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Exploring Service Categorization Across Thematic Domains in Living Labs

Teemu Santonen*

Laurea University of Applied Sciences
Vanha maantie 9, O2650 Espoo, Finland
E-mail: teemu.santonen@laurea.fi

Despoina Petsani

Medical Physics and Digital Innovation Laboratory, School of
Medicine, Aristotle University of Thessaloniki, Thessaloniki, Greece
E-mail: despoinapets@gmail.com

Panagiotis Bamidis

Medical Physics and Digital Innovation Laboratory, School of
Medicine, Aristotle University of Thessaloniki, Thessaloniki, Greece
E-mail: bamidis@med.auth.gr

Evdokimos Konstantinidis

Medical Physics and Digital Innovation Laboratory, School of
Medicine, Aristotle University of Thessaloniki, Thessaloniki, Greece
E-mail: evdokimos@gmail.com

* Corresponding author

Abstract: A recent study proposed a categorization of health and well-being living lab services to contribute to ongoing discussions on management approaches for living labs. However, living labs operate in over 20 thematic domains, potentially introducing bias into previous research results. This study extends earlier findings by examining living lab services across a range of domains beyond health including back-office and auxiliary services. A comparison of RDI services between health (N=19) and non-health (N=19) living labs was conducted, revealing that only one out of 18 services showed differences between the two groups. Additionally, an analysis of back-office and auxiliary services in non-health (N=19) living labs indicated high generalizability and robustness of the proposed service categories across different thematic areas. The study's outcomes help living labs explore various service possibilities as they define their unique service approaches.

Keywords: Living lab, Service, Service portfolio, Comparative analysis

1 Introduction

According to the European Network of Living Labs (ENoLL), Living Labs are open innovation ecosystems in real-life operational environments based on a systematic user co-

creation approach that integrates research and innovation activities in communities and/or multi-stakeholder environments, placing citizens and/or end-users at the center of the innovation process. A recent study by Santonen et al. (2024a) introduced a health and wellbeing Living Labs service portfolio and proposed a harmonized service categorization covering over fifty different services, classified into R&D, back office, and auxiliary services.

Selection bias occurs when the individuals or groups selected for a study are not representative of the broader population that the study aims to analyze, and an unbalanced sample affects the validity of the findings. It is argued that the proposed service portfolio (Ibid.) suffers from selection bias when applied to explain services across different types of Living Labs (Alavi et al., 2020) or Living Labs operating in thematic domains other than health. According to ENoLL (2023), Living Labs operate in over 20 different domains, including e.g. social innovation and inclusion (Edwards-Schachter et al., 2012), health and wellbeing (Santonen, 2020), smart cities and regions (Cardone et al., 2014), education and/or vocational training (O'Brien et al., 2021), and environmental and climate change (Santonen et al., 2017).

Therefore, the main objective of this study is to validate the proposed service categorization across different thematic domains, contributing to ongoing discussions on Living Lab harmonization and interoperability across diverse Living Lab initiatives and ecosystems (Vervoort et al., 2022; Kehayia et al., 2023; Petsani et al., 2022; Mulder et al., 2007). By validating the proposed service categorization across different domains, it is ensured that the portfolio is representative and applicable to a wider range of Living Labs. In future studies, a robust service portfolio can help to draw reliable and comprehensive insights about Living Labs as a whole.

There are many new initiatives aimed at significantly increasing the number of Living Labs, such as the Soil Deal for Europe, which aims to establish 100 Living Labs (SOILL, 2024), and FARCLIMATE, which is establishing 20 Living Labs to develop novel approaches for farming, fisheries, and forestry (FARCLIMATE, 2024). These initiatives increase the need for common frameworks that can be applied across different domains. Better interoperability between Living Labs enables the seamless exchange of ideas, services, and solutions across domains and borders, helping to create a cohesive and interconnected cross-border Living Lab ecosystem (Santonen et al., 2020). A validated and harmonized service categorization can also provide policymakers, researchers, practitioners, and especially Living Lab customers (Santonen and Julin, 2019a) with a clearer understanding of the services Living Labs offer across sectors. This, in turn, creates better business opportunities for Living Labs to meet the needs of diverse stakeholders while maintaining a high level of service quality and innovation capacity.

2 Living labs as service providers

There are many different approaches to describe and define services (Edvardsson et al. 2005). In this study, an approach suggested by O'Sullivan et al. (2002) is taken where the key characteristics of services include the following.

First, services are actions performed by an entity (Living Lab) on behalf of another (i.e. customer purchasing or funding the actions). Living Lab customers can include different types of quadruple helix stakeholder groups, each with different needs (Santonen and Julin, 2019b). It is important to make the distinction between the “customer” who

purchases or funds the Living Lab actions and the “end-user” – a person who ultimately uses or is intended to use the solution whether the solution is a product, a service or a process (Petronikolou, 2024). Currently, most Living Labs operate primarily on project-based public funding from EU, national, regional, or local authorities, supplemented to some extent by private companies (Paskaleva, and Cooper, 2021). Therefore, most of the paying customers are tertiary users a.k.a. persons who will be affected by the use of service or make purchase decisions (Eason, 1987). Living Labs offers the following access options to their services (Santonen et al. 2024a): *Market-driven access* involves a fee, with the study's outcomes potentially remaining confidential. *Excellence-driven access* is granted based on peer-reviewed scientific excellence or other predefined criteria. With the *wide access* option, the Living Lab aims to provide the broadest possible access to its services, such as through virtual access.

Second, services are assets, and they have an inherent value that is transferred from the service provider to the recipient. According to Santonen et al. (2023) Living Labs can provide many types of value for their customers ranging from hard (e.g. financial/process benefits, validity and reliability, improved innovation) to soft values (benefits for the users and society, enhanced collaboration/networking possibilities, safe environment for RDI, and increased skills and capabilities).

Third, services can be combined with other services or sub-services making them aggregation or composition services. Grotenhuis (2017) has argued that Living Lab services and functions are extremely diverse, and lack coordination, leading to overlapping offerings and challenges in meeting current business demands. Prior studies (Dutilleul et al., 2010, Santonen et al. 2024a) have concluded that only a handful of studies have focused on Living Lab services and there isn't a service portfolio (Eschenbächer et al. 2010). To respond to these gaps Santonen et al. (2024a) introduced harmonised service portfolio classified into R&D, back office, and auxiliary services. The study described also a process from seven customer touch points to (1) customer acquisition, (2) detailed project planning and (3) project implementation and dissemination process each with multiple sub-services.

Finally, service interactions consist of a service provider, a service requestor, a service catalogue and sometimes also a service broker who offers services from multiple providers to a requestor. ENoLL can be considered a service catalogue and service broker since they maintain a list of certified Living Labs and can act as an intermediary between Living Labs and potential customers. Furthermore, the newly established Accelup.eu – an online website to post projects and get bids from Living Labs – can also be considered as an online catalogue and a broker.

3 Research methodology

3.1. Data collection

Data collection was conducted in two distinct phases. *First*, Appendix 1 presents a paper-based questionnaire designed around the proposed Living Lab service offering classification, which includes a total of 54 services classified into 22 RDI services, 28 back office services, and 4 auxiliary services (Santonen et al., 2024a). Minor modifications on service titles (e.g. service changed to services) were made comparing to the original version. For each service, respondents were asked to selected one of the following three

options: 1) offering, 2) not offering but relevant and 3) not offering and not relevant. An 80-minute workshop was conducted, beginning with a 15-minute introduction to ENoLL's Harmonization working group, its mission, processes, and prior outcomes related to harmonization. At the outset, participants completed the service offerings questionnaire, with the option to add new services or provide additional comments. Following this, participants were divided into four groups to discuss and debate service portfolio adaptation to various thematic domains, including Health and Wellbeing, Urban Living Labs & Mobility, Arts & Culture, and Energy & Environment. To gather more responses, the questionnaire was distributed to conference attendees during the 2024 Open Living Lab Days (OLLD). OLLD is the flagship annual event organized by the European Network of Living Labs (ENoLL). This global gathering of international Living Labs provides a space for networking, sharing best practices, and discussing current trends and future directions. In total, 21 different Living Labs including 2 health living labs completed the questionnaire in an acceptable manner. The non-health data correspond to the portfolio of Living Labs from 15 domains, as identified and reported in the ENoLL members catalogue (Tricarico et al. 2024). For RDI services, the minimum number of responses for an individual service was 18, while the maximum was 21 resulting in an average 19.6. Response activity for back office and auxiliary services was a little bit weaker, the minimum was 15, the maximum was 21 resulting in an average 18.0. For missing data, pairwise deletion approach was followed (Pigott, 2001, Newman, 2014).

Second, the Accelup.eu website was used as a data source to gather information on the service portfolios of health and well-being Living Labs. A total of 18 service portfolio descriptions were identified. One of these living labs also filled the questionnaire during OLLD. For them Accelup.eu data was used since it describes 3 different living lab environments for that particular living lab. A few differences were noted in comparison to the questionnaire in Appendix 1 and Accelup.eu data. In the Accelup.eu web service, “Equipment and Facility Rental Service,” “Intake and Matching,” and “Public Procurement Support Services” were not included among the RDI services, and the list excluded back office and auxiliary services. Therefore, this study focuses on comparing the 18 RDI services that were common across the two datasets.

3.2. Data analysis

For comparison purposes, non-health (N=19) and health (N=19) Living Lab groups were established. To compare service offerings between health and non-health Living Labs, Fisher's Exact Test was conducted (Fisher, 1970; Agresti, 2012). Fisher's Exact Test is optimal for small sample sizes, as it calculates exact probabilities rather than relying on large-sample approximations (like the Chi-Square test). It is suitable for sample sizes up to 30 or 40, or when the Chi-Square test's assumptions about cell frequencies being <5 are not met. In addition, descriptive statistics analysis regarding “offering”, “not offering, relevant” and “not offering, not relevant” is conducted as an alternative way to evaluate the robustness of the suggested service portfolio. Both back office and auxiliary services are included in this analysis, which covers all non-health living labs that were filling the questionnaire (N=19). In the descriptive analysis, 70 % agreement level is considered as a consensus for “common” living lab services which are expected to be provided regardless of the thematic focus of the living lab.

4 Results

4.1. Comparison of health and non-health living labs services offerings

Table 1 presents the Fisher's Exact Test comparison results of health and non-health Living Labs. Results indicated a significant ($p= 0.022$) difference only regarding Clinical Trials service. Examination of Table 1 reveals that only 1 non-health living lab and 8 health living labs were offering Clinical Trials services. The results strongly suggest that the proposed services seem to be generalizable to non-health living labs as well.

Table 1 Fisher's Exact Test results

<i>Living Lab Services</i>	<i>Non-Health & wellbeing</i>		<i>Health & wellbeing</i>		<i>Fisher's Exact Test results</i>
	<i>N</i>	<i>No/Yes</i>	<i>N</i>	<i>No/Yes</i>	
1. Access to Data	18	4/14	19	8/11	.295
2. Capacity Building	18	3/15	19	4/15	1.000
3. Clinical Trials	16	15/1	19	11/8	.022*
4. Co-creation Sessions	18	0/18	19	3/16	.230
5. Competitor and Market Analysis and Benchmarking	17	11/6	19	10/9	.516
6. Concept and proof of concept tests - feasibility study	18	2/16	19	2/17	1.000
7. Expert opinion and advisory services	19	4/15	19	3/16	1.000
8. Foresighting (trends, weak signals and wild cards)	17	12/5	19	16/3	.434
9. Idea Selection and Testing	19	2/17	19	5/14	.405
10. Impact Assessment and Validation Test	19	4/15	19	3/16	1.000
11. Large-scale real-life testing and piloting	19	6/13	19	7/12	1.000
12. Legal, Regulation and Safety Standards Support	17	13/4	19	13/6	.717
13. Marketing, sales and networking support	18	15/3	19	12/7	.269
14. Post-market surveillance and market acceptance testing	18	16/2	19	15/4	.660
15. Prototyping Test	18	4/14	19	3/16	.693
16. Simulation Test	17	11/6	19	8/11	.202
17. Small scale real life testing and experimentation	18	1/17	19	0/19	.486
18. Usability Testing	17	6/11	19	4/15	.463

* Exact significance (2-sided) at 0.05 level

4.2. Non-health living labs RDI services analysis

Table 2 presents the relative share of offered services and their relevance.

Table 2 Offerings and relevance of non-health living labs services

<i>Service</i>	<i>N</i>	<i>Offering or not offering, relevant %</i>	<i>Not offering, not relevant %</i>
1. Access to data	18	94*	6
2. Capacity building	18	100*	0
3. Clinical Trials	16	25	75*
4. Co-creation sessions	19	100*	0
5. Competitor and market analysis and benchmarking	17	65	35
6. Concept and proof of concept tests - feasibility study	18	94*	6
7. Equipment and facility rental service	17	59	41
8. Expert opinion and advisory services	19	95*	5
9. Foresighting (trends, weak signals and wild cards)	17	82*	18
10. Idea selection and testing	19	95*	5
11. Impact assessment and validation test	19	100*	0
12. Intake and matching	15	80*	20
13. Large-scale real life testing and piloting	19	100*	0
14. Legal, regulation and safety standards support	17	71*	29
15. Marketing, sales and networking support	18	56	44
16. Post-market surveillance and market acceptance testing	18	56	44
17. Prototyping test	18	89*	11
18. Public procurement support devices	16	63	38
19. Simulation test	17	76*	24
20. Small scale real life testing and experimentation	18	89*	11
21. Stakeholder analysis	18	100*	0
22. Usability testing	17	88*	12

* Relative share is 70% or more indicating high relevance among respondents

As a result, 16 out of 22 services (72%) were either offered or considered relevant. Interestingly “Intake and matching” (80%) and “Stakeholder analysis” (100%) excluded from Fisher’s Exact Test due to missing data, were both over the 70% threshold level, indicating high generalizability. In total six services remained below the threshold. The least relevant service for non-health living labs was “Clinical trials” as one could expect based on prior Fisher’s Exact Test results. Other services included “Competitor and market analysis and benchmarking” (65 %), Marketing, sales and networking support (56%), “Post-market surveillance and market acceptance testing” (56%). Also, “Equipment and

facility rental service” (59%), “Public procurement support devices” (63%) which were excluded from Fisher’s Exact Test failed to achieve the threshold. Even if six services remained below the 70 % threshold, five of them possessed clear interest also among non-health living labs due to gaining over 50 % relative share among the respondents.

4.3 Non-health living labs back office services analysis

Table 3 presents the relative share of offered back office services and their relevance.

Table 3 Offerings and relevance of non-health living lab back office services (N=13-19)

<i>Service</i>	<i>Offering or not offering, relevant %</i>	<i>Not offering, not relevant %</i>	<i>Service</i>	<i>Offering or not offering, relevant %</i>	<i>Not offering, not relevant %</i>
1. Data Access Management	85*	15	15. Grant writing / Preparation	61	39
2. Application evaluation	87*	13	16. Innovation network orchestration	94*	6
3. Contract / Consortium Agreement	76*	24	17. IPR management	57	43
4. Data analysis	80*	20	18. Living Lab project management	88*	12
5. Data anonymization and pseudonymization	80*	20	19. Maintenance (equipment, facilities)	53	47
6. Data cleaning	69	31	20. Offer preparation	47	53
7. Data governance policy	71*	29	21. Panel Management	65	35
8. Data management plan	76*	24	22. Quality and risk management	80*	20
9. Desk/Market Research (for project planning purposes)	69	31	23. Research protocol design	82*	18
10. Detailed project planning	76*	24	24. Resource allocation	71*	29
11. Dissemination	100*	0	25. Results reporting / Publication writing	100*	0
12. Ethical application preparation	73*	27	26. Stakeholder engagement	100*	0
13. Fair data compliance process	79*	21	27. Subcontracting negotiation process	25	75*
14. Funding call monitoring	69	31	28. Temporary research funding	67	33

* Relative share is 70% or more indicating high relevance among respondents

As a result, 18 out of 28 services (64%) were either offered or considered relevant, when the 70% threshold level is used as a criterion. Also, 8 services (29%) gained over 50 % relative share among the respondents, resulting 93% acceptance level with lower threshold level. “Subcontracting negotiation process” with 25% relative share gained the least interest, indicating that many of the living labs are self-sufficient when providing services. The second service below 50 % threshold was “Offer preparation”. It is argued that the list of back office services is well received among non-health living labs.

4.4 Non-health living labs auxiliary services analysis

Table 4 presents the relative share of offered auxiliary services and their relevance.

Table 2 Offerings and relevance of non-health living labs services

<i>Service</i>	<i>N</i>	<i>Offering or not offering, relevant %</i>	<i>Not offering, not relevant %</i>
1. Ethics committee review	16	44	56
2. Funding application process	19	79*	21
3. Funding call information	17	71*	29
4. Research site permit	17	76*	24

* Relative share is 70% or more indicating high relevance among respondents

As a result, 3 out of 4 services (75%) were either offered or considered relevant, when the 70% threshold level is used as a criterion. Only “Ethics committee review” with 44% relative share remained below the threshold in indicating weaker generalizability across the living labs.

5 Conclusion and limitations

5.1 Conclusions

This study evaluated the generalizability of the Living Lab service portfolio across different domains. The initial service portfolio for Living Labs (Santonen et al. 2024a), defined during the VITALISE project was focused only on Living Labs operating in the Health and Wellbeing domain. As Living Labs operates in over 20 domains (Tricarico et al. 2024), this study managed to capture representatives of 15 out of 20 domains (75%). In total 37 services (16 R&I, 18 back-office and 3 auxiliary) exceeded 70% agreement threshold and can be considered generalisable beyond the thematic focus. Furthermore, all of the suggested services were offered or regarded relevant at least by 4 Living Labs.

While the literature on the service portfolio of Living Labs is currently limited, various studies have explored their activities (Almirall and Wareham, 2008). We argue that these activities, performed within a Living Lab, can be offered to customers as a broad range of services even if the methodologies and tools are diverse (Leminen and Westerlund, 2017). A harmonized service portfolio is crucial for generating reliable and comprehensive

insights into Living Labs as a whole, making it easier for customers to engage with them. This underscores the need for a shared service portfolio across domains to ensure consistent, high-quality results which can be compared cross-border and between Living Labs. At the same time, it is vital for Living Labs to retain the distinctive qualities of their thematic areas through specialized services. Thus, the objective is to identify and validate a core portfolio of services that all Living Labs can adopt while also defining the specific services unique to each domain. It is argued that the outcome of this study provides a good foundation for the core services.

5.2 Limitations

The sample size (N= 38) compared to the number of certified living labs (N=163) (Tricarico et al. 2024) is relatively small, particularly when divided into subgroups (e.g., 19 health vs. 19 non-health Living Labs). Non-Random sampling was utilized in data collection. The non-health Living Labs sample is limited to OLLD conference participants, while health Living Labs basically includes project participants from Horizon 2020 funded VITALISE-project (No. 101007990). This sampling approach might introduce selection bias and limit the statistical power of comparisons and therefore the generalizability of the findings. However, OLLD as the flagship annual event of ENoLL is known to gather a great variety of different types of Living Labs, thus offering enough variety and representation for our study. VITALISE-project on the other hand included different types Living Labs from Finland, Spain, Greece, Hungary, Belgium and Canada each having their own unique focus and profile.

The questionnaire results were grounded on self-reporting, which can lead to inconsistencies due to interpretation of the service and service level possible over/under-reporting. Since only service titles were presented to respondents, there might also be misunderstandings and different interpretations regarding the content of the proposed services. Health Living Labs service offerings on the other hand were based on their actual offerings, thus could be considered more reliable. Pairwise deletion was used to handle missing data. However, missing data analysis (MCAR test sig. 0.375) revealed them to be completely random and therefore causing no problem.

The 70% and 50% threshold levels for consensus can be argued to be somewhat arbitrary although they are commonly used for example in consensus-seeking Delphi-studies. Therefore, the robustness of claims regarding “common” services can vary based on the threshold level. On the other hand, we can argue that all the suggested services were offered by non-health living labs, thus making them relevant at least some of the living labs. As the study by Santonen et al. (2024a) shows, also health living labs have a variety on service offerings. It is concluded that it is evident that living lab service offerings can vary within one thematic focus area such as health and between different focus areas. Nevertheless, the results verify that the proposed service portfolio provides a robust overview of the possible services Living Labs can offer.

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Appendix 1

Living lab name	
Living lab thematic area	

RDI SERVICES	Offering	Not offering but relevant	Not offering, and not relevant	BACKOFFICE AND AUXILIARY SERVICES	Offering	Not offering but relevant	Not offering, and not relevant
1. Access to data				23. (Data) Access management			
2. Capacity building				24. Application evaluation			
3. Clinical trials				25. Contract / Consortium Agreement			
4. Co-creation sessions				26. Data analysis			
5. Competitor and market analysis and benchmarking				27. Data anonymization and pseudonymization			
6. Concept and proof-of-concept tests – feasibility study				28. Data cleaning			
7. Equipment and facility rental service				29. Data governance policy			
8. Expert opinion and advisory services				30. Data management plan			
9. Foresighting (trends, weak signals, and wild cards)				31. Desk / Market research (for project planning purposes)			
10. Idea selection and testing				32. Detailed project planning			
11. Impact assessment and validation test				33. Dissemination			
12. Intake and matching				34. Ethical application preparation			
13. Large-scale real-life testing and piloting				35. Fair data compliance process			
14. Legal, regulation, and safety standards support				36. Funding call monitoring			
15. Marketing, sales, and networking support				37. Grant writing / Preparation			
16. Post-market surveillance and market acceptance testing				38. Innovation network orchestration			
17. Prototyping test				39. IPR management			
18. Public procurement support services				40. Living lab project management			
19. Simulation test				41. Maintenance (equipment, facilities)			
20. Small-scale real-life testing and experimentation				42. Offer preparation			
21. Stakeholder analysis				43. Panel management			
22. Usability testing				44. Quality and risk management			
				45. Research protocol design			
				46. Resource allocation			
				47. Results reporting / Publication writing			
				48. Stakeholder engagement			
				49. Subcontracting negotiation process			
				50. Temporary research funding			
				51. Ethics committee review			
				52. Funding application process			
				53. Funding call information			
				54. Research site permit			