic inclusion of factors into each stage of the innovation process, Silva et al. (2019) mention some innovation management methods: design thinking, agile methods, project management techniques, etc. Findings from their case studies show the usage of techniques like interviews, focus groups, dialogue sessions, workshops, and discussions with groups of experts for inclusions (Silva et al., 2019).

Owen, Stilgoe, et al. (2013) discuss on using mechanisms like participatory approach and anticipatory governance to build the collective & reflexive process by articulating the specific goals of innovation, ways of modulating the innovation trajectory in overcoming uncertainties and reflecting the value as well as the impact of the technology outcome. Their point is that these RI dimensions ought not to be used as principles only but institutionally embedded in the technology development process (Owen, Stilgoe, et al., 2013). One example is a study done by Bremer, Millar, Wright, and Kaiser (2015) in the aquaculture sector, where they present the

use of an upstream participatory approach for engaging stakeholders in the aquaculture biotechnological innovation. They call it the 'ethical matrix tool', which is to invite stakeholders to workshops discussing the social and ethical considerations, the social acceptance level of innovative technologies within the industry.

What RI offers is not a new or technical innovation approach but a dynamic concept that can guide innovation with normative measurements (Stilgoe et al., 2013). We see the alignment of innovator and the society's needs in innovation, the importance of timely engagement with stakeholders, especially users. On the other hand, researchers have reminded that RRI is an academic or sometimes a top-down policy approach, that the operational implications, i.e. how do companies/innovators implement it during innovation is still understudied (Oftedal, Foss, et al., 2019). Studies are needed to elaborate on the details about methodologies in practice, regarding the design, implementations, and results, etc., which can be evaluated and adopted in a different contextual environment. Also, further investigations on mechanisms for early engagement with stakeholders and analyses on late engagement would be helpful (Silva et al., 2019).

RI for Living Labs

After the assessment of RI, we come to the reason why we adopt it as one fundamental building block for our Living Lab framework in this thesis. RI can be a 'holistic framework' by taking consideration of the 'ethical, social, and legal issues' during the innovation process (von Schomberg, 2011). When innovators strive for approaches for involvement with users and stakeholders during the innovation process, RI can offer its methodologies to help meet the societal needs of the products/services.

The open and interacting space in Living Labs enables inclusion and subsequently reliable market assessment, which effectively reduces the uncertainties in technology and business development (Eriksson et al., 2005). Living Labs have also facilitated sufficient participation from stakeholders, who are generally public agencies, universities, institutes, firms, and users, to collaborate for "creation, prototyping, validating, and testing" of innovative technologies in the real-life environment (Westerlund & Leminen, 2011, p. 20). The focus on user communities brings out insights from the 'human dimension' of technologies and subsequently enhances the 'societal deployment' of the innovative outcome (CoreLabs, 2007).

Researchers have started to take the RI perspective in the health industry innovation, exploring the different dimensions of the innovation system and seeking for improvement (Konrad, Greiving, & Benneworth, 2019; Oftedal et al., 2019). Oftedal and Foss (2019) have pointed out that small companies like start-ups are often facing 'institutional walls' made up by regulations, norms, and cognition in the health sector (p. 141). The existence of the institutional walls makes the RI inclusion for start-ups difficult, but little is known about how they take the challenges (Oftedal & Foss, 2019). Participation in Living Labs helps small firms to engage in stakeholder collaboration and conduct systemic innovation (Schaffers & Turkama, 2012), to speed up the scale-up in the market (Niitamo et al., 2012).

In the findings section, we will further elaborate on this model (Figure 5) with information from the empirical Living Labs practices within the digital health context. The intention is to examine, at which point companies engage with Living Labs, users, and stakeholders, and the level of adoption/integration in terms of RI in practice.

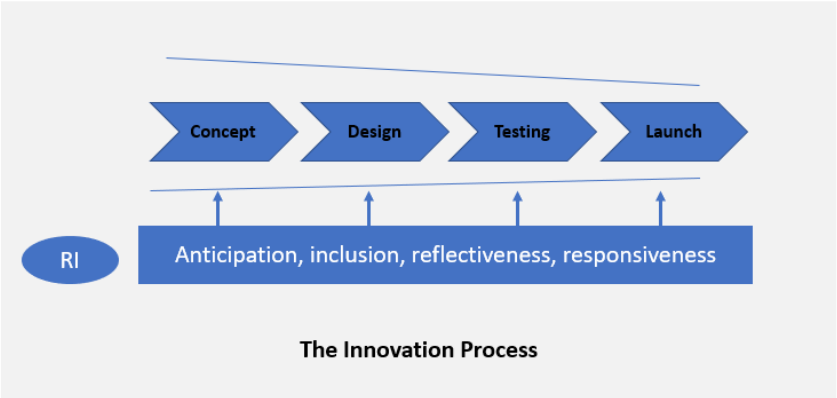

Figure 5.The innovation process on a four-dimensional RI framework

(Source: cf. Iakovleva et al. 2019)

By incorporating the RI framework into the innovation process, we hope Living Labs can integrate the societal and technological factors at a higher level in its contextual environment. We also remind that RI and Living Labs are emerging concepts. Thus studies are needed for verification and further development of the connections and possible propositions. More studies are required to give more insights and reliable help to the implementation of RI practice (Blok & Lemmens, 2015). Organizations like Living Labs should avoid getting into the trap by merely taking RI as a corporate branding tool. In contrast, the key is to incorporate it into their day-to-day innovation process. Collaborating with users, stakeholders, and innovate with

integrated societal and technological approaches in an open environment is what Living Labs have been striving.

2.4 User Involvement in Living Labs

After reviewing the two theories and the implications for user involvement and stakeholder engagement in the innovation process within Living Labs, we proceed to have a closer look at the practices inside Living Labs. In the traditional innovation process, it was the innovators who gather and interpret users' insights, while in Living Labs, users can influence innovation more directly (Almirall and Wareham, 2009). Users' roles, levels of engagement and influence have gradually changed along with the development of Living Labs.

2.4.1 User Roles in Living Labs

Researchers have stressed the necessity of clarifying the different patterns of users' roles, to contribute to the design, implementation, and orchestration for Living Labs (Nyström, Leminen, Westerlund, & Kortelainen, 2014). In addtion, it is essential to uncover the link between the various roles and their impact on the innovation income to support and justify the arrangement, especially user innovators (Leminen et al., 2014).

Bogers, Afuah, and Bastian (2010) in their research categorize user innovators as two types: intermediate users and consumer users. Intermediate users refer to groups that use innovative products to produce their goods/services, such as companies, organizations, scientists. Consumer users are generally individuals or a group of end-users.

Leminen et al. (2014) argue that these broad roles explain little about how exactly users contribute to the innovation process and the outcome. Thus they summarize four different types of user roles in Living Labs based on their interaction with the innovator: *the informant, the tester, the contributor, and the co-creator*. The informant share users' opinions, needs, knowledge and experiences. Living Labs collect information from observations or communications. Testers have user testing in the Living Lab or other real-life environment like hospitals. Contributor act as the real-life users and take part in product development in the Living Lab. Co-creators work more proactively in solving the problem and developing the product with companies and other actors from Living Labs. Living Labs should provide the

‘role path’ for uses to navigate from the more passive roles like the informant and tester to creative roles like the contributor and co-creator (Leminen et al., 2014).

Leminen et al. (2015) further develop this theory, suggesting that users may take multiple roles concurrently and there are other roles besides these four. They measure the impact from the user role on the innovation outcome in terms of novelty and the role mechanism i.e. whether the roles are assigned to users (‘role-taking’) or made by users (‘role-making’). They summarize four types of approaches: *customizer, fabricator, designer, and inventor*. Customizers include the previous roles, informant, tester, and contributor, contributing to incremental innovation. Designers are also role-takers and collaborate with others to develop radical technologies. Fabricators may consist of co-creators, make own roles, and design the scope of contribution for incremental innovation. Inventors are proactive users who make their roles for radical innovation, when users choose to have a low degree of involvement and mainly for incremental innovation. In contrast, when these users take part as proactively co-creators, they are likely to support radical innovation (Leminen et al., 2015).

Nyström et al. (2014) expand this thinking based on cases studies, suggesting four patterns to summarize these role characteristics:

1. Ambidexterity: users are role-taking and role-making at the same time; users need to change from role-taking to role-making to contribute more to the development.
2. Reciprocity: users’ roles lead to the positions and they can redefine their roles after gaining more power.
3. Temporality: users’ roles should be adaptive – to adjust to the network change.
4. Multiplicity: users can take multiple tasks and hold multiple roles in one Living Lab environment.

In the same study, Nyström et al. (2014) reveal 17 roles including ten new ones, for actors including users in the open innovation network within Living Labs, with examples: *the coordinator*, who acts as the representative of users and forward information to others in the network; *the builder*, who promotes the relationship among actors such as users, firms, and Living Labs; *the messenger*, who gather and distribute ideas and information among participants; *the facilitator*, who helps specific groups like user groups and facilitates the actions toward to the goals; The orchestrator who orchestrates and direct the overall network of Living Labs; as well as other roles including the four major roles discussed previously, the informant, the tester, the contributor and the co-creator. The study has provided useful

knowledge on the classification of roles in Living Labs and diversity on the role design for actors, especially users and the consequences.

The role as the co-creator for users has been emphasized because of its contribution to innovation especially radical innovations (Leminen et al., 2014; Nyström et al., 2014), and to facilitate the co-creation is viewed as a Living Lab's core service (Feurstein, Hesmer, Hribernik, Thoben, & Schumacher, 2008). Co-creation is the aim of Living Labs and it generates sustainable values through interactions with users and relevant stakeholders (Bergvall-Kareborn & Stahlbrost, 2009). It is not barely a methodology for producing deliverables but a manner for generating values to share among participants in the Living Lab network (Puerari et al., 2018). The purpose is to shift from the 'triple helix' to 'quadruple helix' co-creation by establishing the collaborative effort among the public, institutions, private bodies, as well as the society (Puerari et al., 2018).

Greve, Martinez, and Neely (2017), in their empirical study, explore further on elements that enable co-creation between co-creators in Living Labs and they spot five critical factors: *customer engagement, relationship management, operating principle, design Layout, and data collection approach* (see Appendix). Each factor consists of several elements to assess the level of co-creation from the different aspect. For example, the customer-company relationship in the innovation, the relationship management – expectations, interaction & approaches, the concept & value for co-creation, the design of the co-creation process, and lastly but critically is the data collection methods and tools used for co-creation (Greve et al., 2017).

The latest research done by Toffolini (2020) suggests that previous approaches often assume that users take careful pre-decided/pre-written roles. However, the building of user roles is a dynamic process, as the roles are emerging during the process of multilevel interactions among the innovation network. Users build their places in these activities gradually and strategically along the innovation process. The study about users' roles should therefore be a continuous and multidimensional process.

2.4.2 User-driven Living Labs

The earlier section (types of Living Labs) has emphasized the user-driven Living Lab. However, there are different interpretations of the user-drive Living Lab. Some researchers refer it as an informal and loosely-structured Living Lab, like a user community or group (Leminen et al.,

2012; Leminen, 2013). Some see it as a more structured and formal Living Lab that engages users as the driving force of the innovation (Dutilleul et al., 2010; Leminent et al., 2015; Liedtke, Welfens, Rohn, & Nordmann, 2012; Westerlund & Leminen, 2011). In this section, we investigate the meaning of a user-driven approach, related theoretical arguments and the implications of using it.

Researchers highlight the importance of creating a user-centric innovation system rather than a technology-centric innovation system, saying that the implementation of Living Labs is based on their involvement of the user, companies, organizations and consumers, in the innovation process (Eriksson et al., 2006). Westerlund and Leminen (2011) list four types of activities in Living Labs: *co-creation, exploration, experimentation and evaluation*, where users are involved in all phrases acting as the vital sources of information e.g., their needs and requirements, and as co-creators for product development. We refer to the definition of co-creator as an individual that "seeks and solves problems, ideates and innovates, and develops the solutions together with the companies' R&D teams and other living lab actors on an equal basis" (Leminen et al., 2015, p. 8).

Westerlund and Leminen (2011) also develop an outline of the four steps for companies to become an 'open-innovator': *producer-driven; user-centric closed; user-centric open; user-driven*. The degrees of openness and user involvement grow when they move from step one to four. In practice, companies start from different steps depending on their own situation.

At step one, producer-driven, the innovation is closed whereby companies contribute the innovation ideas and develop products with minimum communication with users. Users' needs do not convey into the innovation process. Companies only collect user feedback through some third parties, like agents or consultants. There is nothing about co-creation here.

At step two, user-centric closed, companies still innovate in a closed environment, but they pay more attention to users from the beginning stage. They gather data from users by some market research methods like surveys and piloting on selected users. But again, users do not play a key role here and user involvement is not the objective on the organizational level.

At step three, user-centric open, companies have already acknowledged the value of co-creation. However, users are involved merely temporarily once at a particular stage of development. Companies use them to get some feedback and no further engagement afterward. Users are not able to take part in the entire innovation process. At step four, user-driven, the innovation process is open and led by users. Users are collaborating with companies

continuously. Most importantly is that companies have well-defined objectives about the value creation with users and set up the complete infrastructure for the user involvement and co-creation to happen.

Leminen et al. (2016) suggest the relationship between the type of Living Lab structure and innovation outcome, emphasizing that the combination of a provider-driven or utilizer-driven with a distributed network structure, with a future-oriented strategy, are more likely to give rise to radical innovations.

When looking at prior studies, there are still areas to clarify, especially for some key conceptions. These terms 'user-centric', 'user-centered' and 'user-driven' are often interchangeable. However, 'user-centric' and 'user-centered' means putting users in the center of innovation, while 'user-driven' means users are the driving role in the innovation (Dutilleul et al., 2010). To be specific, 'user-driven' is considered as 'user-centered' or 'user-centric', with no emphasis on the 'driven' part. In the European Commission's report (EC, 2009), 'to build the user-centered innovation' is stated in the title. However, in the content, the Living Lab is defined as "a user-driven open innovation ecosystem based on business - citizens - government partnership which enables users to take an active part in the research, development and innovation process" (p. 50). The subsequent elaboration is about involving users early into the innovation process and adopting a user-centric methodology, which does not explain how to realize user-driven innovation. Instead, user-driven innovation means the same as user-centered innovation in the context of having people into innovation activities. In another widely cited paper about the European Union project LIVING LAB on user-driven innovation, researchers talk about user-centered research and design throughout the article with no specific explanation about the user-driven approach (Liedtke, Welfens, Rohn, & Nordmann, 2012).

Firstly, the argument is that a total user-driven approach in the Living Lab is not practical for users as it requires comprehensive management skills, network, resource, and in-depth understanding of the entire innovation process, etc. It is challenging for companies as well, as it means a complete change of the innovation infrastructure to support users to lead the innovation. Another interpretation is that the evaluation criteria on users' interests are above others, including the process itself (Dutilleul et al., 2010, p. 78). It seems relatively more straightforward for Living Labs or companies to facilitate the user-driven approach. Still, it requires the establishment of a system or a process that can oversee and ensure users' interests. How to evaluate this process is another problem.

Living Labs might declare the usage of a user-driven approach, which is the user-centric approach. The fact is that Living Labs themselves remain the driving role. At the same time, users are included as the key actors in collaboration but with a limited level of participation and decision-making power.

Secondly, the implementation of a user-centric co-creation approach within Living Labs is still subject to different understandings (Følstad, 2008; Westerlund & Leminen, 2011). The lack of a shared understanding and practical application could hinder Living Labs' move from the old-fashion of using users for testing only to co-creation. Ballon et al. (2005) point out that the level of user-centric innovation in Living Labs is related to the real-life setting and the extent of user involvement through the feedback loops. Eriksson et al. (2005); Westerlund and Leminen (2011) stress on enabling users in the co-design process with other players. Pallot, Trousse, Senach, and Scapin (2010) adopt the concept from Sanders & Stappers (2008) and measure the evolvement of domain landscapes of the Living Lab research. It shows that there is an evolution with the shift from the user-centered design (where users are the observed participants) to the participatory design (where users are partners/co-creators of innovation). There is wide diversity within the domains.

Although literature and Living Labs have stressed on having users as the source and co-creator of the new technology, the actual practices vary and are far below the ideal level of co-creation (Greve et al., 2017). Users are still acting as the information source with one-way communication, or the testing objects only of technology in some Living Labs, rather than the co-creator; and the gap in involvement and empowerment of users is still significant (Følstad, 2008; Greve et al., 2017; Niitamo et al., 2006).

Thirdly, reviews of past literature show that there is no general methodology towards user involvement or how it happens in Living Labs (Almirall & Casadesus-Masanell, 2010; Følstad, 2008; Puerari et al., 2018). The literature development on user involvement is not extensively implemented in the context of Living Labs. Thus the importance of Living Labs' in generating user involvement needs further support (Schuurman et al., 2015).

Therefore, more studies are needed on the understanding and alignment of the open innovation network and Living Labs' approaches in involving users as important roles for innovation (Leminen et al., 2015). Studies should contribute to fill up the gap in showing Living Labs' value and impact on user involvement with some evaluation methods to support the claims. In this thesis, there will be more discussion in the section of Methods and Tools in Living Labs.

2.4.3 Methods and Tools for User Involvement in Living Labs

One fundamental aim of this thesis is to find out how Living Labs actualize user involvement. Prior research has been exploring the user-centric concept in Living Labs. Eriksson et al. (2005) talk about participatory design at the conceptual level and compare it to the traditional testing & experiment approaches. Ståhlbröst (2008) introduces 'FormIT' methodology that supports user involvement in the development of IT solutions. McNeese, Perusich, and Rentsch (2000) talk about an integrated 'wholistic' approach. Researchers (Holst, Ståhlbröst, & Bergvall-Kåreborn, 2010) show the effectiveness of using an 'open-minded process' for innovation in their case study.

The European Commission Project CoreLabs (2007) lists five key principles regarding the Living Lab methodology:

1. Continuity: it takes time to build the knowledge, establish trust with users & stakeholders, and conduct innovation activities.

2. Openness: to keep the innovation process 'as open as possible' for gaining perspectives and support for user involvement.

3. *Realism*: be a real-life environment setting that differentiates Living Labs from other forms of open co-creation environments.

4. Empowerment of users: to empower users and user groups to actively engage in the process.

5. Spontaneity: the ability to detect and investigate spontaneous reactions and inspirations from users.

Meanwhile, there is a strong need for in-depth studies on the methods and tools used in Living Labs (Leminen & Westerlund, 2017; Rits et al., 2015; Ståhlbröst, 2008; Ståhlbröst & Bergvall-Kåreborn, 2011; Westerlund & Leminen, 2011). Having explicit information about the methods and tools is crucial for evaluation and improvement of Living Labs' approaches, and useful for replications in other Living Labs.

The innovative methodologies and tools in Living Labs are somewhat underdeveloped. Følstad (2008) summarizes some standard methods used: analysis of system logs or automatically collected behavioral data; ethnographic methods; questionnaires; focus groups; observation. The last three are still the traditional methods and there is no specific method for the co-creation purpose.

Mulder and Stappers (2009) review the 'user as co-creator' approach in Europe, showing that the focus is on the 'Lab' portion instead of the 'Living' portion, and Living Labs should have made better usage of the 'ecological validity' of their community-driven approach. Throughout different phases of the innovation process, the traditional lab methods such as interviews, focus groups, idea generation, and tests with lead users, workshops, usability tests, etc. are still prevalent in Living Labs. In contrast, the participation methods and co-creation techniques based on the latest technology like online creative groups, user design, virtual testing, etc., are underused. Therefore, users do not play this co-creator role as proactively as they seem to. It also means that Living Labs are not fully utilizing their core advantages of co-creation in the real-life environment over traditional methodologies.

The 'living methodologies' are found 'heterogeneous' and 'specific' from site to site, meaning maturity is needed for extensive use across Labs. Interestingly, the study shows that Scandinavian countries are doing better in terms of implementing the participatory approach i.e., users as partners (Mulder & Stappers, 2009).

Feurstein et al. (2008) summarize the methods used in Living Labs (Figure 6), pointing out the existence of traditional methods and emerging methods driven by ICT development. Many ways are still in use by Living Labs, and this type of comprehensive research on the methodologies and tools underdeveloped nowadays. We will compare these methods against the current practices among Living Labs in the empirical section of this thesis.

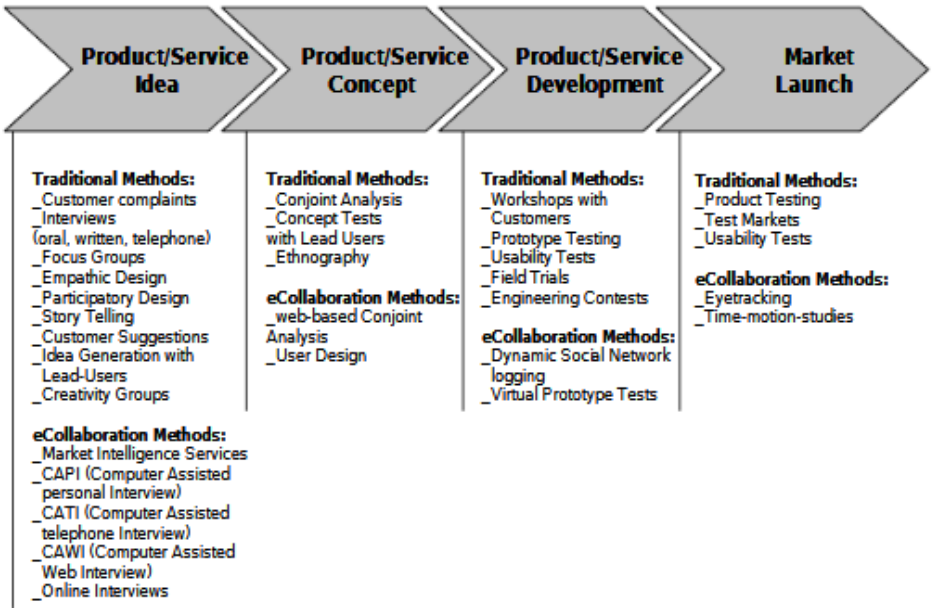

Figure 6.Methods used in Living Labs

(Source: Feurstein et al., 2008, p. 4)

Things like virtual communities, social media and other digital tools are becoming the essential parts of people's daily living. The rapid development of ICT has provided technical support to enable user connections (Ståhlbröst & Bergvall-Kåreborn, 2011).

Mulder (2012) share three Living Labs cases from Rotterdam, the Netherlands, where co-creation methods are used to create an environment for identifying users' needs and stimulating co-creation. One example is about using visual ethnography to understand the elderlies' daily routines and to generate insights for solutions to assist their daily livings. One uses prototyping from the interactive media in a real-life context during the event of Rotterdam Museum Night, where visitors can customize the effect of artwork installations according to their personal preferences. The third case is about using co-creation methods and storytelling for generating ideas in a public-private stakeholder collaboration over the re-use of open public information. These cases confirm the positive effect of co-creation on exploring the potential of Living Labs, and the improvement of services in the public and private sectors. Users' real experiences are the factors that make Labs 'living'. The interaction is the quality that differentiates Living Labs from other approaches.

Veeckman, Schuurman, Leminen, and Westerlund (2013) bring up the four components of the Living Lab approach: *evaluation, context research, co-creation and user role*. To keep users' involvement in different phases of the innovation process, innovators collect their assessment using methods like surveys or in-depth interviews. They interact and co-create with users through participatory methods and run the user context research with ethnographic tools.

Georges et al. (2015) discover several practical guidelines for user engagement in Living Labs field trial, including:

- Share the maturity status with users and monitor their expectations. Users are more prepared with technical issues and more willing to openly share their opinions, whereas, for products that have finished the development phase, they show more frustration with technical problems as they do not influence the design.
- Users are more willing to participate if they have already known/met the developers or researchers.
- Conduct a pre-field trial or usability test before the real-life testing to revolve some functional issues upfront.
- Establish a single point of contact to keep the communication channel open and efficient.

- Motivate the users by considering their feedback and adjust the process to their needs.

This practical guide provides assistance to Living Labs to improve user engagement and can be adopted and adjusted for other Living Labs activities during different stages of the innovation process e.g. the conception or design stage.

In summary, the Living Lab methods and tools development are progressing, but rather slowly. Traditional methods are prevalent. Researchers have presented some examples of exploration of the new ones, which are rather scatted (Georges et al., 2015; Mulder, 2012; Puerari et al., 2018). It generally takes time for validation and application of methods and tools in other Living Lab cases. We have also noticed the similarity in methods and tools between Living Labs and those suggested by RI. The thriving industry of communication tools has created great opportunities for innovators to get users into the co-design process effectively. Future Living Lab initiatives should continue to explore new ways of integrating social dynamics into innovation.

2.5 Summary of Literature Review

To wrap up this literature review section, we start by acknowledging the immense heterogeneity in Living Labs (Ballon & Schuurman, 2015). Those Living Labs have diverse objectives, structures, characteristics, activities, methodologies, as well as research work (Leminen, 2015; Schuurman et al., 2015).

There are various activities carried out under the fancy name of Living Labs to create awareness. Nevertheless, researchers have been working to identify and build some common understanding, characteristics, and divergences of Living Labs (Følstad, 2008; Greve, 2020; Greve et al., 2017). Studies have assessed the variety of user roles and the relation to innovation outcome, as well as the corresponding characteristics of Living Labs in the innovation process (Dutilleul et al., 2010; Leminent et al., 2015; Liedtke, Welfens, Rohn, & Nordmann, 2012; Westerlund & Leminen, 2011).

Living Labs as the open-innovation platforms enable actors, including innovators and users, to create innovative technologies via collaborative actions under the real-world settings and share the values among the network (Leminen, 2012). We walk through the innovation process, figuring out that it is a comprehensive process with multiple stages/steps that should not be

decided by the companies or organizations alone. Instead, it is full of inclusive, flexible, and agile actions with users and other relevant actors (Cooper & Sommer, 2016).

We use open innovation and RI as the two building blocks for constructing this Living Lab theoretical framework as well as the base for exploring user involvement within Living Labs. It aligns with what Greve (2020) has suggested that the Living Lab research should reach out to the mature mainstream research areas such as open innovation. We ought to see the advantage and disadvantages of integrating each one. Open innovation is the foundation of Living Lab theory, providing the ground for innovators to open up to the external environment and unite the entire innovation network. Studies on Living Labs will contribute to the research avenues of open innovation as well (Greve, 2020). On another note, open innovation is abstract, and it lacks practical recommendations for Living Labs, especially user involvement, making it challenging for practitioners.

RI is a core guideline for Living Labs for engaging stakeholders, customers/users, showing the necessity and potential of conducting societal-ethical innovation, but it is more like normative standards or regulations without enough practical information (Silva et al., 2019). The four-dimensional framework is a practicable measurement for developing more profound insights. RI itself still has a lot to improve in terms of clarification of the concepts and terms, practical approaches, measures, and ways of incorporation into the existing methodologies (Blok & Lemmens, 2015; Koops, 2015). Living Labs and other innovators should not take RI merely as a 'top-down' directive (Oftedal, Foss, et al., 2019). Instead, they have to take more initiatives to fine-tune the process of integration and adoption into their innovation strategy and process.

We did not find much in the prior work regarding a systematic integration of Living Lab with some main-stream theories like open innovation and responsible innovation. Meanwhile, it has already acknowledged that more cross-disciplinary perspectives will enrich the research in both Living Labs and the mainstream theories (Greve, 2020).

User involvement is a result of evolution from the traditional in-house development to an open co-creation with users. It is noteworthy that more concepts related to Living Labs should be clarified, such as these important ones like 'user-centric' 'user-driven' 'co-creation'. The common understanding of critical concepts has a direct impact on the literature development and practical implementation of Living Labs.

There can be challenges for companies in adopting the user-centric approach, as there is a great deal of work to do before the transition from old practices to new ones. Small companies

generally have advantages on the path to open innovator as they are more flexible in terms of structure and method, and agile in response to users (Niitamo et al., 2012; Westerlund & Leminen, 2011). However, there is not enough attention has been paid to the applications of user-centric methodologies with Living Labs (Niitamo et al., 2012).

Living Labs in the early days pay more attention to users' experiences with innovative products or services, and nowadays, they have a higher demand for new ways to integrate their work (Puerari et al., 2018). It becomes crucial for Living Labs and companies to learn and analyze the practical methodologies and tools to enable user involvement, which is one of the most necessary elements of Living Labs, during the innovation (CoreLabs, 2007).

While the studies suggest that the customized innovation process and tools are likely to lead to radical innovation, the findings also reveal that Living Labs are trying to simplify the operation and improve the efficiency by using standard approaches (Leminen, 2017). There is the highlight on the need for an in-depth understanding of the characteristics of Living Labs, the methodologies and tools for user and stakeholder engagement to integrate them with the practices during the technological product/service development process (Leminen & Westerlund, 2017; Niitamo et al., 2012). Living Lab researchers and practitioners can perhaps learn from other theories like RI and its methodologies.

Living Labs studies surely have made achievements over a relatively short period; however, we also see there is room for improvement regarding the literature and practical development. Overall, there is a lack of consensus on the Living Lab literature research, which is showing some emergence but still scattered (Greve, 2020).

We have to accept the extensive range of variety. The set-up of Living Labs range from small ones for temporary projects to large national or international ones involving the public, institutes, and big firms; the user groups can range from a small number of individuals to a massive group, online society for example (Ballon, 2015). The targeted industries, topics and stakeholders vary with each case. Therefore, there is certainly no single or few methods that can fit all Living Lab development, or stakeholder/user involvement. There is a demand for more research in the new application domain (Azzopardi & Balog, 2011; Ballon & Schuurman, 2015; Schaffers & Turkama, 2012). Furthermore, there is the call for systemic studies on methodologies for user involvement, which can be evaluated and applied under other circumstances.

3. Context of the Study

In this section, we would like to throw some light on the context of this study, which is the Norwegian health sector, particularly the e-health area, as well as the national innovation approaches. The Norwegian health system is heavily regulated by the government, with most hospitals owned by the public (Oftedal & Foss, 2019). The Norwegian government plays a central role in driving the development of the healthcare industry. Facing the pressure from an aging society and shortage of healthcare providers and personnel, the Norwegian government took a serial of actions to tackle future challenges in meeting the increasing demand from the healthcare sector. Innovation has been a key item on the governmental agenda.

3.1 The Norwegian e-Health Movement

In 2008, the Norwegian government published Report No. 7 (2008-2009), which is to build the 'innovative and sustainable Norway' with plans for innovation in the public sector. For the healthcare sector, the development of new solutions through innovation and the support from the public sectors were highlighted. The public committee was appointed in the National Council in June 2009 to implement the mandates on the development in care services sectors, and the contents included assessing new solutions, giving advice on the design of nursing homes and arranging services to meet the future needs of users (Regjeringen, 2008, 2011).

In 2009, the Norwegian Ministry of Health and Care Services initiated the Norwegian Coordination Reform, focusing on the utilization of resources in the collaboration among the municipality, care services, and the specialist health service. Actions included developing the patient-oriented 'pathway' that integrated patient participation into the healthcare system, building the new roles of municipalities for effective coordination, providing financial incentives to municipalities for health service development, and implementing ICT systems in the health services (Regjeringen, 2009).

In 2011, more concrete plans and actions revealed. The committee announced the second Coordination Reform, which focused on families, communities, and social networks. The committee started a national program for municipal innovation in the care services aiming to establish the incentive structure for promoting innovation in the healthcare sector, and build the infrastructure for systemic research, innovation, and collaboration at the country level.

Cooperation with private companies was emphasized, including practices like the development of future-oriented technical standards in Norway, support in financing, and commercializing innovative projects (Regjeringen, 2011).

The Norwegian Directorate of e-Health (NDE) was established in January 2016 as a subordinate institution of the Ministry of Health and Care Services (Figure 7). NDE defined e-health as the healthcare tools and services supported by ICTs for "improving the healthcare system as a whole, including prevention, diagnosis, treatment, monitoring and management of medical conditions and diseases" (eHelse, 2020). NDE's missions are implementing the national policy, steering e-health via cooperation with regional/local health authorities, technology providers, other interested parties, administrating the development and use of digital solutions for the healthcare sector nation-wide (eHelse, 2016).

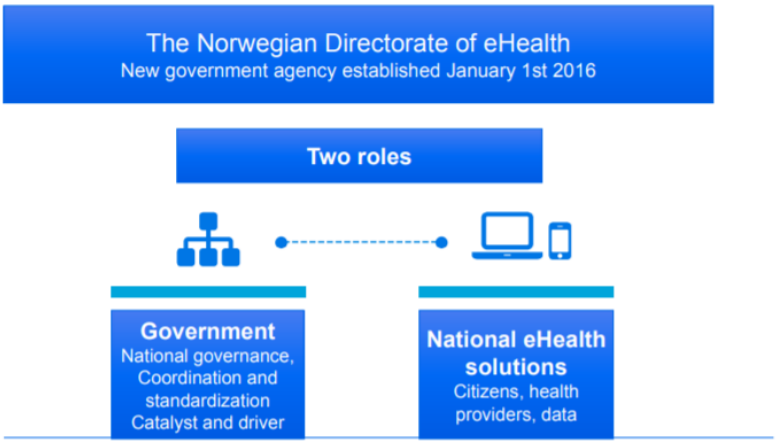

Figure 7.The Norwegian Directorate of eHealth

(Source: eHelse, 2016)

In their National Strategy and Plan for e-Health (2017-2022), NDE listed its six focus areas: digitization of work processes, enhanced coherence for patient services, better use of health data; efficient ways for health care; a common foundation for digital services; national governance and increased capacity of implementation in e-health (eHelse, 2019). Resources and strategic directions have been dedicated to facilitating the digital transformation of the health and care sector (eHelse, 2020).

Along with the wave of national and regional e-health development, public and private healthcare clusters emerged. Here are two major established clusters: Norwegian Smart Care Cluster (NSCC) and Norway Health Tech. We will also cover more information about the

clusters in Oslo, as well as some collaboration network for innovation, like the Norwegian Health Consortium and the Norwegian Catapult.

3.2 Norwegian Smart Care Cluster

Established in 2013, NSCC is a cluster with over 140 companies and 50 municipalities/public institutions as members. Hosted by the innovation company Validé, NSCC is part of the national cluster development program Norwegian Innovation Clusters, a collaboration among Innovation Norway, The Industrial Development Corporation of Norway (SIVA), and the Research Council. The headquarter of NSCC is in Stavanger, with branch offices in Bergen and Grimstad. Their members are all over Norway and internationally (NSCC, 2020).

NSCC serves as a national and international hub for facilitating the collaboration among companies, public sectors, institutions and investors to build the Norwegian health industry by promoting e-health business and sustainable solutions for individuals and creating the ground for innovating cost-effective and quality-assured products/services. The focus area is the smart care- digital solution as the interplay between user-patients and the municipality/hospitals (NSCC, 2020). In November 2019, NSCC qualified for the ArenaPro status from Innovation Norway and SIVA (Validé, 2020).

The cluster divides the work into seven main areas: (1) Helping companies to build their competence and competitiveness via the support from a national test center - Norwegian Smart Care Lab (NSCL); (2) Supporting the research and development for members, including developing and investing national/international/private R&D projects, connecting institutes to companies, expanding the network for future growth and commercialization from R&D results; (3) Helping companies with market development, scaling, funding & internationalization; (4) Integrating companies with the broader network for innovation and offering programs for scaling early phase companies; (5) Growing the cluster network; (6) Developing the regional and national innovation system, with Rogaland, Agder, and Hordaland being the focus; (7). Knowledge generation via education, insights, and knowledge transfer for the health sector (NSCC, 2020).

NSCC has established extensive collaboration networks, nation-wide and internationally. The cluster is actively running activities independently and with other clusters over a wide variety of topics related to innovation in the healthcare industry. NSCC's website shows a long list of

them, such as webinars with companies and citizens for product presentations, themed conferences for the industry, regulatory breakfast meetings with experts, themed workshops for sharing/learning, member meetings with the network and such (NSCC, 2020).

3.3 Norway Health Tech

Norway Health Tech is a not-for-profit membership organization and the largest health cluster in Norway with 270 members. Found in 2009 under the name Oslo MedTech, the cluster renamed themselves to Norway Health Tech in 2017. Their head office is located in Oslo Science Park (NHT, 2020).

Norway Health Tech is a cluster for medical technology with members and partners from various areas of expertise, such as diagnostics, digital health, e-health, biotech, pharma, computer science, human life science, and so on. The vision of Norway Health Tech is to make Norway the world-leading arena for health innovation. Their focus areas are: facilitating the collaboration between the research, health and industrial personnel, assisting the development of demand-driven innovation and clinical research, testing and verifications, helping the business development of members in areas like scaling, financing and procurement. Projects are from various disciplines and the programs include IP & law, educational program, innovative public procurement, mentor program and incubator services for members, etc. They partner with other Nordic and European clusters and establish the cross-sector cooperation for connecting their members into the global network. The EU program promotes innovation in the healthcare sector, from building collaboration and projects using the European funding tools Horizon 2020 (NHT, 2020).

In 2016, Norway Health Tech, Inven2 and Oslo Science Park found the incubator Aleap, which has now developed into the largest health community for start-ups in Norway. Aleap is situated in the Oslo Science Park too. They have supported more than 100 health start-ups since 2016, and today they have over 45 members working in areas of digital health, device, diagnostics and drugs (Aleap, 2020).

Aleap helps health start-ups to grow their business with the support in facilitating knowledge sharing & learning, development, commercialization, a national and international networking with partners and expertise. Services to their members cover areas in IP, legal, regulatory services, design thinking, financing, accounting and production services (Aleap, 2020).

3.4 The Oslo Clusters and the Innovation Network

Oslo is the center for health innovation in Norway, hosting around 80% of the public research and development activities in the health sector (NHT, 2020). Oslo is the home of several large innovation hubs. Oslo Science Park, officially opened in 1989, is an innovation hub with over 3000 companies from areas like ICT, health and medical technology, biotech, energy and environment. Oslo Science Park is run by Oslotech, a company owned by the University of Oslo, Oslo Municipality and SIVA as several companies like Norsk Hydro, Pareto and Dyno Nobel, etc. Oslo Science Park hosts several communities, clusters and incubators, including Norway Health Tech, Aleap, ShareLab and StartupLab. The last two are incubators for biotech start-ups (Forskningsparken, 2020).

Oslo Cancer Cluster, officially opened in 2015 in Oslo Cancer Cluster Innovation Park, is a cluster for cancer research and development. The cluster has around 90 members which are Norwegian and international companies, organizations, hospitals, research institutes, financial institutions doing oncology medication and diagnostics. It also has Oslo Cancer Cluster Incubator for start-ups, pharma, service providers, research institutions, focusing on the cancer field (OCC, 2020).

The joint effort of clusters, organizations, institutes, investors, and public sectors has str, etched the innovation network nationwide. Here are some examples that we encountered during the research for this thesis.

Norwegian Health Consortium (2020) is launch in 2019 by six incubators and Technology Transfer Offices (TTOs), including Aleap, TTO Norinnova, Norwegian University of Science and Technology (NTNU), SINTEF (an independent research organization in Trondheim), Validé and VIS (the former Bergen TTO). Norwegian Health Consortium (2020) provides service packages for health start-ups at 12.5% of the actual cost. The packages include technology research, market insights, business plan evaluation, product design, prototyping and verification, regulatory services, production, market introduction, etc.

The Norwegian Catapult Program, administrated by SIVA, is a governmental scheme for helping companies, mainly SMEs, in the innovation process. There are 7-9 national Catapult centers providing services from concept, prototyping, testing, simulation to product launch, and help companies to access new markets and engage with potential business partners.

Catapult centers are organized by industry. There are Manufacturing Technology, Future Materials, Ocean Innovation, Sustainable Energy and Digicat. Each has a focus area for collaboration (Katapult, 2020).

Having a glance at the e-health initiatives and landscape of the Norwegian infrastructure building for innovation, we gained the background information about the Living Labs and start-ups that we investigated for their work in digital health development. We will move on to the section of methodology to have a closer look at the methods used for data collection.

4. Methodology

4.1 Philosophy of Science

Holden and Lynch (2004) highlight that the research methodology should be consequential to the researcher's philosophical perspective and the phenomenon to be analyzed. All theories of organizations build on two dimensions: a philosophy of science and a theory of society (Burrell & Morgan, 2017). The nature of society is based on the regulatory view or radical change view of the societal structures. In contrast, the nature of science employs a subjective or an objective approach for the research (Holden & Lynch, 2004).

Researchers have to carefully think about the deeper reasons for them to conduct research, by asking questions like 'why research', 'how to research' & 'what to research', and finding out the philosophical answers (Remenyi, Williams, Money, & Swartz, 1998). Easterby-Smith, Thorpe, and Lowe (1991) explain the two fundamentally distinct approaches for research: positivism and phenomenology (Table 1). Positivism adopts quantitative and experimental methods to formulate and test hypothetical-deductive generalizations, and seeks for causal explanations and fundamental laws and reduces the phenomenon to the minimum elements (Amaratunga, Baldry, Sarshar, & Newton, 2002; Easterby-Smith et al., 1991; Remenyi et al., 1998). Phenomenology adopts naturalistic and qualitative approaches for actively and inductively collection of experiences in different contextual settings. The intention is to focus and explain the phenomenon itself in its context but not to find the causes or fundamental laws (Easterby-Smith et al., 1991; Remenyi et al., 1998). It is essential to develop a full picture of their research purposes, the areas of study, and to make 'sensible' choices over usages of the different methodologies (Amaratunga et al., 2002).

Table 1.*Two Schools of Science*

Approach	Concepts	Methods
Positivism	Social structure Social facts	Quantitative Hypothesis testing
Interpretive science (phenomenological)	Social construction Meanings	Qualitative Hypothesis generation

(Source: Amaratunga et al., 2002)

Following the thoughts from the two schools above, research approaches are divided into two different categories: qualitative and quantitative. The qualitative approach relies on observations and words to describe people and reality in the natural environment. In contrast, the quantitative approach follows the academic tradition by focusing on numbers to interpret ideas (Amaratunga et al., 2002). Table 2 shows the comparison between these two approaches in terms of tactics used when conducting the research.

Table 2.*Research tactics and philosophy bases*

Research approaches	Positivistic (quantitative)	Phenomenological (qualitative)
Action research		Strictly interpretive
Case studies	Have scope to be either	Have scope to be either
Ethnographic		Strictly interpretivist
Field experiments	Have scope to be either	Have scope to be either
Focus groups		Mostly interpretivist
Forecasting research	Strictly positivistic with some room for interpretation	
Futures research	Have scope to be either	Have scope to be either
Game or role playing		Strictly interpretivist
In-depth surveys		Mostly interpretivist
Laboratory experiments	Strictly positivistic with some room for interpretation	
Large-scale surveys	Strictly positivistic with some room for interpretation	
Participant observer		Strictly interpretivist
Scenario research		Mostly interpretivist
Simulation and stochastic modelling	Strictly positivistic with some room for interpretation	

(Source: Galliers, 1992, cited in Remenyi et al., 1998)

Qualitative methods have their flexibility for testing the theories (Stainback & Stainback, 1984). In the context of this thesis, prior works show that qualitative methods have gained popularity in the health service and technology research, helping researchers acquire more knowledge related to healthcare (Denny & Weckesser, 2018; Giacomini & Cook, 2000; Nicholas & Catherine, 2000). The qualitative approach is also helpful for investigations in new areas of studies, such as the Living Lab, which is still a relatively new phenomenon (Jamshed, 2014; Schuurman et al., 2015). Meanwhile, researchers have also pointed out the drawbacks of using a qualitative approach in practices, namely volume of data, the complexity of analysis, details of classification record, flexibility, and momentum of study (Richards & Richards, 1994). Therefore, here is the suggestion of using 'triangulation', meaning combination of qualitative and quantitative methodologies to complement and optimize the potential of each method in research (Yin, 2003).

4.2 Research Design

This study employs qualitative research methods, considering the investigative type of research questions and the purpose of developing an in-depth understanding of Living Lab practices and participants' perceptions.

Most data used are the primary data collected via semi-structured interviews. Interview and observation are the most common methods of data collection in qualitative research (Jamshed, 2014; Stainback & Stainback, 1984). Semi-structured interviews are conversational exchanges, where the interviewer obtains information from the interviewee by asking a set of prepared questions (Longhurst, 2009). Unlike structured interviews where questions must be asked in a fixed structure and sequence, semi-structured interviews are more 'flexible' and 'interactive'. Using an interview guide can also help to maintain a systematic and effective investigation, and the rigor and quality of the qualitative research (Jamshed, 2014; Nicholas & Catherine, 2000). The questions are arranged by a certain topic/theme and order, but the interviewer does not necessarily ask the exact questions or follow the exact sequence in every interview. Semi-structured interviews can help to collect more relevant data, such as experiences and perceptions in an 'interactive' way (Mason, 2004). There are also unstructured interviews that are informal and have no interview guide (Sanchez, 2014).

Therefore, the semi-structured interview method is more suitable for this study. Because we want to run the session with some pre-determined topics, but at the same time letting the interviewees share more information from their own experiences rather than following the fixed sequences or questions. Another important reason is that the companies that we interviewed vary in terms of technology, user groups, experiences related to the topics, etc., implying that the information shared will be different. A similar situation applies to Living Labs.

Field observation is another popular qualitative data collection method, where researchers collect data by observing the interactions and behaviors of participants (Stainback & Stainback, 1984). Here we are talking about direct participation observation, where investigators join the social environment, study, and record the findings in notes or journals for analysis (Giacomini & Cook, 2000; Jamshed, 2014). We used this method by taking part in meetings and webinars to observe ways of communication and interaction among Living Labs, institutes, companies and users. We also paid attention to the topics and information mentioned during the session.

Besides, we used some secondary data from online resources, such as organizational reports, publications, and websites of companies, Living Labs, the public sector, and other relevant organizations. The information helped us to prepare for the interviews and build an understanding of their business and innovation activities, as a complement to the primary data collected. We also obtained some secondary data from the interviewees with their permission since we do not share externally. We had the participant lists of the focus group meetings arranged by Lab A (more details in the Data Collection section), to have an idea about the background of participants and the stakeholder groups that they represent. We asked for a copy of the protocols for organizers about the arrangement, introduction documents about the events, the feedback form, etc. Lab A shared the official guide for testing with companies as well. Lab B shared their organizational reports and one conference abstract regarding their background and operation. From Lab B's website, we downloaded six past reports, three are product testing reports with three different companies, and two are study reports on solutions for homecare services improvement.

In total, we conducted interviews with three Living Labs and seven start-up companies. Due to the variety in the definitions and types of Living Labs explained in the earlier sections, we chose a broader range of targets and measured by their actual services rather than their names only. For example, it can be named as a 'Lab', an 'Innovation Lab' or a 'Living Lab'. Each of them has certain services that reflect the characteristics of a Living Lab. Therefore, 'Lab' or 'Labs' are general terms here used to refer to these three Living Labs that we interviewed. It is in line with what Ballon and Schuurman (2015) have suggested that we should investigate Living Labs by their actual practices.

4.3 Data Collection

Data of this thesis were collected between March and July 2020, through voice calls, face-to-face, and video interviews (see Table 3). In total, there are 11 sessions, including 7 with start-ups, 4 with Living Labs, because there was one follow-up meeting with the same Living Labs (Lab A) after three months.

Given the small scale of Living Lab development in Norway, we tried different methods to reach out to Labs and companies at the same time. We reached out to Labs through our network or information found online, and then we sent emails asking for an interview. During or after

the meeting, we asked them to refer us to their client companies. The Labs shared our interview invitation to their network of companies asking them to contact us if interested.

The Living Labs also kept a list of participating companies of their activities like testing or workshops, with some companies that had already given prior consent for future contact. We then emailed the companies asking for an interview. We set the interview method, date and time with those who agreed. All the companies that the Labs shared are start-ups, which is not surprising as it is mostly start-ups who use Living Labs' services at this moment. Start-up A, B, E & F were recruited in this way from Lab A's contact list. Lab C helped us to set up an interview with Start-up G.

At the same time, we sent recruitment information directly to companies found online, e.g., the websites of incubators, clusters, and Living Labs. We went through the company information to confirm that they are doing innovation for digital health. We sent out the invitations based on the contact information found, and then set up the interviews with those who responded.

Back on 22 January 2020, the project team members of "Releasing the Power of Users" including professors from UiS and the Lab A representative, visited Aleap's office in Oslo and had an introductory meeting about Aleap's incubator activities. Aleap has been actively bridging its members (start-ups) with stakeholders and the innovation network, including Living Labs. That was why we decided to talk to their members to understand their ways of innovation and possible collaboration with Living Labs. We asked Aleap to help disseminate our interview invitation to their members. Meanwhile, we screened the list of Aleap's members on their website, chose those that are doing products in digital health, and sent the invitation. In the end, start-ups C &D replied and proceeded to the interview.

Start-up C had dialogues with Lab A before and checked for Lab B's information online but did not establish any collaboration, while Start-up D has no Living Lab encounter. We were interested in finding out the reason behind, and more importantly, to understand their innovation experiences and possible differences in the impact on innovation for start-ups that are not using Living Labs. Start-up F, although recruited from the client list of Lab A, is an Aleap member as well. Figure 8 is an illustration of the relationship among interviewees.

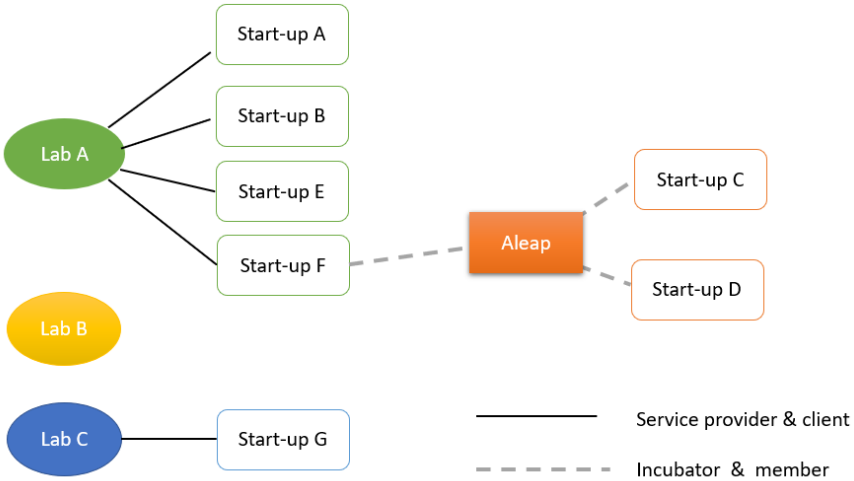

Figure 8.The relationship of interviewees

We used an interview guide (see Appendix) during the interview. There are two sets of interview guides, one for Labs and one for companies. There are some 'core questions' and 'associated questions' (Jamshed, 2014) depending on the topic. Therefore, the majority of the questions in both sets are the same. But we ask some specific questions from the perspective of a Lab and a company, respectively. It is natural as they have different roles and responsibilities and experiences with innovation activities.

The interview guides were approved by the Norsk senter for forskningsdata (NSD) to ensure the compliance of personal privacy requirements. The interviewees were supplied with sufficient information about the purpose of the interview, the type of data collected, the processing and use of personal data. We obtained their consent using the consent form before the meeting.

There were three sections in the set of the interview guide for Labs: Background, Activities and Collaborations. In Background, we asked about their organizational information, innovation types, and partners. In Activities, we gathered details of activities conducted by the Labs. In Collaboration, we asked about companies' collaboration through Labs and measurements. In the set for companies, we had four sections: Background, Innovation, Activities, and Collaborations. In Innovation, we asked more questions about their innovation experiences. We sent the interview guide to the interviewees before the interview.

Most sessions, 9 out of 11, lasted around 50-60 minutes. One session lasted for 45 minutes because of the interviewee's packed schedule. One lasted for 105 minutes, mainly because the

topics were covered extensively with quite a several organizations/companies mentioned and explained while talking and spent time on translating some words between Norwegian and English using Google translate. Both actions had made the session longer than the other ones. Table 3 present a summary of the interviews.

Table 3.*Summary of interviews*

S/N	Interviewee	Date	Duration	Pages of transcript	Method	Source of recruitment	Remark
1	Lab A	10-03-20	60 mins	12	Video-call	University network	
2	Lab A	03-06-20	50 mins	7	Face-to-face	University network	Follow-up meeting
3	Lab B	18-05-20	45 mins	8	Video-call	Lab B website	
4	Lab C	05-06-20	105 mins	9	Video-call	Lab B	
5	Start-up A	20-03-20	60 mins	9	Video-call	Lab A contact	
6	Start-up B	24-03-20	55 mins	12	Video-call	Lab A contact	
7	Start-up C	27-03-20	60 mins	11	Video-call	Aleap website	Incubator member, no Living Lab collaboration
8	Start-up D	02-04-20	60 mins	9	Video-call	Aleap website	Incubator member, no Living Lab collaboration
9	Start-up E	08-04-20	50 mins	11	Voice-call	Lab A contact	
10	Start-up F	09-04-20	60 mins	12	Video-call	Lab A contact	Aleap member
11	Start-up G	02-07-20	50 mins	12	Voice-call	Lab C contact	

We made audio recordings for all the interviews and transcribed them afterward. The interviewees' identities remained anonymous, meaning that they would not be recognized in publications. Information that could reveal their personal identities, such as names or titles were withheld and coded during data analysis. Audio recordings were deleted shortly after being transcribed. The interviewees were aware of and agreed on making the recording and potential usage of the data.

An overview of the Living Labs and start-ups are presented in Table 4 and Table 5, respectively. All of them are situated in Norway, including one company that has offices in both Norway and Sweden. The three Living Labs are from two cities in Norway.

Table 4.*Overview of Living Labs*

Living Lab	Business services	Est.	Location	Start of the business	Employees
Lab A	The center for testing and verifying digital health solutions with users and service providers	2017	Stavanger	Started as a NSCC project	4
Lab B	A living laboratory for testing new welfare technologies with suppliers and users in a real operating situation	2015	Grimstad	Started as a project funded by the Directorate of Health, Norway	1
Lab C	Testing and innovation center for healthcare technologies; interdisciplinary cooperation between institutions and organizations	2019	Grimstad	Started by the funding from the county to implement the innovation	1

Lab A originally started as a project for the health industry by NSCC in 2017 to help companies test and verify innovative products, prototypes, ideas, solve technical, ethical, and legal issues before the solutions are released into the market. It has the advantage of accessing the network through NSCC, as covered in the Context of the Study. And members or who have a connection with the NSCC network can reach Lab A as well. It explains why these start-ups have contact with Lab A. Lab A has five on-going projects currently and with about ten more in dialogue.

Lab B was a three-year project funded by the Norwegian Directorate of Health and hosted by the Grimstad municipality. The first project period was from September 2015 to December 2017. The leader is from the municipality. It has a project manager, and the project members are representatives from the university, the Nurse Association, The Directorate of Health, The Development center for nursing homes and home services, ICT leaders, etc. Lab B began testing welfare technology from suppliers (companies) in 2016 by working with users, including patients, relatives, health service employees, companies, politicians, and other stakeholders.

In the first phase, Lab B developed a method named ‘the Living Lab methodology’, which was based on the systematic approach with users in Lab B during the research and innovation processes. It consisted of 5 steps: *define needs, technical test, user test - lab, user test - home, operation in the health service*.

The main activities included co-creation, execution, trial, and evaluation with the users during the innovation and development of welfare technologies. Lab B had a mission that was the transition from a project in Lab B to the operation in a new Living Lab - Lab C. Lab B received

funding from the Agder county for their second phase (the year 2019 – 2021). Now, Lab B is implementing their methods with Lab C, and they use the user panel more extensively for exploring or testing digital solutions. Lab B has shifted the focus to the user communities on their needs and experiences with new digital welfare and health technology solutions. They have only a few company contacts now as the task has been diverted to Lab C.

Lab C was officially established, with the Board formed in March 2019. It is owned by the university where it is located, and the plan is to include multiple owners in the future. Lab C continues the work of testing different types of welfare and health technology with the collaboration with companies and stakeholders. It has various lab facilities, including housing simulators, usability labs (an environment for testing and evaluating the technology's usability via user interactions), open labs for testing different scenarios. There is also a co-location and interdisciplinary collaboration strategy, with several educational/research organizations, technological labs locating within the same building of Lab C's to make them physically connected. Lab C is currently working on three projects.

The three Living Labs are working with start-ups for now, although they do have contact with numerous big companies that they introduce to start-ups for innovation activities. Lab C has mentioned their plan to bring big companies' solutions to the Lab in the future.

The seven start-ups are from different cities: Oslo (2), Stavanger (2), Trondheim (1), Drammen (1), Tromsø (1). Stavanger and Tromsø are active in digital health development. Oslo is the city with most healthcare companies in Norway and home to major health clusters, as previously covered. Start-up E locates in Drammen, and it is actively working with clients in Stavanger as well. More details about their innovation process and the Living Lab experiences will be covered in the Empirical Findings section.

Table 5. *Overview of start-ups*

Start-up	Products/Services	Est.	Location	Start of the business	Number of employees
Start-up A	Automatic turning mattresses for patients with mobility issues	2017	Stavanger	Started as a student project	5
Start-up B	A consulting firm with creative problem-solving methods in different industries including healthcare	2015	Stavanger	Started with partners	2
Start-up C	Digital solutions for migraine brain treatment	2019	Trondheim	Started from a business case in the field of research in university	6
Start-up D	Digital solutions to analyze dental x-rays for osteoporosis	2013	Jönköping & Oslo	Started as a student project	4
Start-up E	Applications for robot-supported programs for health (e.g. physical training in nursing homes) and education (e.g. language)	2017	Drammen	An innovation partnership contract with the municipality	1
Start-up F	Respiratory healthcare solutions based on machine learning	2017	Tromsø	Based on a research topic in the university	3
Start-up G	A digital solution on notification of changing diapers for patients with cognitive impairment	2018	Oslo	Started from the founder' personal experiences with family members	4

We took part in some meetings and webinars, where we observed how the innovation network communicates and collaborates, including the cluster and the Living Lab with companies, users, and institutions. Table 6 is a summary of those observation sessions happening between January and June 2020.

Three sessions are related to the project "Releasing the power of users - articulating user interests to accelerate new innovative pathways in digital health and welfare sector". It is a research project funded by the Research Council of Norway (RCN) and run by the University of Stavanger (UiS) and Western Norway University of Applied Sciences (HVL), together with international researchers and supporting partners in Denmark, Netherland, Portugal, Germany, UK, and the USA. The project aims to work on the inclusion of diverse users during the innovation processes and building of the co-creative innovative eco-system in digital health. One initiative of this project is to form a multi-disciplinary network called "The Learning Network" to include players like researchers, companies (incumbents and start-ups), public

sectors, communities, etc. to build up an ecosystem in the health industry. Lab A is a member too. This thesis is a part of the project, focusing on Living Labs as a sub-topic, which was why we participated in "The Learning Network" meetings.

The fourth one was a webinar organized by NSCC about social activities - how can new solutions give us an active and social everyday life through all phases of life? Companies presented their digital solutions for end-users, mostly members of Pensioners' Association. All participants logged onto the webinar to join the session. Therefore, we had a follow-up meeting with Lab A and the organizer from NSCC to collect more insights into the motives and concepts of the webinar.

Table 6.*Observation sessions*

S/N	Date	Time	Duration	Method	Venue	Event	Participants
1	20-01-20	11:00 - 12:00	60 mins	Face-to-face meeting	UiS	Pre-meeting for The Learning Network	Companies (Norengros & Lærdal Medical), Lab A, UiS
2	22-01-20	10:00 - 13:00	180 mins incl. break	Face-to-face meeting	Oslo	The kick-off meeting for The Learning Network	UiS, UiT, Lab A, Norwegian Health Network (NHN), companies: CondoVita, ContinYou, Sensio, Innocom, DNV GL, No Isolation.
3	24-04-20	10:00 - 12:00	120 mins	Digital meeting	Virtual space	April meeting for The Learning Network	UiS, UiT, Lab A, Innocom, Pensioner Union representatives, user representatives HelseCampus Stavanger,
4	11-06-20	14:00 - 15:30	90 mins	Webinar	Virtual space	NSCC webinar: Activation and social contact	NSCC, Lab A, Motitech, Jodacare, users (Pensioner Union members), individual users, companies: NoIsolation, Innocom, Visdok, Firbent Terapi, Aktivitetsdosetten, MinMemoria, Posterum.

4.4 Data Analysis

Data analysis exists around every step of the 'investigation process' due to the nature of qualitative research (Stainback & Stainback, 1984, p. 301). We adopt the research model process (Figure 9) from Punch (2000) to develop and organize the research questions without

hypotheses. At the pre-empirical stage, the literature review and context study are conducted around the research questions, which subsequently decides the type of data collected during the empirical stage. At the research design stage, the outline for data collection is developed to make sure the correct data are collected. And then, data analysis is carried to answer corresponding questions.

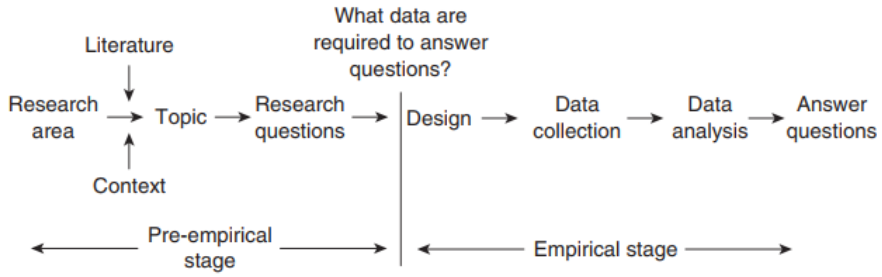

Figure 9.Simplified model of research

(Source: Punch, 2000, p. 11)

Ritchie, Spencer, and O'Connor (2003) suggest the 'analytic hierarchy' for analyzing qualitative data: identifying initial themes or concepts; labeling or tagging data by theme or concept, summarizing data, identify dimensions, refining categories, and refining data, establishing typologies, identify patterns, giving explanations, search for applications of the findings to more extensive theories. We follow this logic to process the data to answer our research questions.

We applied the coding methods, open coding, and axial coding, as in the study developed by Strauss and Corbin (1998). Open coding is "the analytic process through which concepts are identified and their properties and dimensions are discovered in data" (p. 101);. In contrast, axial coding is 'the process of relating categories to their subcategories" according to their level dimensions and properties (p. 123). We evaluated the transcripts according to the thematic framework as in the literature section. The first level outline of the structure, open coding, was to spot the contents related to terms like 'collaboration' 'user' 'user involvement' 'stakeholder' and 'network'. It was an abstract representation of labeling the phenomenon for grouping them into similar concepts (Strauss & Corbin, 1998). Questions in the interview guide were designed and arranged according to this framework. Due to the relatively fluid nature of semi-structure interviews, they were asked in a sequence or format that was not precisely the same during the actual meetings. Thus, the data presented in the transcripts had a similar but somehow loose flow. The first level outline was then critical for us to ensure the correct categorization of the

data based on the dimensions. After that, we proceed to the second level outline, axial coding, to refine the data by identifying the sub-categories to support the categories that stand for the themes. The sub-categories were about contextualizing the phenomenon by answering questions of what, when, where, how, who, and why, using the technique called 'the paradigm'- find the linkage between categories and organize their emerging connections (Strauss & Corbin, 1998). Annotations and notes were also made in the transcripts related to the details about each sub-category. We identified the activities reflecting Living Labs' roles & start-up collaboration, user roles, user/stakeholder involvement, and the extended innovation network connections. We arranged and presented the data in tables, figures, texts (quotes) following the themes and sub-themes to establish a clear understanding before moving to the next level of analysis - mapping and interpretation. Then, we classify the outcome and map it to the theoretical framework, explain the findings, and compare them to the theory. Discussion are made to articulate the reflections from the findings and new understandings derived from there.

To ensure the quality of work for qualitative research, data analysis during this process has to fulfill certain criteria: *credibility, transferability, dependability, and confirmability* (Collis & Hussey, 2013; Lincoln & Guba, 1985). Credibility concerns on whether the research is carried out in a way that the research subjects are identified and described. Transferability is about whether findings from this research can be generalized and applied to other similar situations. Dependability is the concern about whether the research process is rigorous and well documented. Confirmability is about whether this research process is sufficiently covered and supported by assessing the data flow (Collis & Hussey, 2013; Lincoln & Guba, 1985; Moon, Brewer, Januchowski-Hartley, Adams, & Blackman, 2016).

We construct and operate our data collection work based on the four criteria mentioned above and list the key measurements in table 7.

Table 7.*Quality check and measurements for qualitative research*

Criteria	**Measures**
Credibility	Well-developed methods, multiple data sources, and theoretical frameworks are used for gathering insights and developing an in-depth understanding of the area of study. Interviewees are the key personnel involving in the innovation process from each participating organization. Thus they have the vision, relevant experiences, and knowledge to provide inputs for this research work.

Transferability	Full description of the work is provided to build the detailed narration of the contextual information around data collection, such as the background & relationship of participants, methods of recruitment, interview questions, details of the interview process, etc. The aim to share as much evidence of the findings and possibility of extrapolation as possible.
Dependability	Detailed documentation and explanation of the methodology, methods & tools are covered for readers/outsiders to evaluate the research practices; a complete record of the data collected is maintained for further investigation.
Confirmability	The systemic process of data collection and analysis was followed through the process of maintaining the objectiveness of interpretations and recommendations. The documents of the theoretical constructs, details on the procedure, and methodological description are other researchers to assess and yielding of findings.

5. Empirical Findings

We start introducing the empirical findings with a brief look at the interviews with Living Labs and start-ups. We generate the word clouds graphs with the software Nvivo, based on the transcripts by counting the frequency of keywords mentioned. Figure 10 shows the result of the top keywords used by these Living Labs, and Figure 11 shows the top keywords with the start-ups. The most emphasized words by both Living Labs and start-ups are companies, labs, think, product, testing/test, need(s), development, develop, activity, talk, living, project, collaboration, partners, etc. We can see the common interests and objectives of Living Labs and companies are around product development and its facilitation.

Figure 10.Word cloud: Living Lab

Living Labs emphasize the word ‘users’ more than start-ups, who refer to them as ‘patients’ or ‘people’. Living Labs also mentioned more frequently about words like ‘technology’ ‘solutions’ ‘municipality’ ‘services’ ‘help’ ‘information’ ‘time’ ‘involve’ reflecting their business nature and focus that is towards the strategic level of digital health development.

Start-ups use more words like ‘use’ ‘want’ ‘helping’ ‘care’ ‘questions’ ‘business’ ‘meeting’ ‘network’ ‘innovative’ ‘problem’ ‘see’ ‘ask’ ‘way’ ‘cluster’ ‘strategy’ ‘research’ etc. Those words also reflect their business focus, needs, and actions, which are closer to the operational side.

Figure 11.Word cloud: Start-up

5.1 How do Living Labs Collaborate with Companies Like Start-ups?

By analyzing the data collected, we proceed to answer the research questions mentioned at the beginning of the thesis. We start by answering the questions about Living Labs’ collaboration with companies, which are start-ups in this case. We identify the types of these Living Labs, and subsequently, their ways of collaboration with companies (Leminen, 2015). We also examine from the start-up’s perspectives on their Living Lab engagement, including the timing, the methods, and the experiences, etc.

5.1.1 Living Labs in the Collaboration

Table 8 is a summary of the types of current services offered and activities conducted by the three Living Labs. For Lab B, it is their 2nd phase activities after the transition of tasks to Lab C.

Table 8.*Three Living Labs' services and activities*

Living Lab	Activities/Services
Lab A	- Find out the market potential for the product and approaches to the market. - Verify the product functionality and safety via testing, alignment with ethics and legal requirements, etc. - Cost reduction and improvement in the real environment - Panel meetings, workshops (e.g. 'Helsehack' hackathon) and with stakeholders and users
Lab B	- User panel meetings for exploring and defining the needs, as well as sharing of experiences. - Testing new welfare technological solutions in a real operating situation with users (patients, relatives, and healthcare workers); involve the municipality or hospitals when necessary - Collaborating with Lab C for the transition and future innovation and development
Lab C	- Facilitation of innovation projects: expertise mediation, facilitation of stakeholder/user meetings and workshops, connection to business and relevant instruments, counseling, and door openers to the relevant network - Simulators, usability tests of different scenarios, an innovation center for product development; solve issues related to safety or ethics; value-creation to the society.

The statements from Living Labs about their primary business focus also explains their roles and goals in the innovation process. Lab A has a focus on companies, and it engages other actors around their innovation process. Lab B has a mission for the transition of the work into Lab C and doing user-centered innovation. Lab C has a broader vision to facilitate the integration of actors in the innovation network.

> Lab A*: To help companies to find out what they need and provide different services so that they can hopefully verify their products and get into the market more securely. Companies needed to both verify their technology to ensure it works and be secure by testing different solutions in the real environment because that was really difficult for the companies to set up that kind of test and get the right persons on board.*
>
> Lab B*: The goal with the second funding project is to implement the Living Lab methodology that we developed in Lab B in the first three years into Lab C. The goal*

with user involvement, user panel is so good and so important for the future and the e-health.

Lab C*: The primary business focus is to unleash the innovation power in the connection between the four actors private and public sector, academia and research community and the citizens or the users' perspective. The focus is on digital solutions, e-health, and health technology... The most important role is to facilitate, be a driver, listen to opinions, catch, record it; and make the open and trust-based dialogue work, and use the resources to the best of their ability.*

We refer to the definitions of four types of Living Labs networks by their roles in development, suggested by Leminen et al. (2012) in the theory section and map against our findings (Figure 12). We identity Lab B & C as the typical enabler-driven Living Labs, but Lab A as an enabler-driven Living Lab with a particular focus. These Living Labs were formed as a result of actions from the national or regional funding and initiatives for future-oriented innovation in the healthcare industry. In the open innovation environment, Living Labs set their strategic objectives, form the network around their innovation network or the region, co-create the knowledge with stakeholders, companies, and users in the network to address the future challenges in healthcare. The 'enabler' role is evident for the three Living Labs. Companies and users are participants but not the drivers of operation. Thus, Lab A, B & C are considered as enable-driven Living Labs, though their exact missions vary.

Lab A sees themselves as a service provider for testing of healthcare solutions with healthcare providers and users. Lab A facilitates innovation activities, the involvement of users (workshops, meetings, usability tests) and relevant stakeholders (panel meetings) around companies and health services, to develop and verify their products in the real-life environment. Companies do not facilitate the innovation network, but they are the actual innovators who develop their solutions, and they actively utilize Living Lab's service. This collaborative relationship is different from the claim made by Leminen et al. (2012) that companies only have a minimal role in the enabler-driven Living Labs.

For Lab B & C, testing companies' solutions is still an essential part of their job. Nevertheless, their target is to steer the demand-driven innovation in the healthcare industry by putting user involvement in the center of the innovation process.

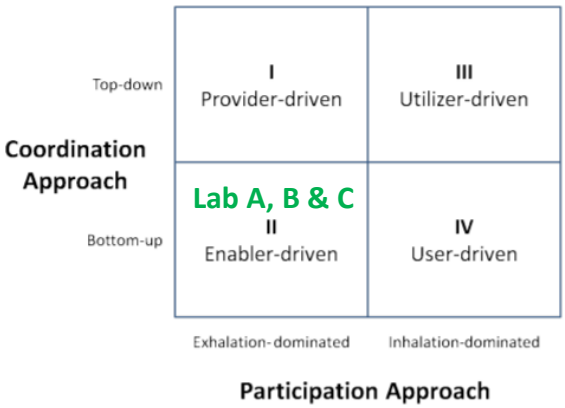

Figure 12.Mapping the matrix of innovation mechanisms in Living Lab networks

(Source: cf. Leminen, 2013, p.11)

Secondly, we examine the innovation process design and tools used by Living Labs during the collaboration, based on the 'two-dimensional framework' proposed by Leminen and Westerlund (2017). We map our finding to the four types: linearizers, iterators, tailors, and mass customizers (Figure 13).

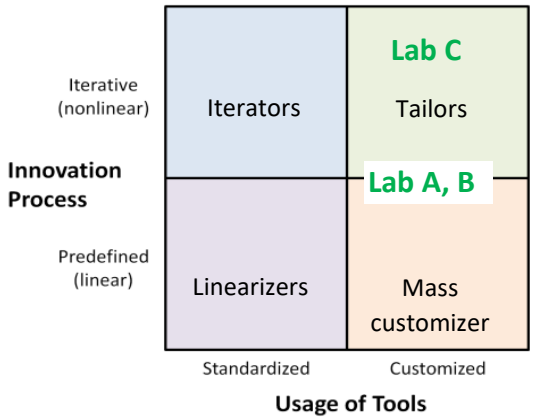

Figure 13.Mapping Living Labs based on the innovation process and tools

(Source: cf. Leminen & Westerlund, 2017, p. 19)

Lab A & B are between mass customizers and tailors. They both have a pre-defined innovation process, from the beginning to the end. Meanwhile, they do not necessarily follow the linear process for all cases. Instead, they show the flexibility to adapt or adjust the steps according to the situation of individual companies. They both use customized methods and tools for different cases. Therefore, we identity Lab A and B as the combination of mass customizers and tailor.

> Lab A*: We help the companies in the beginning, to find out where the market is, what the market potential is, how they can approach the market if there is a need or somebody that will pay for the solution that kind of things in the beginning. Then, when the companies start developing their products, they need to help verify that the products are actually working and they are secure to use and they will align with the General Data Protection Regulation (GDPR) requirements and health laws that all kinds of things they need to comply. We provide all kinds of different services and all of them have what the companies really need at a stage.*

> Lab B*: We have defined the five steps of (Lab B) methodology. Usually, we start at step four because we have the technology. And we experienced that the need had to be more expanded and explored. So, we went back to step one to take through step three and back to step four. And then we could recommend something for step five to the municipality buying the technology or the patients that would like to use it or even the companies maybe... We also experienced that during our project, the first period that some companies were mature enough to take this journey with users in the center and changed the product during this task period back and forth like this. And some companies were not that mature. They felt that their products were good to go, ready to buy. And some companies even wanted us to buy the product, test it, and make a story for them to sell. And that was not our purpose for the project.*

For Lab C, we identified it as a Tailor. Lab C shows more flexibility in terms of customizing both the innovation process and tools according to actual needs, e.g., not precisely following the linear innovation process. Lab C is still at the early establishment stage. It takes time to formulate and finalize their patterns. What we observe now partially depends on their strategies rather than actions. It can become a mass customizer in the future, like the majority of Living Labs (Leminen & Westerlund, 2017). But again, it is also an opportunity for Lab C to develop into a full-grown tailor that offers customized development and tools for supporting radical innovation (Leminen & Westerlund, 2017; Leminen, Westerlund, & Kortelainen, 2012).

> Lab C*: The company is still in the establishment phase, and much of the time is now spent on developing a strategy, building networks, and finding good structures, models, and good partners... Now we want to bring up the network. And we ask: "what do you need?" I don't think it's right for Lab C to decide how we get into our decision on how*

we work. We will have a discussion and find the right way for each company and the role. So, we are working on it, and it's an interesting process.

The findings show that three national/regional initiated Living Labs act as the facilitator of the innovation process for building a sustainable healthcare industry, through innovation activities with various actors. There is a collaboration with companies, users, institutes, municipalities, and so on, but these Living Labs are the ones in the driving seat.

The three Living Labs have developed different types of collaboration with start-ups, with defined roles and responsibilities in the collaborative relationship. It actualizes through a set of activities/services classified into three types:

1. Testing and development of digital health solutions with companies (currently start-ups) with guidance and support in a real-life setting.

2. Connecting public sectors, healthcare personnel, end-users, institutes, and other relevant players into this innovation process, the 4Ps (Westerlund & Leminen, 2011).

3. Catalyzing the demand-driven and future-oriented healthcare solutions for the community and individuals with the multidisciplinary work and utilization of the joint-effort with innovators like companies, organizations, and institutes.

The three enabler-driven Living Labs, as the central parties, decide their patterns of innovation operation, including structures, activities, players, mode of collaborations with companies. We also found the deviation of these enablers in terms of their strategic focus and approaches or there was no exact fit into the classification as suggested by the two-dimensional framework (Leminen & Westerlund, 2017). For the types of the innovation process and tools used for start-ups, Lab A & B are in between the mass customizers and tailors, as they adopt both linear and non-linear innovation process with customized tools. Meanwhile, Lab C is moving towards the tailor, who customizes the innovation process and tools to the needs. These Living Labs are flexible in adapting to the actual innovation process.

Researchers mention that two types of organizations choose to be tailors. One is organizations with no prior experience who would like to explore different approaches and tools, and another type is experienced organizations who wish to develop and experiment with methodologies and tools to achieve their purposes (Kidd et al., 1999; Leminen & Westerlund, 2017; Nyström et al., 2014). Lab C is a new establishment but with the application of a set of developed Living Lab methodology from the prior project in Lab B, as well as the resource support. Thus, it has

the potential to grow into a full-fledged tailor, but it takes time to prove. Further research is also needed to verify whether this type of Living Lab leads to the emergence of radical innovation as opposed to mass customizers who usually bring incremental innovation, as proposed by Leminen and Westerlund (2017). It could be insightful to follow up with Lab A, B & C to observe whether their work leads to incremental or radical innovation in the long run.

5.1.2 Start-ups' Living Lab Engagement

We assess the collaboration with Living Labs from start-ups' perspectives as well. These start-ups encounter Living Labs at different stages of innovation, but mostly towards the late testing stage, i.e., when they already have more or less finished developing their solutions (Table 9). They are introduced to the Living Lab through their network, e.g., cluster, incubator.

Table 9.*Living Lab engagement for start-ups*

	Living Lab engagement in the innovation process		
Start-up	**Who**	**When**	**What**
Start-up A	Lab A, who introduced themselves	Late testing stage (after the prototype is ready)	- Usability test and a report - Testing at a nursing lab in the university - Introducing to a representative from the municipality about implementation in the market
Start-up B	Lab A, via the hackathon	Not directly related to their current projects	- Participation in a themed hackathon workshop - Lab A offered to share information about applying important projects in the EU, but start-up B has already had its network
Start-up C	-	-	- Contacted Lab A before but did not proceed due to cost and distance concerns - Checked the information about Lab B online
Start-up D	-	-	No Living Lab engagement
Start-up E	Lab A, via a partnership	Testing stage	- Lab A arranged a serial of pilot testing with the patients, the next-of-kin and healthcare personnel in the healthcare center - Reports on the testing results
Start-up F	Lab A, via Aleap	Late development stage	- One full-day focus group meeting arranged by Lab A, involving the stakeholder panel (researchers, end-users, municipality, hospital & nursing home employees)
Start-up G	Lab C	Late testing stage	- Ambassador and door opener for getting the into the network with research institutes, the university, organizations , etc. - Multidiscipline advice on the strategy - Bridging potential collaboration with other companies

For those (Start-up A, E, F, G) who have had real innovation collaboration with Living Labs related to their product/service development, there is positive feedback about the outcome. They have also pointed out that the involvement of Living Labs could have happened at an earlier stage of their innovation to make a more significant impact on the outcome.

> Start-up A*: That was a good learning outcome. They made a really good report from it. Since it was quite a late phase, maybe there were not so many things that needed to be adjusted as I can believe it would do in an even earlier phase that the Living Lab didn't exist then…We have joined a lot of activities with the Norwegian Smart Care Cluster, but with the Living Lab, it's quite limited. Because for our side, we have never heard of the Living Lab being mentioned before recently… And not for having so much money as a start-up. We knew Lab B but instead of going there and pay money for it. We'd rather go to different nursing homes because it doesn't cost us anything. They give really good inputs.*

> Start-up E*: They wrote a report, they analyze the security. For me now, to have a report is useful. We have some rules that are to be updated in the norm, so I'd love to have more because it'll be easier. I have that they analyzed the product that I had.*

Before approaching Lab A, Start-up F contacted the OuluHealth Labs in Finland with the help from the University of Tromsø, trying to have a seminar activity. Start-up F paid a visit to the Lab but did not establish the collaboration afterward. Aleap introduced Start-up F to Lab A, who arranged a focus group meeting for them in Stavanger. Stakeholders involved were representatives of researchers, end-users, municipality, hospital & nursing home employees. Happening at the late development stage, the purpose of this workshop was mainly to get feedback on the product concept, interests, potential concerns; most importantly, to confirm Start-up F's business idea about the future market direction and targeted customer group for further development.

> Start-up F*: We were a little bit surprised because we had positive feedback on everything that we confirmed a lot of assumptions the way they worked. This is something that both the patients and the health care personnel would benefit from. We expected to get more negative and more critical feedback. What I'm saying negative is critical. But that was nice because we also received many tips proved well that everything we were saying or claiming worked well on the technological side. Then what inputs we could have, what are the necessary other perspectives to get this*

practically implemented in the practice of healthcare personnel and so on. So, we got a lot of tips that we could map out the feedback…In the end, we received the report giving some suggestions to develop further the product, which was quite helpful.

Start-up G has been actively conducting pilot testing in nursing homes with healthcare personnel and patients. When they started with Lab C, it was already the late testing stage. Therefore they are using Lab C as an advisor on their development, and more importantly, an ambassador and door opener for getting into the extensive network, including the public sector, organizations, research institutes, etc. Lab C also introduced three students with a major in health technology to write their master thesis with start-up G.

Start-up G*: I need people asking the right questions. She (Lab C) is good at asking good questions to make sure we have a good picture and all the involvement regarding things like security, GDPR issues, ethical issues. You need to think across disciplines. That's where I think xx (Lab C) is very important. She wants to combine multi-discipline tips. You have part of the master thesis students. You have part of the engineers, you have the data students, the sensor students, so on and so forth. That's what I see the most unique feature or uniqueness of Lab C. They would like to follow up on the research.*

We asked start-ups C & D the reason why they had no collaboration with any Living Lab. Their answers showed that they had either some practical concerns like cost and distance or did not have any real encounter with the Living Lab's work to start the conversation. They were also satisfied with the current network, and they had no intention to seek help from Living Labs.

Start-up C*: I have been in contact with Lab A, but I found it hard to collaborate with them. Because we are in Oslo and they are in Stavanger and then there is a cost question that it takes x amount of money for those things. It hasn't been our priority yet… I know about Lab B also but just seeing it on the website, so I'm a little bit unsure what the outcome really is. I have talked to the Nordic Proof sometimes about the options. But there is always a cost question for us. Because again, it's a little hard to understand actually what the outcome is and then how to ensure that works is what we need right now.*

Start-up D*: We have pretty good strategies on what kind of partnerships that we want to enter. That is, partnerships in different areas like one strategy are to get hospitals to connect dental clinics, another is to get the collaborations with other features that could be interesting in the portal… Because we have this good collaboration with the*

Sahlgrenska Science Park and Oslo Science Park. We are pretty satisfied with how that works. But if we are thrown out, we have to look for other opportunities that suit our business better. Right now, we are not looking for anything.

Start-up B is a little bit different here. They are mainly a consulting firm working with various industries but does not specialize in healthcare. They provide solutions (problem-solving methods) to their client companies, although they also develop a tangible prototype when needed. They involve users, who are mostly the client companies, early during the conception stage. Start-up B worked with the hospital of Stavanger before over a project on how to use Virtual reality (VR) to treat patients with chronic diseases like dementia. They are a member of NSCC too. Their experience with the Living Lab is the participation of a workshop, called the 'Helsehack' hackathon held by NSCC and Lab A with partners about how to improve health and well-being through data from resources like smartwatches, social media, bank, public reports and so on. Start-up B was among over ten companies and individuals who participated in the two-day workshop. It was also the only hackathon that Lab A has conducted so far.

Start-up B*: But we don't feel like that the Living Lab has reassured us afterward. They just disappeared in a way. I have been thinking maybe they are busy developing the whole and getting ready for the next step. They should really follow up afterward unless there is something wrong that they don't want to work with us. I don't know… They should really build an ecosystem surrounding the Living Lab. There are tons of companies, resourceful companies that can contribute to the Lab and get projects spinning out of the ecosystem... They could invite more companies into the continuous process of bringing in knowledge, sharing knowledge, building the network of cross-competence.*

Start-ups' feedback on the collaboration with Living Labs is somehow neutral if they did not have much interaction, or they had only joined few occasions (like meetings or workshops) that are not directly related to their business interest. They are still positive to future collaboration, but with relatively lower incentives compared to the other group. The Living Lab did not actively approach them either.

5.1.3 Innovation Network Engagement

During the innovation process, companies interact with a wide range of players in the network, as they can't complete the innovation alone. Living Labs as the catalyst and facilitator have helped start-ups for building the network with other players such as governmental organizations, research institutes, and clusters or companies. We asked start-ups their network-building efforts and the help from Living Labs, clusters, or incubators in bridging this connection. Table 10 is a summary of the connected network of innovation for start-ups. It shows that both Living Labs and start-ups are actively approaching and using the network to reach stakeholders, partners, and eventually the market. Start-ups are actively reaching out to the network on their own. It means Living Labs simply play a small role here.

Table 10.*Innovation network engagement for start-ups*

Start-up	Innovation network engagement	Connect via
Start-up A	- NSCC: applying for grants and having projects; networking meetings; introducing to other companies like IT services - Validé: use for specific competence e.g. IP	NSCC
Start-up B	- Established own network with institutes, organizations & companies - Member of NSCC but not actively engaged	Self & network
Start-up C	- The mentor network - Norwegian Health Consortium: Service package for health start-ups - Pattern Office of Norway - Inventas: design and development company	Aleap
Start-up D	- Partnering with specialists across countries in its research area - Institutions doing clinical validations and scientific reports	Mentors, self
Start-up E	- Municipality: GDPR, Data Privacy Impact Assessment (DPIA) analysis - NSCC: promotion of the product - Innovation Norway - Research network in Europe	partnership & self
Start-up F	- NSCC: arranging the collaboration with Lab A - Networks that support EU applications and funding - Norwegian Health Consortium, in discussion for the service package - Norway Health Tech	Lab A & Aleap
Start-up G	- Institutions & research organizations: testing, research collaboration - Governmental research advisors like The Research Council of Norway - NSCC: partner companies for system integration	Lab C & Self

As for Living Labs, this is a critical mission for them to build up the competence of players in the innovation network via collaborations.

> Lab A*: What we are aiming for is to make it easier for companies to have one contact. They can have one contact with Lab and have all the different tests and how to find partners in the right way. It's more efficient. Because it can be very time consuming if*

you try to find different things yourself, that's why we are trying to be the facilitator and help companies to find out what they actually need to do. And then we can provide them with our services, together with our partners. They can also choose to do the tests with other places if they would like to go. They can use us more as a guide if they would like to do that. But hopefully, we would like to have the services to the companies also.

Lab C*: We are working on getting in place through partnership agreements, important that we can play on and strengthen each other's strengths and competence. Co-creation and in this thinking, there is no hierarchy. It is a crucial promise.*

Start-ups confirm the benefits by having Living Labs to connect them to the broader network.

Start-up F: *I think the most important is the resource-saving. Because you can easily get in touch with relevant people, who can help you to take your company to the next stage in your development, without spending too much time on getting the doors finding the right people, and establishing the initial relationship also takes time.*

Start-up G: *They (Lab C) are helping us to get in contact with people. We have attracted the universities to participate in our project. She (Lab C) took us to the Norwegian Research Council…She opens a lot of doors in the university and we are now having someone writing a master thesis on our technology…They can add a lot of value to my company by doing discussions, sending me to the right people, or being able to get market recognition to our technology, including the university and so on. That's how every business relationship should work. It should be beneficial for both parties.*

Meanwhile, all start-ups have been spending a vast amount of effort to access the network by themselves by using all the available resources, including Living Labs. Start-ups' effort on network building is also reflected in the next section of user involvement, where they collaborate with various players, institutions, organizations, healthcare providers to facilitate participation. And for these seven start-ups, they manage most of the network building outside the Living Labs' help. The clusters and incubators contribute more.

5.2 How do Start-ups Engage with Users in Living Labs?

After examining the collaboration model between these Living Labs and start-ups, we take one step further to investigate the current situation and approaches for user engagement during the innovation process.

5.2.1 User Engagement in the Innovation Process

All start-ups highly recognize the importance of user engagement in the innovation process and explore all the possibilities to do so. They begin to include users at different stages of the innovation process. Table 11 is a summary of the findings on start-ups' user engagement during the innovation process. The information is categorized with the answers to three questions: When (at which stage of the innovation process) do start-ups engage users? Whom do they involve? How?

Table 11.*User engagement for start-ups*

Start-up	User engagement in the innovation process		
	When	**Whom**	**How**
Start-up A	Throughout the R&D process: concept, design, development, testing	- End-users (patients) - Healthcare personnel who use the product	- Pre-development: interviews and focus groups - Test MVP and prototypes - Pilot test - User free trial - Feedback and discussions
Start-up B	Concepting & development	- The client companies - Use agencies to collect insights from end-users	- Develop concepts and build project organizations - Develop prototype and outsourced testing if needed
Start-up C	Development & testing	- Doctors in hospitals - Patients - Colleagues	- Prototype and clinical trial - Collaboration with one clinical innovation, technical studies in the hospital
Start-up D	Development & testing	- Dentists in hospitals & clinics	- Observation: 'walk through' with the dentists' routine - Prototype testing on-site - Feedback and discussions
Start-up E	Idea, design, development & testing	- Patients, the next-of-kin and healthcare personnel	- Verification of ideas - Prototype & pilot testing on-site
Start-up F	Development & testing	- Health professionals & patients	- Focus group (via Lab A) - Prototype testing about usability in hospitals with real patients - Feedback on the performance
Start-up G	Development & testing	- Healthcare personnel, patients in nursing homes & relatives	- Pilot testing on-site & feedback - Training to healthcare personnel - Collection of data for further development - User free trial

Start-up A, B, D, E involve users at the design stage and develop the product together with them. Based on the theories on users' roles in the innovation process (Leminen et al., 2014; Leminen et al., 2015; Nyström et al., 2014), the findings show that users have been assigned multiple roles here, like the informant (sharing insights and ideas), the tester (testing the solution), the contributor (suggesting the design and functions).

> Start-up A*: We have them (users) throughout the R&D process before we even started. We had interviews and focus groups with different customer segments, to find out who are the most attractive customers for us in terms of end-user, institution and all those stakeholders, the need for the patients itself, the need for the institution buying the product and the healthcare personnel who is using it. We used a lot of interviews to set the base for the concept and built an MVP, minimum variable product. We tested it with the same customers, also new customers and got feedback. We adjusted more and built prototypes.*

> Start-up D*: In the beginning, we discussed a lot with different dental clinics to see how they would like to see the product in their clinic. Because the dentists are really busy people and when they work they work. It's really important for us to have a process as simple as possible and the thing is how do we achieve that. We went to different dental clinics, sat down with them to see how they would click, how they would upload the image, how they would feel the thing working when they used. And we used their feedback to twist the product and functions to get the optimal product. So, a lot of discussions. You can say that it's developed together with the dentists.*

Start-up C, F involve users when they start the prototype testing, and start-up G starts with the pilot testing, meaning with the fully functional product. The roles assigned to users are mainly the testers and the contributors (Leminen et al., 2014; Leminen et al., 2015; Nyström et al., 2014).

> Start-up C*: As you might already know with medical devices, it's very strict so we can't give the device away to anyone. We have to do it in the clinical setting, so the researchers and doctors started really early with the test with patients. Maybe they tested on ten patients first and then we tested on 20 adults in the past year, and then we will test on 40 adolescents. This is a research that it's the doctors that doing the work. And then we work, for instance, the interface. We tried to show it to colleagues to have it work and get feedback, show that to migraine patients on Facebook to get feedback*

on everything that is related to giving out something because that can be the borderline... But I don't know really think that they involved users that much (before the prototype). I guess they talked more about the science behind it. You have a method that is proven to be effective, and you just want it to be remote. Also when you talk to patients, it should be really really user-friendly, but another expectation is that if it works, I know they want to use it because they want to get better.

Start-up G*: We have been working with the care sector piloting for three years… In the beginning, we, or xx said as I was not in the company in the beginning, "Listen, we have this technology. Do you want to test it out?" "Yes." And then they had an easy first product. We needed the experience from the care personnel who do they work, what is important for them, how this product should work to become a tool that they would like to use with all that benefit. We talked to a lot of people to get a good understanding of how hectic their work was. And today we also get inputs from some of them.*

Start-up F focused on one product, which was an application of the clinical tool analyzing data from their databases. Therefore they did not contact patients or healthcare personnel for getting the data at the early stage while designing the algorithm. They had a focus group meeting with stakeholders, including user (healthcare personnel and end-user) representatives, at the late development stage, arranged by Lab A. They gathered users' feedback to the product concept. They also aligned their customer segmentation based on the information revealed on users' interests and needs. Start-up F started the collaboration with healthcare professionals and patients when the prototype was ready. Users are mainly the informants in this focus group activity, but start-up F also involves them as co-contributors in their prototype testing with healthcare providers (Leminen et al., 2014; Leminen et al., 2015; Nyström et al., 2014).

Start-up F*: Now, we have a prototype that we are testing at two hospitals where we start the testing with real patients. I would say the challenge will be on that side, to actually start testing. And hospitals can also be not so flexible when it comes to the development of health technologies. Because they are more traditional to research and clinical studies, but we just want to test something more from the usability point of view. It might be a little bit confusing between the line of clinical study and usability study to see how users interact in real life and make it more user-friendly, which is not the clinical study. That also gives a lot of feedback on how the algorithm performs.*

The journey is not entirely smooth for all, and they flag out the challenges too.

> Start-up C*: It's difficult to get to users because we have to go through the hospital. If we want to have patients to use our products, we have to go through the hospital. That's a really long process.*

> Start-up E*: I think it's quite smooth because this is an innovation partnership. So, the whole purpose is to innovate together with the users. I think it's more afterward. I would wish the process from developing together to starting to implement could be shorter. Now, it's been one year, and it could have a better speed. I should have started implementing it right away.*

Therefore, the findings have suggested that start-ups are highly aware of the significance of user involvement, and they are actively applying it during the innovation process. The actual practices of participation vary among start-ups. Differences arise from the innovation stage for it to happen, the role of users in this process. And subsequently, the degree of influence users can make to this innovation. Start-ups mainly involve users as the informant, tester, and contributor. In contrast, the co-creator role, where users develop the solution with the innovator on an equal basis (Greve et al., 2017; Leminen et al., 2014; Leminen et al., 2015; Nyström et al., 2014), is not visible based on the information provided.

5.2.2 RI in Living Lab: The Four-dimensional Framework

When talking about user involvement, we ought to return to the topic of RI, as discussed in the theory section. Studies have confirmed the importance of early engagement with stakeholders especially users into the innovation process in the healthcare system, suggesting that actively building the user experience into the design of solution lead to successful innovation (Iakovleva et al., 2019b).

The government, healthcare providers, organizations, and companies have highlight user involvement as well, but then the question is to which extend the relationship is (Bessant et al., 2019b). Therefore, we refer to the four-dimensional framework again as a measurement of user involvement within the innovation process for these Living Labs and start-ups.

Inclusion

Our findings reveal a high degree of inclusion with users during innovation and a high level of awareness about the importance of such integration. Both Living Labs and start-ups recognize users, healthcare professionals, and end-users as a primary source of innovation.

Start-ups' effort on user involvement has been covered in-depth throughout this section of User Engagement in the Innovation Process. The difference is the degree and time of involvement, i.e., which innovation stage for it to happen and how much users shape the participation. Start-ups (A, D & E) involve users since the earlier stage of innovation, by keeping close interaction with users to understand the needs & desires, figure out the product design, verify with testing and continuously adjust it according to the feedback. Start-ups (C & F) involve users later when they have the prototype, which are some models/samples for users to try and evaluate and modify the design according to the feedback. Start-up G has conducted years of pilot testing with target user groups and collecting users' experiences and input before they roll out to the market. As pilot products are the next level of prototypes, they mainly focus on the users' actual usage of the product functions.

The three Living Labs have their strategy for user involvement as well. Lab A has made it clear that their focus is to test companies' digital health solutions, positioning user involvement as part of the service provided to start-ups. Some activities are without users and some with users, and it happens at different stages of innovation depending on the company's needs.

> *We have the Helsehack that works really like a Living Lab activity. But our lab is also about helping the companies verify their products and services and test in a real environment. That's where the Living Lab concept comes in. But this verification process is also important because that's where companies actually show that the technology works or the solution is actually attractive for the market... So that's mainly our focus to help these companies and some of the verifications is that we also test with the real environment so that's maybe what you call the Living Lab activities. But we have a lot more to do.*

However, we should not interpret it as Lab A does not involve users actively. They include users regularly, as they are often the participants of testing. Besides, they form the stakeholder panels and include user groups, especially end-users like the representatives from the Pensioner's Union. They have had three stakeholder panels for different digital health solutions,

including the one with start-up F. Lab A has also utilized its capacity to sketch to a wider inclusion, by having more user sessions for their insights.

> *We don't have many workshops because we tend to focus on the companies' needs. And the company needs are more individual but of course, some of the tests actually need involvements from end-users. For instance, when we test these stockings. You know for the elderly persons, they put on these socks because they have problems with their legs. They put on these health socks that are really difficult to put on. So we have like a test together with 60 elderlies and we had tests different socks with them. It's not a workshop, but it's more like testing to see if the product really works like it intends to. We also had a panel in the end of the session, talking to all the elderlies: what do you really think of these socks? And they had a lot of really interesting things to add to product development.*

Lab B has stressed on the importance of users, especially patients, and the next of kin. After moving to the 2nd phase, Lab B's strategic focus on users shifts from the testing of companies' solutions to exploring users' needs for future-oriented innovation of digital health, which implies more early involvement. They maintain around 40 regular members in the user panel at all time and recruit new ones, as a replacement to those who have left, through various channels like events, references, user group activities, etc.

> *The users for us are both patients and nurses, and the next of kin is a center of user pool for technology… Patients and the next of kins are in the center. And almost always at the start of the health of services of the nurses and so on. But it's not final that it's always like this. It moves depending on what your goal of the technology is and who is going to use it, the patient, the staff or it's just to help. All the things we have to collaborate in the background.*

> *Always include them (users) in defining the needs, developing the product, testing the product, and so on. Every step of the way includes the users. It should be different with different technologies for the end-users. But always put the patient in the center because everything we do in the municipality in the health sector is for the patient. So you need always put the patient in the center and check if it's a good way to go.*

Lab C has clearly stated user involvement as the center of their innovation process by bringing users into the innovation process. They also established the collaboration with the Pensioner's Union, Lab B' user panel, and Hospital of Southern Norway (SSHF) user committee, etc.

In order to develop reliable, secure, user-friendly and cost-effective solutions, an efficient project team with the right composite competence is required. We will strive to connect universities and research institutes, the specialist and municipal sector, private actors and the voluntary sector. User involvement will be central to the entire development process.

Now we have entered a new phase and it will be important to bring good ambassadors to the team. Here I think the users' perspective becomes important. It is also crucial to bring along leaders who understand the importance of doing something new, to be the driving force.

When being asked about the challenges with user involvement, Lab C has acknowledged that the integration is not as deep and wide as expected. More actions should follow to improve the situation.

We started with a workshop, and then we got just one user from the user panel. I think it's not enough. We talked earlier about the balance, so we need more users in the first meeting. We learned that this is not good. It's not good for only one user to get the users' voice. We have to bring a lot of users at an early stage. And I mentioned the kick-off meeting. We got the dependents. We talked about the young people who got their own home. We don't bring in the person but the father. It's not the right person. We really have to bring in the users so that we can listen to what they need. We have to find new ways to bring users into the projects.

Anticipation

For anticipation, Living Labs have their future-oriented strategies for developing digital health and have shown thinking about future possibilities, challenges, and critical issues.

Lab A is aware of issues with the engagement with companies during the hackathon. They figure that there have to be some incentives for them to participate. Lab A has been planning to have a session with the buyer(s) of the solution involved.

We have some activities. We see it's difficult to do that kind of workshop because the companies really would like to have some results that they can do some commercial products on. We struggled a bit with that kind of activity. We can do that for one company. That's easier if the company really has addressed some needs that they would

like to look into in an innovation workshop or that kind of thing. We will do the Helsehack once more on another topic. If we are going to do, we'd like to have a customer who is really going to buy on the other end; otherwise, it's very difficult to have companies to set up time or the workshop.

Lab B and C have also stressed on the importance of sustainable and future-oriented digital health development.

> Lab B*: So, we are in a big change in the municipality and the healthcare service, and in the hospital. And coronavirus has shown that it suddenly makes a big change in a few months, a few weeks. And I think this is just the beginning of something, but we don't know. We are in the middle of the change now, so it's difficult to see how painful it is. And the staff in the healthcare service is feeling more pain than the patient and next of kin. Companies are coming with many solutions but it's always on the top of anything else.*

> Lab C: *I think for the nurses tomorrow, they have to understand more of the technology behind the solutions they work with. This is to meet the challenges of tomorrow in the health sector, with more and more elderly people who need different help and support. In addition, there is an increasing number of people of working age, so we all must think again to maintain the welfare of the society.*

Reflexivity

The interpretation of reflexivity here is the flexibility to use the feedback from users and adjust to meet the societal and ethical requirements along the innovation process. At the same time, it also means the ability to see one's limitations in terms of knowledge, ability, resources, etc.

In the case of Living Labs, they reflect their limitation in capability and resources. And they have the plan for prioritizing items on their list.

> Lab B: *We have some members in the project group but we might have missed some of the competence to do all the stuff. Like in the law segment, you need the competence to help to draft the contract with the companies, with the municipality. It's very complicated. And as a nurse, I have a lack of skills in that segment of the project. We define at the end of the project as well: if you need to go further, you need to try to have*

the lawyer with you to make sure that you can have the right contract with companies to test it and so on. And then you can publish.

Lab C*: I am conscious of getting feedback when I am in demanding processes. Listening becomes very important, but listening is not enough, one must also consider what works. Normally, I think through what has happened, analyze and spend as little resources as possible on pondering.*

For start-ups, they all have shown the continuous work of collecting feedback and timing adjustment of the solutions accordingly. For those who have early engagement with users, this process is even more crucial such as Lab A:

All the time, we used the feedback to adjust it. When we reached the testable prototype used by a real patient, we had one night to see how it worked. Then we had the pilot test with a nursing home and ten patients in three months. After that, we gained so many insights from the customers that have the product for one year while we were doing R&D… We learned that it was really important to have the product out with the customers because what we thought was the most rational thoughts or messages and so on was not the same for the health personnel.

Responsiveness

We notice the co-existence of responsiveness with the other three aspects during the innovation process. The inclusion, anticipation, and reflexivity do not happen in an isolated space, but through regular and close interaction with and timely response to stakeholders including users, partners, other relevant actors in the environment, and to them. Or we put it the other way saying that responsiveness is included in the actions of the innovation process for start-ups and Living Labs. It matches with previous empirical studies (Oftedal et al., 2019).

The promotion and support of user involvement and user-centric innovation from the government and municipalities offer the opportunity to both Living Labs and start-ups to put the ideas into action. While emphasizing the inclusion, innovators must develop a thorough understanding of the degree of involvement as it leads to the level of impact on the innovation outcome. They must respond to feedback and adjust to changes constantly. Meanwhile, they should maintain an overview of the opportunities and shortcomings, as well as foreseeing the societal impact of the innovation in the long run.

5.3 How do Living Labs Facilitate User Involvement for Innovation?

The last question is about the methods and tools used by Living Labs to facilitate user involvement at different stages of the innovation process. The intention is to compare the findings against the methods and tools suggested in the literature section, and we construct the summary of results (Figure 14) with a cross-reference to the research done by Feurstein et al. (2008).

We see that traditional methods are still in the dominant position, with most activities, especially meetings/workshops arranged face-to-face. Regular and specific meetings are organizations to exchange and collect information from users, discussion on the development of digital health solutions, build up trust for further collaboration, etc.

For the modern methods, three Labs have been using multimedia tools like video clips for communicating materials on products/services and sharing of project information to users. Some of the products that they are developing, like video call apps or devices, are for communication too. They generally come with user-friendly design for older people or other patients.

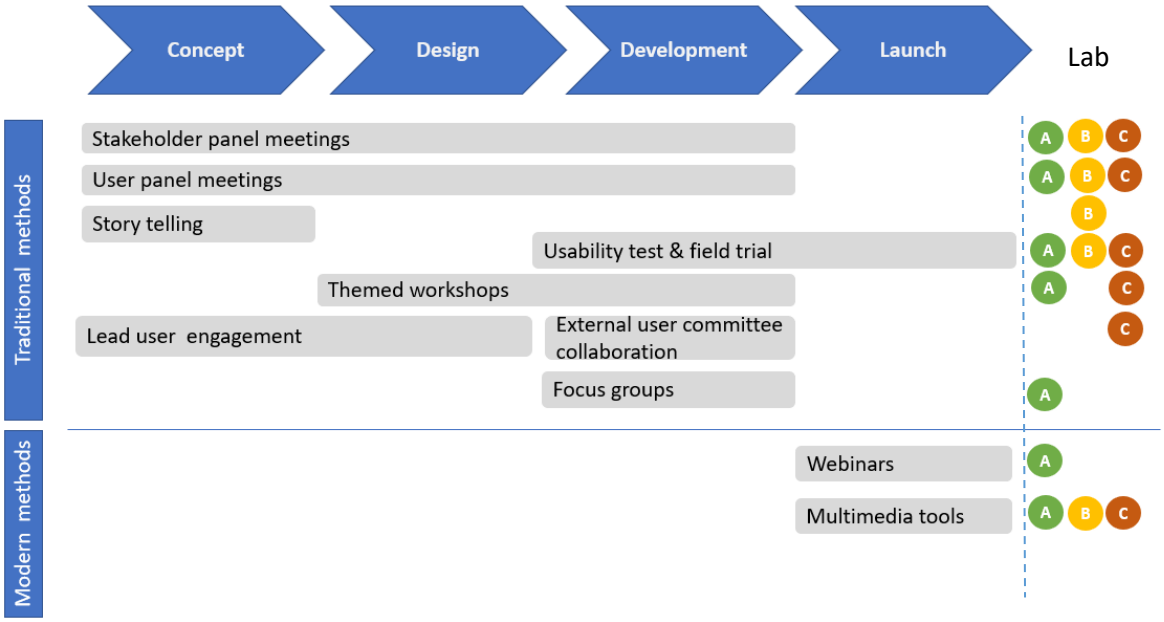

Figure 14.Living Labs' methods and tools for user engagement

Source: cf. Feurstein et al., 2008

Lab B has mentioned the plan of building an online user information pool for users to manage their information and participation with the user panel by themselves.

Lab A uses webinars more often to engage users mostly to share product information, as mentioned in the Data Collection section. This practice has been beneficial during this Covid-19 outbreak nowadays, with many face-to-face sessions being canceled or withheld. Lab A has shown the intention for more plans in the future.

> *It has been a special time in this spring. We just think we need some seminar series because we need to spread the words. So that was the first step, but the next step could be a nice idea to have more real user experiences. And then they can tell the stories. We could maybe plan for that kind of thing in the autumn. We have a program for that.*

Regarding the webinar with users and companies (as mentioned in Data Collection, see Table 7), the event host from NSCC shared the positive feedback from users.

> *They think it's interesting and useful. They get a lot of insights. Because many of the participants are from the Senior Council, they take this information to their Council and use it to influence the decision-makers in their municipalities. They want to learn more about digital development so that they are better equipped to handle and understand what's coming. They seem very happy. They struggle a bit about using the webinar with Teams, the practical webinar but many of them are over 90 years old. So, it's great. Then we just live with the fact that they don't know how to turn on the camera, etc.*

In summary, methods covered above like meetings, workshops, webinars, focus groups are mostly for collecting information and generating insights; usability tests or trials are adopted for evaluating the functionalities and ease of use about the solutions. They are informative, and these regular sessions can help to build the knowledge and trust of users. Meanwhile, openness and user empowerment (CoreLabs, 2007) are not enough for deeper or proactive engagement. Themed workshops and lead user engagement, on the other hand, may create more opportunities for in-depth engagement. There are a few modern methods and tools in the findings. These IT-based solutions offer opportunities for Living Labs and innovators to reach out to a much broader user base, although with some challenges like the access to the tools for older people.

6. Discussions

Leminen et al. (2012) define the four types of Living Lab, based on the founders and central parties of the Living Labs: provider (institutes), enabler (public sectors), utilizers (companies) and users (end-users). We have evaluated and categorized the three Living Labs in this study as enabler-driven Living Labs because they are set up by the enablers (the national or regional public sectors). The enabler-driven Living Labs build the network with multiple parties around, create and share knowledge within the network and drive sustainable innovation in healthcare for the society. This part aligns with its definition from Leminen et al. (2012), and we have found the difference in the involvement of companies. Leminen et al. (2012) suggest that enablers use universities and other research organizations to push innovation to users. Companies only play a minimal role here due to the lack of business incentives. However, our findings suggest that those start-ups who are actively working with Living Labs are the essential innovators who take innovative solutions to users. To start-ups, successful innovation outcomes contribute to the successful launch in the market and business profits. And Living Labs assist them as important facilitators during the innovation process.

We also consider Lab B & C are closer to the description of enabler-driven Living Lab given by Leminen et al. (2012), because they put users in the center of the innovation process. Lab A focuses on testing and verifying companies' digital health solutions. Lab A's strategic focus is on the 'Lab' function, and they have mentioned that the 'living' (user-centered) part is not their priority. However, it should not be interpreted that Lab A does not involve users or ignore their importance. User involvement is the critical element for Lab A's innovation process, which has been confirmed in our findings as well. We judge the type of Living Lab by its actual practices rather than their names (Ballon & Schuurman, 2015). Lab A can be classified as a Living Lab focusing on testing functions (Dutilleul et al., 2010). Meanwhile, they can be seen as an innovation lab with multidisciplinary collaborations as well.

Furthermore, Leminen et al. (2012) define user-driven Living Labs as an informal innovation group formed by a small group of end-users to solve specific issues. It is different from the general understanding of 'user-driven' Living Labs (Dutilleul et al., 2010; EC, 2009), where users are the drivers of innovation activities but not necessarily the founders or facilitators. The scope of user-driven Living Labs can be much more extensive than that from the theory of Leminen et al. (2012). Although there are various interpretations of 'user-driven' and numerous

discussions on the user-driven approach up to now, the definition of user-driven Living Labs should be clarified in this case.

For the types of innovation processes and tools used by Living Labs during their collaboration with start-ups, the actual practices are more flexible than what the literature has suggested. Leminen and Westerlund (2017) make a clear-cut within Living Labs adopting a linear or non-linear innovation process, standard or customized tools. However, we have found it is difficult to draw the line because Living Labs are often switching between approaches or adopting a set of combined methods depending on individual cases. They have certain pre-defined innovation processes to follow and standard tools to use; at the same time, they customized the innovation processes and tools to suit specific needs when necessary.

Another vital implication from Leminen and Westerlund (2017) is that higher customization (flexibility) has a higher chance of introducing radical innovation. It means that tailors stand a higher chance over mass customizers, iterators, and linearizers. We are not able to verify the innovation outcome in this study as it requires long-term and in-depth follow-up with Living Labs and companies. Especially, Lab C is still a newly founded Living Lab with the potential to become a tailor, but it requires more investigations to follow.

One important finding is the information about the innovation stage of engagement: (1) start-ups and users; (2) start-ups and Living Labs. When do start-ups involve users? When do start-ups use Living Labs? Prior studies have stressed the early engagement of users as it provides useful context-specific insights on the likely societal and economic effects of the innovation (Ballon et al., 2005), as well as the key approach for co-creation (Von Schomberg, 2012). Also, empirical studies have shown that late engagement in the innovation process generally leads to small adjustments to the solution and minor impact on the result of the entire development process (Silva et al., 2019).

Our findings prove that start-ups actively involve users in the innovation process. The recognition of the importance of user engagement echoes the prior research findings (Iakovleva et al., 2019b; Von Schomberg, 2012). Half of the start-ups have early user involvement from the designing phases, making use of the process, and developing solutions to meet users' needs. Another half involves users after they have already developed the prototypes or even the pilot products, where users are mainly included to test the functionalities and provide feedback for further improvement. The roles assigned to users by start-ups are generally the informant, tester, and contributor, but not the co-creator role (Leminen et al., 2014; Nyström et al., 2014).

Living Labs, especially Lab B & C, have highlighted user involvement and user-center innovation, which do not necessarily refer to having users as co-creators. Users need the role path to define their roles and transit to the co-creators by themselves (Leminen et al., 2014; Leminen et al., 2015), but how Living Labs support this transition is not clear yet. Greve et al. (2017) suggest that even though literature and Living Labs have emphasized on having users as the co-creators, the actual situation is still far below the expectation because users remain as the information source and testing objects in some Living Labs. Our findings reflect the same argument.

All start-ups are actively reaching out to the broader network for innovation, such as public sectors, public & private clusters, organizations, institutes, healthcare providers, etc. They utilize all the available resources, including Living Labs, to gain access. It is notable to point out that they get more help from their other resources like the clusters and incubators other than Living Labs.

Numerous studies have shown the significance of Living Lab's contribution in facilitating user innovation, especially co-creation with companies (Bergvall-Kareborn & Stahlbrost, 2009; Feurstein et al., 2008; Leminen et al., 2014; Nyström et al., 2014; Puerari et al., 2018). Start-ups in this study involve Living Labs at different stages of innovation, but mostly towards the late testing stage when they need Living Labs to test and verify their solutions. However, our findings show that Living Labs miss a large part of the innovation process.

Taking into the consideration of three factors (user, innovation network, and Living Lab), we explore the possible reasons for these start-ups' late engagement with Living Labs:

1. The awareness of Living Labs to start-ups. Do start-ups know the existence of Living Labs early enough? In the study, start-ups generally know about Living Labs when they have already started their product development, as their network refers them to the Living Labs. Start-ups do not have much information about Living Labs or what they can offer before approaching them. Living Labs have said that most of the time, the companies reach out to them, but not the other way. Therefore, there is certainly room for improvement to bring up the awareness of Living Labs to start-ups and widen the communication channels so that Living Labs can be involved in the early phases of innovation.

2. The necessity of using Living Labs from the start-up' perspective. Some start-ups mention the concern on the cost of using the service from Living Labs, as they are living on funding. Some start-ups are satisfied with the achievement of using the current network for

collaborations on research, testing, development, and other related tasks. Living Labs become optional in this case. Although Living Labs have the potential to help start-ups in the innovation, the lack of visibility and interaction might make them not so attractive to start-ups. And for those start-ups who have late engagement with Living Labs, the impact on innovation generated from the collaboration is lower than that of the early engagement. Therefore, the full potential of Living Labs' value is not shown to start-ups.

Regarding the methodologies and tools for user involvement, we see that Living Labs mostly follow the traditional ones who have clear advantages in terms of effective communications, interactions, and relationship building, etc. The limitations are that it is difficult to reach large audiences and bounded by physical accessibility. The rapid-developing IT industry has provided some new tools like web-based or mobile-based communication tools, which can reach a much broader group, especially when the physical meetings/workshops are not available. The usage of modern tools is growing but has a much smaller ratio compared to the traditional ones. Nevertheless, researchers, Living Labs, and innovators are continuously exploring new ways of engagement with users for sustainable innovation.

6.1 Conclusions and Theoretical Implications

To conclude, we confirm the Living Lab's role as a facilitator and its importance on collaboration within the innovation system, which includes companies, institutes, public and private organizations, users (healthcare professionals and patients), and other relevant players. Living Labs orchestrates collaboration among the network players and enables knowledge sharing throughout the innovation process. Meanwhile, the heterogeneity of Living Labs leads to diversity in many aspects like the objectives, structure, activities, etc. Their ways of collaboration with start-ups and users are different, as well as the methodologies and tools used.

We have contributed to the literature regarding the types of Living Labs (Leminen et al., 2012), and Living Labs' innovation tools (Leminen & Westerlund, 2017). Confirming the variety of Living Labs, we show that under the same category of enabler-driven Living Labs, there are variances among Living Labs due to their different strategic focus. Companies as innovators and suppliers of the solutions are overlooked in the theory of enable-driven Living Labs. The definition of user-driven Living Lab from Leminen et al. (2012) states users as the central organizing party, which is different from the common understanding of user-driven Living

Labs, where users are the proactive participants and influential innovators but not necessarily the organizers (Dutilleul et al., 2010; EC, 2009). Besides, Living Labs adopt a flexible mix of the innovation processes and tools to suit individual companies, not just merely a choice between a set of standard or customized processes or tools (Leminen & Westerlund, 2017).

This study has also confirmed that Living Labs and start-ups have recognized the significance of user inclusion during the innovation process (Iakovleva et al., 2019b; Von Schomberg, 2012). The differences among the practices are the stage and degree of inclusion. It echoes with the prior research that the implementation of user involvement approaches subjected to different understandings of Living Labs (Følstad, 2008; Westerlund & Leminen, 2011). However, one thing in common for both Living Labs and start-ups is about users' roles in innovation. Users are assigned roles like the informant, tester, and contributor, meaning positions with minor impact on the innovation outcome. The actual practices of users as co-creators and its empowerment is still below what has been promoted or assumed (Følstad, 2008; Greve et al., 2017; Niitamo et al., 2006).

Lastly, but importantly, the late engagement with Living Labs hinders start-ups' to fully discover the benefits of utilizing Living Labs in the innovation process, as what has been suggested by the literature (Greve, 2020). More empirical studies could be helpful to clarify the cause and provide the remedy from both Living Labs' and start-ups' perspectives.

6.2 Implications for Practitioners

The Living Lab is still a new phenomenon in Norway, especially to the digital health sector. The e-health initiatives by the Norwegian government has provided the opportunity for Living Labs to contribute to the digital health innovation.

We suggest that Living Labs expand their ways of connecting to start-ups, raise awareness in the network, and promote the assistance that they can offer to start-ups. Living Labs should help start-ups to build a deeper understanding of the actual practices and potential benefits of having early Living Lab engagement into the innovation process. Living Labs' broad network connection is another advantage that should be shared and fully utilized by start-ups.

Living Labs should keep on exploring new methods and tools for engaging users and social dynamics into innovation. We should take into consideration that this word 'new' does not necessarily imply the latest technology, but a better manner to effectively integrate users into

the innovation process. Careful consideration is essential on how to implement with users, especially the elderly, who are generally not very IT-savvy, especially the latest technology. Living Labs might also consider more collaboration with institutes to do some systemic investigations and find advice from researchers as covered in the theory sections.

For start-ups, it is worth spending some time and effort in exploring the potential collaboration with Living Labs in the early stage of innovation. They should have a deeper understanding of Living Labs from different aspects to see the benefits of collaboration in the long run. They should fully utilize Living Labs to build the network for innovation and assess to users and resources.

Start-ups should consider their strategy for user involvement as early as they start the innovation. They should be able to picture the different impacts on the development of the solutions by involving users in the early stages, like building the ideas/concepts instead of late ones like testing and verification.

6.3 Limitations

There are several limitations to this study. Firstly, the sample size is small for both Living Labs and companies. It is critical as the increased sample size is one way to enhance the validity and quality of the research (Long & Johnson, 2000; Nicholas & Catherine, 2000). One reason is that the Covid-19 outbreak in 2020 has halted a lot of business activities in Norway. It took a long time to recruit interviewees, especially for Living Labs during this period. It subsequently delayed the recruitment of their participating companies as well. Another reason is that Living Labs are still new in Norway, so we only have a limited number of potential targets to approach.

Secondly, it is about the timeframe of this study. Lab C is very new and it has been in operation for less than a year. It has a full set of plans for companies and user involvement, but most activities are not yet in action at this stage, which makes it difficult to conclude the impact of their work now.

Thirdly, we did not have the chance to utilize the observation method fully. The original plan was to participate in workshops or seminars held by Living Labs to observe their interactions with users and companies, collect information as a supplement to interviews (Mason, 2004). But due to Covid-19, the workshops were either canceled or replaced by webinars. We participated in one session and collected some data. The limitation with the webinar is there

were little interaction between companies (presenting their products) and users (mainly silent). We have acknowledged the effectiveness of this 'new norm' of digital activities, which has gained considerable popularity during the past months. They certainly have potential and flexibility for enhancing interactions. We expect the time of combined use of both face-to-face and digital activities in healthcare to come.

6.4 Future Research Avenues

This study uses qualitative research to investigate the collaboration between Living Labs and start-ups and user involvement in the innovation process. Future research could consider some quantitative research methods to generate statistics to verify and add on to the findings, or even some mixed methods and technology-assisted techniques for further studies (Greve, 2020).

Prior researchers have articulated different users' roles and the impact on innovation (Leminen et al., 2014; Leminen et al., 2015; Nyström et al., 2014). Our study has investigated the methods of user involvement for Living Labs, and there is a blurred area in how exactly Living Labs actualize the user-centered innovation and the vision of co-creation. It would be insightful to follow up with Living Labs systemically about their actual work (like some projects or activities) and get the details from the collaboration in the long run (Schuurman et al., 2011).

Another research field could be the expansion of underdeveloped literature on methodologies and tools used in Living Labs (Georges et al., 2015; Mulder, 2012; Puerari et al., 2018). Both literature and empirical work are needed to integrate them into the innovation activities smoothly (Leminen 2017). There is a need for systemic studies on methodologies for user involvement, which can be evaluated and applied under other circumstances.

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Appendix

Interview guide for Living Labs

A. Background

1. Could you briefly tell us about your position and role in this organization?
2. When and how was this organization established? How long have you been working here?
3. What is the primary business focus of your organization?
4. What kind of innovation services do you provide and products that you develop?
5. Who are your partners (e.g. public sectors, investors, institutes , etc)? What are the conditions of becoming one?

B. Activities

6. What are the activities conducted by your organization?
7. Who are the participants? How do you select them?
8. What is your organization's role in organizing the activities?
9. What is the structure of these activities? For example, e.g. who is the decision makers among the stakeholders? Is there a driving or controlling role, or everyone is at the same level?
10. What is the help or guidance that you provide to participants (companies) during those activities?
11. What are the objectives of having these activities? How to measure?
12. How do you ensure the effective integration of the stakeholders? How to ensure the end-user engagement?
13. What are the major challenges? How do you handle?
14. Do you discuss with stakeholders on how to improve?
15. What normally happens after the discussion?
16. Do you also collaborate with other innovation networks? How and why?

C. Collaboration

17. Does the Lab help firms to facilitate the stakeholder collaboration (e.g. startup – startup, startup – incumbent, startup-network)?
18. If yes, what are the programs? How are the programs managed? If no, why?
19. What are the challenges to you in this collaboration?
20. Is there a business model for the collaborations? How is developed?
21. Do you measure and review the outcome of collaboration? How and why?

Interview guide for start-ups

A. Background

1. Could you briefly tell us about your position and role in this company?
2. What is the primary business focus of your company?
3. Do you actively seek for corporate partners, e.g. investors, institutions, startup community, incubator, accelerators , etc?

B. Innovation

4. What kind of innovative products or services do you develop?
5. Who are the target users/market?
6. How do you reach the target users/market?
7. Do you involve end-users in your innovation development? When and how?
8. What are the major challenges during the innovations process?
9. How do you handle the challenges?

C. Living Lab Activities

10. Do you work with any Living Lab (or e.g. Norwegian Smart Care Cluster)? How did you get to know about the Living Lab?
11. How long have you been a participant?
12. What are the conditions that you must fulfil before or after participating? Fee?
13. What kind of activities do you participate in the Living Lab? What services are you using?
14. Who are the stakeholders that you work with there? Can you freely choose them?
15. Could you briefly describe the structure of this Living Lab? For example, whether there is a driving or controlling role during the activities, or everyone is at the same level?
16. How do you engage end-users in the Living Lab? What are the differences by doing it here?
17. What is the help and/or guidance received from the Living Lab during those activities?
18. What do you expect from joining these activities?
19. How do you measure whether the expectations are met?
20. What works best to you in these activities?
21. Do you discuss with other parties on how to improve and what are these topics? What normally happens after the discussion?

D. Collaboration

22. Do you collaborate with other stakeholders on innovation, besides the regular activities e.g. meetings/ workshops arranged by the Living Lab? How?
23. What are the objectives or benefits from having these external innovations?
24. What are the programs for achieving them? How are these programs managed? What are the challenges?
25. Do you have a specific innovation strategy and/or business model for this kind of collaboration? How are they developed?

26. Does the Living Lab help to facilitate the above collaboration?
27. How do you measure and review the outcome of the collaboration?
28. Do you also collaborate with these companies outside the Living Lab? Elaborate.

Five critical factors for facilitating co-creation in living labs

Co-creation Factor	Co-creation Element	
#1: Customer Engagement	1.1	Customer capabilities, skills & motivation
	1.2	Willingness to co-create
	1.3	Social context
	1.4	Perceived relevance of service
	1.5	Attitudinal factors
	1.6	Mobilizing behaviour
	1.7	Type of product/ service
	1.8	Personal goal clarity
#2: Relationship Management	2.1	Dialogue
	2.2	Managing expectation
	2.3	Stakeholder interaction & participation
	2.4	Expected benefits
	2.5	Mutual learning
	2.6	Managing relationships
	2.7	Engage a suitable and wide set of actors & resources
	2.8	Integration/ Involvement
		Relationship: JOSEPHS – Co-creator
	2.9	Convey seriousness of co-creator contribution
	2.10	Tailored approach for guidance
	2.11	Opportunity to give feedback about JOSEPHS
	2.12	Recruitment & continuous training of guides
		Relationship: JOSEPHS – Company
	2.13	Background information about company
	2.14	Sharing best practices
	2.15	Consulting through a tailored project template
	2.16	Creation of networking opportunities
#3: Operating Principle	3.1	Comfortable atmosphere
	3.2	Proactive, enthusiastic guides
	3.3	Room for action/ interaction/ discontinuation
	3.4	LL as a consulting/ service provider
	3.5	Continuous feedback & immediate adjustment
	3.6	Establishing themes

	3.7	Relevance for B2C & B2B
	3.8	Understanding the concept of JOSEPHS
	3.9	Central location in city centre
#4: Design Layout	4.1	Clear structure & storyline
	4.2	Intuitive elements of familiar behaviour
	4.3	Self-explanatory signage
	4.4	Service Facilities
	4.5	Infrastructure & layout of living lab
	4.6	Access to operant resources
	4.7	'Hands-free approach'
	4.8	Design of Island: key elements & order
	4.9	Reflect work-in-progress status to encourage feedback
	4.10	Try out space
	4.11	Playful and interactive setting and design
	4.12	JOSEPHS layout: innovation as 1st impression
#5: Data Collection Approach	5.1	Interactive and engaging data collection tools
	5.2	Tailoring tools
	5.3	Explicit research question
	5.4	Workshop to reach specific audience
	5.5	Capture first impression & receive authentic feedback
	Total Elements: 50	

Source: Greve et al., 2017