Principles for Implementing Modularity in Healthcare

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Abstract
Modularity can help address urgent societal needs of cost reductions and improved patient centeredness in healthcare, but has only rarely been implemented in that sector. We propound that this is at least partially due to the lack of guidance on reorganizations of existing healthcare offerings in a modular way. We identify three principles to do so: 1) the service architecture should be decomposable; 2) a proper service specification process should be introduced; and 3) the presence of interfaces should be ensured. Following these principles should help policy makers as well as managers to implement modularity in existing healthcare offerings.

Keywords: Modular healthcare; service modularity; implementation

Introduction and theoretical background
Ageing populations and better healthcare technologies will lead to increasing demand for health services in the upcoming years (Centraal Plan Bureau [CPB], 2013). Furthermore, the call for user-driven and demand-based services is also increasing (Commission of the European Communities [CEC], 2009); more and more patients will want to have more power over their own care (e.g. National Institute for Public Health and the Environment [RIVM], 2014). At the same time however, the available budget for healthcare is stretched to the limit in many countries. In the Netherlands for example, it is predicted that a family with a modal income will spend 50% of it on healthcare in 2040, which is almost double the percentage in 2012 (CPB, 2011). Therefore, the need to increase the efficiency of the healthcare system is urgent. We address this challenge through the lenses of modularity. The modularity concept can be of help to address these two needs at concurrently, as it enables cost reductions, yet at the same time achieve patient centeredness (De Blok, 2010; Van der Laan, 2015).

Modularity originates from the Operations Management domain and is a way to (re) organize a product or service offering. It concerns the decomposition of a product or service in parts that can be managed independently and used interchangeably (Mikkola & Gassman, 2003; Schilling, 2000). Those parts can be mixed-and-matched in a variety of ways (Sanchez, 1996) and combined to form a functional whole (Baldwin & Clark,

1997). Modularity emerged in a manufacturing environment (Starr, 1965), and a few studies have investigated the concept in service settings (e.g. Voss & Hsuan, 2009). In recent years, modularity has gained attention in healthcare as it can help address the pressing societal demands in this sector (e.g. Bohmer, 2005).

While the urgency to improve the efficiency and patient centeredness in healthcare is high and while research shows that modularity can theoretically be applied in healthcare, actual implementations of modular healthcare are hard to find (e.g. Soffers *et al.*, 2014; Van der Laan, 2015; Vähätalo & Kallio, 2015). We propound that this is at least partially due to the lack of guidance on how to transform a non-modular service offering to a modular service offering. In general, healthcare offerings are rarely built from scratch. Both the services themselves and the companies providing them usually already exist and change over time. A fair amount of literature focusses on the design principles of modularity in healthcare (e.g. Van der Laan, 2015), but little attention is paid to the actual transformation of non-modular healthcare offerings into modular ones. Therefore, our research question is: "What are the principles that should be followed when reorganizing healthcare in a modular way?"

The paper is organized as follows. First, we describe the research methods which we used to answer the research question. After that, the synthesis of the articles found in the literature review is given. Finally, we provide a discussion of the results, a conclusion, managerial implications and leads for future research.

Research methodology

We conducted qualitative research to distil the principles for reorganizing healthcare in a modular way from the literature. Our research can be seen as exploratory because it aims to seek new insights. The research aim was investigated through a literature review. Because research on modularity in healthcare is scarce, this literature review also includes papers that focus on modularity in other services and on modular production.

For our literature review, we extracted useful sources from two dissertation theses on modular healthcare provision by De Blok (2010) and Van der Laan (2015). Furthermore, we drew upon the extensive literature review of Vähätalo (2012). As an addition to the articles identified via the two theses and the literature review of Vähätalo, we carried out a supplemental literature search for the period from 2010 up to and including 2016. Furthermore, relevant articles were identified using citation tracking to identify recent papers that cited known relevant papers, in addition to the snowball method by which literature in already found papers was looked up.

For the literature search, the following databases were searched:

- Web of Knowledge;
- ScienceDirect; and
- PubMed.

The search parameters were that the articles: 1) are written in English or Dutch; 2) are in the research area's 'operations management', 'business administration', 'healthcare', 'operations research management science', 'business economics' or 'health care sciences services' for Web of Knowledge or the fields of 'business, management and accounting', 'economics, econometrics and finance', 'medicine and dentistry', 'nursing and health professions', or psychology for ScienceDirect; 3) were published in 2011-2016; and 4) were published in refereed journals or books. As keywords, we specified that 'service' and 'modularity' or 'modularization' should be included in the title, keywords or abstract. In this process, a total of 109 articles were identified. Next, we read through the abstracts

of the 109 identified papers to select relevant papers that were not included in De Blok (2010), Van der Laan (2015) and Vähätalo (2012). This led to the selection of 11 articles.

Next, we analyzed the articles extracted from the theses by De Blok (2010) and Van der Laan (2015), the literature review of Vähätalo (2012), the ones identified by means of citation tracking and snowball sampling and the papers found via the literature search. We used them to get a thorough grasp on the concept of modularity and specifically a) modular health services and b) modular (re)design. The papers provided a firm understanding of the core of (healthcare) modularity, namely combining independent, interchangeable parts to form a functional whole, a modular package (Baldwin & Clark, 1997; Mikkola & Gassmann, 2003; Schilling, 2000). We extracted the necessary elements for proper modularization from this core.

Finally, we used this knowledge to analytically derive the principles for modular reorganization, i.e. the transformation of a non-modular healthcare service into a modular one. Conceptually, these principles concern both the design of healthcare services and the process of providing them. The synthesis of our research is described next.

Synthesis of the articles

To reorganize healthcare in a modular way, i.e. to transform non-modular healthcare offerings into modular ones, the principles an organization should follow concern not only the design of the healthcare offerings but also the process of providing them. With this in mind, we deduced three principles for reorganizing healthcare in a modular way, see Table 1.

Table 1 – Principles for reorganizing healthcare in a modular way

Principle	*Design or process?*
Decomposable service architecture	Design
Service specification process	Process
Interfaces	Design & process

In modular product design, a product is crafted such that it consists of multiple independent, interchangeable parts that all bring about one function of the product (Geum, Kwak & Park, 2012). This can only be achieved when it is possible to separate a product in parts. In other words, the product architecture should be modular (De Blok, 2010; Chen & Liu, 2005). For healthcare services, such a scheme is called the service architecture (Schmidt & Sköld, 2011; Voss & Hsuan, 2009). The first principle for transforming healthcare in a modular way is that there should be a *decomposable service architecture*, i.e. it should be possible to distinguish independent, interchangeable modules with a specific function.

A healthcare service needs to be responsive towards patients' needs to ensure that everyone receives the care s/he needs and wants. To achieve this degree of customization, several of the independent parts described above are chosen and combined to form a modular package (Sundbo, 1994). This 'mixing and matching' (Mikkola & Gassmann, 2003; Schilling, 2000) is done in the *service specification process* (Voss & Hsuan, 2009). Designing this process such that the need for customization is served is the second principle for reorganizing healthcare in a modular way.

The combined service parts of course have to form a functional whole. This is facilitated by the third principle for reorganizing healthcare in a modular way: introducing *interfaces* that enable interaction and communication between the parts (e.g. Baldwin & Clark, 1997; Pekkarinen & Ulkuniemi, 2008; Salvador *et al.*, 2002). In an analogy where

a service package is a piece of carpentry, interfaces would be the nails and glue that hold the piece together.

Below, the three principles for transforming non-modular healthcare to modular healthcare are examined in more detail. To make clear what these principles mean in practice, some empirical insights – mainly from the residential mental healthcare sector and the sector for long-term care for independently living elderly – are discussed too.

Decomposable service architecture

Service architecture is a topic that has received little attention in the academic literature (Menor *et al*., 2002). Voss and Hsuan (2009) are amongst the first to dive into the concept. They argue that a service can be split up in two types of elements: nodes and linkages. Linkages are the interfaces mentioned above; they are described in more detail below. Nodes are the service elements that bring about a functionality of the service and can be *modules* or *components*. The distinction between components and modules is not straightforward as many authors use the concepts interchangeably (e.g. Mikkola & Gassmann, 2003; Pekkarinen & Ulkuniemi, 2008; Voss & Hsuan, 2009). Although a mere obscurity about the terms involved does not degrade the modularity concept, it is important to explicate the terminology used.

In this paper, components are seen as the smallest elements a service can be divided in (e.g. Pekkarinen & Ulkuniemi, 2008). A module is defined as "one or several service elements [i.e. service components] offering one service characteristic "(Pekkarinen & Ulkuniemi, 2008, p. 87). Modules are indivisible and changes within a module can be made independently from other modules. In other words: a module is a subassembly (Gershenson *et al*., 1999). Modules can be newly designed or created by "segregating existing monolithic service offerings into service modules" (Böttcher & Klingner, 2011, p. 323). The latter is done when reorganizing existing healthcare offerings. Hence, a non-modular healthcare service can only be transformed into a modular one if it is possible to distinguish modules.

In healthcare, we have observed evidence in the long-term care for the elderly (De Blok, 2010) and in residential mental healthcare (Soffers *et al.*, 2014). De Blok (2010) finds that care for the elderly can indeed be decomposed in modules such as 'washing' and 'getting dressed'. These modules can be organized in service bundles such as 'care' and 'housing'. In residential mental healthcare, Soffers *et al.* (2014) find that most of the care could be decomposed in modules which could in turn be grouped in service bundles and sub-bundles on a functional basis. A part of the residential care offerings could not be decomposed into modules; this concerned highly customized care (to very diverse and individual needs of patients) and conversations which patients. It is interesting to note that these conversations serve a double function as both care and interface, the third principle for reorganizing healthcare in a modular way.

Service specification process

In the service specification process, modules are combined (i.e. mixed and matched) to form a modular package (Sundbo, 1994). The outcome of this process is a customized healthcare package. This package can consist of both standardized modules and modules tailored to the customer's needs and wishes (De Blok, 2010). For successful transformation of non-modular healthcare services to modular ones, it is vital to introduce a proper service specification process. In that way, the healthcare service can be tailored to the patient's needs and wishes.

Service specification can occur before as well as during the service provision, and if the service is delivered on an ongoing basis, further modification of the service package

can take place over time (De Blok, 2010). This modification includes adding, altering and removing modules. Two variants of the initial service specification exist. First of all, modules can be put together from a pre-determined set to form a unique package (Sundbo, 1994; Voss & Hsuan, 2009). Using this *menu driven* approach is advocated by Bohmer (2005) as a way to combine standard and custom healthcare. An alternative to the menu driven approach is the *prototype driven* approach. Here, the organization has made several "starting points" (i.e. combinations of modules) from which the specification by the consumer starts (Randall *et al.*, 2005; Voss & Hsuan, 2009). Chorpita *et al.* (2005) explain that in psychotherapy, prototype treatments are made for various disorders, which can be further specification by the care professional by adding extra modules.

Because of the specific characteristics of healthcare, it is also important *how* the service is delivered. First of all, customer involvement is very strong as healthcare services are created in close interaction between healthcare professionals and patients (Jaakkola & Halinen, 2006). Secondly, patients face a severe knowledge disadvantage (Jaakkola & Halinen, 2006). And thirdly, Berry and Bendapudi (2007) note that healthcare customers may be more emotional, sensitive and/or dependent and that they may be reluctant, they do not desire the service. Therefore, the healthcare process itself should be tuned towards patients' needs and wishes. This is achieved through personalization, adapting employee interpersonal behavior such that it suits a patient's preferences (Wind & Rangaswamy, 2001).

Again, this principle of reorganizing healthcare in a modular way is found present in residential mental healthcare (Soffers *et al.*, 2014) and in the long-term care for the elderly (De Blok, 2010). Soffers *et al.* (2014) find that a preliminary care package is determined before residential care provision starts. This package is fine-tuned during the first six weeks of care provision. This period is devoted to information gathering to do so. After that, the package is finalized but possibilities for adaptation remain, for example during the annual evaluations. De Blok (2010) discovers that in the long-term care for independently living elderly, the specification process partly occurs before the service provision starts and partly during the service provision. Again, possibilities for adaptation remain.

Interfaces

The third principle for reorganizing healthcare in a modular way is ensuring the presence of interfaces, the (typically standard) linkages between modules that allow interaction and communication between them (Salvador *et al*., 2002; Voss & Hsuan, 2009).

There are different types of interfaces (e.g. De Blok *et al*., 2014). A distinction can be made between interfaces that *support variety* and interfaces that *ensure coherence*. The first type of interfaces enables combinations and substitutions of modules, aiming for adaptation of the modular package to the customer's needs (e.g. Baldwin & Clark, 1997; Miozzo & Grimshaw, 2005; Salvador *et al*., 2002). They do so by providing a stabilized but not rigid structure (Voss & Hsuan, 2009). This open character of the interfaces makes it possible to take into account the situation of particular customers and leaves room to professional judgement of the service providers (De Blok, 2010). The interfaces that aim for coherence make the modules combined in a modular package form a functional whole (Chen & Liu, 2005; Voss & Hsuan, 2009). These interfaces are fixed and rigid rules such as procedures and protocols (Miozzo & Grimshaw, 2005); an exemplary rule is that the module 'sweeping the floor' always has to be performed before the module 'mopping the floor' (Böttcher & Klingner, 2011). De Blok (2010) stresses the closed character of these interfaces, because they provide limited flexibility, have to be strictly followed, and are independent of the situation of particular customers.

Because interfaces support variety and coherence, they also enable *re*configuration of the service package. They do so because they allow changing and substituting modules over time whilst making sure the service package is still functional and coherent after the adaptations (De Blok, 2010; Miozzo & Grimshaw, 2005). Especially in the healthcare sector, it is important to continuously meet the needs and preferences of patients (De Blok, 2010).

A distinctive feature of services is the strong involvement of people in the service provision (e.g. Gwinner *et al*., 2005). This is especially so in healthcare (e.g. Jaakkola & Halinen, 2006). Therefore, next to making a distinction between interfaces based on their goal (coherence vs. variety), De Blok *et al.* (2014) differentiate between interfaces based on the interaction entities. They consider interfaces facilitating interactions between *modules* and interfaces targeted at interactions between the *providers* involved with a care package. The interfaces that provide coherence and variety concerning modules support and direct the interactions and interdependencies between those modules (e.g. Chorpita *et al*., 2005; De Blok, 2010). Interfaces of the other type (with providers being the interacting entities) support and direct the information exchange between service providers (De Blok *et al.*, 2014).

In a four-case study, De Blok *et al.* (2014) find several interfaces that manage the interactions between care modules and healthcare providers in a setting of long-term care for independently living elderly. Interfaces have rarely been extensively researched (Voss & Hsuan, 2009). The study of De Blok *et al.* (2014) forms a noteworthy exception. Unlike in the manufacturing industry, there are hardly any industry standards for service interfaces (Pekkarinen & Ulkuniemi, 2008). Therefore, their findings provide valuable insights in how interfaces manifest themselves in modular service provision – and in particular in modular healthcare provision – especially since the mechanisms identified were very similar in all cases.

De Blok *et al.* (2014) offer a typology in which main dimensions are distinguished: interface aims (providing either variety or coherence) and interface entities (components or service providers). Interfaces aiming for variety are characterized as open and interfaces aiming for coherence are characterized as closed. Interfaces between service providers support the information to flow between the service providers that are involved. From these two main dimensions, the interface types depicted in Table 2 are derived:

Table 2 – Interface typology (De Blok et al., 2014)

	Interacting entities		
		Between components	*Between providers*
Aim	*Variety*	O-C	O-I
	Coherence	C-C	C-I

Open-customer (O-C) flow interfaces enable components to be combined and re-combined, according to individual customer needs. Suppose an organization that offers several types of care (meal services, housing services), provides clients with a brochure in which all possibilities for care are described. This brochure is an example of an O-C interface. It allows for variety among the clients, as each individual (client) now has a grip on all possible services and can choose from the provided types of care based on individual needs.

Closed-customer (C-C) flow interfaces enable the arrangement of components in a way that interdependencies among components are managed and that components work together. They enable the customer to "flow" from one component to another. An example is strict planning rules that allow different components to be combined. These

planning rules allow for a coherent modular package, in which all components work together.

Open-information (O-I) flow interfaces provide a structure in which service providers are brought together so that information concerning e.g. package (re)configuration can be exchanged. An example of an O-I interface is needs assessment, where the modular package of the client is evaluated and (if needed) revised. In this process, the needs of each individual client are evaluated by several service providers, enabling modular packages to be individualized, so needs assessment contributes to variety.

Closed-information (C-I) flow interfaces provide a set and codified arrangement of interactions so that interactions are predictable and the amount of information that has to be exchanged is diminished. An example of a C-I interface is a work schedule. This type of interfaces contributes to the coherence of a modular package, as specific rules for the various involved service providers are offered.

The study of De Blok *et al.* (2014) also shows that not all interfaces (or interface types) are equally important for all service types. The interfaces aiming at variety, for example, were more prevalent in care and welfare services, where extensive individualization is required. Coherence-aimed interfaces on the other hand were found more important where there were strict requirements and mistakes are potentially disastrous, such as in medical treatment or medication.

In the residential mental healthcare, interfaces were found to be significantly present, although not all interface types equally so (Soffers *et al*., 2014). Information flow interfaces (between providers) were most abundantly present. Examples are team meetings and meetings with every change of shifts as O-I interfaces and an electronic patient plan and residential care plan as C-I interfaces. Barely any O-C interfaces were found, but work schedules for some care modules and strict planning rules for e.g. medications are examples of identified C-C interfaces. De Blok (2010) does find O-C interfaces in the long-term care for the elderly such as product books and pre-combined prototype packages. As C-C interfaces, she identifies various planning rules. Other examples of interfaces include pre-set lines of communication and continuous assessment of the clients' needs (O-I) and strict division of labour and care dossiers (C-I).

Discussion and conclusion

It is expected that the demand for health services will increase in the upcoming years (CPB, 2013). Moreover, the importance of patient centeredness in healthcare is getting stronger (CEC, 209; RIVM, 2014). These two developments conflict with the fact that healthcare budgets in many countries are reaching their limits. Hence, efficiency in healthcare is more important than ever. This challenge can be addressed by introducing the modularity concept in healthcare. Modularity is known to enable cost reductions and at the same time achieve patient centeredness (De Blok, 2010; Van der Laan, 2015).

While research has shown that modularity is applicable to healthcare, actual implementations of modular healthcare are rare (e.g. Soffers *et al*., 2014; Van der Laan, 2015). We propound that this is at least partially due to the lack of guidance on how to transform a non-modular healthcare service to a modular healthcare service. This paper addresses this research gap by identifying the principles an organization should follow when reorganizing healthcare in a modular way.

We find that three principles are crucial for reorganizing existing healthcare offerings into modular ones: 1) the service architecture should be decomposable; 2) a proper service specification process should be introduced; and 3) the presence of interfaces should be ensured. We propound that if these principles are fulfilled, this will help the actual implementation of modularity in existing healthcare offerings .

This paper has important practical relevance. In essence, it paves the way to actually transform non-modular healthcare into modular healthcare. The identified principles are useful for policy makers as well as managers as they provide the means to address urgent societal needs of increasing efficiency in healthcare on the one hand and improving patient centeredness on the other hand by implementing modularity.

From a scientific point of view, it advances theory on healthcare modularity by focusing on the reorganization of existing healthcare offerings, as opposed to designing modular healthcare offerings from scratch. This is useful as existing research largely focusses on the design of new service offerings rather than redesigning existing ones.

We see several leads for future research. The most important one is to conduct a case study in which organizations go through the process of transforming a non-modular healthcare service into a modular one. In this case study, it could be studied if the principles identified in this research are necessary and sufficient. In addition, the case study would provide examples of how the principles are fulfilled in practice. Additionally, actual implementation of modularity will make it possible to test whether modularity can actually achieve the expected benefits of more efficiency combined with better patient centeredness.

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