‘Livings Labs’ for New Health Concepts and Medical Technology in Cluster Development

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Abstract. *The development of medical clusters is high on the agenda of many policymakers in the European Union. Constructing medical clusters may draw on the presence of living labs of different kinds in the regions involved. Living labs are practical environments for innovation aiming at a better mix and match between stakeholders for co-development and reduction of time-to-market through an early involvement of user groups. Living lab settings range from delimited environments for co-creation and development, like a city quarter, a hospital, creative workshop or university campus, to local and regional networks and platforms of open innovation. Participants in living labs are typically universities, research institutes, user groups, small and large firms, non-profit institutions (like most public hospitals) and local/regional authorities. Accordingly, living labs find themselves in a dynamic multi-actor situation that needs to be dealt with, both in their design and management. The focus of this paper is on living labs for healthcare innovation and on potentials for cluster development. Healthcare is under pressure as a consequence of the aging population, and fast increasing population with chronic conditions and shortage of resources. The paper identifies critical factors in the design of medical living labs and speculates on the role of living labs in the construction of clusters based on a single case study.*

Keywords. *Living Labs, Innovation, Health, Medical Technology, Critical Factors, Clusters*

1 Introduction

In European Union regions a wave of new initiatives to establish and grow clusters of high technology activity has emerged since the mid-2000s.The European Union with its publications labeled Europe INNOVA/PRO INNO evidences this development. Already in 2002, Lundequist and Power, discussed the mechanisms needed to put a cluster-based regional development strategy into practice. The key behind cluster development today is not only collaborative networking among various stakeholders in the value chains but also open innovation through these networks.

Open innovation has become a key strategy in the knowledge-based economy. The demand for cost reduction and a more efficient and quicker market introduction in a globalized economy has urged many universities, technology institutes and firms to adopt models of open innovation. The underlying assumption is that actors, in their attempts to advance their technology, can use both internal as external ideas and resources for development, and internal as well as external paths to markets (Chesbrough 2003). In the line of Chesbrough et al. (2006), open innovation among organizations can be defined as: the systematic encouragement and exploration of a wide range of internal and external sources of innovation opportunities, consciously integrating that exploration with organizations' capabilities and resources, and broadly exploiting those opportunities through multiple channels (West and Gallagher 2006).

The general logic of open innovation is based on the idea of distributed knowledge and resources. However, opening up the innovation process by organizations is not about just releasing control and hoping for the best (Boudreau and Lakhani 2009), it is about carefully implementing mechanisms to govern, shape, direct and, if necessary, constrain external innovators. Note that certain aspects of open innovation in healthcare are not new (like co-design (De Couvreur and Goossens 2011) and co-creation (Nambisan and Nambisan 2009). It needs also to be realized that the term open means 'relatively open' on a wide spectrum of openness with fully closed and fully open on each of the ends (Dahlander and Gann 2010).

So far, commercialization of university knowledge has been structured within Triple Helix constellations (university-business-governments). Two major changes are however taking place at universities, and that is the elaboration of a combined inside-out with outside-in approaches in open innovation and, related to this, an increasing number of actors involved from different sectors (De Backer and Cervantes 2008).

An important development is the purposeful engagement of user-groups or customers in commercialization processes and practices (Thomke and von Hippel 2002; Bogers et al. 2010; Priem et al. 2012). The end user's role, accordingly, has shifted from a research object to a pro-active role where user groups perform as co-creators of product and service innovations (Fahy et al. 2007). Applying an active input of users as co-creators – including their feed-back in developing and testing – is generally seen as important ways of better serving the needs of users and society, like in renewable energy, safety, transport and healthcare and medical technology (Shah et al. 2009; Edvardsson et al. 2011).

The concept of living labs has been introduced in the early 2000s fuelled by ideas of moving research from laboratories to real-life settings, of open innovation and particularly involving user-groups (Lepik et al. 2010). However, the concept itself has remained fuzzy since then, including different organizational levels, different ambitions and comprehensiveness in practice (Higgins and Klein 2011). For this reason, the paper first attempts to delineate the concept of living labs and find their commonalities. In a second part, the paper attempts to identify critical factors in practice, given particular aims of living labs.

The paper is concerned with the role of living labs dedicated to healthcare and medical technology in building medical clusters. Given the increased needs and opportunities for innovation provided by the aging population, the need for a multidisciplinary approach and an increased emphasis on healthcare models in which public health, prevention (instead of merely curing) and self-management of patients are paramount. In addition, innovations in healthcare are difficult to introduce due to the regulatory system, the system of finance and reimbursement, entanglement within the transmural care processes and complex product-service combinations.

The structure of the paper is as follows. The concept of living labs is explored and defined in section 2. Section 3 discusses what factors are conceived as critical for the processes that determine success of living labs, using a study of the literature. These factors are illustrated and elaborated in section 4 using a set of five case studies of medical living labs, from the Netherlands and from abroad. This section forms the basis for analysis of cluster development connected with one of these case studies (section 5). Section 6 concludes and formulates some policy recommendations.

2 Living labs as an open innovation tool

The concept of living labs is credited to William J. Mitchell at Massachusetts Institute of Technology (MIT). Due to insights into the potentials of computing, sensing/monitoring and information technology, he proposed in the early 2000s to move various types of research from laboratories to in vivo settings, in other words to 'wired' living settings such as in a building or a city, thereby enabling to monitor users' responses to and interactions with innovations.

A major contribution to the rise of the Living Lab concept came from research on the origin of innovations, in particular on the potentials of users as an important source. Thus, by drawing on the work of Von Hippel (1986) and Thomke and Von Hippel (2002), a greater emphasis was put on involving users more actively and early in the process of new product, process and service development (Hoyer et al. 2010). At the same time, as previously indicated, the concept was fuelled by the recognition of the benefits of models of open innovation. The concept was 'embraced' by the European Commission in 2006 and became a strong tool in attempts to increase the level of innovativeness of European countries, resulting in the launch of a pan-European network of 19 living labs under the umbrella 'European Network of Living Labs (ENoLL 2012). Since then, living labs have spread over Europe in various waves (EC 2008; EC 2010), first merely focusing on the introduction of new ICT tools but later on extended to other fields of application.

The aim of living labs can be described as follows, i.e. in line with the previous ideas, to speed up innovation and make it more efficient by an early matching with user-needs, for example, concerning information and communication technology (Eriksson et al. 2005; Fahy et al. 2007; Følstad 2008; Wolfert et al. 2010; Nystrom and Leminen 2011). In particular approaches, however, a stronger emphasis is laid on the aim to provide better solutions for societal problems, like energy saving and healthcare and cure, sometimes named 'community-driven innovation' e.g., Van der Walt et al. (2009). The practice of open innovation requires a methodology to organize and manage collaborative research, development and commercialization of results.

Instead of defining living labs rigorously we connect with the reality of its practice: methodologies and settings termed living labs range from open innovation platforms, eventually urban areas e.g. Amsterdam Innovation Motor (AIM 2011) and regions, to delimited real-life environments used for co-creation and testing, like houses, living quarters, hospitals, stadiums, airports, university campus (ENoLL 2012), etc. In fact what Følstad describes, drawing on experiences in development of ICT, are two different types of living labs (Følstad 2008): 1) open innovation platforms, acting as a real-world environment for collaboration among stakeholders in the value chain; 2) limited environments (related to physical infrastructures, facilities and social settings) with strong involvement of user groups.

Despite differences in size, setting and organization, all living labs share three main characteristics: a) an early involvement of user groups, from the beginning of development activity through ideas or leads (co-creation and co-design) aside from validation and testing using their feedback; b) a physical environment which represents the real-life environment, such as in living, work, traveling, cure and care and sports; the living lab environment could be virtual but is often bound to a location and related to a particular social setting, physical infrastructure of facilities, and networks; c) an open network that brings together stakeholders sharing the desire to support a better and quicker take-up of innovations in the market and/or to improve communities' circumstances through practical and incremental innovations.

The most common organization at the regional network/platform level is the public-private partnership. Stakeholder networks in living labs are typically universities, research institutes, user groups, small and large firms, non-profit institutions (like most hospitals) and local/regional authorities. Most of them have different reasons to be involved in living labs (Soetanto and van Geenhuizen 2011):

- User-groups: through close contacts with designers and producers new products and services are better matched with users' needs.

- Universities and research institutes: more knowledge can be brought to market and it goes quicker; in addition, impacts of inventions and new findings can be tested in reality leading to more valid results and improved understanding.
- Companies, large and small ones: through co-creation and user feedback they produce products and services that better match with user (customers) needs, thereby shortening time to market and reducing risks.
- Intermediaries: these institutes build networks, provide services to the networks, etc. but have no direct stake in the outcomes.
- Non-profit or public institutions, like most hospitals, railway stations, and sporting stadiums: as a specific user-group, they benefit from a higher quality level of their services, but also from an increase in basic performance, like safety.
- Financial institutes: they finance the research projects that originate from living labs and are performed in networks.
- Local/regional authorities: they provide legitimation as a neutral actor to a living lab; they may also act as a co-creator of various public services, like in its primary services (e-governance) and in other services like health- and childcare.

It stands to reason that if stakeholders are involved with widely different aims and interests, and if interdependency is high among important stakeholders, important delay may be caused and the balancing of interests becomes a sine qua non for management or governance of the living labs.

3 Critical factors

In the current stage of maturity and implementation of the living labs approach, it is very difficult to evaluate this approach by taking the heterogeneity of aims and end-goals into account. Also living labs do not have a sufficiently long history to perform a historic case evaluation in a systematic way. However, it is possible to evaluate whether prerequisites and conditions are obtained that enable making the living lab successful. So our literature analysis (Almiralli and Wareham, 2008; Dutilleul et al. 2010; Eriksson et al. 2005; Niitamo et al, 2006; Ståhlbröst 2008;

Bergvall-Kåreborn and Ståhlbröst 2009 intents to identify which factors are critical in bringing necessary structure and processes to reality.

1. The involvement of users is most often mentioned, particularly the need for close and intensive interaction. However, this requires a match between the research issues and users' abilities and experiences, particularly accounting for heterogeneity (different needs) among users and addressing the right motivation among them.
2. The stakeholders and the required functionalities of the networks are in second place, but for diverse reasons, like the need to include business stakeholders such that vertical cooperation in the value chain is guaranteed, but also the realization that it may be rather difficult to get them all involved due to various barriers. The participation of public stakeholders needs specific attention in situations where community processes and practice ought to be improved.
3. The technology is in third place, pointing to the need to involve technology and application providers (ICT), in particular to facilitate living labs in user evaluation and user monitoring (thus using novel technology as a tool).
4. The business models are also in third place, pointing to the need for openness and neutrality, particularly the need to avoid one actor to play a key role deterring other stakeholders from participation. In addition, openness and neutrality serve the need to allow new technology and business models to enter the living lab.
5. Remaining practical factors include ethical issues and issues of intellectual ownership, balancing of interests of stakeholders, quality of the management of the networks, access to finance, and an efficient translation of new ideas or leads into projects, etc.

We now turn to the two types of medical living labs with a couple of examples of them to illustrate the above critical factors.

4 Case studies

We will discuss five case studies, two as delimited environments for co-creation and testing with users, and three regional networks/platforms.

Most living labs that are currently operational in healthcare innovation, have a focus on acceptance and use of information and communication technology (ICT) for support of elderly and people with a chronic condition: also referred as ambient assisted living. The objective of ambient assisted living is to extent the time of living independently at home by use of smart homes or home automation and e-health. The tasks are communication, protection (and safety) through sensors and alarm, and increasing in-house participation in sports (fitness). Also, measurement on a distance could be involved, like measuring blood pressure.

Case study 1 is an example of this class of living labs, targeting a rather specific user group (Table 1). In a technological sense, the living lab is relatively simple without the aim of bringing new technology to market. The technology is already there, but needs to be adapted to the specific user group. The major driver of this living lab is a societal one and the major complexity is social given the isolation of and cultural barriers with the target user group (Kop 2011).

Case study 2 is clearly contrasting with the previous one. Users are clinicians and hospitals. The focus is on finding new solutions in medical devices and surgical technology and bring them quickly to market by developing adequate networks. This effort causes not only technical complexity but also stakeholder (actor) complexity. Companies are more prominently featuring in this class of living labs, calling for business models that connect with relevant segments of value chains, and for sufficient openness and neutrality. Building appropriate networks between clinicians, companies, financers, etc. that facilitate the translation of new ideas and inventions into viable research projects is a critical factor in this class of living labs.

Table 1. Small scale living labs*

	Case study 1	**Case study 2**
Name	Doornakkers: living area Eindhoven (Netherlands)	i360, hospital in Dublin RCSI (Ireland)
Founding year	2010	2008
Working years	2010-2011	2008-
Stage	Finished	ongoing
Application area	ICT and healthcare (later home safety included)	Healthcare/surgery
Organization	Brainport Health Innovation	Hospital and network
Aim and means	Accessible, affordable and good quality healthcare and prevention, by increasing awareness and acceptance (use) of ICT tools for home care and fitness training	Market introduction of new/adapted medical devices and surgical technology by building networks for raising research projects
User groups	Elderly of Turkish origin in their homes (15 test persons)	Clinicians (indirectly patients)
Team FTE	?	2
Investment size	?	?
Investor	Province of North Brabant	Royal College of Surgeons
Physical setting	Living quarter: homes	Hospital: surgical rooms
Time frame	Short (1.5 years)	Long
Stakeholders aside from user groups	• Eindhoven municipality • Province of North-Brabant • Brainport Health Innovation (also including ICT companies)	• Royal College of Surgeons • Companies
Stakeholder complexity	Relatively low	High
Technical complexity	Relatively low	High
Social complexity	Relatively high, due to cultural barriers and isolation of user group	Rather high
Results	Behavioral and health changes (decrease of blood pressure; loss of body weight; increased sporting)	?
Qualification	Success (assessed by project team)	?
Critical factor a)	Solid preparation to learn about needs and problems of users	Appropriate networks supporting the development of viable research
Critical factor b)	Relevance for user groups was clear because connection with special elderly houses to build	Involvement of clinicians
Critical factor c)	Trust in relation with user groups: project worker lived among them; coaches from Turkish community.	Support from associated organizations: enterprise Ireland
Shortcomings	?	?
Future steps	Application to other city quarters and user groups	?
Governance (or management?)	Small project team	?

*Sources: www. brainport.nl; www.enterprise-ireland.com; Kop (2011)

We now turn to the type of living labs that covers open innovation networks in regions and act as platforms. The first of the three living labs discussed in Table 2, is the Medical Field Lab (MFL) in Maastricht (Netherlands). The MFL has gained most experience due to its older age. It had a comprehensive mission with a broad area of application, broader than more recently started Pontes in Utrecht, Netherlands. In contrast, case study 3, Health Innovation Lab (HIL), Copenhagen region, Denmark, is still small scale and in the stage of demonstration projects (simulation labs). User groups are patients and clinicians in all three case studies, the hospital is explicitly a user group in HIL due to the demand for inventions to be applied in new construction of hospitals, like concerning operation theatres and patients' waiting rooms. Because HIL has a focus on simulation-driven innovation, critical factors are the selection of relevant participants and useful simulation tools, matching participants' capabilities with requirements of these tools.

Cases like MFL and Pontes are typically vulnerable to stakeholder complexity because large business are involved and situations need to be avoided in which large companies deter smaller ones from participation. However, vertical cooperation within the value chain needs to be pursued to gain better commercial results. Finding the best solution for such contradictory situations is critical and rather time-consuming due to the process of balancing interest. In addition, a critical factor for both living labs is the availability of multidisciplinary expertise. Critical factors specific for MFL are the one-stop-shop approach: i.e. to provide a single point of contact and services. In complex organizations such as a hospital as well as in a large cluster of external partners, easy access to clear services system is vital to maintain efficient and productive interaction. Another critical factor of success was the funding and financing support for project ideas. Expertise on funding programs and access to a network of investors provided a tailored financial services for development activities. This was combined with support for writing proposals: both for scientific grants and business plans.

Factors potentially hampering the growth of these living labs as networks or platforms nurturing research projects, included the dependence on single persons in the management for the essential expertise. Continuation of the initiative was endangered by leave of key persons.

Table 2. Larger scale projects (regional networks/platforms)

	Case study 1	**Case study 2**	**Case study 3**
Name	Medical Field Lab, Maastricht, NL	Pontes Medical, Utrecht, NL	Healthcare Innovation Lab, DK
Type of organization	Public-private partnership	?	Public-private partnership
Founding year	2006, originated from trial office of orthopedic surgery	2008, started as Medical Technology Innovation Center	2009
Working years	2006-2011	2008-	Feb. 2010-Feb. 2012 (demonstration projects)
Stage	Currently inactive	Ongoing	Almost ended
Application area	Life sciences, cure/care medical technology, healthcare innovations	Cure/care medical technology	New products, services and organization forms in health services
Underlying organization	Maastricht University hospital and its networks	Utrecht University hospital and its networks, later joined by VU and AMC academic hospitals	Healthcare Center Denmark (University Hospital Herlev)
Aim and means	Better utilization of knowledge from the hospital connecting in- and outbound networks and raising projects	Open innovation to better use knowledge from the hospital using (co)creation, and new ventures (acceleration)	User-driven (patients and clinicians) innovation by identifying simulation potentials in hospital
User groups	Patients and clinicians	Patients and clinicians	Patients, clinicians, hospitals
Team FTE	4	6	?
Investments	?	2 million Euro	?
Investors	University hospital Maastricht, Province of Limburg and Province of North Brabant	University hospital Utrecht, Ministry of Economic Affairs, Province of Utrecht, Municipality of Utrecht	Regional Growth Forum of The Capital Region of Denmark (Program for user-driven innovation)
Physical setting	Region	Region	Region (capital city region hospitals), and in-hospitals living labs*
Time frame	Long	Long	Short (demo projects)
Stakeholder complexity	High	High	No signs
Technical complexity	High	High	High
Social complexity	Rather high	Rather high	?
Results 1)	38 projects formulated as a proposal of which 11 achieved a grant	3 projects realized	3 demonstration projects to test the lab model (e.g. long-distance heart care)
Results 2)	Project volume of 18 million Euro accomplished		

Overall qualification	Success	Success (but not clear in which terms)	premature
Critical factor a)	One-stop-shop approach	Multidisciplinary expertise	Right method in selecting participants and simulation tools
Critical factor b)	Multidisciplinary expertise through network	Structured innovation process	?
Critical factor c)	Project formulation attractive for investors	Co-investor	?
Short-coming	-Success dependent on one key person (director) -Change of status from hospital department into a limited company	?	?
Future steps	?	?	?
Governance	?	?	?

Sources: www.medicalfieldlab.nl; www.pontesmedical.com; www.regionh.dk ; HICD (2009).
*Simulation labs on the spot (simulation of real-life and imaginary situations to generate new ideas and inventions).

We may conclude so far that designing living labs as overlapping networks or platforms seem more complex and affected by critical factors than living labs as delimited learning and R&D environments. Within the last class of living labs, those with the aim of innovation in medical technology seem more complex than the ones with the aim of home care and technology adjustment to patients.

5 Cluster development and collaborative networks

The role which living labs – in a broad sense - may play in the development of clusters is illustrated in this section using the case study of Medical Field Lab (MFL) in Maastricht. The achievement so far is one of the essential features of cluster development, namely the establishment of large set of collaborative networks between the lab (university/academic hospital) and various partners like multinationals, SMEs, and other organizations (Lundequist and Power, 2002; OECD 2007). The networks we address are, however, partial networks and are not concerned with inter-firm networks or networks between firms and other organizations. First, we introduce in MFL and present some key characteristics of the networks, and next we present an analysis of the ‘strength’ of the relationships within the cluster area.

The Medical Field Lab was established in 2006 and based in a university hospital in the southern part of the Netherlands: Maastricht. The field lab originated from a hospital trial office (department of orthopaedic surgery). The main objective of the Medical Field Lab was creating public-private collaborations between internal partners (medical specialists and researchers) and companies within the areas of life sciences, medical technology and healthcare innovation. The overall aim was a better use of ideas, expertise and facilities of the university hospital to create added value for science, society and business.

The team consisted of a multidisciplinary staff (medical, technical, policy and business) which could make use of expertise from other departments (e.g. medical, legal, finance) in the university, depending on what was required by the activities of the Medical Field Lab team. Besides an internal network of support, there was access to an external network of organizations who could provide expertise or facilities not available in the hospital.

The field lab used a ‘one-stop shop’ approach for the hospital staff (internal partners) as well as companies (external partners). An idea, problem or need was screened for potential value with respect to science, society and business, by which it was decided whether the initiative should be continued to the project development phase. Subsequently partners were invited and R&D scenarios were formulated which resulted in project proposals for subsidy programs (national or EU) and/or private investors.

Initially the Medical Field Lab was a department of the hospital but later the organisation was established as a limited company as part of the university holding. The organization was led by a Chief Executive Officer who reported to the holding director. Members of the hospital directorate participated in the supervisory board of the holding and had a full ownership of both the holding and of the Medical Field Lab. Partners of the Medical Field Lab originated from (inter)national research collaborations, industrial partnerships and regional network. Partnering through regional networks was facilitated by regional development agencies and not-for-profit organisations.

Between 2005 and 2010 the Medical Field Lab evaluated 196 leads from which 133 cases were selected for further elaboration. Nineteen cases failed in maturing to a full project proposal. The remainder cases were formulated in subsidy proposals for a variety of national and EU funding programs.

In total, 114 projects and sub-projects with a total project volume of 17.812.387 euro were created. Each (sub-)project had a different constellation of partners (in total 60) depending on the type and stage of development. Partners participated with in-kind and/or cash investments. The projects resulted in a variety of patents, products and services ranging from biogels, orthopaedic devices, medical equipment, surgical instrumentation, software to new or improved healthcare services.

We now describe some important characteristics of the networks, including their spatial pattern. Of course, the outcomes on spatial patterns depend on how the cluster around Maastricht area is defined. We perceive the cluster - which is a cross-border one - as encompassing the cities of Maastricht, Eindhoven, Leuven, Hasselt, Liege and Aachen i.e. ELAt[1]. The area covered is almost identical with the ELAt area, a cross-border technological Topregion established in 2004. However, we also consider a somewhat larger area in our analysis, also including the cities of Breda as well as Wageningen and Nijmegen in the Netherlands.

Table 3 indicates some basic features of the networks, type of partners, location of partners, and project volume per partner (euro). Small and medium-sized enterprises are the largest category, with half of the partners. Multinational enterprises (smaller and larger ones) and education/research are next largest types of partners: 20% and 18% respectively. Considering a larger area, most partners are within the cluster, i.e. 68%. Taking a smaller area, approximately ELAt, the share of partners drops to 55%. Overall, the relationships tend be spread over a relatively large area. In terms of project volume, the following can be stated. Most of the

[1] Eindhoven-Leuven-Aachen triangle

project volumes tend to be relatively small, with 75% below 420.000 euro, but there are various project volumes of over or close to a million euro.

In our preliminary analysis of ‘strength of network relations’ we use project volume (in euro) as an approximation of strength. Our assumption is that early cluster formation is evidenced by larger project volumes in relationships within the cluster compared to relationships with partners outside the cluster.

Table 3. Characteristics of Medical Field Lab’s networks

Characteristics		**Abs.**	**%**
Type of partner	Government	2	3.3
	SME	30	50.0
	MNE	12	20.0
	Education/research	11	18.3
	Healthcare providers	5	8.3
	All relationships	60	100.0
Location of partner	Cluster (larger area)	41	68.3
	Outside cluster	19	31.7
	Cluster (smaller area)	37	61.7
	Outside cluster	23	38.3
	All relationships	60	100.0
Project volume (euro)	Small (<= 250.000)	34	57.6
	Large (>250.000)	25	42.4
	Small (<134.550)	15	25.4
	Medium (134.550-420.000)	30	50.8
	Large (> 420.000)	14	23.7
	All relationships	59	100.0

Note a. Size classes based on 25 and 75% percentiles

Table 4 shows that there were more projects initiated with partners within the cluster surrounding Maastricht, but the project volume (in euro) was proportionally larger with partners outside the local cluster. In more detail, of all projects within the smaller cluster 38.9% is relatively large (taken here as more than 250.000 euro); this is in contrast with projects with partners outside the cluster, where 47.8% is relatively large. Put it in another way, most projects within the smaller cluster (61.1%) are relatively small (this is 52.2% outside the cluster), a difference that is statistically significant. If we take the cluster somewhat larger, there is not much difference. This ‘unexpected’ situation rests on the presence of more important relationships with universities/research institutes and SMEs abroad, like with the Cleveland Clinic Foundation and ZinMedical Corp. in Cleveland US, and Glasgow Caledonian University and Peacock’s Medical in UK. This of course aside from some large projects within the cluster, like with DSM and BMM (a public, private partnership) in Geleen, close to Maastricht, and Philips and TNO in Eindhoven.

Table 4. Project volume in and outside the cluster area

Project volume (smaller cluster)	**Cluster Abs.**	**%**	**Outside cluster Abs.**	**%**	**Total Abs.**	**%**	**Chi square**
<= 250.000	22	61.1	12	52.2	34	57.6	2.887 *
>250.000	14	38.9	11	47.8	25	42.4	0.905
Total	36	100	23	100	59	100	9.152 **

*p<0.1; **p<0.01

Project volume (larger cluster)	**Cluster Abs.**	**%**	**Outside cluster Abs.**	**%**	**Total Abs.**	**%**	**Chi square**
<= 250.000	25	62.5	9	47.4	34	57.6	5.333 *
>250.000	15	37.5	10	52.6	25	42.4	1.581
Total	40	100	19	100	59	100	30.9444 **

*p<0.1; **p<0.01

The overall picture suggests that strong innovation networks in the early years of cluster development were created by the field lab to a larger extent beyond the cluster (globally) than locally within the cluster.

6 Conclusion and implications

In this paper we defined and explored living labs as a relatively new instrument in open innovation. Following the actual use of living labs, we defined it at two levels: as open innovation networks or platforms in a city or region and as delimited real-life environments used for co-creation and testing together with user groups. The two most important critical factors, according to a scan of the literature, are involvement of user groups and a network of stakeholders whose expertise is suitable for the complexity of the innovations aimed for. On the basis of five case studies we could elaborate these factors. Regarding user groups: 1) the inclusion of users is a delicate process of matching between the development objectives and their motivations and abilities, 2) it is important to create a close relationship with users through frequent interaction. With regard to stakeholders, like universities, small and large companies, financial institutes and local/regional authorities, etc., it is paramount that 1) networks can be created with an adequate coverage of the value chain, 2) relevant stakeholders can be included in serving the aim of efficient collaboration. While the last is most prominent for medical living labs with a high stakeholder complexity aiming to bring new technology to market, less might be true for small scale medical living labs with a stronger community role and dedicated on implementing existing concepts and technology.

In addition, we explored one particular living lab (a network type) in the southern part of the Netherlands, i.e. Medical Field Lab. Most of the networks are with SMEs (50%) and multinational enterprises (20%). Remarkably, in the early years of cluster development strong relationships (indicated by large project volume) were built within the region but also, and to a larger extent, beyond the cluster and globally.

Data on living labs in healthcare innovations and medical technology are scarce and fragmented, no standardized information is available and if available, it is in general difficult to access. Of course this is because there is no central problem-owner of living labs in this sector. However, the national ministries responsible for healthcare could be the ones to take-up the role of building data-bases on living labs. This connects with the need for a good documentation and monitoring of living labs in order to grasp the learning generated in these labs and building scientifically sound models that could support the establishment of next generation living labs.

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