

## Exploring the scalability of a digital health intervention:

### A value network approach

**Pedro Alves Andrade da Silva Brum**

*Master Science Degree in Biomedical Engineering, Instituto Superior Técnico*  
pedro.brum@tecnico.ulisboa.pt

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#### Abstract

Innovative technology has been showing the potential to be an adequate venue for improving the quality of care delivered. Any health service or treatment provided through the adoption and use of innovative technology in healthcare can be seen as a digital health intervention. Thus, understanding conditions that may facilitate their implementation at scale, has been increasingly important.

This dissertation focused on evaluating the potential of using a value network as an aiding tool to assess the scalability of a digital health intervention. For this purpose, this study contributes with a first suggestion of a value network modeling framework. The value network modeling framework was applied to an illustrative case study in the Portuguese health context. This allowed the demonstration of how the technical component of the framework can be applied in practice. The final result of the suggested framework is a value network that successfully depicts the dynamics involved in the implementation of the digital health intervention in a healthcare system and the quantified value added by this intervention to each stakeholder. This value network helps in answering whether the digital health intervention is worth it or not, which is a crucial question in assessing its scalability. We suggest that is a way that a value network may be used as an aiding tool to assess the scalability of a digital health intervention.

**Keywords:** Value Network; Scalability; Digital Health Intervention; MCDA; Framework

#### 1 Introduction

One of the main goals of the healthcare system is to provide universal health coverage [1, 2]. Good health can be achieved at a low cost whenever resources are allocated toward more cost-effective care [3]. Therefore, the commitment to universal health coverage demands a transformation of the healthcare system grounded on appropriate care and efficient use of resources [3, 4]. Innovative technology shows the potential to be an adequate venue for improving the quality of care delivered and collecting evidence, supporting decision-making across all levels and stakeholders of the system [5, 6, 7, 8].

Any health service or treatment provided through the adoption and use of innovative technology in healthcare can be seen as a digital health intervention [7]. As with any health intervention, it is needed to be tested first on a small scale and then assess its suitability to be scaled up, i.e., the scalability of the intervention [9, 10]. The concept of scalability was defined by [9] as "the ability of a health intervention shown to be efficacious on a small scale and/or under controlled conditions to be expanded under real-world conditions to reach a greater proportion of the eligible population while retaining effectiveness" (p. 289). Good practices and successful implementations of technological innovations have been identified. However, it has been difficult to understand how these can be

sustained within contexts and scaled up to new contexts [11]. This highlights the importance of building evaluative and performance monitoring systems into any significant health promotion investment so that funds can be withdrawn if it does not meet intended objectives [9]. Some studies [12, 13, 14] have been suggesting the use of models from the business management literature to possibly help to assess the scalability of the implementation of the innovative technology in a healthcare system. One of these models, which has been used for many years and across several industries is the value chain [15, 16]. However, while a value chain has been defined as the entire production chain from the input of raw materials to the output of the final product consumed by the end-user [17], the 'value network' terminology is often used in studies across many sectors, to reflect activities being increasingly spread across many specialized firms, including studies of the healthcare and pharmaceutical sectors [18, 19]. The model of a value chain that consists of all the value-generating activities [17] is not enough today to aid in the decision-making in an extended enterprise. In contrast, the model of value network does [20]. The fragmented nature of the healthcare system makes a network and customer-centric approach such as the value network particularly attractive as an analysis tool [21]. A value network is defined as "a dynamic network of legally independent, collaborating

actors who intend to offer a specific service, and in which tangible and intangible value exchanges take place between the actors involved" [22] (p.347).

This work aims to evaluate the potential of using a value network as an aiding tool to assess the scalability of a digital health intervention. It is necessary to review the literature on existing frameworks to model a value network so that a proper design of a value network was performed. In this work, we aim to suggest a value network modeling framework that is based on and is an enhancement of the frameworks existing in the literature. Furthermore, we aim to use a case study to illustrate how the value network can be modeled and potentially validate that the value network can be used as an aiding tool to assess the scalability of a digital health intervention.

## 2 Background

There is enormous potential for digital health interventions to be effective, cost-effective, safe, and scalable interventions to improve health and healthcare [7]. As with any health intervention, it is needed to test first on a small scale and then assess its suitability to be scaled up, i.e., the scalability of the intervention [9, 10]. For complex interventions, the consideration of factors associated with 'scalability' is essential since it is vital information that can help policymakers and decision-makers to facilitate the widespread adoption and implementation at scale [9, 10]. The proven effectiveness of a health intervention on its own cannot be enough to reach widespread adoption. There is a need for tools that can produce reliable information on scalability considerations. Since any health service or treatment provided through the adoption and use of innovative technology in healthcare can be seen as a digital health intervention [7], a digital health intervention is directly linked to innovative technology, and therefore, the innovative technology adoption in healthcare is linked to the scalability of a digital health intervention. The literature has mentioned several challenges to achieving the adoption of innovative technology in healthcare. Two of the biggest challenges are the health system fragmentation and the value assessment [8, 23]. To assess the scalability of health interventions with proven efficacy, it is crucial to answer the following two questions [24]: "Does it work in practice? Is it worth it?". Therefore, if the stakeholders could see the value that the digital health intervention adds, then the innovative technology associated with it would be more adopted, and therefore the digital health intervention would have more potential to be scaled up.

Following this reasoning and considering the nature of the challenges presented, one possible solution to overcome these challenges, which will be the focus of this work, is the design and use of a value network model that may be used as an aiding tool to assess the scalability of a digital health intervention.

## 3 Literature Review

To fulfill the objectives of this work, it was necessary to perform a review to identify and analyze the existing literature on 'value network'. It is important to highlight that the literature on this topic is sparse and dispersed. Additionally, little research exists on its application in the context of healthcare settings. Consequently, the literature review was crucial to gather all the definitions and perceptions of this concept to make us understand the variations between them, giving us a wider perspective on what comprises a value network and how we can model it. Before exploring how a value network can be modeled, it was necessary to understand the value network concept. Likewise, before defining the value network concept, it was important to introduce the value chain concept and find out the motivations that drove certain organizations to adopt a value network approach. The value chain concept was developed for the first time by Michal Porter during his studies on competitive advantage [17]. This is a model to think strategically about business activities (value activities) in terms of costs and contribution. However, even though the value chain concept initiated the first steps, a wider and deeper thought about value creation was shaped, into the concept of a value network [25]. While in the value chain, there is a sequential and linear logic to the process organization to reach value creation, in the more fluid value network, the process does not have a rigid order but works at the same time in a network within which there are also external organizations [26]. The increased globalization, widespread use of new technology, and pressure to be online, flexible, and efficient have resulted in the formation of strategic alliances, joint-ventures, and partnerships, and a steadily increasing flow of inter-organizational knowledge [27]. Since the first use of the value network concept, there have been used many definitions of this term through the years in studies regarding multiple sectors, including the health sector. In this work, we will adopt the definition of [22]. This is the most recent definition found that contains all the characteristics to accurately describe a value network. They state that "a value network is defined as a dynamic network of legally independent, collaborating actors who intend to offer a specific service, and in which tangible and intangible value

exchanges take place between the actors involved" (p.347).

A value network model can have multiple and diverse purposes in its use. A value network model is an adequate tool that allows the definition of actors' roles and understanding of their main functions [28, 29]. It also allows knowing how all the actors are linked together and what are their value exchange mechanisms to produce economic and social value [29, 30, 31]. In the case of the health sector, a value network model leads to the understanding of how organizations such as service providers, physicians, and hospitals are linked together and how they co-operate to produce value for the patient [21]. A value network model aids in the analysis of a given situation in a way that provides useful guidance in developing feasible alternatives [32]. This contributes to the value network to be a great tool that can be used to support decision-making [31, 32, 33, 34]. [21] defends that a network and customer-centric model such as the value network is particularly attractive as an analysis tool. It enables the identification of bottlenecks and information gaps that impact a healthcare system's performance [21]. An analysis of the value network model right from the beginning of a project may improve the success rate of health services development and deployment, and lead to substantial savings in costs and resources [35].

To use the value network as a tool that possibly can help in the assessment of a digital health intervention, it was necessary to know first how exactly a value network can be successfully modeled, so it was needed to explore the literature where a value network was modeled and applied. The review of this literature was fundamental to understanding what are the existent frameworks to model a value network and if any of them are, in fact, suitable to the context of our study. However, most of the studies only focused on applying the value network for a certain purpose, without providing a clear and structured methodology to accomplish it. Therefore, we consider that these value networks were modeled through an ad-hoc process. This can hinder subsequent researchers that are trying to replicate the process to reach similar accomplishments and hinder subsequent researchers that are trying to advance the value network model of the study or adapt it to other research areas. The absence of a structured methodology can also raise questions about the validity of the value network designed [36]. Thus, these studies should not be a reference point when modeling the value network. Nevertheless, three frameworks to model a value network were found in this review, the Allee (2011) value network modeling framework, the

Daaboul et al. (2014) value network modeling framework, and the Grudinschi et al. (2015) value network modeling framework. These three frameworks provide significant and structured guidance to model a value network. Additionally, they were validated through their application in case studies. In table 1, it is presented a summary of the features of each framework to compare them.

Framework	Objective	Det	Part	Pur	Ser	Res	Val	Chal
Allee (2011) modeling framework	Generic framework to be used in all contexts		X		X			
Daaboul et. al (2014) modeling framework	Framework constructed for decision-support for Mass Customization design		X	X		X	X	
Grudinschi et al. (2015) modeling framework	Generic framework that can be used in all contexts	X			X	X		X

Table 1 – Features of each framework

Note: Det=Each step is detailed; Part=Identifies the participants; Pur=Assigns a purpose to the value network; Ser=Can be applied to a service provision context; Res=Considers resources and assets of each participant; Val=Identifies the value that each participant earns from the value network; Chal=Identifies the challenges of each actor; Despite the limitations, the Grudinschi et al. (2015) framework can be used in all contexts, provides a structured guide of clear steps to follow when modeling the value network, considers both the tangible and intangible value, and identifies the resources and assets of each participant of the network and identifies the challenges of the activity of partnership of the value network under consideration. Therefore, we conclude that this framework can be further explored and enhanced to be suitable for our work's goal. However, despite being the most appropriate of the three, this is not entirely the appropriate tool to be used in the context of this study, to aid in the assessment of the scalability of a digital health intervention. This framework does not include a step that focuses on the identification of the participants of the value network. Additionally, it does not assign a purpose to the value network and does not identify the goals of its participants. Consequently, the added value that the digital health intervention adds to each participant cannot be quantified. Therefore, the focus of this work was centered on suggesting a new value network modeling framework by trying to enhance the Grudinschi et al. (2015) modeling framework in order to generate a value network model that may help to answer the question of whether a digital health intervention has scalability or not. In general, we aimed to use the suggested framework to model a value network that can be used as a tool that may help future researchers to assess the scalability of a digital health intervention. A major step in this direction would be the addition of a phase of quantification of the value added by

the adoption and use of the digital health intervention in a healthcare system to each participant through the use of multicriteria decision analysis (MCDA) [37].

#### 4 Methodology

In this work, we built upon the value network modeling framework developed by [31], adapting it and overcoming its limitations to reach our goal of achieving a framework to model a value network that may be used as an aiding tool to evaluate the scalability of a digital health intervention. Before presenting this framework, we need to present our chosen definition for concepts that are fundamental in modeling a value network. Our value network is composed of stakeholders, which are any naturally occurring entity that is affected by organizational performance [38], e.g., hospitals, patients, or medical device manufacturers. These can be a donor stakeholder, which is a stakeholder that “donates” the tangible or intangible asset, or a recipient stakeholder, which is a stakeholder that “receives” the tangible or intangible asset. Additionally, it is composed of transactions and deliverables. Transactions consist of the flow of tangible and intangible assets. They are represented as arrows between stakeholders. A transaction can be tangible or intangible. A tangible transaction is expressed as a green arrow, while an intangible transaction is expressed as a red arrow. Tangible transactions are contracted, mandated, or expected by the recipient stakeholder as part of the delivery of a product or service, e.g., telemonitoring the heart rate, blood oxygen saturation, and blood pressure, while intangible transactions are all the unpaid or non-contractual transactions that make things work smoothly and help build relationships, e.g., transfer of knowledge in the treatment of heart diseases. Deliverables are the assets that are delivered from one stakeholder to the other. A deliverable can be tangible (e.g., pacemaker) or intangible (e.g., knowledge and expertise on heart diseases). Moreover, in this framework, value is defined as the amount of satisfaction created by fulfilling a certain goal of a beneficiary party. It is subjective, it is dependent on the circumstances, and it is tied to the specific goals of the beneficiary party [40]. Our value network modeling framework must be one where each step is depicted and where the steps follow a logical sequence to the value network designer. One of the key aspects of the framework must be its reproducibility. According to a U.S. National Science Foundation (NSF) subcommittee on replicability in science [39], “reproducibility refers to the ability of a researcher to duplicate the results of a prior study using the same materials as were used by the

original investigator. That is, a second researcher might use the same raw data to build the same analysis files and implement the same statistical analysis in an attempt to yield the same results. Reproducibility is a minimum necessary condition for a finding to be believable and informative” (p.3-4). This means that anyone who applies the modeling framework to a specific problem using the same data should obtain similar value networks, i.e., value networks with the same stakeholders, transactions, and deliverables. Moreover, the value network resulting from this framework should correctly depict all the players involved in the implementation of a digital health intervention in a certain healthcare system, as well as all the transactions between each one of them that is fundamental to the success of the intervention. It should be plainly represented what is being transacted, to whom the transactions are directed, and whether they are tangible or intangible. Additionally, the goals of each stakeholder should be identified since they are crucial to making the designed value network a proper input to a value measurement approach, which must be also part of the framework. Overall, we need to have a framework that produces a value network model that can be considered requisite. A requisite decision model is defined as a model whose form and content are sufficient to solve a particular problem [41]. In this case, the value network can be considered a requisite model when its form and content are sufficient to appropriately depict the dynamics involved in the implementation of a certain digital health intervention in a healthcare system and sufficient to be a good input to a value measurement approach. Following this logic, the value network modeling framework proposed in this work, represented in figure 1, can be implemented using specific steps in a certain order and logic. This framework can be considered a sociotechnical process since it combines the technical elements of modeling a value network with the social aspects of conducting interviews with the stakeholders [42]. This framework consists of four distinct phases: context definition, value network structuring, value network refining, and value analysis. The first three phases are mostly based on the Grudinschi et al. (2015) value network modeling framework with influences from the Daaboul et al. (2014) and Allee's (2011) modeling frameworks. The suggestion of the addition of a value analysis phase, where the value that the digital health intervention adds to each stakeholder is planned to be

identified and quantified is one of the contributions of this framework.

**PHASE 1: Context definition**

The first phase of this framework consists of the definition of the context of the value network. In this phase, the network designer should identify the stakeholders and their respective goals. The first step of this phase consists of the identification of the stakeholders involved in the digital health intervention under consideration. All the stakeholders that are clearly confirmed to take part in the digital health intervention. Afterward, we proceed to the identification of the network stakeholder's goals. It consists of understanding what are the main goals that each stakeholder intends to achieve through the digital health intervention under consideration. This step can be done through a combination of two approaches. The goals should be defined from the description or documentation of the digital health intervention and should be identified through interviews or surveys with the stakeholders. After the stakeholder's goals have been identified, it should be attempted to identify if there are any missing stakeholders that are crucial to that specific value network based on the response of the previously identified stakeholders. This works as a way to prevent the network designer from missing any stakeholder, thus preventing its validity from being called into question [38]. As it can be seen from the scheme (figure 1), if any missing stakeholders are identified, the network designer should go back to the first step, adding these stakeholders to the list of identified stakeholders. Then, as before, it will be necessary to identify this new stakeholder's goals. This is an iterative process that should be executed until no more new stakeholders are identified. Only then, it can be proceeded to phase two.

**PHASE 2: Value network structuring**

The second phase of this framework consists of the structuring of the value network. As suggested by [31], the next step is based on identifying the perception of each stakeholder regarding its own added value to the network through the use of interviews. Based on their answers, transactions between stakeholders can start being modeled. It is important to understand what is the deliverable involved in each transaction, whether the transaction is tangible or intangible, and to who is the transaction directed. This step generates a first value network model consisting of each stakeholder's delivered transactions.

The next step, as also suggested by [31], consists of identifying the perceptions of each stakeholder's received value from other stakeholders in the network through the use of

interviews. This step essentially consists of the identification of the transactions from other stakeholders that add value to each stakeholder, from the perspective of the recipient stakeholder, i.e., each stakeholder's received transactions. Moreover, this step acts as a validation of the transactions that were previously identified by each stakeholder and it may add transactions that were not mentioned in the latter step and, therefore, generates a value network without the unvalidated transactions. Then, if a

new transaction is identified in the last step by the recipient stakeholder, it should be validated through confirmation with the donor stakeholder. The transactions that are validated should be added to the value network model. Afterward, it can be proceeded to phase three.

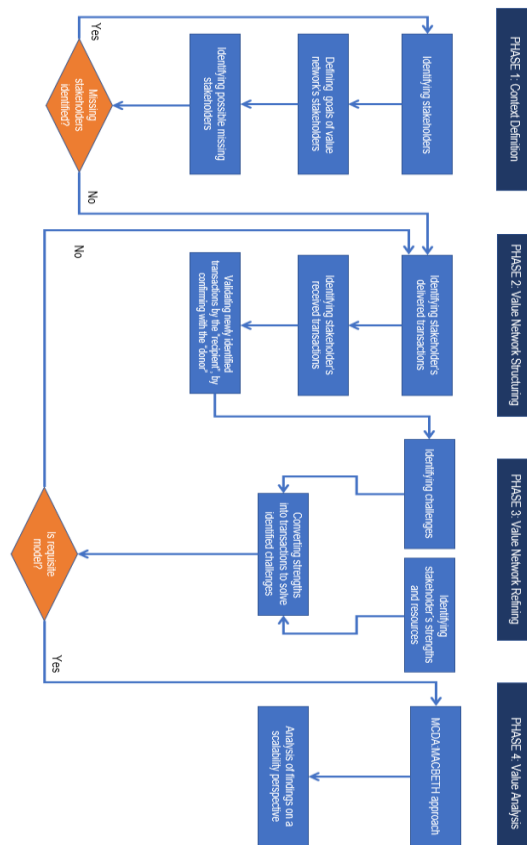


Figure 1- Framework to model the value network

**PHASE 3: Value network refining**

Phase three consists of the refinement of the value network. This phase consists of three steps that combine to refine the value network model by adding transactions to solve existing challenges in the implementation of the intervention by the stakeholder with the more appropriate resources, if possible. The next three steps are all based on steps suggested by [31]. Firstly, the challenges and stakeholders' strengths and resources are identified. The network designer should identify the challenges in

the activity of partnership that still exist, i.e., the challenges in the activity of partnership that have not been resolved through the previously identified transactions. If any challenge is identified, the network designer should then identify the strengths and resources (intangibles and tangibles assets) of every stakeholder. Subsequently, these strengths and resources may be converted into transactions to respond to the challenges. In this step, the network designer must explore how every challenge could be solved, so that it creates value for the patients and other stakeholders. It must be identified who has the best ability and resources to solve the challenge, and what type of value could be created to network stakeholders by solving the challenges in a specific way. Before going into phase four, the network designer should deliberate on whether the value network model is satisfactory or not. In other words, the network designer should analyze whether the model can be considered requisite, and therefore adequate to be a good input to phase four or whether it still needs to be revised. If the model can be considered requisite, it can be proceeded to phase four, the value analysis. Otherwise, phase two and phase three should be repeated until the model can be considered requisite. This iteration helps the model to improve its quality and legitimacy.

#### **PHASE 4: Value analysis**

Finally, the last phase of the framework consists of value analysis. In this phase, the value that the digital health intervention adds for each stakeholder is identified and quantified. It will be used multicriteria decision analysis or MCDA. To be more precise, the MCDA technique that will be used is MACBETH.

Since the main goal of this phase is to quantify the value added for each stakeholder, a set of criteria has to be identified and organized to achieve an acceptable model for each stakeholder. To achieve this, the interviews with the stakeholders in the preceding phases are truly crucial to understand what they really value in a digital health intervention and what they want to achieve from it. The goals identified in the interviews are fundamental to structuring the problem of the MCDA process. These interviews with the stakeholders are the basis to select the criteria, build the value functions for each criterion, and for the assessment of their respective weights. Therefore, they are crucial to calculate the value score of the digital health intervention to a certain stakeholder. The final result of this step should be a value network in which each node of the network, i.e., each stakeholder has a value score, which corresponds to the value that the digital health intervention adds to each

stakeholder. After the value has been quantified for each stakeholder, the network designer should analyze the findings from a scalability perspective.

As previously mentioned, to assess the scalability of health interventions with proven efficacy, it is crucial to answering the following two questions [24]: “Does it work in practice? Is it worth it?”. Therefore, the value network modeled through the use of this framework that has the value score added by the digital health intervention on each node helps to answer whether this intervention is worth it or not. This is a first suggestion of how the value network can aid in the assessment of the scalability of a digital health intervention.

### **5 Case Study**

We applied the value network modeling framework presented in the last chapter to an illustrative case study [43]. Our main goal was to demonstrate how it can be applied in practice. The case study was provided by VOH.CoLAB and consists of a project that they are involved in, EasyHealth4Covid. Despite this being a real-life case study, we consider this case study illustrative [43] since there were some limitations when applying the framework to this case study, mainly in terms of conducting interviews with stakeholders of the value network. We tried to get the results as close to reality as possible by researching the project documentation, researching the stakeholders involved, and reviewing the literature on digital health interventions similar to this one. Nevertheless, the most important is to demonstrate how the technical component of the framework can be applied and identify how it could be improved in future research rather than to seek to provide a thorough and “accurate” exposition of the real data that one would obtain from the interviews with the stakeholders.

#### **5.1 Case description**

EasyHealth4COVID is a project that aims to develop telecare solutions that are easy to implement for the elderly population and that complement the NHS assistance capacity, creating value for all citizens and the healthcare delivery systems. It aims to develop a telehealth solution to monitor the population at risk for COVID-19 infection, promote their safety, and facilitate communication with clinical teams [44].





framework, the Daaboul et al. (2014) value network modeling framework, and the Grudinski et al. (2015) value network modeling framework. After a thorough analysis of each of these modeling frameworks, it was concluded that none of them was entirely the appropriate framework to model a value network suited to be used in the context of this study, to aid in the assessment of the scalability of a digital health intervention. Therefore, the next objective was to suggest a value network modeling framework that could be used in this context. In general, this objective was successfully accomplished. Nevertheless, further review of the value network literature is encouraged to better summarize and agglomerate this sparse and dispersed literature.

## **6.2 Discussion of suggested value network modeling framework**

This work aimed to suggest a value network modeling framework to be used in the scalability assessment of a digital health intervention. This suggested framework should model a value network that could be used as an aiding tool in the assessment of the scalability of a digital health intervention. We suggested a value network modeling framework, by trying to enhance the Grudinski et al. (2015) modeling framework. This framework can be considered a sociotechnical process since it combines the technical elements of modeling a value network with the social aspects of conducting interviews with the stakeholders [42].

Technically, since the components that constitute the value network were specified, and since the proposed value network modeling framework consisted of clear steps that followed a logical sequence, in other words, a step-by-step guideline, the value network modeling process is easy to understand and follow. By having these characteristics, we ensured that this framework had reproducibility. Hence, this modeling framework counters one of the major problems of the value network literature, the lack of step-guided and reproducible methods to model a value network.

The output of this modeling framework is a value network that effectively depicts all the stakeholders involved in the implementation of the digital health intervention in a healthcare system. Moreover, the value network model produced depicts the transactions that are fundamental in this process between each of the stakeholders. It shows what is involved in the transaction, to whom the transactions are directed, i.e., the recipient stakeholder, as well as the stakeholder responsible for carrying out the transaction, i.e., the donor stakeholder, and if it is tangible or intangible.

We also highlight the importance of having a phase such as phase three of our framework, the value network refining, which was only present before in Grudinski's value network modeling framework [31]. This phase can contribute to the addition of transactions to the value network that the stakeholders themselves could not identify on their own as important to a successful implementation of the intervention in the healthcare system. Therefore, enhancing the collaboration in the network by adding new transactions can improve the probability of a digital health intervention being successful in the healthcare system in which it was implemented, reinforcing the value network as a great support tool. Thus, our framework goes beyond the objective initially set and also helps to improve the probability of a digital health intervention to be scaled up.

Despite not being represented in the value network model, the identification of the goals of the stakeholders is a crucial step of this framework since they are fundamental to making this value network model a suitable input to a value measurement approach. The suggestion of the addition of a value measurement approach to be applied in a value network, which is critical to the assessment of the scalability problem, is one of the improvements of this modeling framework since it clearly distinguishes this one from the previous frameworks that were found in the performed literature review. This is the first value network modeling framework that could be used in a healthcare context that goes beyond the value network design and suggests that the value added for each stakeholder, in this context by the implementation of the digital intervention, should be quantified through the application of an MCDA method. However, this study only focused conceptually on the result final that the MCDA value measurement approach should generate.

In summary, we were able to provide a first suggestion of a framework that models a value network that may be used as an aiding tool to evaluate the scalability of a digital health intervention, and, additionally, that helps to improve the probability of a digital health intervention to be scaled up. However, it is crucial to highlight that this modeling framework, is still at an early stage. Thus, it is crucial for future research to be carried out to improve and validate this modeling framework. It should be explored how problem structuring methods (PSMs) can aid the structuring of the value network, it should be explored and tested the use of other methods to gather the data from the stakeholders to model the value network such as Delphi and Decision Conference, and it is critical that future research focuses on the technical component of the



value measurement approach since this study only focused conceptually on the result final that the MCDA value measurement approach should generate.

### **6.3 Discussion of the value network as an aiding tool to assess the scalability of a digital health intervention**

This work aimed to explore the potential of using the value network as an aiding tool to assess the scalability of a digital health intervention. The final result of this framework is a value network that successfully depicts the dynamics involved in the implementation of the digital health intervention in a healthcare system, including the value score added by this intervention to each stakeholder. This value network helps in answering whether the digital health intervention is worth it or not, which is a crucial question in assessing its scalability [24]. This is a first suggestion of how the value network can aid in the assessment of the scalability of a digital health intervention. Nevertheless, scenario analysis emerges as a possibility to further explore how the value network may be used as an aiding tool to assess the scalability of a digital health intervention. March et al. (2012) defined scenario analysis as internally consistent stories about ways that a specific system might evolve in the future. Depending on the results obtained from the value measurement approach, there are alternative outcomes, i.e., scenarios. Using scenario analysis, it may be provided different options for future development paths resulting in varying outcomes and corresponding different scalability implications.

### **6.4 Discussion of case study**

This work aimed to apply the value network modeling framework, using a case study in the Portuguese context. However, one big limitation of this study was the fact that the modeling framework was only applied to an illustrative case study since we were limited in terms of conducting interviews with stakeholders of the value network, and so, these were not carried out. Therefore, when applying this sociotechnical approach to this case study, we were able to only demonstrate the technical component of the framework. Nevertheless, this illustrative case study was important to demonstrate how the technical component of modeling a value network can be performed, which helps a subsequent researcher that may have to model a value network that represents their specific problem. However, since we were limited in conducting interviews and the interviews with the stakeholders are crucial to the value measurement process and we were not able to perform them, we have not explored phase four of the framework in this illustrative case study. The absence of the social component of this

framework, which compromised the data sample to model the value network and the assessment of phase four, made it not possible to validate this framework.

Therefore, it is important to underline once again that the value network modeling framework that was suggested in this study is still in a very early stage and it is crucial for it to be applied in its fullness without any restraints, such as conducting interviews, to a real-world case study to fully validate it.

### **7 Conclusion**

The main focus of this work, manifested in Chapter 1, was to evaluate the potential of using a value network as an aiding tool to assess the scalability of a digital health intervention. To do so, a literature review was carried out to determine what are the existing methods to model a value network. It was found a gap in the value network modeling methods literature since most of the studies that modeled and used the value network did not provide a clear and structured methodology to model it. Nevertheless, the literature review carried out resulted in three studies that effectively propose value network modeling frameworks: the Allee (2011) value network modeling framework, the Daaboul et al. (2014) value network modeling framework, and the Grudinski et al. (2015) value network modeling framework. However, none of these frameworks generated a value network that could be used as an aiding tool to assess the scalability of a digital health intervention. Hence, the focus of this work also shifted towards suggesting a value network modeling framework that generated a value network that could be used in the context of this work.

This work made a first suggestion for a value network modeling framework. The proposed value network modeling framework consisted of clear steps that followed a logical sequence, which makes the value network modeling process much easier to understand and follow. By having these characteristics, we ensured that this framework had reproducibility. The first three phases of this framework are focused on the modeling of the value network. So, they can be used as a guideline for any researcher that needs to model a value network as a supporting tool, and therefore, adapted and used for any type of problem. It is not exclusive to the scalability of a digital health intervention problem. This modeling framework adds value to the value network literature since it gathers more information on and presents in more detail the value network modeling process. Hence, this modeling framework tackles one of the major problems of this literature, the lack of step-guided and reproducible methods to model a value network. Additionally, we also need to

highlight the importance of having a phase such as phase three of our framework, the value network refining, since, with this phase, our framework goes beyond the objective initially set and also helps to improve the probability of a digital health intervention to be scaled up.

This work aimed to evaluate the potential of using the value network as an aiding tool to assess the scalability of a digital health intervention. For this purpose, it was suggested to add a value measurement approach to be applied in the value network to quantify the value added to each stakeholder by the digital health intervention. This is one of the contributions of this modeling framework since it separates this one from the previous frameworks that could be used in a healthcare context. This value network helps in answering whether the digital health intervention is worth it or not, which is a crucial question in assessing its scalability [24]. This is a first suggestion of how the value network can aid in the assessment of the scalability of a digital health intervention.

This work also aimed to apply the value network modeling framework, using a case study in the Portuguese context to validate it. However, one big limitation of this study was the fact that the modeling framework was only applied to an illustrative case study [43] since interviews with stakeholders were not carried out. Therefore, when applying this sociotechnical approach to this case study, we were able to only demonstrate the technical component of the framework. Nevertheless, this illustrative case study was important to demonstrate how the framework can be applied, despite not using data obtained from the interviews with the stakeholders.

## 7. References

- [1] World Health Assembly, 58. (2005). Social health insurance: sustainable health financing, universal coverage and social health insurance: report by the Secretariat. World Health Organization.
- [2] Latko, B., Temporão, J. G., Frenk, J., Evans, T. G., Chen, L. C., Pablos-Mendez, A., Lagomarsino, G., & de Ferranti, D. (2011). The growing movement for universal health coverage. In *The Lancet* (Vol. 377, Issue 9784, pp. 2161–2163).
- [3] Savedoff, W. D., de Ferranti, D., Smith, A. L., & Fan, V. (2012). Political and economic aspects of the transition to universal health coverage. In *The Lancet* (Vol. 380, Issue 9845, pp. 924–932).
- [4] Sobel, H. L., Huntington, D., & Temmerman, M. (2015). Quality at the centre of universal health coverage. In *Health Policy and Planning* (Vol. 31, Issue 4, pp. 547–549).
- [5] Saranummi, N., Korhonen, I., Kivisaari, S., & Ahjopalo, H. (2006). A Framework for Developing Distributed ICT Applications for Health. In 1st Transdisciplinary Conference on Distributed Diagnosis and Home Healthcare, 2006.
- [6] Kijl, B., Nieuwenhuis, L. J., Huis in 't Veld, R. M., Hermens, H. J., & Vollenbroek-Hutten, M. M. (2010). Deployment of e-health services – a business model engineering strategy. In *Journal of Telemedicine and Telecare* (Vol. 16, Issue 6, pp. 344–353).
- [7] Murray, E., Hekler, E. B., Andersson, G., Collins, L. M., Doherty, A., Hollis, C., Rivera, D. E., West, R., & Wyatt, J. C. (2016). Evaluating Digital Health Interventions. In *American Journal of Preventive Medicine* (Vol. 51, Issue 5, pp. 843–851).
- [8] Vannieuwenborg, F., Van der Auwermeulen, T., Van Ooteghem, J., Jacobs, A., Verbugge, S., & Colle, D. (2016). Bringing eCare platforms to the market. In *Informatics for Health and Social Care* (Vol. 42, Issue 3, pp. 207–231).
- [9] Milat, A. J., King, L., Bauman, A. E., & Redman, S. (2013). The concept of scalability: increasing the scale and potential adoption of health promotion interventions into policy and practice. In *Health Promotion International* (Vol. 28, Issue 3, pp. 285–298).
- [10] Zamboni, K., Schellenberg, J., Hanson, C., Betran, A. P., & Dumont, A. (2019). Assessing scalability of an intervention: why, how and who? In *Health Policy and Planning* (Vol. 34, Issue 7, pp. 544–552).
- [11] Howard, S. K., Schrum, L., Voogt, J., & Sligte, H. (2021). Designing research to inform sustainability and scalability of digital technology innovations. In *Educational Technology Research and Development* (Vol. 69, Issue 4, pp. 2309–2329).
- [12] Chesbrough, H. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. In *Industrial and Corporate Change* (Vol. 11, Issue 3, pp. 529–555).
- [13] Broens, T. H. F., Huis in't Veld, R. M. H. A., Vollenbroek-Hutten, M. M. R., Hermens, H. J., van Halteren, A. T., & Nieuwenhuis, L. J. M. (2007). Determinants of successful telemedicine implementations: a literature study. In *Journal of Telemedicine and Telecare* (Vol. 13, Issue 6, pp. 303–309).
- [14] Spil, A. A. M., & Kijl, B. (2009). E-health Business Models: From pilot project to successful deployment. *IBIMA business review*, 1, 55–66.
- [15] Handfield, R. B., Walton, S. V., Seegers, L. K., & Melnyk, S. A. (1997). 'Green' value chain practices in the furniture industry. In *Journal of Operations Management* (Vol. 15, Issue 4, pp. 293–315).
- [16] Higgins, A., Thorburn, P., Archer, A., & Jakku, E. (2007). Opportunities for value chain research in sugar industries. In *Agricultural Systems* (Vol. 94, Issue 3, pp. 611–621).
- [17] Porter, M. E. *The Competitive Advantage: Creating and Sustaining Superior Performance*. NY: Free Press, 1985.
- [18] Edwards, P. J. (2009). Value networks identify innovation in 21st century pharmaceutical research. In *Drug Discovery Today* (Vol. 14, Issues 1–2, pp. 68–77).
- [19] Harrington, T. S., Phillips, M. A., & Srari, J. S. (2016). Reconfiguring global pharmaceutical value networks through targeted technology interventions. In *International Journal of Production Research* (Vol. 55, Issue 5, pp. 1471–1487).
- [20] Daaboul, Joanna & Castagna, Pierre & Bernard, Alain. (2012). FROM VALUE CHAINS TO VALUE NETWORKS: MODELING AND SIMULATION.
- [21] Peltoniemi, T. (2016). The Impact of Digitalization on the Medical Value Network. In *Communications in Computer and Information Science* (pp. 23–36).
- [22] de Reuver, M., & Bouwman, H. (2012). Governance mechanisms for mobile service innovation in value networks. In *Journal of Business Research* (Vol. 65, Issue 3, pp. 347–354).
- [23] King, N. (2020). Modeling organisational value realisation in e-prescribing exchanges as a service value network. In *International Journal of Networking and Virtual Organisations* (Vol. 23, Issue 3, p. 220).
- [24] Haynes, B. (1999). Can it work? Does it work? Is it worth it? In *BMJ* (Vol. 319, Issue 7211, pp. 652–653).
- [25] Ricciotti, F. (2019). From value chain to value network: a systematic literature review. In *Management Review Quarterly* (Vol. 70, Issue 2, pp. 191–212).
- [26] Peppard, J., & Rylander, A. (2006). From Value Chain to Value Network: In *European Management Journal* (Vol. 24, Issues 2–3, pp. 128–141).
- [27] Westergren, U. H., & Holmström, J. (2012). Exploring preconditions for open innovation: Value networks in industrial firms. In *Information and Organization* (Vol. 22, Issue 4, pp. 209–226).
- [28] Allee, V. (2003). Value Networks and Evolving Business Models for the Knowledge Economy. In *Handbook on Knowledge Management* (pp. 605–621).
- [29] Allee, V. 2011. Value network mapping basics. Accessed May 15, 2021, <http://www.valuenetworksandcollaboration.com/mapping/networkmapping-basics.html>
- [30] Allee, V. (2000). RECONFIGURING THE VALUE NETWORK. In *Journal of Business Strategy* (Vol. 21, Issue 4, pp. 36–39).
- [31] Grudinski, Daniela & Hallikas, Jukka & Kaljunen, Leena & Puustinen, Antti & Heinänen, Sanna. (2015). Creating value in networks: A value network mapping method to assess the current and the potential value network in cross-sector collaboration. *Innovation Journal*. Vol.20.
- [32] Fjeldstad, Ø. D., & Ketels, C. H. M. (2006). Competitive Advantage and the Value Network Configuration. In *Long Range Planning* (Vol. 39, Issue 2, pp. 109–131).
- [33] Daaboul, J., Castagna, P., Da Cunha, C., & Bernard, A. (2014). Value network modeling and simulation for strategic analysis: a discrete event simulation approach. In *International Journal of Production Research* (Vol. 52, Issue 17, pp. 5002–5020).
- [34] Vesselkov, A., Hämmäinen, H., & Töyli, J. (2018). Technology and value network evolution in telehealth. In *Technological Forecasting and Social Change* (Vol. 134, pp. 207–222).
- [35] Nieuwenhuis, L. J. (2010). Business Modeling and Value Network Design Case Study for a Tele-Rehabilitation Service. In *Proceedings of the 4th International Workshop on Enterprise Systems and Technology*. 4th International Workshop on Enterprise Systems and Technology.
- [36] Leung, L. (2015). Validity, reliability, and generalizability in qualitative research. In *Journal of Family Medicine and Primary Care* (Vol. 4, Issue 3, p. 324).
- [37] Marsh, K., Lanitis, T., Neasham, D., Orfanos, P., & Caro, J. (2014). Assessing the Value of Healthcare Interventions Using Multi-Criteria Decision Analysis: A Review of the Literature. In *Pharmacoeconomics* (Vol. 32, Issue 4, pp. 345–365).
- [38] Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C. H., & Stringer, L. C. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. In *Journal of Environmental Management* (Vol. 90, Issue 5, pp. 1933–1949).
- [39] Bollen, K., Cacioppo, J. T., Kaplan, R., Krosnick, J., Olds, J.L. (2015). Social, Behavioral, and Economic Sciences Perspectives on Robust and Reliable Science (National Science Foundation, Arlington, VA, 2015).
- [40] Daaboul, J., Da Cunha, C., Le Duigou, J., Novak, B., & Bernard, A. (2015). Differentiation and customer decoupling points: An integrated design approach for mass customization. In *Concurrent Engineering* (Vol. 23, Issue 4, pp. 284–295).
- [41] Phillips, L. D. (1984). A theory of requisite decision models. In *Acta Psychologica* (Vol. 56, Issues 1–3, pp. 29–48).
- [42] Baxter, G., & Sommerville, I. (2011). Socio-technical systems: From design methods to systems engineering. In *Interacting with Computers* (Vol. 23, Issue 1, pp. 4–17).
- [43] Jackson, M. C. (1991). Illustrative Case Studies. In *Systems Methodology for the Management Sciences* (pp. 215–235).
- [44] VOH.CoLAB. (2020, December 20). EasyHealth4Covid: solução digital para cidadãos com elevado risco de infeção por Covid-19. Retrieved from <https://voh-colab.org/pt/projects/easyhealth4covid-solucao-digital-para-cidadaos-com-elevado-risco-de-infecao-por-covid-19/>