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MSc Strategic Product Design

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Graduation project

Mapping systemic complexity of design in the cancer carepath.

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Master Graduation project

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Executive summary

Designers, developers, and researchers creating cancer-focused innovations rely on effective implementation and adoption within the desired context to improve the cancer care path. However, cancer care contexts are Complex Adaptive Systems, characterized by numerous interacting elements whose changes can unpredictably affect the entire system. This complexity poses significant challenges for these professionals.

This graduation project explores how designers, developers, and researchers can understand the elements and interactions that influence the successful implementation of innovations in cancer-care contexts, considering their inherent complexity.

Using a "Research through Design" approach, data were collected through 2 main activities. Initially, a literature review of four healthcare implementation frameworks identified factors affecting implementation success. Subsequently, I conducted interviews with nine members of the 4D PICTURE team to explore factors they identified as affecting technology implementation in cancer-care contexts. The data were analysed and synthesized using GIGA-mapping techniques, resulting in a detailed visualization of the cancer care path's complexity for technology implementation.

The resulting map illustrates the cancer care path's complexity, identifying seven domains, 28 elements, and over 50 connections impacting technology implementation. The findings emphasize the importance of understanding the systemic nature of cancer care and the interdependencies among various elements. Additionally, the research explores how and when the community can be involved in developing the technology to enable successful implementation.

The research concludes that understanding the complexity of cancer care contexts is crucial for developing technologies that can be successfully implemented. It determines that in complex systems, the holistic view provided by GIGA-maps is essential for recognizing how different elements interact and influence each other, which is vital for effective technology implementation.

This study contributes to the field of implementation science by visualizing the relationships between various elements from implementation frameworks. It also advances cancer research by identifying elements that can act as barriers and enablers of implementation in healthcare. Additionally, it provides insights into the role of community involvement in cancer care.

However, the research had limitations, including constraints on analysing more frameworks and conducting additional interviews. It focused on a European context and three types of cancer: melanoma, prostate cancer, and breast cancer. Further research on different contexts and cancer types can enrich the system, show new relationships and uncover new ways of communicating its complexity. Finally, this can be further developed as a design tool to improve the practical relevance of the map and help professionals in the development of cancer-focused technology.

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Glossary

Abbreviations

CAS: Complex adaptive system

Definitions

Community:

Refers to patients, clinicians, caregivers, Organisational managers, and any other actor who will be influenced by the technology.

Connection:

Relationships, actions, situations, interactions, or dependencies between elements.

Context:

The set of circumstances or unique factors that surround a particular implementation effort (Damschroder et al., 2009, p. 3).

Designer:

Professionals who apply principles of design to develop solutions in the healthcare sector.

Developer:

Professionals who build software and digital tools in healthcare.

Domain:

A category that groups elements in the system.

Element:

Individual entities in the system, such as people, technological characteristics, and environmental conditions.

Researcher:

Professionals who conduct studies to generate new knowledge, evaluate the effectiveness of interventions, and inform evidence-based practices in healthcare.

1. Introduction

1.1. 4D PICTURE

4D PICTURE is an international project funded by the European Union in the healthcare domain that aims to enhance the experience of cancer patients during their cancer care journey. The project is specifically focused on three types of cancer: melanoma, prostate cancer and breast cancer (Rietjens et al., 2024). 4D PICTURE expects to achieve its goal by ensuring that the patients' health preferences are acknowledged and respected throughout their process. This involves providing support for treatment and care decisions at each phase of the disease, considering the needs of patients, caregivers, and healthcare providers (Rietjens et al., 2024).

To achieve this objective, several tools that facilitate the shared decision-making processes (also referred as Decision support tools) have been created (Metro-Mapping, prognostic tools and Metaphor menu). The development of such tools has been done by a multidisciplinary team of experts which have been initially implemented in the context of The Netherlands as a pilot for the overall project. As 4D PICTURE is an international project, such tools are expected to be improved and then replicated in other countries across Europe (Rietjens et al., 2024).

1.2. Literature review

1.2.1. Implementation in healthcare

Implementation in healthcare refers to the means by which a new intervention, innovation, policy, program or practice is put in use and gets incorporated within a health organization or healthcare context (Damschroder et al., 2009; Nilsen, 2015). The implementation process is crucial for the successful adoption of an intervention, as it is the "transition period during which targeted stakeholders become increasingly skilful, consistent, and committed in their use of an intervention"(Damschroder et al., 2009, p. 3), to achieve the integration and adoption of that intervention in the health context (Damschroder et al., 2009; Nilsen, 2015).

As Greenhalgh et al. (2004) mentions, implementation of an intervention happens when it is adopted by targeted individuals who later pass it on to other targeted individuals. In some cases, these interventions are later abandoned or replaced; others never achieve adoption (Eccles & Mittman, 2006). The abandonment and replacement of the innovations may occur due to the unsustainability of the intervention after the pilot phase, the overestimation of complexity in the context (Van Dyk, 2014), or because they fall short to provide the expected value in the context where it was implemented (Damschroder et al., 2009). For example, a review on telehealth in heart failure found multiple types of barriers regarding why innovations failed the implementation; barriers related to technology, team, staff, business and financial, patients, governance and regulations aspects, were obstacles in the adoption of innovations (Greenhalgh et al., 2017a).

In implementation research, the term ‘context’ refers to “the set of circumstances or unique factors that surround a particular implementation effort” (Damschroder et al., 2009, p. 3). These factors interact actively between them and influence the success of implementation of innovations at different points of healthcare delivery: The Patients, The Provider Team, The Organization, The Technology and Market or Policy (Damschroder et al., 2009; Ferlie & Shortel, 2001; Greenhalgh et al., 2017b). “The more complex an innovation or the setting in which it is introduced is, the less likely it is to be successfully adopted, scaled up, spread, and sustained” (Greenhalgh et al., 2017b, p. 2). Furthermore, healthcare delivery exists in a historical, cultural, economic, political, technological and social climate; all these factors affect the implementation success in the context (Urquhart et al., 2014; Van Dyk, 2014).

Based on the paragraph above, the success of implementation is dependent on the interaction of multiple factors in a context, and “instead of a hierarchy or linearity of cause and effect, each of these dimensions has to be considered simultaneously” (Kitson et al., 1998, p. 150). Therefore, we need to consider complex systems as a determinant for the implementation of the innovations.

1.2.2. Complex adaptive systems (CAS)

A system is defined by Greenhalgh et al. (2018) as "an assembly of agents that interact with each other" (p. 2). There have been multiple studies that have shown the parts of systems as separate elements (also called agents) such as the people, the intervention, the context and others. These studies suggest that the interactions and influences of the elements towards the others, are straightforward and predictable (Braithwaite et al., 2018).

This suggestion conceives the elements "as additive, where the sum of the parts equalled the whole (system)" (Braithwaite et al., 2018, p. 5). These systems can be referred to as 'Simple', or 'Complicated', where simple systems have few elements, and Complicated systems have many. In these types of systems, the relationships between the elements are established and unvarying, which makes the system behaviour predictable (Greenhalgh et al., 2018; Samut-Bonnici, 2015).

Contrary to the Simple and Complicated systems, there is another type of system which is "composed of agents with ill-defined and unstable boundaries that may act in unexpected ways, whose actions are interconnected so that one agent's actions change the context for other agents" (Greenhalgh et al., 2018, p. 2), to these we refer to as Complex Adaptive Systems (CAS). Most interventions in healthcare and social care can be considered to be CAS (Greenhalgh et al., 2018; Greenhalgh & Papoutsi, 2018; Haldane et al., 2019).

In CAS, the relationship that occurs between the elements (and with the context) is more valuable than the individual behaviour of each element; a change in one element will affect the others and the system in unpredictable ways (Braithwaite et al., 2018; Greenhalgh et al., 2018; Plsek & Greenhalgh, 2001). Additionally, the boundaries of the complex systems are not well defined, the elements can be part of multiple systems, and these systems can be embedded in other systems. Therefore, the change in an element or a system will affect the others, and these interconnections can cause tensions and contradictions that cannot always be resolved (Plsek & Greenhalgh, 2001).

Nevertheless, the changes in elements or interactions, will cause an adaptation in the system (and its elements) with rules that are not necessarily logical, explicit or shared between them (Greenhalgh & Papoutsi, 2018; Plsek & Greenhalgh, 2001); “the mental models and rules within which independent agents operate are not fixed (…) and the only way to know exactly what a complex system will do is to observe it: it is not a question of better understanding of the agents, of better models, or of more analysis” (Plsek & Greenhalgh, 2001, pp. 626–627). Moreover, the behavioural changes of a CAS are unpredictable; depending on each element’s point of view, the adaptation can be seen as an improvement or deterioration of the system (Plsek & Greenhalgh, 2001).

Finally, the constant, non-linear and interdependent interaction between the elements of a CAS is what defines the behaviour, “the observable outcomes are more than merely the sum of the parts” (Plsek & Greenhalgh, 2001, p. 626), as opposed to Simple and Complicated systems. Nevertheless, Complex Adaptive Systems have an inherent pattern; they self-organize naturally by the interaction of the elements, generating ‘order’ in the system (Plsek & Wilson, 2001). For instance, in healthcare the implementation of innovation will create the need for the system to adapt and accommodate to the changes. Haldane et al. (2019) mentions, one way to induce positive changes in the healthcare system is by involving the community (patients, clinicians, caretakers or others impacted or involved with the innovation); allowing them to not only be in charge of their health decisions, but also on how services should be designed and delivered.

1.2.3. Community participation in healthcare

Community participation in healthcare has been getting more attention with time; initially with the 1978 Alma Ata declaration which stated community participation as focus for primary health care (World Health Organization [WHO] & United Nations Children's Fund [UNICEF], 1978). More recently, the attention came from the declaration of the Sustainable Development Goals, which declares universal health coverage as the main goal, and claims that community participation and people centredness are key to achieve it (Haldane et al., 2019).

The 1978 Alma Ata declaration defines the terms Community and Community participation in the following ways: A community "consists of people living together in some form of social organization and cohesion. Its members share in varying degrees political, economic, social and cultural characteristics, as well as interests and aspirations, including health" (WHO & UNICEF, 1978, p. 49). Moreover, Community participation is "the process by which individuals and families (of a community) assume responsibility for their own health and welfare and for those of the community and develop the capacity to contribute to their and the community's development" (WHO & UNICEF, 1978, p. 50).

Additionally, the Alma Ata declaration mentions the health professionals as a part of the community where they work (WHO & UNICEF, 1978). In this definition, the clinicians must have continuous conversation with the rest of the community to align views and activities related to healthcare. This constant communication allows the health professionals to understand the community better and the reason behind their views, emotions and aspirations regarding their health (WHO & UNICEF, 1978).

In research, multiple words are used to refer to this interaction with the public, sometimes without making a difference between them: involvement, engagement and participation (National Institute for Health and Care Research [NIHR], 2021). Nevertheless, the NIHR describes the differences between them (Table 1). The NIHR refers to the 'Public' (in this graduation project 'community') as "patients, potential patients, carers and people who use health and social care services as well as people from specific communities and from organisations that represent people who use services. Also included are people with lived experience of one or more health conditions, whether they're current patients or not" (NIHR, 2021).

Concept	Definition
Involvement	Research being carried out 'with' or 'by' members of the public rather than 'to', 'about' or 'for' them. It is an active partnership between patients, carers and members of the public with researchers that influences and shapes research.
Participation	When people take part in a research study.
Engagement	When information and knowledge about research is provided and disseminated.

Table 1 - Definition of involvement, participation and engagement. By (NIHR, 2021)

This interaction with the community in research is now considered as 'best practice' for the improvement of health and social systems across the globe and enables a patient cantered practice to achieve more equitable healthcare (Cluley et al., 2022; De Weger et al., 2018; Haldane et al., 2019). Beyond the benefits of community participation for achieving better and more equitable healthcare, there are other benefits of interacting with the community for research. Firstly, it can improve the prioritisation of research, allowing it to be more relevant and valuable for users. Secondly, evidence shows that it improves the dissemination and implementation of findings as the users that were involved in the research can influence others in the community (Brett et al., 2014). Lastly, it also creates positive impact in the organization creating a more robust healthcare system that improves health outcomes (Haldane et al., 2019).

Despite the benefits and impact of involving the community in research, there is not a lot of studies that apply community participation in the implementation, replication and scale of innovations (the latter stages of research) (Cluley et al., 2022). This can be caused by the perception that community participation is only used to improve health outcomes, "rather than a process to implement and support health programs to sustain these outcomes" (Haldane et al., 2019, p. 19). Finally, community participation helps create changes in social, economic and political settings for better healthcare, and this does not happen in a linear and systematic way, but rather in complex interactions and processes (Haldane et al., 2019).

1.3. Problem frame

The designers, developers & researchers who create cancer-focused innovations rely on implementing the technology (or intervention), in the desired context and its adoption by targeted users over time to improve the cancer care path. This goal could be achieved by considering:

The barriers and enablers of implementing a new technology.

The complexity of implementation in healthcare systems.

The involvement of the community in the implementation process to enable adoption.

Current literature focuses on explaining the different elements that need to be considered in the implementation of innovation, the barriers that can arise, and on the relevance of community participation for the successful implementation and adoption of technologies. However, there is no body of literature (found by the author) that describes how these elements interact with each other as a complex system and how designers, developers & researchers can navigate this complexity to achieve implementation of the innovation in cancer-care contexts.

1.4. Reserch question

Considering the knowledge gap, context mentioned above and the complexity that exists in healthcare contexts, this graduation project will focus on:

Main research question

How might designers, developers and researchers comprehend the elements and interactions that influence the successful implementation of an innovation in cancer-care contexts considering its complexity?

Secondary research questions (SRQ):

SRQ1:
What are the factors described in frameworks that impact the successful implementation of innovations in health contexts?

SRQ2:
What are the elements that influence implementation of technology in cancer-care contexts and how do they interact?

SRQ3:
How could the community participate to have a better implementation process?

2. Methodology

To address the research question in this project, I use the approach of Research through Design to explore the implementation context of cancer care. Research through design "focuses on how design actions produce new and valuable knowledge" (Zimmerman & Forlizzi, 2014), and is useful for tackling complex problems (Godin & Zahedi, 2014; Zimmerman et al., 2010). With this approach I used literature research, and Interviews followed by analysis and synthesis of the information collected with Giga-mapping techniques.

2.1. Literature research

I reviewed literature to identify existing frameworks for technology implementation in healthcare. This review helped recognise key domains, elements and connections that influence the technology of implementation, answering the answer the SRQ1.

2.1.1. Search and selection of frameworks

To identify relevant frameworks for the implementation of technology in cancer care, I employed the snowball method.

The search terms used were Innovation implementation in healthcare, Implementation frameworks, Healthcare technology implementation and Healthcare innovation. For this review, only publications in English were included.

The selection process began with an initial screening of titles and abstracts to identify potentially relevant studies. Then, full-text articles were scanned to ensure they were directly relevant to the research question. This approach allowed me to select four commonly mentioned frameworks in the literature: the NASSS Framework, the CIFR Framework, the PRISM Framework, and the PARiSH Framework.

Data bases used:

BioMed Central

Google Scholar

Journal of Medical Internet Research

ScienceDirect

The National Centre for Biotechnology Information

2.1.2. Analysis of frameworks

For the analysis, I read the full texts of the selected frameworks and extracted the factors that were mentioned as affecting the implementation of technology in healthcare. I then compared the various frameworks to identify similarities and differences among them. Finally, for the synthesis of information, I identified 8 domains, 29 elements, and 35 connections across the frameworks that were relevant to addressing the research question.

2.2. Interviews

2.2.1. Research design

In order to answer the SRQ2 and SRQ3, I conducted 9 semi-structured interviews with team members from the 4D PICTURE project, who are involved in the design, development, or research of cancer-focused technology. The objective was to identify elements influencing technology implementation within a real project in a cancer-care context and how these elements interact between them (See Appendix A). This method was chosen as it provides the ability to understand the implementation phenomenon in the context of the 4D PICTURE project told by the people that experience it.

2.2.2. Participants and setting

The setting was online (using the platform Microsoft Teams), chosen to accommodate participants located in Spain and the Netherlands and maintaining consistency in the interview environment across all participants. This online setting provided flexibility for the professionals, allowing them to participate in the study according to their schedules. Additionally, Microsoft teams provide virtual face-to-face interactions regardless of participants' geographical locations.

The participants were recruited from the 4D PICTURE project team, with diverse roles and responsibilities in the project. Among the participants were three designers, two developers, one project coordinator, one representative responsible for ethical considerations, and two researchers. Despite their varied roles, all participants contributed valuable insights into the dynamics and practices within the project, enriching the exploration of implementation of technology in cancer-care contexts.

2.2.3. Data collection method

During the interviews, participants were encouraged to share their perspectives, experiences, and thoughts related to the implementation of healthcare innovations within the project. To ensure accuracy and completeness of information, interviews were recorded using a digital recording device and transcribed for in-depth analysis.

Throughout the data collection process, efforts were made to establish rapport, build trust, and create a conducive environment for open dialogue and reflection. Participants were assured of confidentiality and anonymity, and their privacy rights were respected at all times.

2.2.4. Analysis of data

Upon completion of the interviews, each transcription was anonymized to ensure participant confidentiality. Transcriptions provided a textual representation of participants' responses, allowing for analysis and interpretation of their perspectives and insights.

For the analysis, the transcripts were coded and grouped, facilitating the identification of elements and connections. This process was undertaken in Atlas.ti, as this platform facilitates the upload of multiple transcripts, code each separately and group codes between the multiple transcriptions; making the analysis process more efficient.

The data analysis was an iterative process that resulted in the identification of 8 domains, 27 elements and 26 connections that influence implementation of technology in cancer-care context. Additionally, I defined insights on how and when the community could be involved in the implementation process, and the challenges that can occur.

2.3. GIGA-mapping

To synthesize the information gathered through literature and interviews, I employed GIGA-mapping. This is a visualization tool used for interrelating and understand the knowledge gained from the research, and communicating complex systems (Sevaldson, 2011). This technique allowed me to synthetize and map all the elements and connections derived from the interviews and literature review, to answer the main research question.

In order to create the GIGA-map I used the web-based tool Kumu.io, as it allowed me to iterate multiple times the domains, elements and connections on the map, facilitating the sense-making of the data collected without losing descriptive information of each of the components. Finally, this map was validated with 4D PICTURE members to evaluate its usefulness and perceived value.

2.4. Ethical considerations

Ethical approval was obtained from the Human research ethics committee of TU Delft (Appendix B). Prior to the interviews and validation informed consent was obtained from all participants, who were assured of their confidentiality and anonymity. Data were stored securely and only accessible to the research team and all the transcriptions were anonymised to assure confidentiality.

3. Process and results

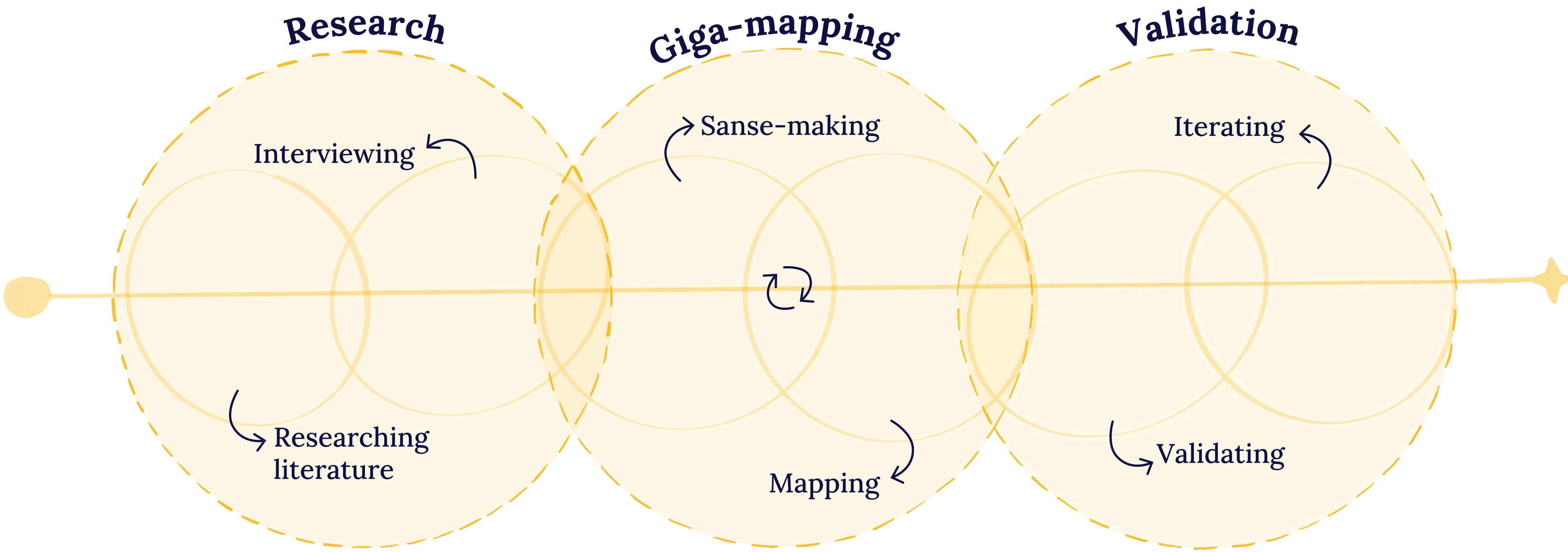


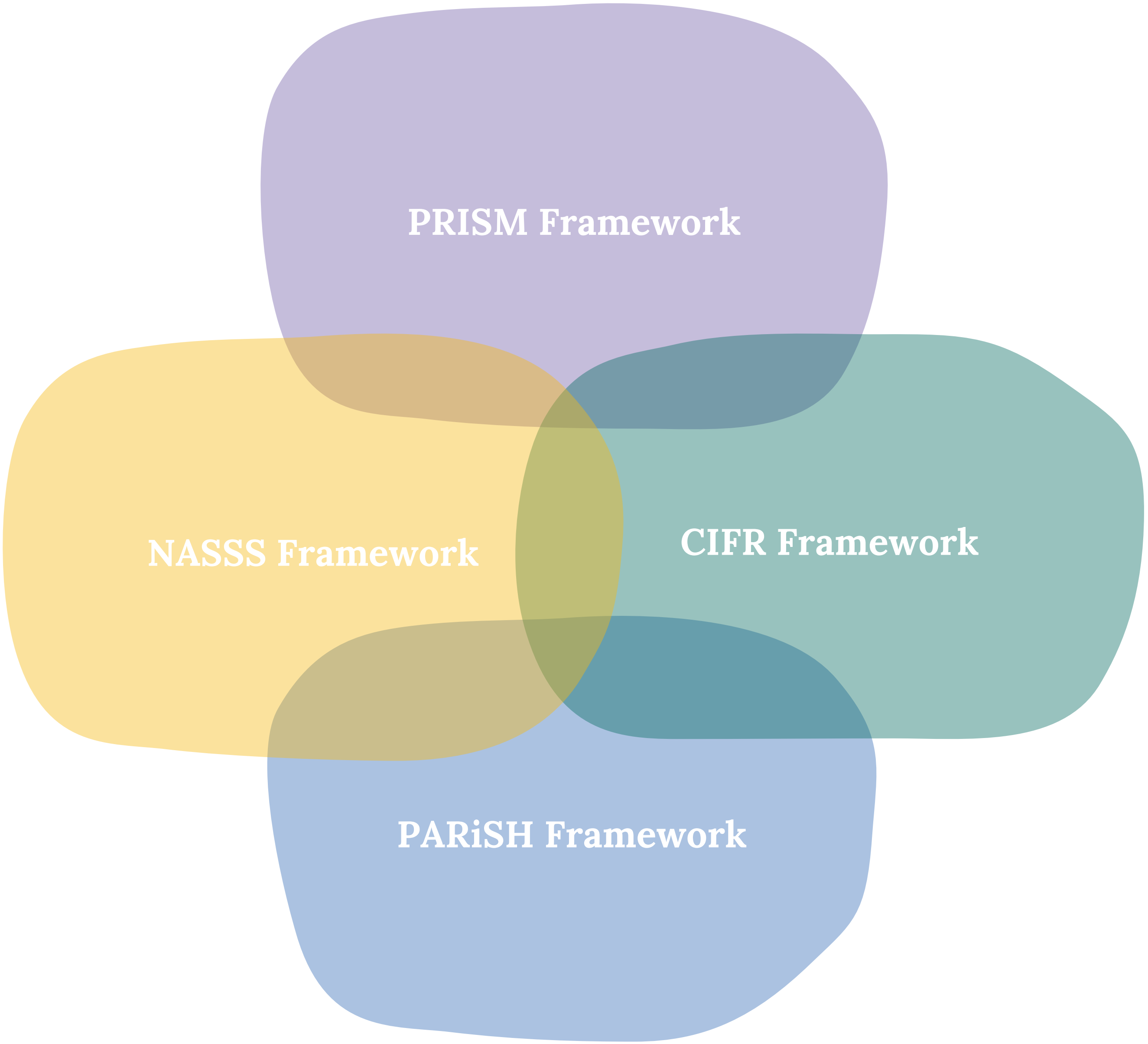
Figure 1 - Process followed during the development of the project.

3.1. Literature research

3.1.1. Implementation frameworks

Recently, there has been an increase in the interest to establish a theoretical base to create strategies for implementation, such as the use of models, tools, frameworks that help researchers to gain insights into the mechanisms by which implementation is more likely to succeed (Nilsen, 2015). "A framework usually denotes a structure, overview, outline, system or plan consisting of various descriptive categories, (...) and the relations between them" (Nilsen, 2015).

For this graduation project, I analysed 4 frameworks: NASSS framework, CIFR framework, PARiHS framework, and PRISM framework. These frameworks show multiple factors present in the implementation of technology and describe multiple layers of the health-care context: the individual level, the organization level and the context level.


PRISM Framework
NASSS Framework
CIFR Framework
PARiSH Framework

NASSS Framework

The Nonadoption, Abandonment, Scale-Up, Spread, and Sustainability (NASSS) framework, developed by Greenhalgh et al. (2017b), provides an approach to theorize and evaluate the implementation and sustainability of health-care focused technologies. The framework acknowledges the multi-element nature of implementation within complex healthcare systems and suggest interplay of various elements that influence the success or failure of implementation efforts.

NASSS FRAMEWORK						
The Condition or Illness	**The Technology**	**The Value Proposition**	**The Adopter System**	**The Organization(s) Implementing the Technology**	**The Wider System**	**The Embedding and Adaptation Over Time**
Nature of condition or illness	Material features	Supply-side value	Staff	Capacity to innovate	Political & policy	Scope for adaptation over time
Comorbidities & sociocultural influences	Type of data generated	Demand-side value	Patient	Readiness for technology and change	Regulatory / legal	Organisational resilience
	Knowledge needed to use		Carers	Nature of adoption / funding decision	Professional	
	Technology supply model			Extent of change needed to routines	Socio-cultural	
				Work needed to implement change		

Figure 2 - Domains and elements of NASSS framework. Adaptation from Greenhalgh et al. (2017b)

Domains & elements

The NASSS framework comprises seven domains, each representing key elements (Figure 2) that shape the implementation and its integration into healthcare contexts.

1. **The Condition or Illness:** This domain encompasses two elements: the nature of the health condition targeted by the technology, and the comorbidities and sociocultural influences. For example, the suitability of a patient to make use of the technology.

2. **The Technology:** Central to the framework is the consideration of the technology itself, including the elements: Material features, the data generated, the knowledge to use the technology and the supply model of the technology.

3. **The Value Proposition:** This domain examines the perceived value of the technology to various stakeholders. The elements are the supply-side value and the demand-side value.

4. **The Adopter System:** The diverse actors involved in technology adoption and implementation; including as elements the staff, the patient and carers. Here we find factors such as fear of losing job and the perceived safety of the technology from the Staff perspective, the acceptance and workload from the patient's perspective, and the level of support from carers and their trust on the technology.

5. **The Organization(s) Implementing the Technology:** This domain focuses on the organizational context within which the technology is deployed, involving the elements: Capacity to innovate, readiness for technology or change, Nature of adoption, and work to implement change.

6. **The Wider System:** The framework considers the broader sociopolitical, economic, and cultural context in which healthcare technologies are situated, recognizing the influence of external forces on implementation outcomes. Here we can find the elements Politics and Policies, regulations, Socio-cultural and Professional bodies.

7. **The Embedding and Adaptation Over Time:** Finally, this domain includes the elements scope for adaptation over time, and organisational resilience.

CIFR Framework

The Consolidated Framework for Implementation Research (CFIR), introduced by Damschroder et al. (2009) and updated in 2022 (Damschroder et al., 2022), is a comprehensive framework designed to facilitate the study of factors influencing the implementation of health services research findings into practice. The CFIR is grounded in the recognition that successful implementation is dependent on a multitude of interacting factors operating at multiple levels of the healthcare system, including individual, organizational, and environmental dimensions.

Domains & elements

The CFIR comprises five major domains (Figure 3), each capturing distinct yet interrelated elements of the implementation process.

1. **Innovation:** This domain focuses on the attributes of the intervention being implemented, including the elements the innovation source, the evidence base, the relative advantage, the adaptability, the trialability, innovation complexity, the design, and cost.

2. **Outer Setting:** The influence of the external environment surrounding the organization, encompassing elements such as critical incidents, local attitudes, local conditions, partnerships and connections, policies & laws, financing, and external pressure.

3. **Inner Setting:** This domain explores the organizational context within which the implementation occurs, including the elements: structural characteristics, relational connections, communications, culture, tension for change, compatibility, relative priority, incentive systems, mission alignment, available resources, and access to knowledge & information

4. **Individuals:** Recognizing the role and characteristics of individual actors in the implementation process, this domain examines elements such as high-level leaders, mid-level leaders, opinion leaders, implementation facilitators, implementation leads, implementation team members, other implementation support, innovation deliverers, innovation recipients, the individual needs, their capability, the opportunity, and motivation.

5. **Implementation process:** The CFIR emphasizes the importance of implementation processes, including the elements: teaming, assessing needs, assessing context, planning, tailoring strategies, engaging, doing, reflecting & evaluating, and adapting.

CIFR FRAMEWORK					
Innovation	Outer Setting	Inner Setting	Individuals		Implementation Process
			Roles subdomain	Characteristics subdomain	
Innovation source	Critical Incidents	Structural characteristics	High-level Leaders	Need	Teaming
Innovation Evidence Base	Local Attitudes	Relational Connections	Mid-level Leaders	Capability	Assessing Needs
Innovation Relative Advantage	Local Conditions	Communications	Opinion Leaders	Opportunity	Assessing Context
Innovation Adaptability	Partnerships & Connections	Culture	Implementation Facilitators	Motivation	Planning
Innovation Trialability	Policies & Laws	Tension for Change	Implementation Leads		Tailoring Strategies
Innovation Complexity	Financing	Compatibility	Implementation Team Members		Engaging
Innovation Design	External Pressure	Relative Priority	Other Implementation Support		Doing
Innovation Cost		Incentive Systems	Innovation Deliverers		Reflecting & Evaluating
		Mission Alignment	Innovation Recipients		Adapting
		Available Resources			
		Access to Knowledge & Information			

Figure 3 - Domains and elements of CIFR framework. Adaptation from Damschroder et al. (2022)

PARiHS Framework

The Promoting Action on Research Implementation in Health Services (PARiHS) framework, introduced by Kitson et al. (1998), offers a comprehensive framework for understanding and facilitating the implementation of evidence-based practice in healthcare settings. Grounded in the recognition that successful implementation requires the integration of evidence, context, and facilitation, the PARiHS framework provides a base for assessing and enhancing the implementation process.

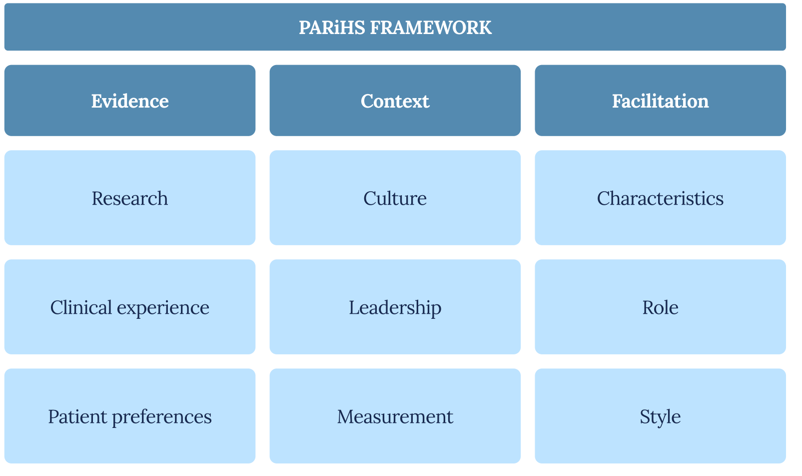


Figure 4 - Domains and elements of PARiHS framework. Adaptation from Kitson et al. (1998)

Domains & elements

The PARiHS framework comprises three core domains (Figure 4) which interact dynamically to influence implementation outcomes.

1. **Evidence:** This pillar encompasses the quality, quantity, and relevance of the evidence supporting a particular practice or innovation. It includes the following elements: research, clinical experience, and patient preferences.

2. **Context:** The context pillar refers to the organizational and environmental factors that shape the implementation process, including the elements culture, leadership, and measurement.

3. **Facilitation:** Facilitation represents the technique by which an individual influences and makes thing easier for others. The elements that integrate this domain are the personal characteristics, the facilitators' role, and style of the facilitator.

PRISM Framework

The Practical, Robust Implementation and Sustainability Model (PRISM) is a comprehensive framework designed to guide the integration of research findings into practice. Developed by Feldstein & Glasgow (2008), PRISM offers a structured approach to implementation planning and execution, emphasizing practicality and sustainability.

Domains & elements

The PRISM framework consists of four key domains (Figure 5), each essential for successful implementation and sustainability.

1. **Program (intervention):** This component focuses on the intervention or program being implemented and is divided in the organisational perspective and the patient perspective. this domain includes the elements: readiness, strength of evidence base, addresses barriers of frontline staff, coordination across departments and specialties, burden (complexity and cost), usability and adaptability, trial-ability and reversibility, ability to observe results, patient centeredness, provides patient choices, addresses patient barriers, seamlessness of transition between program elements, service and access, burden (complexity and cost), and feedback of results.

2. **External Environment:** This domain includes elements, such as payor satisfaction, competition, regulatory environment, reimbursement, and community resources.

3. **Implementation and Sustainability Infrastructure:** This domain addresses the structures, processes, and resources needed to support both initial implementation and long-term sustainability of the intervention. It includes the elements performance data, dedicated team, adopter training and support, relationship and communication with adopters, adaptable protocols and procedures, facilitation of sharing of best practices, and plan for sustainability

4. **Recipients:** Recipients refer to the individuals and organisations affected by the implementation of the program or intervention. It includes the elements organisational health and culture, management support and communication, shared goals and cooperation, clinical leadership, systems and training, data and decision support, staffing and incentives, expectation of sustainability, patient's demographics, disease burden of patients, competing demands, and knowledge and beliefs of patients.

PRISM FRAMEWORK					
Program		External Environment	Implementation and Sust...	Recipients	
Organizational perspective	Patient perspective			Organizational characteristics	Patient characteristics
Readiness	Patient centeredness	Payor satisfaction	Performance data	Organizational health and culture	Demographics
Strength of evidence base	Provides patient choices	Competition	Dedicated team	Management support and communication	Disease burden
Addresses barriers of frontline staff	Addresses patient barriers	Regulatory environment	Adopter trining and support	Shared goals and cooperation	Competing demands
Coordination across departments and specialties	Seamlessness of transition between program elements	Reimbursement	Relationship and communication with adopters (bridge research)	Clinical leadership	Knowledge and beliefs
Burden (complexity and cost)	Service and access	Community resources	Adaptable protocols and procedures	Systems and training	
Usability and adaptability	Burden (complexity and cost)		Facilitation of sharing of best practices	Data and decision support	
Trial-ability and reversibility	Feedback of results		Plan for sustainability	Staffing and incentives	
Ability to observe results				Expectation of sustainability	

Figure 5 - Domains and elements of PRISM framework. Adaptation from Feldstein & Glasgow (2008).

3.1.2. Results from analysis of frameworks

By analysing the frameworks, I identified multiple Domains, Elements and some connections which comprise the system of 'innovation implementation in healthcare'.

Domains Identified	PARiSH	CIFR	NASSS	PRISM
The technology or innovation	Evidence	Intervention Characteristics	The Technology	Program
The external setting		Outer Setting	The Wider System	External Environment
The organisation setting	Context	Inner Setting	The Organization(s) Implementing the Technology	Recipients
The adopters	Facilitation	Individuals	The Adopter System	Recipients
The implementation process	Context, Facilitation	Process	The Embedding and Adaptation Over Time	Implementation and Sustainability Infrastructure
The value perception	Evidence	Inner Setting, Individuals	The Value Proposition	
The Illness			The Condition or Illness	
The Adaptation Over Time			The Embedding and Adaptation Over Time	Implementation and Sustainability Infrastructure

Table 2 - Aggrupation of the Frameworks domains

Domains

From the four analysed frameworks, I grouped the similar domains in order to understand which ones were present in multiple frameworks (Table 2). After this, I could recognise overlaps between the frameworks (Figure 6) that helped understand better the differences and commonalities between them. Finally, with this analysis I identified the relevant domains present in the implementation of technology in health contexts.

From this analysis, I identified 8 domains in total: the technology or innovation, the external setting, the organisation setting, the adopters, the implementation process, the illness, the value perception, and the adaptation over time (Figure 6). From these 8 domains, there are 4 which are present in all of the frameworks reviewed (the technology or innovation, the adopters, the implementation process, and the organisation setting), another two domains that are present in 3 frameworks (the external setting and the value perception). Finally, one domain that is present in two frameworks (the adaptation over time) and, one domain (the illness) that is only explicitly mentioned in the NASSS framework.

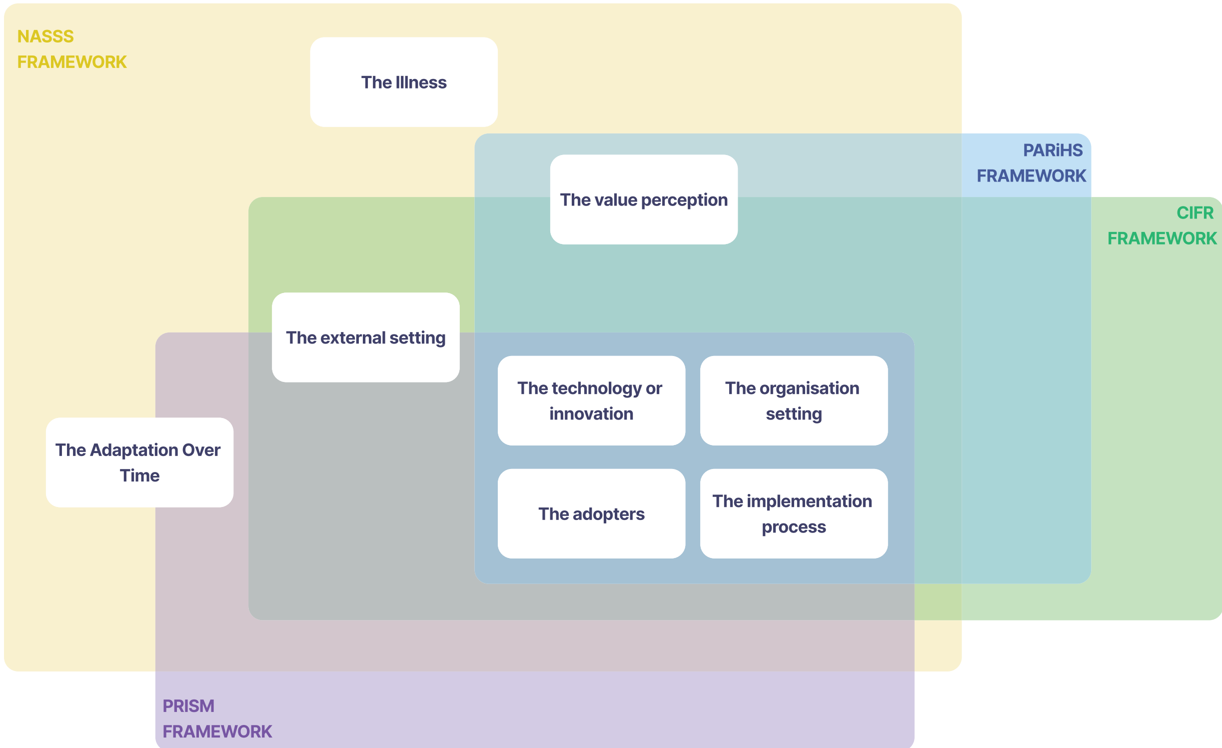


Figure 6 - Overlaps in the domains of the frameworks.

Elements identified

From the frameworks I grouped the elements that referred to similar topics and assigned them a descriptive name. After this, I categorized the elements in the respective domains that were defined above. As a result of this process, I compiled the relevant domains and elements that help implement technology in healthcare successfully (see Appendix C for definitions of the domains and elements).

Domains	Elements
The technology or innovation	Cost of technology, characteristics of technology, Data and information generated by the technology, and Validity of technology
The external setting	Technology landscape, culture, Political environment.
The organisation setting	Organisational culture, financial capacity, structure and operation, Technological setting, Data management.
The adopters	Patients, clinicians, caregivers, Organisation Managers, and Healthcare organizations.
The implementation process	Training, Feedback, Change workload, adaptability, the innovation deliverers.
The value perception	Need of the technology, Priority for the adopter, Relative advantage.
The Illness	Nature of the illness and comorbidities.
The Adaptation Over Time	Adoption and sustainability

Table 3 - Domains and elements identified across Frameworks, Appendix C.

Connections identified

Based on the Frameworks, the Elements and Domains interact with each other in a complex way (Figure 7). Nevertheless, these interactions (connections) are not explicitly described in any of the frameworks.

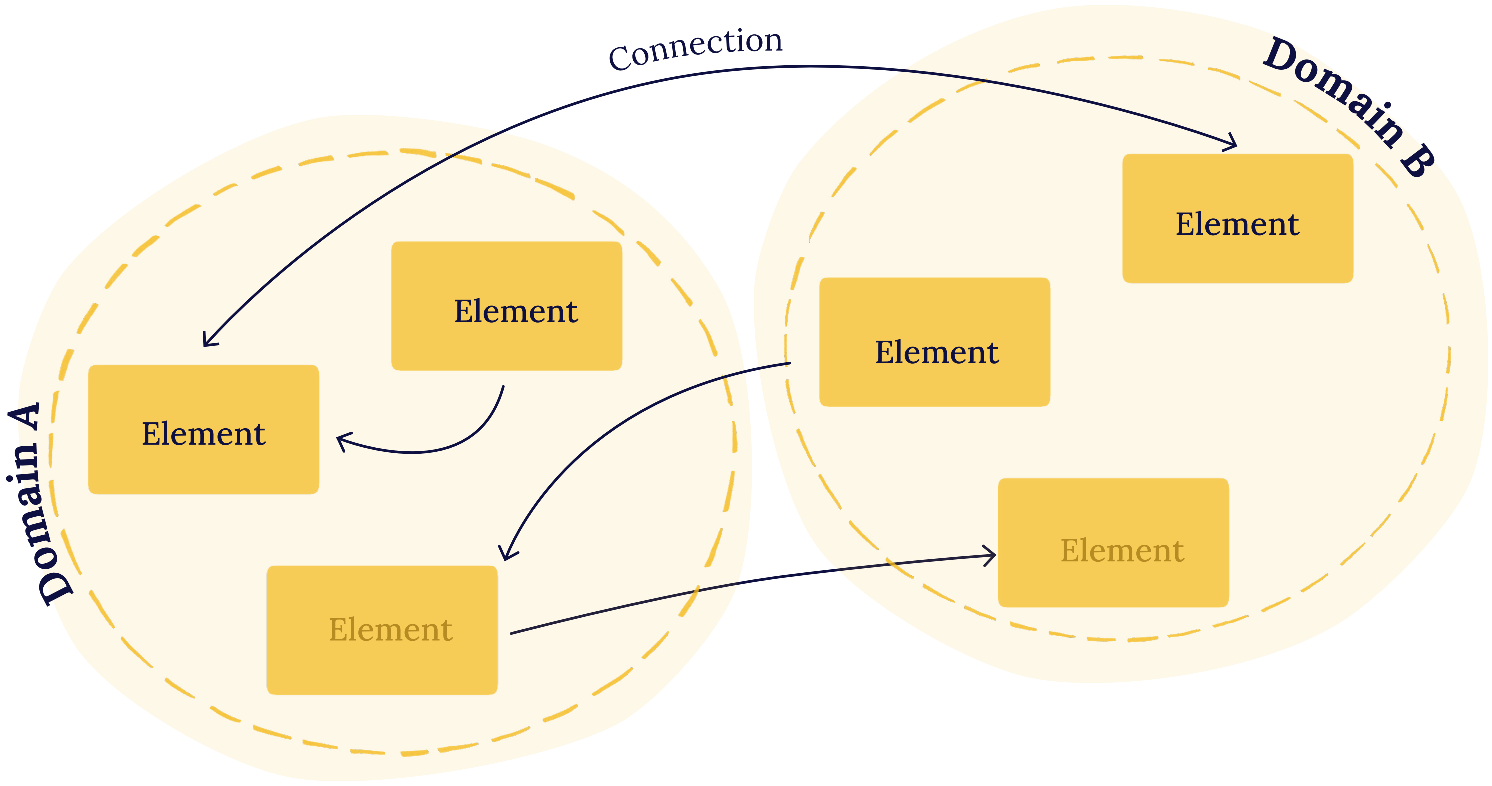


Figure 7- Components of the system.

To identify connections, I analysed the description of the domains and elements of each framework and extracted correlations between elements in the system. In the following pages (p. 44-47), I describe the connections identified.

Leadership:

Managers and organisational leaders, influence the dissemination of the innovation in the organisation, as they encourage (or discourage) clinicians on the use and attitude towards the technology.

Relative advantage:

Adopters have a perception of the relative advantage that the technology has in comparison to the current solution or other options in the market. This influences the perceived value of the innovation and their attitude toward its implementation.

Organisational Processes:

The implementation of technology might change a process that the organisation has. This change influences the structure of the organisation and its the other internal processes.

Health funding:

The political environment determines the strategies, funding, regulations and incentives to spread innovations across organizations.

Data obsolesce:

The changes in the technology landscape generate obsolesce of data used by the technology or the organization.

Team communication and relationships:

Good communication and relationships between the employees of an organisation facilitate the dissemination and implementation of technology.

The culture of an organisation influences the communication and relationship between the different hierarchies and teams.

Workload and routines:

The implementation of a technology can generate disruption on the work routines of the clinicians which can influence the attitude they have towards the technology. This can be mitigated with a plan for the transition period until is adopted.

The technology can increase or decrease the workload that the clinicians have. This influences the disposition of users to adopt the technology.

Emotional and physical exhaustion of clinicians influence the attitude towards the implementation of the technology.

Trust & legitimacy:

The adopters value perception on the technology is influenced by the trust and perceived legitimacy of the provider of the technology.

Trust in data:

The information that the technology provides to adopters influences their perceived trust on the technology, influencing their disposition to implement the technology.

Suitability for innovation:

Some conditions in the illness might not be suitable for the use of the technology. Such as patients with illness considered as high risk, unpredictable or atypical. Additionally, the context and characteristics of the patient might also influence this suitability for the technology.

Employee rotation:

High employee rotation in an organisation generates instability for its operation and structure. More stability helps to have an adequate time period to implement and adopt a technology.

Complexity perception:

The complexity perception of the innovation affects the adopter's self-efficacy towards the use of the innovation.

Training for use:

The quality of training provided by the deliverer team for using the technology, influences the adoption by clinicians, patients and/or caregivers.

The access that the adopters have to information & knowledge on how to incorporate the innovation on the current work tasks, influence the readiness for implementation of the organisation.

Support for care:

Patients that receive support from their families, friends or colleagues, have more self-efficacy towards the use of the technology.

Policies for innovation:

Local laws determine regulations regarding the functionality and use of technology which influences the implementation and use of the technology in the organisation.

Self-efficacy:

The self-belief that clinicians can use the innovation influence the implementation climate in an organizational level.

The self-efficacy of the adopters towards the innovation influences the likeliness of adoption.

Team dependencies:

The operation of an organisation defines the dependencies between teams and individuals, these dependencies affect the workload of implementation of a technology as it requires coordination across departments and teams.

Identification with the organisation:

The clinician's relationship and commitment with the organization influence on their willingness to engage and make an effort on implementing a new innovation.

Competitiveness:

The technological landscape creates competitive pressure to implement a technology in an organization. This might be due to other organizations or key partners implementing the technology or the organisation itself aims to create competitive advantage over their competitors.

Value perception:

The value perception that adopters have towards the technology influences the perceived relative advantage that the technology has over current or other solutions.

Early monitoring:

The possibility to monitor early results from the technology helps adopters to see the value of the technology.

Implementation climate:

The environment in the organisation and the disposition of the individuals to implement a technology, influences the implementation climate of an organisation. This includes a learning climate, incentives and rewards for implementation, tension for change, and relative priority.

Continuity of treatment:

The likelihood of a patient continuing cancer treatment is influenced by the healthcare system, the organizational structure, and the patient's environment. The continuity or discontinuity of treatment influences the likeliness of adoption of the technology.

Communication with patients and caregivers:

The communication from clinicians with patients and caregivers affects their trust on the clinicians and the likeliness of adoption of the technology. This communication is influenced by the use of technical language when explaining to users and the amount of time they have with each patient.

Quality and validity of innovation:

Adopters' perception on the validity and quality of the technology (such as delivering the expected outcome), influences its likeliness of adoption.

Data relevance:

The data produced by the technology needs to be relevant and understandable for the adopters. This will create more trust in the technology.

Fear of losing job:

The functional characteristics of the technology can trigger clinicians' fear of job replacement, leading to resistance in adopting the technology.

Safety perception:

The characteristics of the technology influence clinicians' perceptions of its safety. This perception influences the value perception of the technology.

Early monitoring:

The possibility to monitor early results from the technology helps adopters to see the value of the technology.

Condition perception:

Progression and severity of the health condition shape the patient's perception of their own health and beliefs about the illness. These perceptions, in turn, influence the patient's health decisions and self-efficacy in using the technology.

Daily routines & workload:

The patient's context and illness affect their daily routines, and the workload required to manage their health condition. These routines and workload, in turn, influence the likelihood of adopting the technology.

Health decisions:

The technology and the information that it provides, influence the decision-making of patients and caregivers regarding the cancer-care path. This allows the users to make shared choices of patient's treatment and health.

Costs of implementation:

Implementing a new innovation might generate costs like acquisition cost, management and support costs, and more. These costs influence the perceived value of the innovation and are tied to the adopters' capacity to acquire it.

Readiness for implementation:

The resistance to adopt the innovation in an organisation, the decision makers opinion, the implementation climate on the organisation and the training given to staff on the use of the technology, influence the readiness of the organisation to start implementing a new technology.

Aesthetics & technical features:

The physical and functional characteristics of the innovation influence the adopter's perception of aesthetic and usefulness of the technology. This perception influences the perceived trust and value of the technology.

Influence & opinions:

Opinions from peers that are subjective to their experience with the technology is influential on the value perception of adopters on the technology.

3.2. Interviews

3.2.1. Results of interviews

The interviews were coded to extract the domains, elements and connections that influence implementation of technology in cancer-care contexts. Additionally, I gathered insights on how the community could participate to have a more successful implementation process.

Some of the domains, elements and connections that were extracted from the interviews were also identified in the literature review. Nevertheless, the interviews add different perspectives or relationships between them.

Domains & Elements

From the interviews, 8 domains were identified (see Appendix C for definitions of the domains and elements): The technology or innovation, The external setting, The organisational setting, The adopters, The implementation process, The illness, The external actors, and The implementer team (Table 4).

Domains	Elements
The technology or innovation	Cost of technology, characteristics of technology, and trialability.
The external setting	Technology landscape, culture, Political environment, healthcare systems, end of life.
The organisation setting	Patient setting, financial capacity, structure and operation, Technological setting.
The adopters	Patients, clinicians, caregivers, Organisation Managers.
The implementation process	Training, Feedback, adaptability.
The Illness	Nature of the illness, progression of the illness, severity of the illness, treatment.
The external actors	Policy makers and government, ethics boards, cancer researchers.
The Implementer team	Innovation deliverer

Table 4 - Domains and elements identified in the Interviews, Appendix C.

Connections

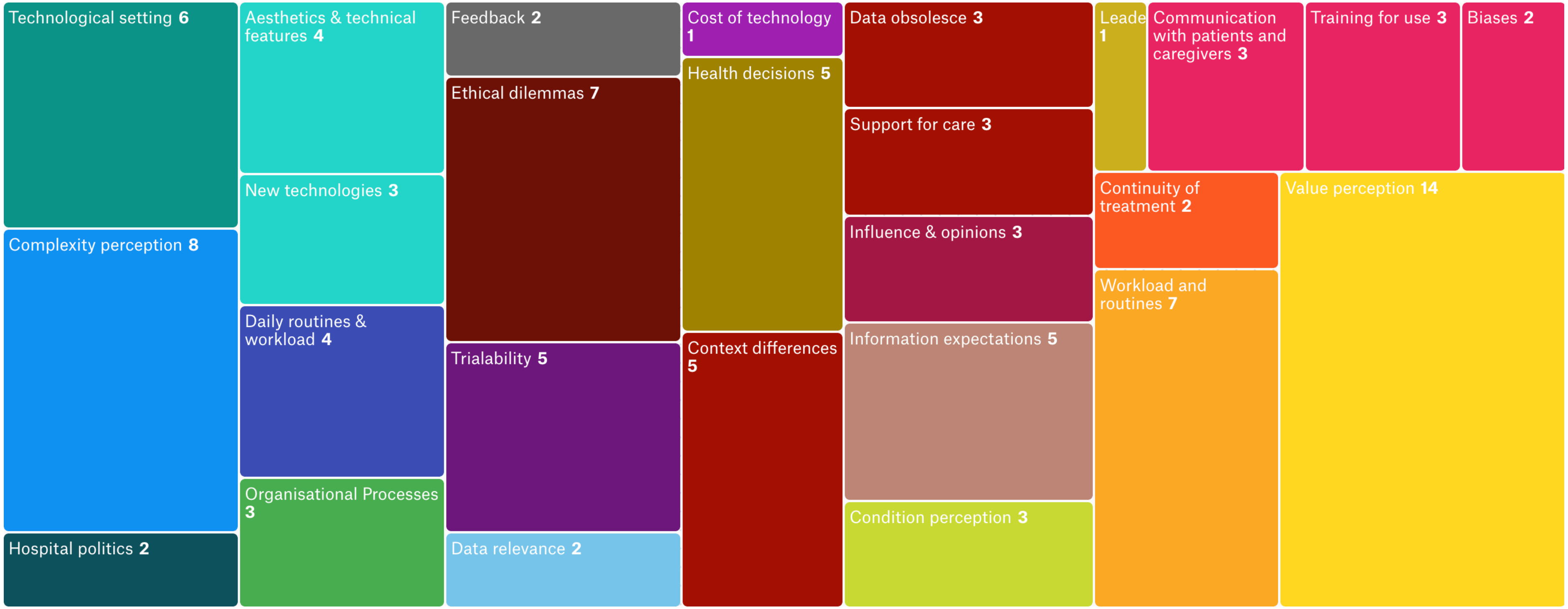


Figure 8 - Connections identified from the interviews.

The total connections identified with the interviews were 26 (Figure 8). Value perception was the most mentioned connection, with 14 references to it throughout all the interviews. Other frequently mentioned connections were Complexity perception (8 times), Ethical dilemmas (7 times) and Workload and routines (7 times). In the following pages (p. 51-54), I describe the connections identified:

Workload and routines:

The clinicians have multiple tasks and work on a daily basis and their time is limited, this influences the communication with patients and caregivers.

The workload that the technology creates in the routines of the clinicians, influence their likeliness of adoption.

Value perception:

The clinician's perception of value regarding the technology is influenced by the effort that they have to do when implementing and adopting the technology and their perception on how the technology increases or decreases their daily workload.

The patients and caregivers value perception of the technology is influenced by their perception of usefulness and complexity of the technology.

Leadership:

Respected clinicians and Organisation Managers help create acceptance of the innovation and more use of the tool among colleagues.

Data obsolesce:

When there is improvement in technology and research in the cancer field the data that the technology uses might become obsolete. This influences the relevance if the data for the adopters and the technological setting of the organisation.

Training for use:

Adopters need to be trained by the implementer team in order to generate skills and knowledge on the technology. Getting knowledge and skills influences the value perception of the adopters and reduced the complexity perception.

Communication with patients and caregivers:

The health condition of the patient and his literacy level influences the communication that they have with the clinicians.

The communication that clinicians have with patients and caregivers is influenced by the type of cancer that the patient has and their expectation of information. For example, some patients with breast cancer can have different expectation of information than a patient with prostate cancer

The communication with patients and caregivers, is influences by the terminology used by the clinicians. For example, in some cases the patients and caregivers are not knowledgeable of medical terms that are used by the clinicians. This influences the trust in the clinicians and their health decisions.

Condition perception:

The way that the patient perceived their own health state influences the decisions they make about their cancer-care path.

The way that clinicians perceive the health condition of the patients influences on the decisions they make for the patient's treatment plan (or end of life).

Ethical dilemmas:

The ethical and moral stance of adopters influences their decisions and care preferences. For patients, this affects the choice between pursuing treatment or opting for end-of-life care. For caregivers, it shapes decisions made on behalf of the person they care for. For clinicians, it determines their willingness to initiate, continue, or discontinue treatments for patients.

Feedback:

The innovation deliverers rely on feedback of the adopter to design, test and improve the technology.

Support for care:

Caregivers support on patients influence the self-efficacy that the patients have to use the innovation

The involvement and support that caregivers have in the patient's cancer-care path is influenced by their culture. Different cultures have different opinions on the level of involvement of their caregivers, some patients value more their autonomy than others.

Caregivers' involvement and support is influence by the health condition of the patient and his abilities. For example, if the patient has low literacy level or if the health condition does not allow the patient to be independent, the caregiver has more involvement.

Aesthetics & technical features:

The adopters' perception of the technology's usefulness influences their perception of its value. Moreover, the adopters might give different use to the technology, therefore, their perception might be different from each other.

Data relevance:

The data used by the technology is constrained by the models developed by the implementer team, which are influenced by the data available in the technology landscape. This data might be limited to provide reliable information or to be used for all kinds of patients. This limitation in the data influences the trustfulness and relevance of the technology.

Continuity of treatment:

The structure of the healthcare system and the organizations' affects patient continuity in treatment. For example, if the process for scheduling appointments is too complex, patients may discontinue treatment, either willingly or unwillingly, or may not consistently see the same doctor. This discontinuity impacts the adoption of the technology.

Organisational Processes:

The technology that is going to be implemented affects the structure and workflow of the organisation, for example some of the processes might be analogue and other automated, the technology might change how some of this work.

Information expectations:

The patient's health preferences and their culture, influence their expectation on information about the illness.

Context adaptation:

Countries have varied healthcare systems, and organizations differ in structure and operations. These differences influence how technology is implemented and how it should be adapted for each context.

Health decisions:

Patients, caregivers, and clinicians make health choices regarding cancer care based on their cultural background, ethical stance, biases, and information provided by the technology. These decisions may involve starting, continuing, changing, or discontinuing treatment, as well as opting for palliative care at the end of life.

Shared-decision making can be perceived different per culture, this is also influenced by the type of communication that patients and caregivers have with their doctor.

Costs of technology:

For an organisation the costs of technology are not only the acquisition cost. Implementing a new technology might create costs for hiring new employees, changing the current workflow, maintaining the technology and supporting staff with problems they might incur. This impacts the financial setting of the organisation.

New technologies:

There is constant innovation in the technological landscape, this innovation generates technology obsolesce, diversification in systems, and changes in the inner technological setting of an organisation and the patient setting. The technologies that want to be implemented, need to align with the current technological setting and be improved through time to not become obsolete.

Complexity perception:

The technology can be perceived as complex by clinicians if it adds workload to the technological systems they already need to use in their work.

Adopters perceive the technology as less complex when it's intuitive, easy to use, and does not need a lot of training or changes in their routine.

The information provided by the technology might be perceived as complex by the adopters. For example, some patients and clinicians are not literate in statistical analysis, therefore, providing statistical information might increase the complexity for them.

Trialability:

If the adopters are able to try the technology first (like a pilot), they will be more confident on making the decision to acquire it and increase the perceived value of it. This also help to gain feedback from users and to disseminate easier the technology in the organisation.

Biases:

Biases against certain groups can affect the data used by the technology, making it crucial to recognize these biases and limitations. Ensuring the technology functions correctly for diverse individuals requires addressing these issues in the information models.

Influence & opinions:

Managers and decision makers of the healthcare organisations influence on clinicians' opinion on a technology.

Daily routines & workload:

The technology influences the daily routine of the patients and might increase or decrease the workload they need to do to manage their health condition. This workload and routines influence the likeliness of adoption of the technology.

Political setting:

Politics both inside and outside the organization affect its processes and structure. Within the organization, this is influenced by managers and decision-makers who perceive the technology's value and decide whether to adopt or discard it.

Technological setting:

The technology impacts the organization's technological environment, and vice versa. For the technology to be valuable to adopters, it should adapt to the existing technological setting.

Community participation

From the interviews with the 4D PICTURE team, I found insights on how the community could be involved for successful implementation of technology. More specifically, the challenges that might be present in the implementation, when should the community be involved, how can they be involved and why is relevant to involve them:

Why is it relevant to involve the community?

Involving the community in the development of technologies allows to generate conversations with users (and in the context) about the technology. This helps to co-create technologies that are valuable for the user needs, facilitating the implementation in the context.

The community can provide first-hand experiences and points of view on the decisions they make through the cancer-care path. This helps the implementer team to develop a technology that is tailored to their context.

Involving caregivers is relevant, as depending on the culture and health condition of the patients, they might be the ones making decisions and using the technology. Therefore, their input as carers in the development can facilitate the likeliness of implementation in the patient context.

When could the community be involved and how?

Although the goal is to have a successful implementation, the community involvement should happen since the start of the project until adoption. By doing this, the implementer team allows the community to provide feedback throughout the whole process and decrease the risk of failing the implementation. This includes the research stages, the design stages, testing, iterating and eventually implementing the technology.

During the design and development of the technology, the community could be involved in co-creation and testing sessions, providing feedback to improve it.

Once the technology is developed the community can be involved in pilots where they implement the technology in their context and provide feedback of their experience. By doing this, the implementer team can plan better for future deployments in other contexts and improve the technology for it to adapt better to the user's environment.

To involve the community, the implementer team should act as facilitators of conversations between them and the users. This role enables them to have more honest and open communication, to understand better the user's situation and to create trust in the technology.

Challenges of involving the community

Involving clinicians in the project (at any stage) is difficult due to the time constrains that clinicians have due to their job.

Recruiting patients poses several challenges. Due to their role, contacting them requires approval from the organization's ethical boards. Patients have limited time to participate because of medical appointments and procedures. Additionally, finding patients willing to collaborate or having the health condition to do it is difficult. Finally, reimbursing patients for their time involves ethical dilemmas and providing value for them.

Designing for cancer care is challenging because patients are in a vulnerable situation. Therefore, it is important to initially test with less vulnerable users, and as development progresses, to increasingly involve the target users.

It is important to recognize that even when testing and gathering feedback from target users, research bias is inevitable. Participants are often those who are passionate or interested, not necessarily the most critical or the ones who are more reluctant to change.

3.3. GIGA-mapping

A map (GIGA-map) was developed to analyse and synthetise the collected information in an iterative process (Appendix D). It represents the systemic complexity of technology implementation in cancer-care paths. This map integrates the domains, elements, and connections identified from both the literature review and interviews; visually representing them to facilitate the understanding of the complexity (Sevaldson & May, 2022).

3.3.1. Mapping process

Initially, I mapped the domains found on the literature with its elements. After, I created the connections between the different elements based on the descriptions found in the multiple frameworks. Nevertheless, I realized that visualizing the domains in the map was not necessary, as these are too broad, and the main relationships and interactions happened between elements.

After having the initial map of the elements found in the literature review, I mapped the elements and connections from the interviews, this enriched the GIGA-map and helped to compare the found elements and connections from both sources (Figure 9).

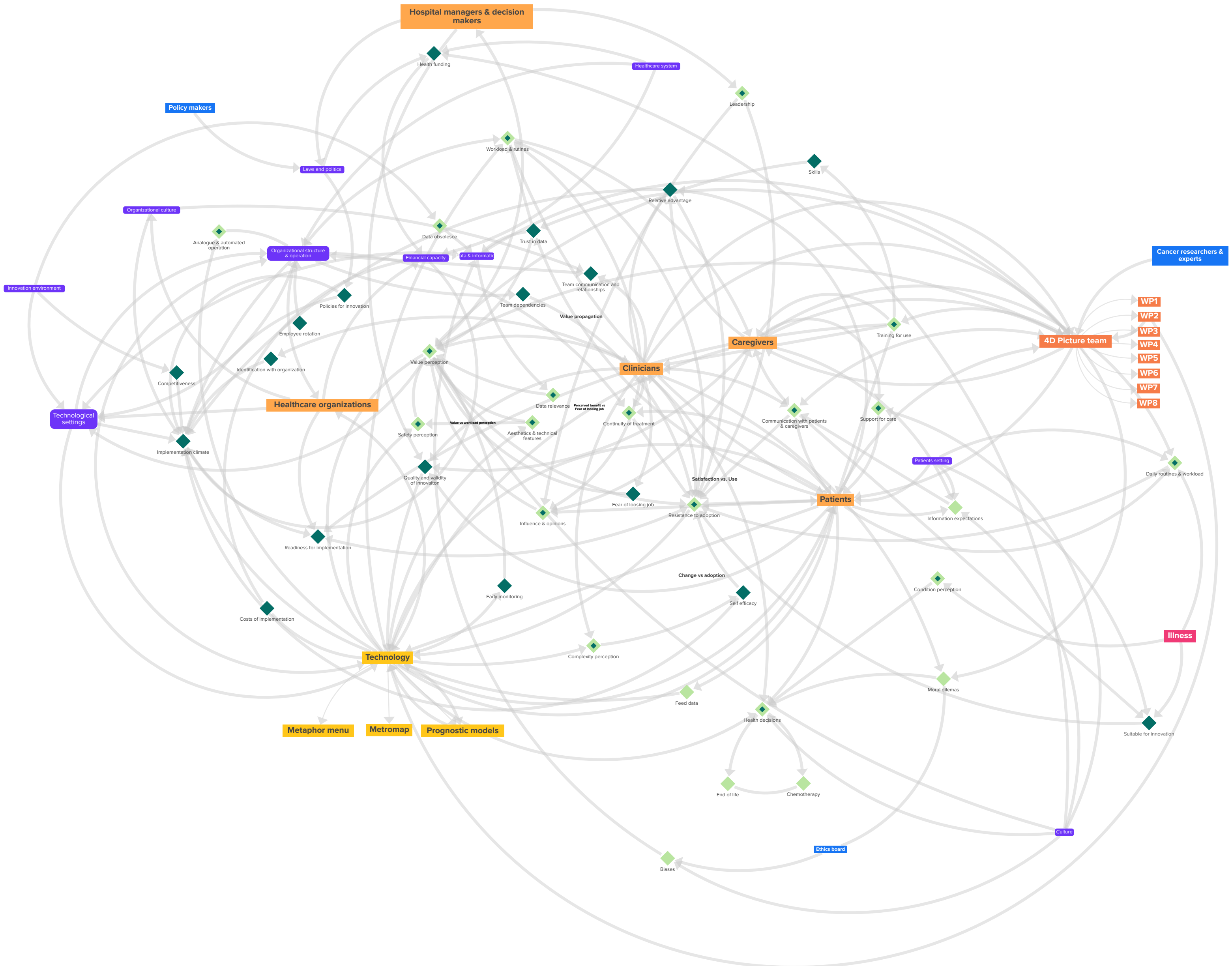


Figure 9 - GIGA-MAP with the elements that influence the implementation in cancer-care contexts, Appendix D.

The mapping process was iterative, and some domains and elements were merged or removed. For example, the domain 'Adaptation process' extracted from the frameworks, was excluded because it was out of the scope of the research. The element 'Deliverer of innovation' from the frameworks was merged in the domain 'the implementer team' from the interviews. Furthermore, some of the elements (and domains) shifted to become connections, such as 'the value perception' and 'the implementation process'. This shift occurred because they did not work as independent elements but as relational links between other components. For instance, 'the value perception' could be understood as the connection between a clinician and the characteristics of the technology, reflecting the clinician's assessment of the technology's worth and utility. And the implementation processes were interactions (such as training or collecting feedback) that would happen between adopters and implementer team.

After this iteration process, the system resulted in 7 domains and 28 elements (Table 5). Additionally, I defined the connections between the elements (shown as arrows & diamonds shapes in Figure 9) which resulted in 53 connections.

Domains	Elements
The adopters	Clinicians, Patients, Caregivers, Organisation Managers and Healthcare organisations.
The Implementer team	Innovation deliverer
The external actors	Policy makers and government, Ethics board, and Cancer researchers.
The external setting	Healthcare system, Culture and location, Technology landscape, Political environment, and End of life.
The organisation setting	Patient settings, Organisational culture, Financial capacity, Structure and operation, Technological setting, and Data management.
The Illness	Nature of the illness, Progression of the illness, Severity of the illness, and Treatment of the illness.
The technology or innovation	Costs of technology (acquisition, maintenance and implementation), Characteristics of technology, Data and information of technology, and Validity of technology.

Table 5 - Compiled domains and elements from the frameworks and interviews.

Defining Connections

Diamonds

The diamonds represent the way that two elements interact. For example, in the Figure 10, the diamond 'Feed data' acts as the connection between the patients and the decision support tools (the Technology). In the map shown above (Figure 9), we find 3 types of diamonds: Connections – interviews; Connections – Literature; Connections – Literature & interviews. These represent the information source to build this part of the map.

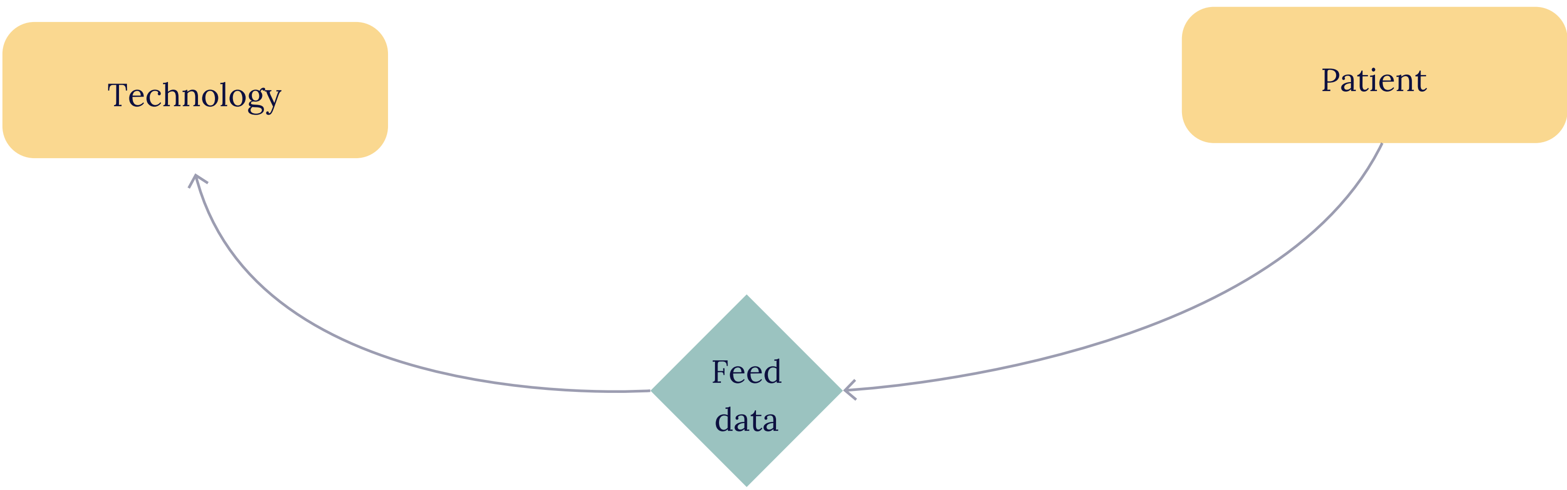


Figure 10 – Directed relation between Patients and Decision support tools.

Arrows

These are representations of the directions of relationships that exist between the elements. They might be directed, mutual or undirected.

Directed relation: Refers to one-way relationships, where entity A influences entity B. For example, in Figure 10 the arrow indicates that patients "feed data" to the decision support tool.

Mutual relation: Show a two-way relationship where both connected elements influence each other. For example, in Figure 11 the arrow indicates that the readiness for implementation influences the resistance to adoption, and the other way around.

Undirected relation: Show a connection where one element does not have an influence on the other, although indicates that the two elements are related. For example, in Figure 12 the arrow shows a relationship between end of life and chemotherapy as both are options that the patient has, nevertheless, none of them influence the other.

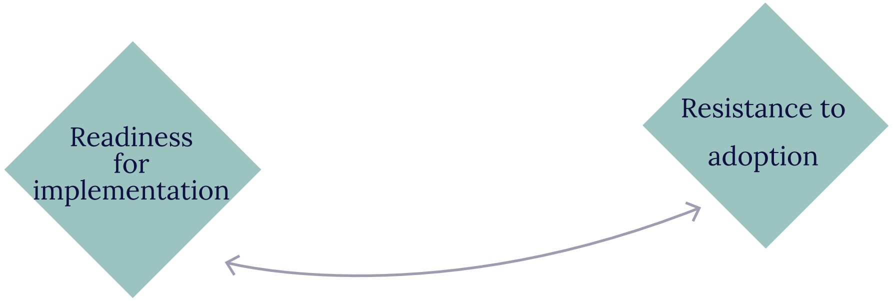


Figure 11 - Mutual relation between Readiness for implementation and Resistance to adoption.

Figure 12 – Undirected relation between end of life and chemotherapy.

3.3.2. Validation of the map

The map was validated with 4 members of 4D PICTURE project team to answer this research questions:

Are the factors included in the map (domains, elements, and connections) perceived as relevant for addressing the needs and challenges of the 4D PICTURE project?

What are the Team perceptions on the usability of the map in relation to the 4D PICTURE project?

How do team members perceive the usefulness of the map in the various stages of the 4D PICTURE project?

How do the team perceived that the map can be used by different roles of the 4D PICTURE project?

Validation process

In order to achieve the goal of this validation and give response to the research questions, I conducted online semi-structured interviews. This method helped to deepen on the perceptions and views of the interviewees which was relevant to validate the information in the map (see Appendix E).

The 4 participants had participated in the first round of interviews and had roles as designers, developers or researchers in the project. Among the 4 participants there were 2 designers, 1 developer, and 1 researcher. During the interviews, participants were asked guiding questions, and they shared their perspectives on the relevance of information and usefulness of the map. To ensure the completeness of information and accuracy during the analysis of data, the interviews were recorded using a digital recording device and they were transcribed and anonymized for analysis.

Analysis of data

The transcriptions allowed me to analyse the perspectives of the participants and highlight relevant information. The analysis process was conducted in the software Figma, in three steps. First a categorization of the verbatims, secondly an arrangement by themes, and finally the analysis of themes and verbatims to create insights (Appendix F).

Categorization of verbatims:

In this process I grouped the responses of the interviewees by questions, where each of the questions were placed on the top of the sheet and the respective answers under each of them (Figure 13). Each of the colours represented a different participant, this was relevant to be able to capture all the perspective of the person even if the topics that they refer to belonged to different questions. After this, I created statements that phrased what the participants mentioned in the quote, which would be helpful to cluster by themes more easily.

Figure 13 - Validation analysis-answers.

Arrangement by themes

For this process I took the statements and grouped them into themes and divided them by the question that those themes were answering (Figure 14).

Insights creation

Finally, in this step I created the insights that reflected the relevant findings form the interviews and gave response to each of the research questions of the validation (Figure 14).

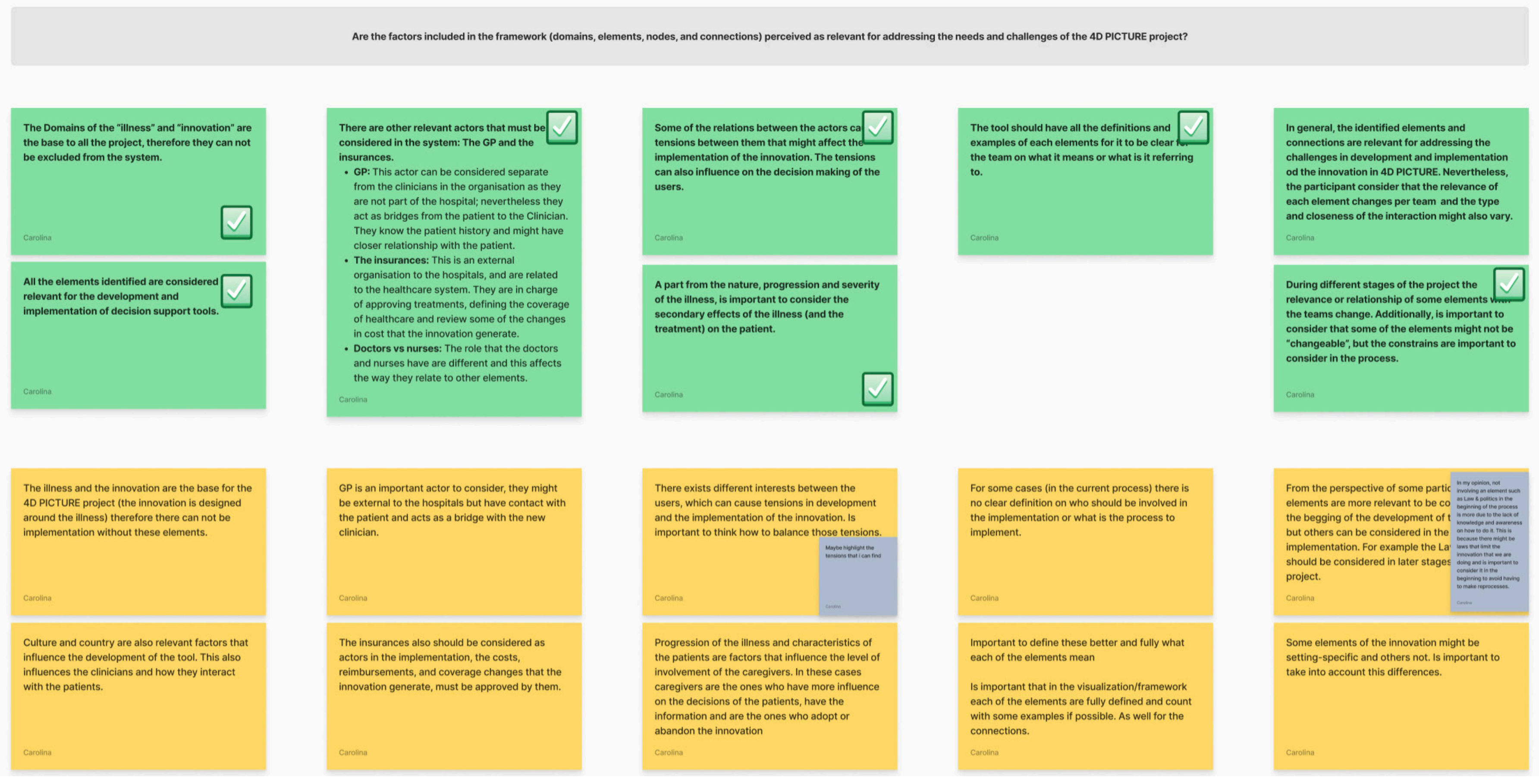


Figure 14 - Validation Analysis-Clustering & insights.

Results of validation process

Overall, the results indicated that the elements shown in the map are relevant for addressing the challenges of implementation in cancer-care contexts, and that the map is useful for the team in multiple parts of the project.

Relevance of elements

Other relevant actors for the cancer-care system

Important considerations of the elements and the system

Usefulness of the map

Who could use it

When to use it

Other considerations

Relevance of elements:

From the conversations with participants, I found that all of the elements (from the different domains) were recognized in the cancer-care context of 4D PICTURE project. Nevertheless, there were some factors that the participants considered were missing and important considerations in this matter.

Other relevant actors for the cancer-care system:

General Practitioners:

This actor can be considered separate from the clinicians in the organisation as they are not part of the hospital; nevertheless, they act as bridges from the patient to the Clinician. They know the patient history and might have closer relationship with the patient since they have made previous consultations with them.

Physicians and nurses:

The role that the doctors and nurses have are different in the organisations and this affects the way they relate to other elements in the system. For the case of cancer-care, is relevant to see the different relationships that these actors might have in the context.

The insurance companies:

This is an external organisation to the hospitals and are related to the healthcare system. They are in charge of approving treatments, defining the coverage of healthcare and review some of the changes in cost that the innovation generate.

The secondary effects & treatment:

Apart from the nature, progression and severity of the illness, is important to consider the secondary effects of the illness (and the treatment) on the patient. This element might cause influences on the system that are not currently portrayed.

Important considerations of the elements and the system:

Relevance of elements by stage of the project:

During different stages of the project the relevance or relationship of some elements with the designers, developers & researchers might change. For example, for the team might be relevant to consider the laws & politics during the implementation phase of the project but not during the research phase.

Technology implementation:

The domain technology is inherent to the process of implementation. Therefore, it cannot be thought of as an individual elemnt, all connections and elements are related to it in this map.

Understanding of elements:

The map should have all the definitions and examples of each element, to ensure the correct interpretation and understanding of the system by all users.

Changing relationships:

The actors and their relationships might change depending on the context. For example, some countries have insurances as part of the healthcare system, in others they are private organizations that relate to the healthcare system.

Tensions:

Some of the relations between the actors cause tensions between them that might affect the implementation of the innovation. For example, the communication of the doctor vs the communication of the patient might be very different, creating tensions during the care journey; this tension might have effects on the rest of the implementation system.

Usefulness of the map:

Apart from validating if the information was relevant, I wanted to validate the usefulness of the map for designers, developers and researcher. As a result from the interviews, I found that although having the map as tool is relevant for the team; the way that the different roles use it and the relevance it has for their jobs, is not the same (Figure 15) Additionally, the participants consider that the map can be used in different points of the project. Nevertheless, the purpose and use changes depending on the moment (Figure 16).

Who could use it:

Managers:

The participants consider that the tool could be relevant for the managers of the project to see the system and consider the elements that could be present during the project, and plan accordingly.

Team leaders:

The participants consider that the tool could be relevant for the leaders of the design, development and implementation teams, as this can serve as an overview of all the elements that are influencing for the successful implementation of the innovations and manage them in their teams.

Designers and developers:

The participants consider that the tool could be more useful for the teams that are in charge of the design and development of the innovation, as it provides a guide on what elements are important to consider for the creation of the technology.

Researchers:

The researchers see the map as a way to contextualize themselves for the project, but not as a tool for helping with their tasks and responsibilities in the project.

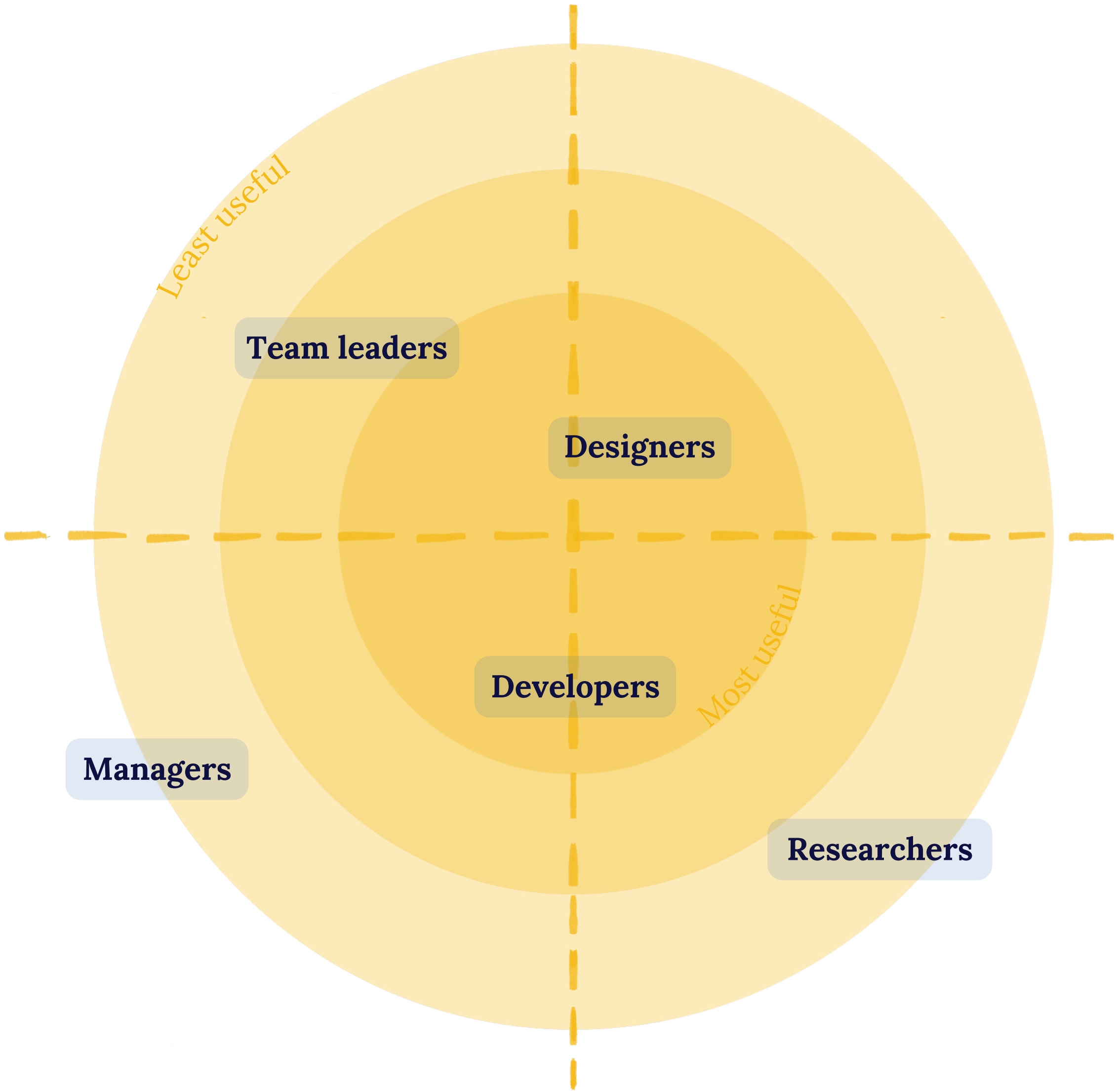


Figure 15 - Usefulness of the map for the different roles of the team.

When to use it:

In the beginning of the project:

For this stage the purpose of the tool is focused on contextualising the team into the setting of the innovation and the different elements that interact.

In the research stage:

The purpose of the tool in this stage is to visualise the different elements that affect the innovation and research further in the topics that are less known or more relevant for them.

In the development of the innovation:

For this stage, the purpose of the tool is focused on helping the team to consider the elements, how they affect each other and suggesting actions that help the development of the innovation. Additionally, in this stage it could help guide interviews and co-creation with patients to trigger conversations of different points that could affect the innovation. Finally, it would help to foresee the effects that a proposal could have on the rest of the system and evaluate its viability.

Pre-implementation of the innovation:

For this stage, the purpose of the tool is to evaluate if the innovation considers all the elements that influence the successful implementation and assess what aspects need to be solved before the actual implementation starts.

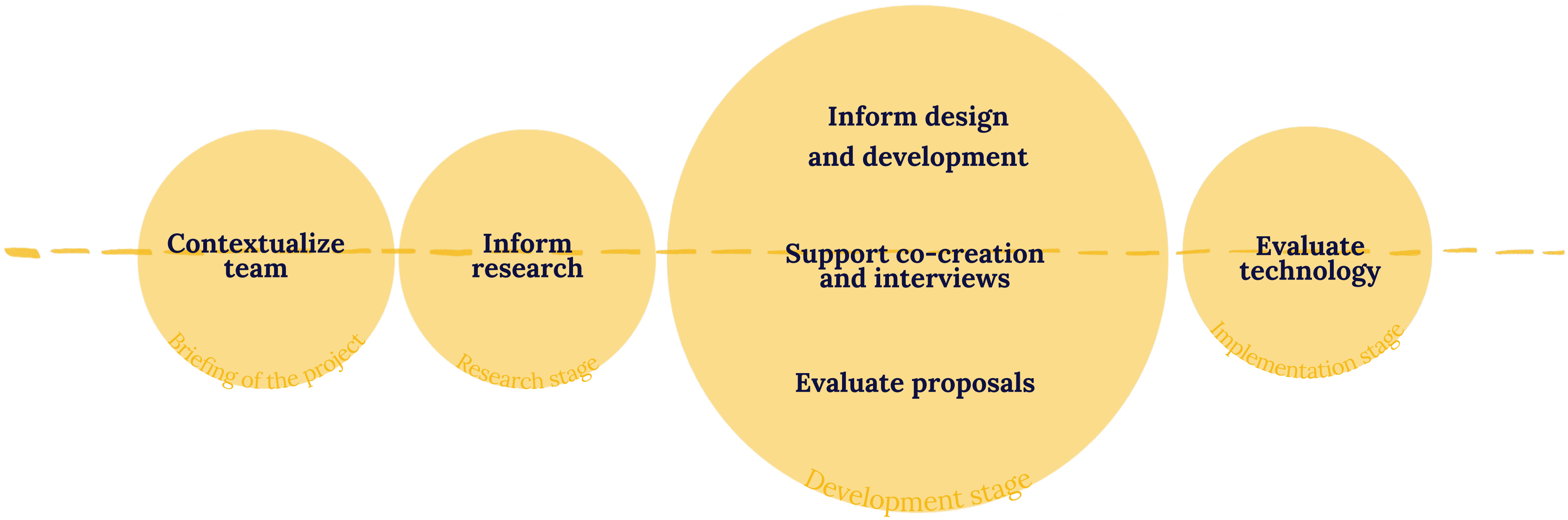


Figure 16 - Usefulness of the map for the different moments of the project.

Other considerations:

The participants consider that the tool should be tailored to the different types of cancer, as there are some differences that are important to consider in the development of the innovation such as the difference on secondary effects between cancer or the social stigma that it can bring.

The participants consider that the tool should highlight the most important connections between the elements, the ones that have more influence or are the most influenced. This could help its readability and comprehension.

The map as it is portrayed with Kumu.io is attractive to the participants at first glance but is overwhelming because of the amount of information that is visible at the same time. The team would prefer to have more readability of the information.

Conclusions from validation

Feedback from the team was used to further refine the map, ensuring it effectively conveyed the complexity of the system and supported the comprehension of the implementation process in cancer-care contexts.

Some additional elements need to be incorporated to the map in order to improve its usefulness. First, identifying nurses, General practitioners and insurances in the system will provide better definition of the elements and connections, and improve the readability of the tool. In order to do this, further research is needed to explore the connections that they have with the other elements in the system. Secondly, the visual design of the map needs to be explored in order to increase the readability of the map and decrease the overwhelming feeling of complexity. For this, I propose a categorization of factors that I will introduce in the following section. These categories were not tested; therefore, they should be evaluated in future work to assure its usefulness.

3.3.3. Iteration: Proposed areas & recognizable connections.

To enhance the visualisation of the map and increase its readability, I categorized the map by 6 areas (Political, Operational, Technological, Economical, Socio-cultural, and Psychosocial) and included colour coded arrows to the system.

Connections

To facilitate readability of the connections in the map I included colours that define the type of relationship that the two elements have:

Positive relations:

As seen in Figure 17, this type of relationship shows that if the element A increases, then the element B increases; or if the A decreases, then the B also decreases (Sevaldson & May, 2022). These are represented in green.

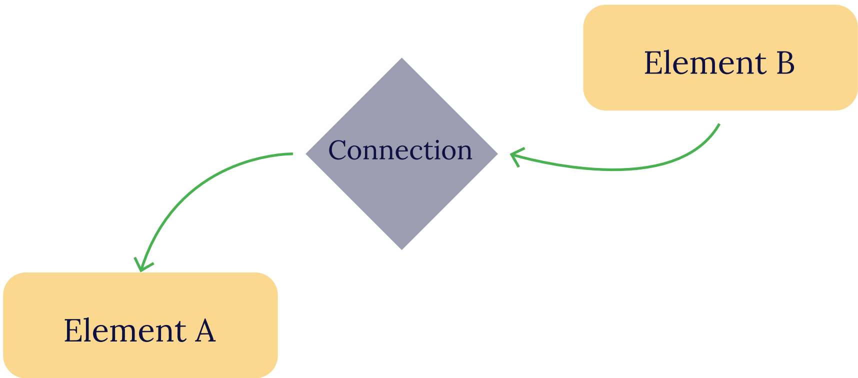


Figure 17 - Positive relation.

Negative relations:

As seen in Figure 18, this type of relationship shows that if the element A increases, then the element B decreases; and if the element A decreases, then the element B increases (Sevaldson & May, 2022). These are represented in red.

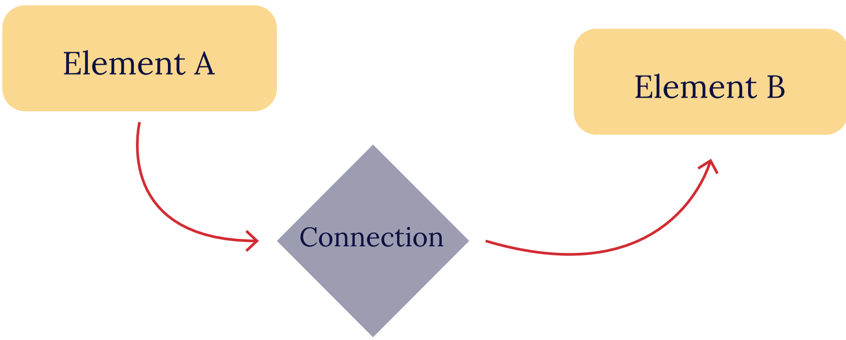


Figure 18 - Negative relation.

Areas

With these areas, it could be easier to visualize the multidimensional and intricate nature of technology implementation in cancer care at first glance, while viewing the system as a whole.

It is important to acknowledge that as this is a CAS; there are no clear limits between the components, and the elements can belong to and relate to multiple areas at the same time. Nevertheless, this categorization of the whole map can aid the comprehension of the multiple relationships and focus the attention on different aspects of the system, making the tool more user-friendly and actionable.

Finally, is important to point out that these categories are not based on any specific theoretical framework but are derived from my experience and observation of the implementation of technology in business contexts.

Economical:
This area encompasses the financial and economic factors of implementing technology for the cancer care path.

Political:
This area encompasses the influence of governmental and policy-making processes on the cancer care path.

Technological:
This area clusters the technical aspects involved in cancer care, and the influences or a technological landscape beyond the organisation.

Socio-cultural:
This area groups the societal and cultural influences on the implementation of technology in the cancer care system.

Operational:
This area groups the practical aspects of implementing and managing technologies within healthcare organisations.

Behavioural:
This area clusters the individual's emotions and feelings that affect individual behaviours and feelings.

4. Project outcome

The Map as a visual tool for comprehending systemic complexity of design in the cancer care-path

As an outcome of this graduation project, I created a map of the complexity of the cancer care path (see Appendix G). This visual tool is mainly targeted toward cancer care designers and developers to facilitate the comprehension of the factors that influence the successful implementation of technology in the desired context. This map is meant to assist project teams during the development process of such innovations, from the briefing stage until the implementation in the desired setting.

Components of the map

The map shows all the elements (28), connections (53), domains (7), and areas (6) defined during the GIGA-map process. Additionally, it includes suggestions on how to read the map and the legend for each of the elements.

The Domains are represented by distinct colours (and in the case of technology and illness they are represented by an obround in the map).

The Elements, which are the individual parts of each domain, are depicted as rectangles with the domain's corresponding colour.

The connections between these elements are illustrated using diamonds and arrows, highlighting the direction and nature of interactions.

Within the connections, dots appear to represent adopters—stakeholders such as clinicians, patients, caregivers, healthcare organizations, and organizational managers—each are represented by a different colour. These dots present in the connection indicate the individuals or groups involved or affected by the relationship.

The areas divide the map into six coloured sectors, each representing a different aspect, underscoring the multidimensional nature of the system.

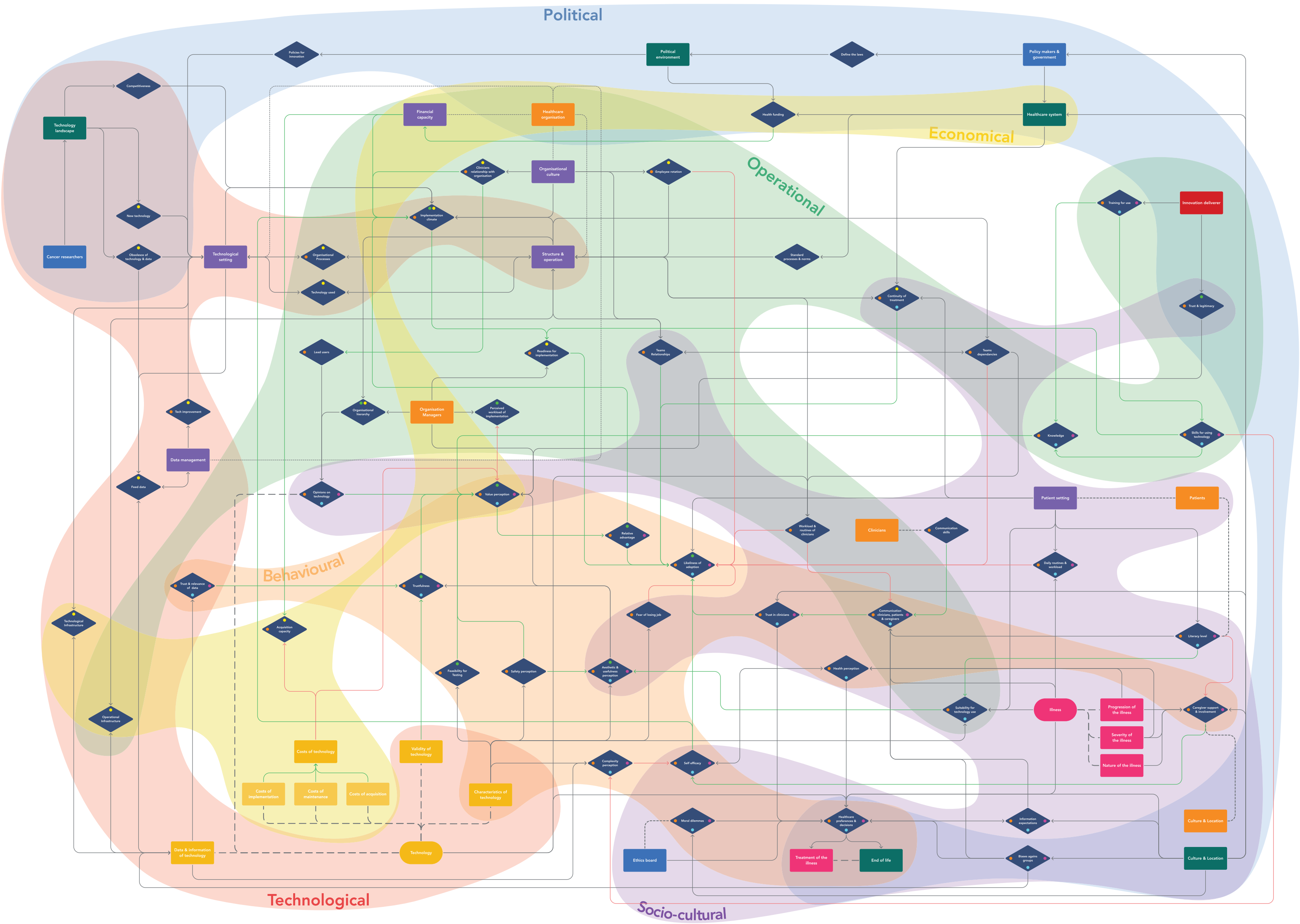


Figure 19 - Map of the systemic complexity of design in the cancer care path, Appendix G.

How to interpret the map

The map shows the domains and elements that are part of the system, and how they interact with each other in complex ways. As cancer care is a CAS, there is no order or sequence that can be established to use this tool. However, I suggest two ways to use it:

1. Start in one point and follow: Start reading from any element and follow the connections throughout the map.

2. Review by themes: Choose a theme and follow the connections inside that theme to go through all its elements.

Legend

Types of elements

- Connection
- Element
- Domain

Domains

- Implementer
- Illness
- External setting
- Organisational setting
- External actors
- Technology
- Adopters

Types of connections

- Undirected relation
- Directed relation
- Mutual relation
- Positive relation
- Negative relation

Adopters in connections

- Organisation managers
- Health organisation
- Caregiver
- Patient
- Clinicians

5. Discussion & conclusions

5.1. Discussion, limitations and further research

The main research question for the study was: ‘How might designers, developers, and researchers comprehend the elements and interactions that influence the successful implementation of an innovation in cancer-care contexts considering its complexity?’

To address this question, three secondary research questions were defined and explored using ‘Research through Design’ approach, helping to answer the main research question. Here I will discuss the findings from each of them to latter discuss the results for the main research question.

SRQ1: What are the factors described in frameworks that impact the successful implementation of innovations in health contexts?

All of these frameworks can be used as a guide for the implementation of innovation in health contexts. Each of them identifies critical factors that need to be addressed for successful implementation of a technology. These factors can go be on an individual level, an organization level, or a contextual level and are defined as domains, elements and connections. In total there are 8 domains, 29 elements and 35 connections described in frameworks that form the complex system of implementation in healthcare.

While these frameworks identify and explain the essential domains and elements involved in the implementation of health innovations, they fall short in outlining the dynamic interactions between these elements. The frameworks acknowledge that health contexts operate as complex adaptive systems, but they do not provide detail on how these elements interconnect and influence each other to create such systems. Understanding these interactions is crucial to comprehend the interdependencies and feedback loops within this CAS, which impact the success of implementation of technology in healthcare contexts.

SRQ2: What are the elements that influence implementation of technology in cancer-care contexts and how do they interact?

Based on the interview findings, the elements that influence implementation of technology in cancer-care contexts are numerous as well as the relationships between them. A total of 27 distinct elements organized into 8 domains, and 26 key connections among these elements were defined. Additionally, some of the factors identified overlap with the results from the frameworks analysis, and some are new additions to the overall system. Finally, the influence of the factors might change depending on the project, context or illness, increasing the complexity of the system.

SRQ3: How could the community participate to have a better implementation process?

The interviews analysis provided insights on how the community could be involved by the designers, developers and researchers, in order to develop technologies that the users see value and are feasible for the respective context (such as the clinic or the patients home). This is a crucial but challenging job, since there are several obstacles, nevertheless is a valuable process to enable implementation and adoption of innovation.

Final result

The analysis of results shows the multiple factors (7 domains, 28 elements, and more than 50 connections) that influence the implementation in healthcare, making it a CAS. In order to facilitate designers, developers and researchers to comprehend them, a GIGA-map of the system was built.

After the validation of the map, I found that the GIGA-map is helpful for designers, developers and researchers in the implementation of technology in cancer-care context. The map provides a comprehensive view of the elements and interactions found in the cancer-care system. Furthermore, it can help the different roles of a project (specially designers and developers) to understand the system as a whole and focus on specific factors that they want to address for the successful implementation of a technology in the desired context.

Implications and Contributions:

Implementation in healthcare:

As mentioned before, the successful implementation of technologies in cancer care, impacts the adoption of the innovation by its users. This study contributes to the knowledge on the field by describing possible factors that influence the success of implementation and how they influence each other.

Complexity in healthcare:

This study supports Kitson et al. (1998), by illustrating that healthcare comprises multiple dimensions that must be considered simultaneously. Moreover, the layers, domains and areas proposed in the map help to emphasize this complexity but allows designers, developers and researchers to focus on specific parts of the system. Additionally, the map serves as a tool to correctly estimate the complexity of a specific context, decreasing the probability of technology abandonment.

Community Involvement:

Community involvement is relevant for creating technology that delivers value to its users and is feasible for them. This research provides insights into how and when the community can be involved to enable the successful implementation of technology.

Implementation frameworks:

The findings of this project align with current literature in implementation science, corroborating elements identified by existing implementation frameworks. However, this study extends existing knowledge by identifying the similarities between the frameworks and illustrating the interactions among these elements.

Limitations

Scope and Time Constraints:

The research was constrained by time, limiting the number of frameworks studied and restricting the interviews to nine participants.

Geographical Limitations:

The study was conducted within a European context as part of the 4D PICTURE Project. Further research is needed to explore regional differences.

Illness limitations:

The graduation project was limited by the experience of 4D PICTURE members with cancer, focusing on Melanoma, Prostate cancer and Breast cancer.

Researcher validity:

Since this study was conducted by only one individual, interpretation biases can be present on the analysis of frameworks and interviews.

Future Research Directions:

The result of this research is the first attempt to visualize the implementation of technology in cancer care as a CAS. Although the number of elements and connections found in the map is considerable, this is still a superficial representation of the complexity of the system. Further research on this topic can help enrich the system and discover new ways of communicating its complexity. Additionally, future studies should examine the applicability of the findings in different geographical regions and cancer types to validate and expand the results. Finally, additional research could explore how this map can be utilized as a design and development tool by project members, potentially increasing its usability and practical impact.

5.2. Conclusion

By understanding the systemic complexity of cancer care contexts, designers' developers and researchers could develop technologies that enable its successful implementation in the desired context.

In systems such as this, the sum of the parts is more relevant than the individual elements, and a holistic understanding is key to the successful deployment of technology in these settings. This can be achieved through the use of Giga-maps that provide both an overarching view of the system and details of the domains, elements and their connections.

The GIGA-map developed in this graduation project serves as a valuable tool for visualizing these elements and detailing how these interactions occur. Additionally, it provides insights on how and when to involve the community in the development of the technology to create value and consider their context. Finally, it can be used by different roles on a project and in different stages of the development of the project, increasing its value.

This research contributes significantly to understanding the complexity of technology implementation in cancer-care contexts, complementing existing literature in implementation science. Additionally, it expands the knowledge on the challenges of implementation in healthcare, by providing a list of factors that influence this process. Finally, it supports the knowledge for community involvement in healthcare contexts.

Further exploration into the differences between various contexts is encouraged, as this will enhance the robustness of the system and provide deeper insights into contextual variations. Finally, the findings of this research suggest practical applications of this map, suggesting that it can be adapted into design tools for real-world applications, facilitating the practical implementation of technology in cancer-care settings.

In conclusion, this graduation project has provided a detailed exploration of the complex factors influencing innovation implementation in cancer care. By integrating and expanding upon existing frameworks, it provides a rich tool for designing in the systemic complexity of cancer care contexts.

6. Final thoughts

My master's program gave me the tools and knowledge I needed to tackle this project. It also helped me develop the right mindset for dealing with complex problems and uncertainty, which are part of projects like this one. Additionally, it taught me to face challenges and adapt throughout the project.

Problem scoping:

Working on this part of the project was a challenge since it was important to define a relevant scope that I could enjoyed and learn from. I used what I learned in my master's program to search in databases, dive into the literature and define a solid research question. In this phase of the project, I learned about systems theory and complexity, which was key for understanding the systemic complexity of cancer-care contexts.

Research:

For the research, I conducted literature review and interviews. Both were helpful in gathering the knowledge I needed for the project. Getting participants for the interviews was difficult, but the 4D PICTURE was very helpful. For future interviews, it can be helpful to have a dedicated team to recruit and schedule participants since it takes too much time.

This project phase was a great exercise to improve my ability of analysing high amount of information. Finally, learned how to decide when I have enough data to continue to the next phase.

Mapping:

Giga mapping was a long but rewarding process that really helped me understand the complexity of cancer-care. I had to go back to the literature and interview findings multiple times to make sure everything made sense and was accurately represented. Here's what I learned:

Choosing the Right Tool: There are lots of tools out there like Figma, Miro, and even just paper and post its, but they all had issues when it came to dealing with complex mapping. They weren't great for iteration, which was really important at the exploratory stage. Eventually, I found Kumu.io, which was good for constant iteration and discussing the map with others, though it took some time to learn how to use it well.

Elements vs. Connections: Figuring out what should be an element and what should be a connection was tricky because the literature didn't offer much guidance on this. It was a learning process that involved a lot of iteration and consultation with an expert.

Dealing with Uncertainty: This was my first time mapping something so complex, so I had to get comfortable with not knowing exactly how the map would turn out or if it would be valuable to achieve the aim of the study.

Overall, the GIGA-map was a fantastic tool for tackling the design challenge. It gave me a clear picture of all the elements and their interactions and helped validate the information with the 4D PICTURE team.

Project management:

Managing my own time was key to complete the project. I had to balance my own expectations with those of my mentors, which usually aligned but sometimes I needed to make decisions to keep the project on track. Planning ahead was challenging since I didn't know exactly what the outcome of the project would be but having a list of specific activities helped me stay organized and get through the project. Finally, having helpful and kind mentors made the process more enjoyable; they made the difference by providing guidance and different perspectives throughout the project.

The role as a Strategic product designer:

I believe having a strategic designer on the team for healthcare innovation is crucial. We learn to handle complexity, seeing the big picture, and facilitating valuable conversations.

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8. Appendices

1. Appendix A: Interviews Research guide
2. Appendix B: Ethics approval
3. Appendix C: Definitions
4. Appendix D: Giga map
5. Appendix E: Validation research guide
6. Appendix F: Validation process
7. Appendix G: Final map
8. Appendix H: Project brief

All apendixes can be found in a separate document

TU Delft

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Master Graduation project

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