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Turning modularity upside down

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CentER

Turning modularity upside down:

Patient-centered Down syndrome care
from a service modularity perspective

VINCENT PETERS



**Turning modularity upside down:
Patient-centered Down syndrome care from a service modularity
perspective**

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**Turning modularity upside down:
Patient-centered Down syndrome care from a service modularity
perspective**

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List of abbreviations

BM	Bert Meijboom
C	Components
C-C	Closed-customer
C-I	Closed-information
COREQ	Consolidated criteria for reporting qualitative research
DS	Down syndrome
EHR	Electronic health record
ENT	Ear, nose and throat
ERP	Enterprise resource planning
EV	Esther de Vries
HCE	Home care for the elderly
IT	Information technology
ICT	Information and communication technology
LF	Lisa Fransen
M	Modules
MP	Modular package
MSA	Modular service architecture
NGO	Non-governmental organization
O-C	Open-customer
O-I	Open-information
SCM	Supply chain management
VP	Vincent Peters
WHO	World Health Organization

Chapter 1. Introduction

An increasing number of people are living with complex care needs resulting from multiple chronic conditions which are leading to functional and cognitive impairments and mental health challenges (van der Heide et al., 2018; Kuipers, Cramm & Nieboer, 2019). These complex care needs make adequate care delivery difficult due to the involvement of multiple care providers. Currently, most care services are single disease-oriented and treatment decisions are often mainly directed at improving medical outcomes (van der Heide et al., 2018; Kuipers et al., 2019). As a result, this disease-centered approach in current care delivery is insufficiently responsive to people with complex care needs; it is not optimally tailored to their needs and preferences (Vähätalo & Kallio, 2015).

Making care more patient-centered may be the way forward. Patient-centered care has the potential to better tailor care to the needs and preferences of patients with complex care needs (van der Heide et al., 2018). The Institute of Medicine (2001) defined patient-centered care as providing care that is respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all care-related decisions. Eight dimensions of patient-centered care have been identified: (1) patients' needs and preferences, (2) information and education, (3) access to care, (4) emotional support, (5) family and friends, (6) continuity and transition, (7) physical comfort, and (8) coordination of care (Gerteis et al., 1993). Although all dimensions are considered important in the delivery of patient-centered care (Rathert, Wyrwich & Boren, 2013), it has been suggested that two dimensions are more important than others in delivering patient-centered care for patients with complex care needs (Gill et al., 2014; Berghout et al., 2015; van der Heide et al., 2018). First, the individual *needs and preferences* of patients should be taken *as the starting point* for the provision of care (van der Heide et al., 2018). Berwick (2009) posits that care provision should be more than just meeting the patients' needs and preferences, it should emphasize them. Care providers should start listening to the patient (Silander et al., 2017) and incorporate their preferences and needs in care provision. The care providers have an important role in realizing this. Second, all relevant care providers should be *adequately informed* and the delivery of multidisciplinary care should be *coordinated* (Gill et al., 2014), because input from multiple care providers with different specialized backgrounds is required for the effective treatment of patients with complex care needs. Poor coordination between care providers could lead to ineffective and unsafe care (Meijboom, Schmidt-Bakx & Westert, 2011), which could eventually result in health risks. Emphasizing patients' needs and preferences and the coordination of care seems especially important in the delivery of patient-centered care for people with complex care needs. From a societal perspective, it is important that healthcare services become more responsive to the complex needs of these people.

An example of a patient group with complex care needs is Down syndrome (DS). DS is a complex congenital condition (Bull, 2011) and the most prevalent genetic cause of intellectual disability in humans; the overall world-wide prevalence of DS is ~1:1000 (de Graaf, Buckley & Skotko, 2017). Although people with DS share a typical appearance, intellectual disability, and delayed motor development, each individual with DS is unique. In addition, many individuals with DS experience various comorbidities, therefore, people with DS have complex healthcare needs. Examples are problems of hearing and vision, autoimmunity, (airway) infections, and heart defects (Weijerman & de Winter, 2010). The prevalence and severity of these comorbidities vary. This makes individuals with DS a very diverse and

heterogeneous patient group from an early age, despite their common genetic background (trisomy 21). Providing adequate healthcare and interventions in the early life of individuals with DS improves physical and mental development (Weijerman & de Winter, 2010; Bull, 2011).

Typically, a multitude of healthcare providers is involved in healthcare for children with DS (van den Driessen Mareeuw et al., 2017). In the Netherlands, 22 pediatric outpatient clinics organize multidisciplinary team appointments (so-called “Downteams”) for children with DS, including a visit to the pediatrician, speech therapist, physiotherapist and others. Besides, they also consult healthcare providers in primary care (e.g., general practitioner, speech therapist). This indicates that a wide network of professionals (e.g., pediatrician, speech therapist) and organizations (e.g., paramedical practices, hospitals) provides the necessary care and service components for treatment and support of individuals with DS. Collaboration and coordination between the various professionals and organizations involved is crucial. Delivering uncoordinated care could lead to inefficient care and unnecessary duplications, in terms of gaps or overlap in treatment (Lugtenberg et al., 2011; van den Driessen Mareeuw et al., 2020). In some cases, a lack of coordination could even result in health risks, for example when patients receive conflicting treatment or medication from different care providers. The multiple involved healthcare providers and organizations and variety in required care and service components reflect the complexity of healthcare provision for individuals with DS. Healthcare providers increasingly look for ways to (re-)organize current DS healthcare provision, while at the same time extending options for adaptation to individual patient’s needs and preferences (Fransen et al., 2019; van den Driessen Mareeuw et al., 2020). The challenge is to provide care that is both coordinated and patient-centered (i.e., tailored to the complex healthcare needs and preferences of children with DS and their carers).

In this doctoral thesis, the challenge of providing care that is both coordinated and patient-centered is addressed from a modular perspective. Modularity is rooted in general systems theory and is based on dividing a complex system into smaller subsystems that can be designed and managed independently (Simon, 1962; Starr, 1965). These independent subsystems can be optimized individually but must be coordinated to achieve the overall system goals (Schilling, 2000). The independently functioning subsystems can be recombined to address a variety of heterogeneous customer needs. Schilling (2000) defines modularity as “a continuum that describes the degree to which a system’s components can be separated and recombined, and it refers to the tightness of coupling between components and the degree to which the rules of the system architecture enable or prohibit the mixing and matching of components” (p. 312). Schilling (2000) argues that almost all systems are, to some extent, modular since 1) all systems are characterized by some degree of coupling between components, and 2) most systems have components that are almost completely separable and combinable.

The concept of modularity traditionally stems from manufacturing settings (Bask et al., 2010). In manufacturing, modularity implies that modules can be assembled and tested on separate lines (Sanchez & Mahoney, 1996). When the production of the independent modules is finished, they can be sent to the final assembly of the product in the required sequence. Since each module is assembled separately the corresponding components and the module itself can be standardized, allowing for the reuse of components and modules (Ulrich, 1995).

As such, modularity implies that changes in one part of the product do not require changes in other parts of the product (Hoetker, 2006). Moreover, it allows for flexibility in production because modules can be assembled in different configurations of a product (Sanchez & Mahoney, 1996; Baldwin & Clark, 1997). Besides, the modular approach leads to significant reductions in the complexity of the production process (Ulrich & Tung, 1991; Takeishi & Fujimoto, 2001) and, consequently, in reduced assembly costs (Ulrich & Tung, 1991). These outcomes stem from various successful examples of products that use modular designs such as aircrafts (Brusoni & Prencipe, 2001) automobiles (Takeishi & Fujimoto, 2001; MacDuffie, 2013), household appliances (Sanchez & Sudharshan, 1993), personal computers (Langlois & Robertson, 1992; Hoetker, 2006) and software (von Hippel, 1994).

The primary goal of modularity is to address a variety of heterogeneous customer demands by (re)combining components into a variety of configurations. The more potential configurations there exist, the more likely it is that configurations will be found that meet the heterogeneous demands of customers (Baldwin & Clark, 1997; Schilling, 2000). For example: a kitchen can be assembled from a range of components (e.g., dishwasher, oven, stove). The wider the range of components that can be selected and combined into the final kitchen, the wider the range of possible modular kitchen configurations to meet the heterogeneous demands of customers. When systems become more modular, customers have more opportunities to choose a kitchen configuration that truly meets their needs and preferences, whether it is a standardized configuration or a customized configuration. The example of a modular kitchen shows two things. First, if customer demands are heterogeneous, but there is a restricted range of available components of the system, modularity enables flexibility of the system but does not increase the range of possible configurations (Schilling, 2000). Second, if there is a wide range of available components, but customers' demands are homogeneous, there is less to be gained from a modular system. It becomes a matter of determining the best combination of components that fulfills the needs of all customers (Langlois & Robertson, 1992). Thus, modularity can be described as a continuum on which systems can vary in terms of offering configurations with a restricted range of possible components to offering configurations with a wide range of possible components. Depending on the customer demands, service providers can offer rather standardized modular packages or more tailored modular packages.

More recently, research on modularity has moved beyond manufacturing and entered the context of services (Bask et al., 2010). In services, modularity promises to relieve problems of complexity in systems (Baldwin & Clark, 1997). Service modularity concerns the decomposition of a complex service into independently functioning modules, each of which consist of separate components (Baldwin & Clark, 1997). This allows organizations to mix and match components into modular service packages in such a way that these packages are tuned to individual needs and requirements. As such, it enables efficient customization and responsiveness to individual requirements (Baldwin & Clark, 1997; Schilling, 2000).

We use modularity as a perspective in this doctoral thesis that guides categorization and interpretation of a real-world phenomenon. The modular perspective can simplify information processing (Gavetti & Levinthal, 2000) and provides a means for interpreting contexts that are not modular by nature (MacDuffie, 2013). Since the healthcare professionals involved in chronic healthcare provision for children with DS in the Netherlands did not express themselves in modularity terms or considered their care provision as being modular, we described the practices executed by these healthcare professionals in modular terms. The

modular terms used in this doctoral thesis are our well-considered interpretations of the working methods and practices in the provision of chronic healthcare for children with DS. By doing so, we pursued a modular perspective on this type of healthcare. For example, we assigned the distinct parts of the consultations from each individual healthcare professional as modules (e.g., Physical examination) and identified components as elements of healthcare provision that belong to a certain module (e.g., Movement skills as part of the module Physical examination), as per our definition of modules and components. In other words, we interpreted our context in modular terms. This kind of modular interpretation of research contexts has been applied frequently in the existing service modularity literature (e.g., de Blok, 2010; Soffers et al., 2014; Avlonitis & Hsuan, 2017).

There are several important concepts related to the theory on service modularity. In a young research field like service modularity, it is common that the research language of this field is still developing (Brax et al., 2017). As a result, several definitions of the important concepts related to service modularity can be found in the literature. Throughout this doctoral thesis, we will use the following definitions:

- *Modules* are relatively independent parts of a service offering with a specific function that can be offered individually, or in combination (Rajahonka, 2013).
- Within modules, *components* can be distinguished; they are the smallest elements in which a service offering can be meaningfully divided (de Blok et al., 2014).
- The decomposition of a complex system into modules and components is captured in the *modular service architecture*. Voss & Hsuan (2009) define this as “the way that the functionalities of the service system are decomposed into individual functional elements to provide the overall services delivered by the system” (p. 546). It is an intelligible visualization of the display of all modules and components of a particular service and provides a comprehensive modular representation of a service offering (Voss & Hsuan, 2009).
- Combining and connecting various components and modules creates a *modular package* (de Blok et al., 2010a). This ‘mixing-and-matching’ leads to an individualized modular package for each customer; these modular packages can result in an individualized service: components in a modular package can be replaced or individually adapted according to the needs of each individual customer, without necessarily having to completely change the modular package (Fransen et al., 2019).
- *Interfaces* prescribe how components, modules and service providers in a modular system mutually interact (Salvador, 2007). They manage interaction and communication in a modular service offering (Voss & Hsuan, 2009).

Interfaces are important elements of modular services because they manage interaction and communication within a modular service offering (Voss & Hsuan, 2009). They make sure that the combined, but independent, modular parts form a functional, coherent whole (Baldwin & Clark, 1997). The mixing-and-matching of various components by means of interfaces leads to the creation of a coordinated, yet customized modular package. Voss and Hsuan (2009) describe interfaces in two distinct dimensions: 1) interfaces in the *content* dimension connect individual components and/or modules and manage possible interactions between their contents, and 2) interfaces in the *people* dimension connect the various people involved in service provision and allow them to exchange information with and about customers. Eissens-

van der Laan et al. (2016) describe the latter dimension more precisely as “the people dimension refers to the interactions between the service provider and the customers” (p. 310). The service modularity literature emphasizes the importance of interfaces (Peters, Meijboom & de Vries, 2018), but only a few studies explicitly focus on interfaces (e.g., de Blok et al., 2014; Spring & Santos, 2014).

The key feature of service modularity is that it allows service providers to mix-and-match components into coherent modular packages in such a way that these packages are optimally tuned to the needs and preferences of individual customers (de Blok et al., 2010a). Because of its potential to provide coordinated yet customized services, modularity is applied in a variety of service settings such as banking services (Moon et al., 2011), construction services (Doran & Giannakis, 2011), ICT services (Böttcher & Klingner, 2011), legal services (Giannakis et al., 2018), logistics services (Rajahonka, 2013; Cabigiosu et al., 2015), and tourism services (Voss & Hsuan, 2009; Avlonitis & Hsuan, 2017). Healthcare services is another context with great potential for exploiting service modularity. In this setting, complimentary care components have to be combined into an effective, integrated whole (Johnson, 2009; Chung et al., 2012) with the various dissimilar components originating from multiple care providers with different specialized backgrounds, either as individual professionals or as organizations where these professionals are employed.

Given its potential, an increasing amount of studies are exploring the possible application of modularity in healthcare services. These studies have been carried out in areas such as mental care, elderly care, and to a lesser extent in hospital care. They focus on the applicability and implications of modularity in healthcare services. Studies on mental care (Chorpita, Daleiden & Weisz, 2005; Weisz et al., 2012; Soffers et al., 2014) explored whether the concept of modularity is applicable in healthcare services provided by mental healthcare institutions. Studies on elderly care (de Blok et al., 2010a; de Blok et al., 2010b; de Blok et al., 2013; de Blok et al., 2014; Broekhuis, van Offenbeek & van der Laan, 2017) explored the application of modularity and modularity principles in the field of long-term care for the elderly. Studies on hospital care (Bohmer, 2005; Meyer, Jekowsky & Crane, 2007; Silander et al., 2017; Silander et al., 2018; Zhang, Ma & Chen, 2019) addressed the applicability of modularity in the context of hospital healthcare services. Also, conceptual studies have been conducted on the applicability of modularity in health services in general (Vähätalo, 2012; Vähätalo & Kallio, 2015; Bartels et al., 2020). The results of the abovementioned studies provide evidence on some of the benefits and enablers of modularity in healthcare services: increased personalization and customization (de Blok et al., 2013), increased variety to address heterogeneous demand (de Blok et al., 2010b; Soffers et al., 2014), delivery of coordinated and customized services (de Blok et al., 2014). However, evidence on the applicability of modularity in *complex* healthcare services, for example on healthcare for people with complex care needs, is missing.

Interfaces are especially important in modular healthcare services for people with complex care needs. To accomplish fulfillment of these complex care needs, multiple healthcare providers with different specialized backgrounds are required who offer a diversity of components (Vähätalo, 2012). These complimentary care components from multiple providers have to be combined into an effective, functional modular healthcare package (Johnson, 2009; Chung et al., 2012). Clinical protocols and guidelines describe how certain components have to be performed and by whom but could be inaccurate when combining and

recombining care components (de Blok et al., 2014). Likewise, the order of components may be crucial, and problems could occur when no coordination is provided. Interfaces could guide the technical interactions between components in order to ensure that the patient gets the right care (de Blok et al., 2014). In addition to interfaces between care components, also interfaces between care providers involved are crucial. Multiple healthcare providers are involved in the provision of complex modular healthcare and, as a result, intensive coordination is required between professionals (e.g., medical, paramedical and non-medical specialists) and organizations (e.g., hospitals, home care, social support). Problems can occur among healthcare providers when a patient moves from one provider to another (Manser et al., 2010). If it is unclear for care providers which information needs to be exchanged or when the exchange of information is incomplete (D'Amour et al., 2008; Manser et al., 2010), this can result in health risks for patients in terms of overlapping or missing treatments (Singer et al., 2011). Coordination is even more important when patients transition to another organization (Schoen et al., 2007; Johnson, 2009), when handovers between specialists from different organizations take place (Chung et al., 2012; Auschra, 2018). Conceptually, interfaces have the potential to guide the interactions between service providers involved in complex modular healthcare, because they create interactions and allow for communication within a modular service (Voss & Hsuan, 2009).

Like services in general, healthcare services are characterized by the indispensable involvement of the patient (customer) in service provision (Lovelock & Gummesson, 2004; Sampson & Froehle, 2006). Because of the inseparability of production and consumption in many services (Grönroos, 1998, Vargo & Lusch, 2004; Sampson & Froehle, 2006), service delivery is typically characterized by interactions between customers and providers (Gittell, 2002). These interactions imply that customers become active participants in the design, production and delivery of services (Bitner et al., 1997; Vargo & Lush, 2004; Sampson & Froehle, 2006). Thus, customer involvement is a central feature of service production (Sampson, 2000; Vargo & Lusch, 2004; Sampson & Froehle, 2006). Conceptually, interfaces are able to connect the various people involved in modular service provision and allow them to exchange information with and about customers, recalling the theory as initially proposed by Voss and Hsuan (2009). Interfaces have the potential to guide and manage interactions between service providers and customers and are particularly relevant to retrieve the needs and preferences that are considered relevant by customers. In healthcare services, this is especially important because patients increasingly emphasize that they want their voices to be heard; they call for services that are tailored to their needs (Silander et al., 2017).

However, interfaces between providers and customers are overlooked in the service modularity literature. Given the prominent role of customers in services (Lovelock & Gummesson, 2004; Sampson & Froehle, 2006), it is striking that the predominant view on interfaces in the service modularity literature is primarily based on the perspective of the service provider (supply-side) rather than the customer (demand-side) (Pekkarinen & Ulkuniemi, 2008; de Blok et al., 2014; Spring & Santos, 2014; Broekhuis et al., 2017). This observation is even more remarkable since service providers increasingly need to deal with heterogeneous customer needs (Bask et al., 2011). Service providers commonly assume that they fulfill customers' needs, but it turns out that customer needs are often only partially fulfilled (Soffers et al., 2014). As a result, interfaces between service providers and their customers are necessary to determine whether the heterogeneous customer needs have been truly met; only customers know whether their needs and requirements have been fully

considered and addressed. The lack of knowledge on interfaces between service providers and customers results in a limited understanding on the role of customers in modular services (Brax et al., 2017; Iman, 2018).

The main purpose of this doctoral thesis is to advance knowledge on service modularity in complex service provision. We used chronic healthcare for children with DS as an example of complex service provision. The aim is to advance knowledge on service modularity by 1) exploring complex healthcare provision, an example of complex service provision, from a modular perspective and 2) exploring to what extent a modular perspective can support the provision of customer-centered service provision. This doctoral thesis explores the applicability of a modular perspective on chronic healthcare provision for children with DS as the case under study. Therefore, the following central research question is addressed in this doctoral thesis:

How can insights from service modularity, and in particular interfaces, make chronic Down syndrome healthcare provision more patient-centered, from the perspective of service providers (healthcare professional) and customers (patients and their carers)?

To address the central research question, five research questions have been formulated. Each question defines a different chapter of this doctoral thesis.

The first part of this doctoral thesis focusses on interfaces in service modularity. Current service modularity literature only provides a basic understanding of interfaces, despite its attributed importance (Voss & Hsuan, 2009; de Blok et al. 2014). Furthermore, the numerous approaches in definitions and conceptualization of interfaces impede rigorous studies and constrain the development of the field of service modularity. Therefore, we performed a scoping review on the literature with regard to interfaces in service modularity to offer more clarity on the concept of interfaces in service modularity. The following research question was studied: *How can interfaces in modular services be defined and characterized according to the literature?* (Chapter 2).

The scoping review revealed that more research should be conducted on the topic of interfaces in service modularity, especially regarding complex modular services. Healthcare is an interesting domain in which to conduct those studies due to the involvement of multiple providers and organizations who deliver a variety of components. A pilot study was conducted in order to explore the potential application of service modularity for patients with complex care needs, illustrated by the field of chronic DS healthcare in the Netherlands. In doing this, chronic DS healthcare was described from a service modularity point of view. This pilot study was considered essential for this doctoral thesis because it evaluated the feasibility of service modularity for future investigations. This study adopted a modular perspective for analyzing healthcare provision for people with complex care needs and explored whether the aspects of modularity can be recognized within chronic DS healthcare provision. The following research question was addressed: *How does modular service provision affect the delivery of care for Down syndrome patients?* (Chapter 3).

The pilot study showed that a modular perspective is useful for analyzing healthcare provision for people with complex care needs. This provided direction for the remainder of the studies

in which we further elaborated on the possible application of certain modularity concepts. A multiple case study in four hospitals in the Netherlands was conducted to collect empirical data on healthcare provision for children with DS, provided by Downteams. This resulted in a better understanding of the complete collection of different types of care components and modules necessary for treatment and support of children with DS and the providers (professionals and/or organizations) responsible for delivering the various components and modules. The scheme in which this is presented is called the modular service architecture (MSA). The MSA provides a comprehensive representation of a service offering (Voss & Hsuan, 2009) and thereby facilitates the mixing-and-matching of modules and components to address the needs and requirements of customers. Previous studies on the application of MSA are limited and take the perspective of the service provider only (Broekhuis et al., 2017; Silander et al., 2017). In modular healthcare services, this perspective reflects the provision of services aimed at improving medical outcomes and does not respond to the individual needs and preferences of people with complex care needs. The medical outcomes are often not the most relevant from a patient's perspective, as these patients often attach greater value to functional outcomes and overall wellbeing (van der Heide et al., 2018). This study is the first to explore from the perspective of the customer as well as the service provider how MSA can help to address customers' needs in complex service provision. As such, the applicability of MSA in chronic healthcare provision for children with DS is explored from the perspective of the patients and their carers besides that of the healthcare professionals. The following research question was addressed: *How does modular service architecture support the provision of person-centered care in complex service offerings?* (Chapter 4).

The MSA of chronic DS healthcare provided a comprehensive representation of healthcare provision in terms of modules, components, and providers. Only with such a complete modular representation of the service offering, it is possible to mix-and-match components and identify the interfaces involved in modular service provision. The interfaces are essential for the coordination of the involved service providers and, consequently, the coordination of the modular service (de Blok et al., 2014). However, services are becoming increasingly complex due to the involvement of many different service providers, stemming from multiple organizations. In such complex multi-provider settings, the coordination of service providers and components is challenging as the number of components is relatively high and responsibilities are shared between several autonomous providers. Our scoping review (Chapter 2) showed that there is very little understanding about interfaces in multi-provider settings, especially when interfaces cross organizational borders (Peters et al., 2018). Therefore, this study explored how modular interfaces manifest in multi-provider settings and how they can improve coordination and customization of services. The following two research questions were addressed: 1) *How can interfaces be described in a multi-provider context?* and 2) *How can interfaces support the delivery of integrated patient care in a multi-provider context?* (Chapter 5).

The insights from the study on interfaces in multi-provider settings showed that interfaces are required to deal with the various dissimilar healthcare modules and components originating from multiple care providers with different specialized backgrounds, from multiple organizations. Although the study showed that interfaces promote coordination and customization in modular services, it was observed that interactions with patients were

overlooked. Consistent with healthcare services, patients underline the need for their voices to be heard and call for services tailored to their needs (Silander et al., 2017). Conceptually, interfaces in service modularity have the potential to manage and guide interactions and make sure that the combined, but independent modular parts form a functional whole (de Blok et al., 2014). Voss and Hsuan (2009) describe interfaces in two distinct dimensions: 1) interfaces in the *content* dimension, and 2) interfaces in the *people* dimension. However, further elaborations of interfaces in the people dimension in the literature only address the mutual exchange of information between service providers (de Blok et al., 2014). Remarkably, interfaces between service providers and *customers* are not addressed despite their active role in services (Bitner et al., 1997; Vargo & Lusch, 2004; Sampson & Froehle, 2006). To advance knowledge on interfaces, especially interfaces between service providers and customers, in complex modular services the following research question was addressed: *What is the role of interfaces in complex modular services? And to what extent are they patient-centered?* (Chapter 6).

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Chapter 2. Interfaces in service modularity: A scoping review

Abstract

This paper is intended to provide a scoping review on interfaces in service modularity. There is little detailed understanding of this concept despite its attributed importance. We identified 12 papers, showing that interfaces in service modularity is an area still open to research, especially with regard to interfaces that cross organisational boundaries. We found common themes in the available literature: the nature of interfaces, service fragmentation, and predefined interfaces. Further research is needed on interfaces in service modularity, especially for complex services with components that stem from multiple, autonomous organisations. More specifically, there is a need for more studies that explore in detail how interfaces manifest themselves, and how they can be addressed to improve complex service provision. In addition, we argue why healthcare could be an interesting domain in which to conduct those studies. Our paper's contribution comprises a detailed description of interfaces in service modularity, the dissemination of summarised research findings and suggestions for potential future research.

Keywords: Interfaces; Service modularity; Scoping review; Complex service provision; Supply chain management

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2.1 Introduction

Research on modularity has moved beyond manufacturing, extending to areas in supply chain management (SCM), for example supply chain design (Fixson, 2005), mass customisation (Mikkola, 2007), and supply chain flexibility (Gualandris & Kalchschmidt, 2013). More recently, modularity has entered the context of services, such as service architecture (Tuunanen, Bask & Merisalo-Rantanen, 2012), human interaction (de Blok et al., 2010), and customer involvement (Iman, 2016). The mainstream research on modularity seeks to understand how complex systems can be decomposed into simpler subsystems with well-defined interface specifications, so each subsystem can be designed and managed independently (Baldwin & Clark, 1997).

Each of these subsystems can be optimised and they must be coordinated to fit the overall goal of the complex system (Simon, 1962; Schilling, 2000); this is the role of interfaces. Interfaces are the linkages between subsystems that allow interaction and communication between those components (Voss & Hsuan, 2009). They provide loose coupling of subsystems, making sure that they can function independently. Moreover, they allow for substitution of subsystems if the system requires it, even when subsystems will be delivered by different organisations (Schilling, 2000). The notion of interfaces is thus a key element in the field of modularity.

Interfaces make sure that combined, but independent, modular parts form a functional whole. Their role is twofold: on one hand they establish boundaries, but on the other hand they develop connections. This indicates that without interfaces, a system would simply collapse. This is certainly true for services that operate in a complicated network of various stakeholders (e.g., construction services, health services, tourism services). Those networked operations underline the importance of modularising services; they facilitate the division of tasks within the network, rather than each provider doing the operations by themselves (Bask et al., 2010). This follows from the fragmented structure of those services, and the complicated needs and wishes of customers that increase the complexity of the context (Nolte et al., 2012).

More specifically, health services must deal with high risk at 'boundaries' such as handover moments between professionals; potentially, interfaces could decrease those risks. If health service providers are to meet challenges such as those mentioned above, they will have to put more effort into finding new, effective ways of organising their services (Vähätalo & Kallio, 2015). One way could be the modularisation of those services.

Although the functioning of interfaces is well understood in the product modularity literature, the implications are less apparent in the service modularity literature (Vähätalo, 2012). Current literature in service modularity only provides basic understanding of interfaces, despite its attributed importance (Voss & Hsuan, 2009; de Blok et al., 2014). Furthermore, the numerous approaches in definitions and conceptualisation of interfaces impede rigorous studies and constrain the development of the field of service modularity. While several authors have classified existing literature on modularity using a rather broad approach to the subject (Bask et al., 2010; Campagnolo & Camuffo, 2010; Vähätalo, 2012; Iman, 2016; Frandsen, 2017), this is the first review paper aiming to provide an overview of past research and to identify common themes in the literature on interfaces in service modularity.

In order to elucidate the concept of interfaces in service modularity, in this paper we address the following question: *How can interfaces in modular services be defined and characterised according to the literature?*

The purpose of this review paper, therefore, is to compare the literature on interfaces in service modularity, highlighting what they have in common, how they differ and which are the critical issues. As such, we offer more clarity with respect to the definitions and conceptualisations of interfaces in service modularity. This paper advances our understanding of interfaces in service modularity by presenting the diverse conceptualisations, definitions and implications.

The paper has been divided into six sections. The Introduction briefly introduces the topic and highlights its importance. The Theoretical Background section gives an overview of modularity and interfaces. The Methodology section discusses the review methodology we used. The next section presents the results from our review and is followed by a section which discusses the new understandings and insights about the issue at hand. The Conclusion section concludes with the findings from our review.

2.2 Theoretical background

2.2.1 Modularity and interfaces

Service modularity has its roots in manufacturing. In the past years it has been a fast-emerging area of research (Bask et al., 2010) and, consequently, various review papers have been produced on this matter (Table 1). Table 1 reveals that scholars do not provide consistent conceptualisations and definitions in the service modularity literature. Many disciplines have contributed to service modularity research, making modularity a way to design services so that customised service packages can be created from distinct components for individual customers (Pekkarinen & Ulkuniemi, 2008). Services are distinguished from products in the use of modularity in that services do not only have an outcome dimension but also a process dimension (Voss & Hsuan 2009). The outcome dimension describes the bundle of services offered, both tangible and intangible, (Grönroos, 2000) and the process dimension refers to the interactions between the service provider and the customers, and to the activities that need to be carried out to transform customer inputs into service outputs (Eissens-van der Laan et al., 2016).

In this paper we follow Rajahonka's (2013) definition of a module: "*a relatively independent part of a system with a specific function and standardised interface*" (p. 47). There is no universal understanding of modules, since many authors use the concepts of modules, components, and elements interchangeably (Pekkarinen & Ulkuniemi, 2008; de Blok et al., 2014). In order to develop a common language, we want to make a clear distinction between these different concepts. We interpret them as concepts that each fulfil their own specific role in a service offering (Table 2). The definition by Rajahonka (2013) serves as the starting point for this paper and is in line with the following three design principles that underpin the concept of modularity.

Table 1. Summary of review papers on (concepts of) service modularity.

Authors	Review method	Relevant findings	Relevant suggestions
Bask et al. (2010)	Systematic literature review	Interfaces are important in product, process and service modularity, yet we know little about their conceptualisation and implication.	Authors of literature on service modularity do not provide or use consistent terms and definitions.
Campagnolo & Camuffo (2010)	Literature review	Very few works have tried to identify interfaces despite their important conceptual functioning.	Ambiguity in definitions and measures of the modularity concept impedes rigorous empirical studies.
Iman (2016)	Critical review	Service modularity is still in its infancy. To make matters worse, there are also numerous approaches to using the modular concept and its underlying concepts.	Future studies should utilise the available data to develop the measurement and concepts of service modularity.
Vähätalo (2012)	Systematic literature review	The results revealed that although the need for joint delivery and service coordination is recognised, there is no description of modular partnerships or interfaces on the organisational level.	Emphasis should be placed on defining interface specifications between service providers on both the professional and the organisational level.

The first design principle entails that each module should have a *specific function*, meaning that the module is expected to contribute to the overall service offering. The function of a module can be helping, providing or facilitating something in, or for, the process (Ulrich, 1995). In other words, it should be possible to distinguish independent, interchangeable modules with a specific function. The notion of ‘specific’ refers to the level of detail in which functions are specified. Functions can be specified in general (e.g., visit Florence) or in more detail (e.g., visit the cultural highlights of Florence). The second design principle, *relative independence*, implies that components comprising a module should be mutually interdependent, but that the interdependence with other modules should be minimised (Campagnolo & Camuffo, 2010). This principle relates to the ‘mixing-and-matching’ process of a modular package, which is a process of choosing and combining modules in order to achieve a customised service offering.

Table 2. Definitions of concepts used.

Concept	Description
Component	The smallest elements into which a service offering can be meaningfully divided
Module	A relatively independent part of a system with a specific function and standardised interface.
Service offering	Combination of several modules that are connected to each other
Service provider	A professional that fulfils their assigned role in a service offering
Organisation	An organisation that fulfils its assigned role in a service offering

Using the travel example, changing the public transport component or the museum component within one module does not affect the design of the other modules. The last design principle, *standardised interfaces*, involves the typically standard linkages between modules that allow for interaction and communication between them (Voss & Hsuan, 2009). Interfaces make sure that the combined independent modules can form an integrated whole (Baldwin & Clark, 1997). A travel company should arrange that modules and components are connected, e.g., making sure that the transportation component is linked to the right museum component. They are essential for connecting modules into a variety of service configurations to address the diverse needs and wishes of customers. This connectivity is the reason we have a specific interest in the concept of interfaces.

Moreover, interfaces specify in detail how components will interact with each other; they define the fit, connection and communication between the components (Baldwin & Clark 1997). This definition of interfaces is commonly used in the literature and serves as a good starting point for our exploration of the concept of interfaces in service modularity.

Interfaces are an important aspect of modularity, both in products and services. In modular products (Fixson, 2005), interfaces manage the connections and interdependencies across various types of physical components that comprise the final product and are typically standardised. Furthermore, interfaces enable the substitution and exchange of these components (Sanchez & Mahoney, 1996). In modular services, interfaces also enable the substitution and exchange of components and it is suggested that interfaces include people, information and rules governing the flow of information (Pekkarinen & Ulkuniemi, 2008; de Blok et al., 2010). The distinctive factor in service modularity, as compared to product modularity, is the central role of people. Based on the arguments above, de Blok et al. (2014) proposed an adapted definition of interfaces in service modularity: *“the set of rules and guidelines governing the flexible arrangement, interconnections, and interdependence of service components and service providers”* (p. 186).

2.3 Methods

By systematically searching, selecting, and synthesising existing knowledge, scoping reviews are suitable for knowledge synthesis that addresses an exploratory research question aimed at mapping key concepts and gaps in research related to a defined area or field (Colquhoun et al., 2014). A scoping review combines a systematic literature search with a qualitative thematic analysis. Our efforts here aim at more detailed understanding of the diverse conceptualisations of interfaces in service modularity. We followed the iterative methodology for scoping reviews as described by Arksey and O’Malley (2005), and further enhanced by Levac, Colquhoun and O’Brien (2010): 1) identifying the research question; 2) identifying relevant studies; 3) study selection; 4) charting the data; 5) collating, summarising, and reporting results, and 6) consultation exercise.

2.3.1 Search strategy

We systematically searched Web of Science, Google Scholar, Elsevier, JSTOR, and WorldCat Discovery. The databases were selected to be comprehensive and to cover a broad range of disciplines. We used 2000 as the starting date for the search because that was the year of Schilling’s (2000) landmark publication. Also, according to Frandsen (2017), research in service modularity increased substantially around that time. Search strategies were similar for

each database (Table 3). A librarian at Tilburg University verified the databases and search strategy of our study.

Table 3. Search strategy.

Database	Search Strategy	Search Limit
Web of Science	“Service modula*” AND interface*	January 1, 2000 – December 31, 2016
Google Scholar	“Service modularity” AND interface*	
Elsevier	“Service modula*” AND interface*	
JSTOR	“Service modula*” AND interface*	
WorldCat Discovery	“Service modula*” AND interface*	

Titles were included in the next selection phase when it was demonstrated that service modularity, as such, was discussed in the paper. Most titles (N = 231) were removed because they dealt with modularity of software or systems engineering. Abstracts were scored for relevance based on more narrow inclusion and exclusion criteria (Table 4). VP scored all abstracts and BM and EV each independently scored a random selection of 25% of all abstracts. The 10% of papers for which VP, BM, and EV differed in their scoring were all passed on to the third phase, the full text selection. VP scored all full texts for relevance, and BM and EV each independently scored a random selection (25% of all full texts each). Only papers dealing with the concept of service modularity that went at least briefly into the subject of interfaces, thereby revealing one or several features of interfaces, were included in the final selection of full texts.

Table 4. Criteria for inclusion and exclusion.

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> • Papers focusing on the application of service modularity; • Papers focusing on the application of interfaces in service modularity; • All kinds of scientific publications: journal papers, books, proceedings, theses, etc. 	<ul style="list-style-type: none"> • Papers concerning service modularity or interfaces in computer science/information systems/engineering; • Papers where service modularity is not the main topic; • Modularity of devices; • Written in languages the research team does not master (Not English or Dutch); • No full text available.

In order to find any additional relevant papers that had been unintentionally overlooked in the search, the snowball method was applied: going through references of papers already included. To this end, VP scanned the reference list of all full text papers and used judgement in deciding whether to pursue these further. If a title suggested the paper was potentially relevant, it was retrieved and, after examination of the full text, VP decided whether the paper should be included in the final selection.

2.3.3 Data extraction and analysis

Consistent with Arksey and O’Malley’s (2005) framework, we extracted data related to our research question; this was inspired by a semantic-level, thematic analysis approach (Braun & Clarke, 2006). First, data was entered into a Microsoft Excel spreadsheet. Data included

authorship, publication year, research design, research setting, research aim, phenomena of interest, how modularity/interfaces was used and definition/description of interfaces provided. This step facilitated further data reduction and coding.

Second, all data regarding the conceptual elements involved in the application of interfaces in service modularity were extracted from the papers. We did this by transforming those sentences into more precise data for classification, by tracking the main concepts and the papers that supported each piece of evidence. Sentences regarding interfaces were gathered in each paper, and the concepts that emerged in those sentences were transformed into coded information such as 'interface entities', 'interface aims', and 'fragmentation'. This was important for identifying the common themes within the papers.

Next, we categorised the concepts found. For instance, 'service fragmentation' was found to be a common theme. All papers dealing with that concept were analysed to enhance information about its role. The approach based on these three steps allowed us to answer our research question. Any differences in interpreting the content of papers or their underlying themes were resolved through discussion. This is in line with the iterative nature of all the stages in scoping reviews (Levac et al., 2010).

2.3.4 Consultation exercise

An expert in the field of service modularity was approached to review the list of selected papers. This is the final stage in the scoping review methodology of Arksey and O'Malley (2005). The expert concluded that the list seemed to include all relevant papers on interfaces in service modularity, but proposed an additional follow-up search strategy to compare with the outcomes of our strategy. The proposed search strategy consisted of the keywords service* AND modula* AND interface* and was the same for each database.

2.4 Results

The literature search yielded 365 papers, three were added using the snowball method; 12 papers were included in the final selection (Figure 1; Table 5). The outcomes of the additional strategy as suggested in the consultation exercise did not yield any additional papers.

2.4.1 General description of the papers included

The selected papers span two decades. Two were written in the 2000s and ten between 2010 and 2016 and were all submitted to different journals. Interestingly, the papers described only two sectors: healthcare and logistics service providers. The remaining three papers were of a conceptual nature. The predominant research design was exploratory, using qualitative research methods. A case study research design was used in seven papers, three papers were reviews combined with empirics and two of the papers consisted of conceptual reasoning (Table 6; 7).

Figure 1. Flowchart of selection process.

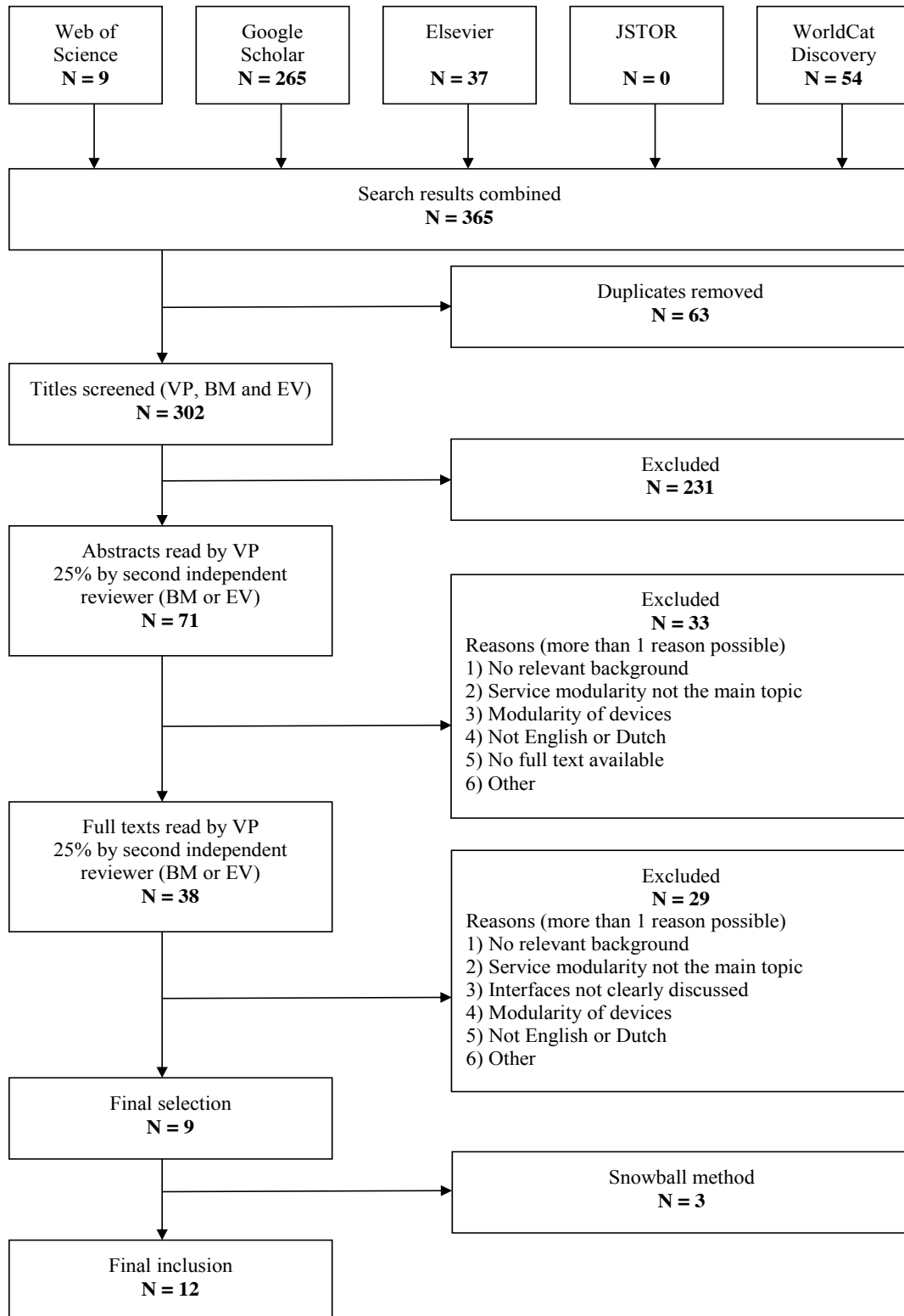


Table 5. Selected papers.

Initial selection	
1	Cabigiosu, A., Campagnolo, D., Furlan, A., & Costa, G. (2015). Modularity in KIBS: The case of third-party logistics service providers. <i>Industry and Innovation</i> , 22(2), 126-146.
2	de Blok, C., Meijboom, B. R., Luijckx, K., Schols, J., & Schroeder, R. (2014). Interfaces in service modularity: A typology developed in modular healthcare provision. <i>Journal of Operations Management</i> , 32(4), 175-189.
3	Iman, N. (2016). Modularity matters: A critical review and synthesis of service modularity. <i>International Journal of Quality and Service Sciences</i> , 8(1), 1-15.
4	Rajahonka, M. (2013). Views of logistics service providers on modularity in logistics services. <i>International Journal of Logistics Research and Applications</i> , 16(1), 34-50.
5	Soffers, R., Meijboom, B., van Zaanen, J., & van der Feltz-Cornelis, C. (2014). Modular health services: A single case study approach to the applicability of modularity to residential mental healthcare. <i>BMC Health Services Research</i> , 14, 210-220.
6	Spring, M., & Santos, J. (2014). Interfaces in service and process modularity. Paper presented at the 5th International Seminar on Service Architecture and Modularity, January 16-17, Copenhagen, Denmark.
7	Tuunanen, T., Bask, A., & Merisalo-Rantanen, H. (2012). Typology for modular service design: Review of literature. <i>International Journal of Service Science, Management, Engineering, and Technology</i> , 3(3), 99-112.
8	Vähätalo, M. (2012). Modularity in health and social services: A systematic review. <i>International Journal of Public and Private Healthcare Management and Economics</i> , 2(1), 1-15.
9	Van der Laan, M. R. (2015). <i>The feasibility of modularity in professional service design: Towards low cost person-centred care</i> (Doctoral dissertation, University of Groningen). Groningen, the Netherlands: University of Groningen.
10	Voss, C. A., & Hsuan, J. (2009). Service architecture and modularity. <i>Decision Science</i> , 40(3), 541-569.
Snowball method	
11	de Blok, C., Luijckx, K., Meijboom, B., & Schols, J. (2010). Improving long-term care provision: Towards demand-based care by means of modularity. <i>BMC Health Services Research</i> , 10, 278-293.
12	Gittel, J. H., Hagigi, F., Weinberg, D. B., Kautz, C., & Lusenhop, W. (2008). Modularity and the coordination of complex work. Paper presented at the Annual conference for Industry Studies, May 1-2, Boston, MA.

Table 6. Summary of literature with interfaces in service modularity as the main topic.

First Author, Year	Interface type	Interface definition	Interface example
de Blok et al. (2014)	Closed-customer (C-C)	Enable the arrangement of components in a way that interdependencies among components are managed and that components work together	Strict planning rules
	Open-customer (O-C)	Provide a structure that enables components to be combined and re-combined, according to the individual customer needs	Brochure with services
	Closed-information (C-I)	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	Work schedule
	Open-information (O-I)	Offer a structure in which service providers are brought together so that information concerning e.g., package (re)configuration can be exchanged	Needs assessment
Spring & Santos (2014)	Structural	Regard the outcome dimension of service modules	Handover from provider A to B
	Procedural	Relate to the temporal nature of the delivery of services	Agreement between bus driver and hotel
van der Laan (2015)	Functional	Focus on linking modules with one another	Information exchange between information systems
	Organisational	Focus on coordinating work between providers and making interactions among various (groups of) service providers manageable	Internal contract

2.4.2 Findings

De Blok et al. (2014) developed a typology on interfaces in service modularity that is based on two dimensions, interface *entities* and interface *aims*.

The interface entities refer to the decomposition level – components and services providers – while the interface aims can either provide coherence or provide variance. The authors label the interfaces that create coherence as ‘closed’ interfaces, since they strive for standardisation and unity. The interfaces aiming at providing variety are called ‘open’ as they enable individualised adaptations for each customer. The interface entities stem from the analytical level at which they are in play: either on the component level or on the service provider level. Interfaces between components support the *customer* flow from component to component and interfaces between service providers affect *information* flow in the service package as a whole (de Blok et al., 2014). Based on those insights, four different types of interfaces can be

distinguished: closed-customer (C-C), open-customer (O-C), open-information (O-I), and closed-information (C-I) interfaces.

Spring and Santos (2014) make a distinction between *structural* and *procedural* interfaces. Structural interfaces address the outcome dimension of service modules whereas procedural interfaces address the temporal nature of the service delivery. The procedural interfaces focus on integration of the process dimension of service offerings and relate to the interaction between the service provider and the customer.

Van der Laan (2015) makes a distinction between *functional* and *organisational* interfaces. Functional interfaces link content parts with their own specified function and align the outcome dimension of a service offering. Organisational interfaces link service providers, including customers, and are expected to align the process dimension of a service offering.

Insights on interface conceptualisations are summarised in Table 6. All in all, this shows that the topic of interfaces is largely overlooked, despite the acknowledgement that interfaces constitute a research priority (Voss & Hsuan, 2009). Systematic studies of interfaces in practice, and their relationship to outcomes of modularity, remain scarce (Voss & Hsuan, 2009; de Blok et al., 2010; Tuunanen et al., 2012; Soffers et al., 2014). Available studies mostly focus on interfaces as a means of linking and connecting components or modules, but do not elaborate on how to further specify, define and recognise interfaces (Voss & Hsuan, 2009; Vähätalo, 2012; Rajahonka, 2013; Iman, 2016).

This results in too little understanding about how interfaces manifest themselves in the service sector (Gittell et al., 2008; Rajahonka, 2013; Soffers et al., 2014; Cabigiosu et al., 2015), as in-depth empirical papers on interfaces in modular services, testing conceptualisations of interfaces in service modularity, are rare (Soffers et al., 2014). Rajahonka (2013) reasons that this may be due to there being fewer industry standards in services than in the manufacturing industry. The remainder of the results section is organised along three themes.

2.4.2.1 Nature of interfaces

Little is known about the nature of interfaces and the analytical level at which interfaces are at play. Following this, there is an ongoing debate in the literature about whether interfaces provide linkages between components and service providers, or between customer and service provider (Gittell et al., 2008; Voss & Hsuan 2009). Vähätalo (2012) added organisations to this debate, revealing that there is no readily available description of interfaces at the organisational level. Iman (2016) argues that this debate stems from the fact that the literature is inconsistent on whether service providers are defined as professionals or organisations. Some papers use the term service provider to refer to organisations (Rajahonka, 2013; Cabigiosu et al., 2015) whereas others use the term to refer to professionals (de Blok et al., 2010; Soffers et al., 2014). As a result, it remains unclear how interfaces have been conceptualised in the existing literature. More specifically, it is not clear at which analytical level interfaces are at play in the delivery of (multiple) components in the total service offering. Vähätalo (2012) was the first to address this issue. She argued that understanding the nature of interfaces becomes even more important when multiple components are supplied by multiple, independent service providers who are responsible for these components. The functioning and our understanding of interfaces might be affected when modules or components originate from multiple, autonomous organisations.

2.4.2.2 *Service fragmentation*

Some papers (de Blok et al., 2010; Vähätalo, 2012) indicated that organisational boundaries were problematic when a customer required services from multiple organisations instead of a single organisation. The complicating factor is that these organisations become dependent on each other, something which stems from the structure of the complex services and has a negative effect on the coordination of those services. According to Vähätalo (2012), the fragmented structure of services is attributable to a lack of interfaces. An essential element in preventing service fragmentation is information exchange between organisations and service providers (Vähätalo, 2012). This is a challenging task because it is difficult to synchronise operations and information exchange (Cabigiosu et al., 2015). Use of IT such as electronic health records (Soffers et al., 2014) and other contemporary developments in information systems in general (Cabigiosu et al., 2015) have been found to be one of the ways to improve information exchange between professionals within and across organisations. However, this seems counterintuitive because the modularisation of services ensures that *less* information exchange (between modules) is required, since more information is readily available within modules (Cabigiosu et al., 2015). De Blok et al. (2010) and Vähätalo (2012) also point out that when modules stem from different organisations and service fragmentation occurs, the need for information exchange becomes more evident.

2.4.2.3 *Predefined interfaces*

Demand heterogeneity and expanded service requirements from customers increasingly challenge organisations and professionals from different sectors (Vähätalo, 2012). However, if organisations collaborate to address demand heterogeneity and service requirements, problems arise when interfaces are not specified before the collaboration begins (Gittell et al., 2008). Voss and Hsuan (2009) argue that when interfaces are defined in advance, the possibility of connecting, complementing and substituting modules is enhanced, with little effort involved in the coordination. This becomes evident when sensitive information is exchanged through an interface, for example personal information via an electronic patient file (Soffers et al., 2014). It should require little coordination to establish boundaries through interfaces, even though it should be possible to share knowledge, competences and information among service providers. Developing such interfaces requires well organised and consistent coordination (Gittell et al., 2008; Tuunanen et al., 2012). Predefined interfaces have the potential to facilitate collaboration among multiple organisations from different sectors (Vähätalo, 2012). Iman (2016) suggests that if interfaces cannot be fully specified in advance, the embedded coordination, often assumed to be a consequence of interfaces in service modularity, is challenged.

2.5 Discussion

2.5.1 Alignment of the papers explicitly addressing interfaces

Three papers explicitly addressed interfaces in service modularity, i.e. de Blok et al. (2014), Spring and Santos (2014), and van der Laan (2015). All three papers developed their own conceptualisation of interfaces in service modularity. They distinguished between interfaces that link components (content) with one another and interfaces that are responsible for linking service providers (people) with one another.

Table 7. Summary of literature on interfaces in service modularity.

First author, year	Research design	Research aim	Main implications of interfaces in service modularity
Cabigiosu et al. (2015)	Case study	To investigate service modularity and inter-organisational coupling in a knowledge intensive business.	Customised interfaces are important for information and knowledge transfer.
de Blok et al. (2010)	Case study	To examine the application of modularity in long-term care for the elderly.	Problems at interfaces between and within (large) healthcare organisations have been recognised.
Gittell et al. (2008)	Case study	To explore the concept of modularity in a professional service context and whether higher levels of complexity increased or decreased the modularity of their coordination.	Interfaces between modules need to be specified in advance, indicating that how modules will interact must be well defined.
Iman (2016)	Review	To investigate the existing research, to provide a critique of the empirical literature and to discuss future research opportunities on service modularity.	If interfaces cannot be fully specified in advance, this challenges the assumed embedded coordination.
Rajahonka et al. (2013)	Case study	To increase our understanding of the concept of service modularity and to present examples of applications of modularity approach in logistics services.	The importance of interfaces is understandable because logistics is an industry involving multiple network partners often operating around the globe.
Soffers et al. (2014)	Case study	To explore the applicability of modularity in residential care provided in Assisted Living Facilities of Dutch mental healthcare institutions.	Only a minority of the interfaces concern modules and a large number of interfaces concerning people could be identified. The lack of module interfaces caused a lack in clarity about the available modules.
Vähätalo (2012)	Literature review	To study the potential relevance of modularity in the health and social service sector.	There is no description of interfaces on the organisational level. Interface specifications could facilitate collaboration among multiple providers from different sectors.
Tuunanen et al. (2012)	Literature review	To present a typology for modular service design.	It is important to take a better look at interfaces: i.e., the connectivity of service components in the modular service offering.
Voss & Hsuan (2009)	Case study	To gain more understanding of the nature of service architecture and modularity.	Identify key interfaces between different parts of the service. Service design often includes customer contact, communication with the customer through a choice of modes and channels. Information transfer is a key interface.

The interfaces that link components support the mixing-and-matching of a service offering, and the interfaces that link the service providers with each other facilitate the coordination of work between service providers.

However, we think the conceptualisations of interfaces made by these different studies can be aligned because, in fact, *customer* flow interfaces (C-C and O-C) address the same

dimension as *structural* interfaces and *functional* interfaces do. They all focus on the *outcome* dimension of a service offering and refer to the content part of the service offering, i.e. interactions between components or modules. Additionally, *information* flow interfaces (C-I and O-I) discuss the same dimension as *procedural* interfaces and *organisational* interfaces do; they focus on the *process* dimension of the service offering and provide linkages between service providers. It refers to the ‘people’ part of the service offering, i.e. interactions between service providers. The alignment of those conceptualisations is shown in Figure 2.

Figure 2. Visualisation of interface types.

		<u>Outcome</u> dimension of a service offering	<u>Process</u> dimension of a service offering
		<i>Structural</i> interfaces <i>Functional</i> interfaces	<i>Procedural</i> interfaces <i>Organisational</i> interfaces
	Interacting entities		
Interacting aim		Between modules/components	Between providers
	Variety	<i>O-C</i> interfaces	<i>O-I</i> interfaces
	Coherence	<i>C-C</i> interfaces	<i>C-I</i> interfaces

Note: Derived from de Blok et al. (2014), Spring & Santos (2014) and van der Laan (2015).

The ‘labels’ applied to those interface conceptualisations relate to Grönroos (2000) and, more recently, Eissens-van der Laan et al. (2016) definition of boundaries of a service offering. They refer back to the theoretical distinction between the outcome and the process dimensions of a service offering. As argued above, the conceptualisations by de Blok et al. (2014), Spring and Santos (2014) and van der Laan (2015) differ in wording rather than content. What does make a difference is that de Blok et al. (2014) discovered the dimensions of the interacting aims ‘variety’ and ‘coherence’ in both the outcome and the process dimensions. As such, their typology is more comprehensive. Our research shows that interfaces on the outcome and process dimension are required to ensure pertinent service delivery over time. However, the current conceptualisations do not capture the modularisation of services in multi-provider contexts. In more complex service offerings, interfaces need to establish connections across organisational boundaries. We believe our classification of interfaces in service modularity will contribute to a more detailed understanding of the concept and that illustrating them will provide insight into how interfaces manifest themselves in practice, especially in complex service provision.

2.5.2 Interfaces in complex services

The common denominator of the themes revealed in the results section is the lack of knowledge on interfaces in complex service provision. The papers included in our review were all produced in a single-provider context and have therefore not examined interfaces that cross organisational boundaries. It seems to be the case that organisational boundaries are

problematic when customers require services from multiple, autonomous organisations, and this is often the case in the healthcare sector. Healthcare is a complex domain due to the necessary involvement of multiple healthcare providers which leads to inter-organisational problems such as communication, integration and coordination (Meijboom, Schmidt-Bakx & Westert, 2011).

Those problems are often discussed under the heading of chain care, and this idea of ‘a chain of activities’ is related to SCM practices. Managing relationships among the providers involved is essential for the integration of professionals and organisations along the supply chain and the related coordination tasks (Xie & Lawley, 2015). Interfaces in service modularity, conceptually, have the potential to guide those relationships.

With a broader view on this topic, SCM practices are also discussed by means of modularity in production systems (Takeishi & Fujimoto, 2001; Bask et al., 2010). Efficient production of a product portfolio is often attributed to the flexibility of manufacturing (Ulrich, 1995), which is primarily a function of (product) architecture and the technology used within the supply chain (Ramdas, 2003; Gualandris & Kalchschmidt, 2013). Modularity allows these components to be mounted in separate lines, thus forming modules that are sent to the final assembly line (Baldwin & Clark, 1997; Takeishi & Fujimoto, 2001). Thus, there is a significant reduction in the complexity of the production process. For this to happen, certain aspects of modularity that influence subsequent decisions in the production process must be considered, namely: i) product architecture, which specifies the modules of the system; and ii) interfaces, which are responsible for the interaction of the modules (Baldwin & Clark, 1997). Once more we see the importance of interfaces. Therefore, we make a comparison of the interfaces in service modularity and production system modularity (see Table 8). We found that service modularity literature is mostly influenced by manufacturing modularity that follows the traditional systems view and approach. Our comparison shows that service modularity does not yet capture the multi-layer structure of complex services. Moreover, there is potential for studies that apply principles from modularity in production systems, like standardisation of interfaces and interface specifications, in a service context. These concepts play a vital role in production systems. In modular services, there is little evidence about their role in complex service offerings.

2.5.2.1 Healthcare as potentially fruitful research area

The healthcare sector is a domain comprising many medical specialties focused on various age segments, for example children and elderly people, and concerned with physical and/or with mental ailments (Frenk et al., 2010). This generates a substantial number of care providers. Even when focusing on a specific disease (e.g., dementia) or target group (e.g., independently living elderly), multiple disciplines and providers are often necessary to ensure continuity of care (D’Amour et al., 2008). At the organisational level, concepts such as primary and secondary care indicate the highly specialised nature of healthcare provision (Frenk et al., 2010). As a consequence, specialisation among professionals creates sharp boundaries, both between an organisation’s own professionals and across organisations (Vähätalo & Kallio, 2015).

Few services in healthcare are provided by a single provider, or even by a single organisation. Instead, treatment takes place over a long period of time and involves multiple providers (de Blok et al., 2014; Soffers et al., 2014).

Table 8. Comparison of interfaces in service modularity and modularity in production systems.

Conceptual element	Summary description	Comparison	References
Interdependence between modules	Degree of structural independence the modules/components have among themselves.	<ul style="list-style-type: none"> Both in services and production systems there is a certain degree of interdependence between modules arranged. 	Baldwin & Clark (1997); Takeshi & Fujimoto (2001); Voss & Hsuan (2009); Gualandris & Kalchschmidt (2013)
Customer included	Refers to the degree of customer involvement in service delivery/production process.	<ul style="list-style-type: none"> In services, interfaces include people and this makes it less predictable as opposed to production systems. 	Takeshi & Fujimoto (2001); de Blok et al. (2010); Iman (2016)
Standardisation of interfaces	Makes it possible to recombine the components of services without an elaborate adaptation of interfaces.	<ul style="list-style-type: none"> In production systems, this enables the possibility of fewer changes in machinery, even with more variation. In services, this is less common due to the absence of industry-wide standards that provide descriptions of processes in service delivery. 	Ulrich (1995); Baldwin & Clark (2000); Ramdas (2003); Rajahonka (2013); de Blok et al. (2014)
Interface specification	Specifications of interfaces must be visibly specified to avoid inconsistencies when coupling modules and components.	<ul style="list-style-type: none"> In production systems, interfaces are predefined in order to ease the overall production process. In services, there is less emphasis on interface specification. 	Sanchez & Mahoney (1996); Takeshi & Fujimoto (2001); Vähätalo (2012)

For the actual process of treatments and procedures designed to serve patients, this implies that complementary care components must be combined into an effective, integrated whole (Johnson, 2009; Chung et al., 2012). Failure over time to properly link and align various types of components, modules and providers might have severe consequences for the patient's wellbeing (de Blok et al., 2010). A tight fit between the complementary components and the providers involved will prevent gaps as well as duplications. This tight fit can be achieved through interfaces because they provide linkages between components and service providers that allow interaction and communication between them (Voss & Hsuan, 2009). So, as well as interfaces between care content components, interfaces between the service providers involved are crucial, at both the professional level and the organisational level. As a result, it is possible to understand the supply side of healthcare as a collection of modular packages

built from cure, care and social services (Vähätalo, 2012). The sector therefore serves as a fruitful avenue for further exploration of the role of interfaces in complex service provision.

2.5.3 Strengths and limitations

To our knowledge, this is the first review in the service modularity literature that has taken interfaces as the central unit of analysis. Scoping reviews are a relatively new approach for which there is not yet a universal study definition nor a definitive procedure (Levac et al., 2010). To compensate for this, the research was guided by a protocol reviewed by a research team with expertise in scoping reviews. We have guaranteed the rigour and transparency of our review by following the steps for executing a scoping review as described by Arksey and O'Malley (2005). Next, our data analysis was inspired by the seminal work of Braun and Clark (2006). The analysis involved a constant moving back and forward within the data, the coded extracts of data that we analysed, and the analysis of the data that we produced. We thoroughly reviewed our study against all 15 criteria and determined that we met them all (Table 9). To illustrate, one important criterion was 'ongoing analysis to refine the specifics of each theme' (Braun & Clark, 2006) which we fulfilled by going back to collated data extracts and organising them into a coherent and sound theme. In doing this, we did not merely paraphrase the content of the data extracts, but identified what was of interest about them and why.

Our scope was broad, and we have attempted to sketch out what is currently known about interfaces in service modularity. Consulting someone with relevant expertise as the last step of the scoping review enabled us to check whether we had unintendedly missed relevant papers, and strengthened our paper. Lastly, as recommended by Creswell and Miller (2000), we made use of peer review to assess the quality of our findings. Another researcher analysed the data independently and any discrepancies in interpretations were resolved through discussion. This enhanced the validity of our research.

2.5.4 Agenda for future research

In this section, we offer directions for future research in the form of tentative propositions and related methodological suggestions.

Modular services are increasingly delivered as part of a complex system involving multiple providers. Within these multi-provider contexts, individuals from different organisations with often different professional backgrounds are expected to work together. In turn, this may well give rise to conflicts on organisational procedures or professional values respectively. As a consequence, standardisation of interfaces proves difficult. While this standardisation may reduce coordination costs, the within and between module coordination mechanisms will remain demanding (e.g., interoperable IT systems) given the high complexity of these services (Cabigiosu et al., 2015). Based on the above, we formulate the following proposition:

Proposition 1. Modular services that need input from multiple different service providers constrain the standardisation of interfaces.

Table 9. Adherence to the criteria checklist for good thematic analysis.

Phase	Criteria	Check
Familiarising	1. The data have been read to an appropriate level of detail.	We immersed ourselves with the data to the extent that we were familiar with the depth and breadth of the included articles.
Coding	2. Each data item has been given equal attention in the coding process.	We worked systematically through the entire data set, giving full and equal attention to each data item.
	3. Themes have not been generated from a few vivid examples (an anecdotal approach), but instead the coding process has been thorough, inclusive and comprehensive.	We made sure that codes identified a feature of the data that appeared interesting to the authors.
	4. All relevant extracts for all each theme have been collated.	We coded the extracts manually, by using highlighters, and collated them in Microsoft Excel.
	5. Themes have been checked against each other and back to the original data set.	We considered how different codes may combine to form an overarching theme.
	6. Themes are internally coherent, consistent, and distinctive.	We discussed (candidate) themes and sub-themes and made sure not to overlook relevant codes in the data.
Analysis	7. Data have been analysed - interpreted, made sense of - rather than just paraphrased or described.	We fulfilled this by going back to collated data extracts and organising them into a coherent and sound theme. We identified what was of interest about them and why
	8. Analysis and data match each other - the extracts illustrate the analytic claims.	We gave full and equal attention to each coded extract, and identified those interesting aspects in the coded extracts that formed the basis of common themes in our data.
	9. Analysis tells a convincing and well-organised story about the data and topic.	We reported on three themes. Each theme is clearly linked back to the overall research question, but each is distinct.
	10. A good balance between analytic narrative and illustrative extracts is provided.	We ensured this by including examples from the included articles, while staying on a conceptual level.
Overall	11. Enough time has been allocated to complete all phases of the analysis adequately, without rushing a phase or giving it a once-over-lightly.	Since coding is an ongoing organic process, we assured that we went back and forth between the data.
Written report	12. The assumptions about, and specific approach to, thematic analysis are clearly explicated.	By describing our data analysis in the method section, we made sure that the assumptions of thematic analysis were clear.
	13. There is a good fit between what you claim you do, and what you show you have done – i.e., described method and reported analysis are consistent.	We thoroughly explained our approach to the scoping review as described by Arksey and O'Malley (2005).
	14. The language and concepts used in the report are consistent with the position of the analysis.	We moved from the levels of phrases, sentences and paragraphs to the level of the writing as a whole, to their context-independent meanings, fitting the semantic-level.
	15. The researcher is positioned as active in the research process; themes do not just 'emerge'.	We guaranteed this by going back and forth between the data. We constantly questioned whether the right codes belonged to the right theme.

There is potential for future studies to synthesise and operationalise the knowledge gained in this scoping review. This is necessary in order to further our understanding of interfaces in service modularity. Areas that merit examination in greater depth are the nature and definition

of interfaces, as well as the ways in which they vary with context. One way of addressing this is to conduct studies with interfaces as the central unit of analysis, instead of interfaces being just one theme among many (Voss & Hsuan, 2009). Key decisions revolve around issues such as delineating the boundaries of each component and establishing predefined interface specifications to ensure smooth functioning between modules (Voss & Hsuan, 2009). Moreover, there is a need for studies to explore how interfaces manifest themselves in multi-provider contexts (Vähätalo, 2012), with special reference to coordinating and integrating fragmented services such as healthcare. We propose:

Proposition 2. Interfaces in complex modular services improve coordination of decomposed tasks within service provision not only across professional boundaries, but also organisational boundaries.

How should predefined interfaces work? Essentially, by specifying in advance exactly how subsystems will interact with each other. A predefined interface, such as a planning scheme, comprises the a priori specification of what organisations must do individually so that joint actions are coordinated. This is in contrast with independent organisations who may coordinate their activities by communicating and making decisions as they go (Puranam & Jacobides, 2005). While components can be developed autonomously by different organisations, coordination of the overall system is generated through the presence of interface specifications embedded in the service architecture, thereby shifting the burden of coordination away from managerial authority (Sanchez & Mahoney, 1996). It is in this sense that predefined interfaces “embed” coordination, as suggested by Iman (2016). Interfaces enable linked subsystems to act in a coordinated manner, by specifying ex ante what each subsystem must do in order for the complex system to work effectively (Baldwin & Clark, 2000). In complex services such as construction and healthcare, this becomes even more important because of the fragmented structure of those services. We therefore postulate:

Proposition 3. Predefined interfaces promote the assumed coordination embedded in interfaces.

From a broader theoretical perspective, we argue that interfaces are useful concepts for understanding the architecture of complexity (Simon, 1962). They demarcate the sub-systems that comprise the complex system as well as the manner in which sub-systems interact with each other. It is important to note that interfaces refer not only to those points where the linkages in a complex system manifest themselves, but also to the nature of those linkages (Puranam & Jacobides, 2005). Loose coupling of sub-systems through interfaces embraces the idea that most systems are neither entirely decoupled nor fully coupled and instead are nearly decomposable (Simon, 1962). We therefore argue that in services, as opposed to products, in addition to the complete independence of action across sub-systems, the major issue is the extent to which the nature of the interaction between subsystems is fully predictable.

2.6 Conclusion

Publications on interfaces in service modularity are scarce. The available literature focuses on interfaces 1) between *components* as they are needed in the formation of a coherent service offering, and 2) between *people*, in order to construct the service entity that meets the changing needs of customers. Little is known about interfaces 3) between *organisations* that facilitate collaboration and coordination with multiple, autonomous organisations, perhaps

even from different sectors, in a coordinated service offering. This is especially the case in services such as construction or healthcare as they often operate in a complicated and fragmented network of various stakeholders. Service modularity, and in particular the concept of interfaces, is important in understanding how organisations can overcome the complexities of customer needs for complex services. We conclude that more research should be conducted on the topic of interfaces between organisations, especially on the role of interfaces in the case of complex service provision. By understanding interfaces in service modularity as a possible way of preventing service fragmentation that involves the emergence of new connections within and across organisational boundaries, this paper provides a bridge between service modularity research and SCM practices.

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Chapter 3. Modular service provision for heterogeneous patient groups: A single case study in chronic Down syndrome care

Abstract

Background

Service modularity could be promising for organizing healthcare delivery to heterogeneous patient groups because it enables cost reductions while also being responsive towards individual patients' needs. However, no research on the applicability of modularity in this context exists. To this end, we conducted a qualitative single-case study on chronic healthcare provision for Down syndrome patients, delivered by multidisciplinary pediatric Downteams in the Netherlands, from a modular perspective.

Methods

We conducted six semi-structured interviews with coordinators of multidisciplinary Downteams in six hospitals. In addition, we gathered data by means of observations and analysis of relevant documentation. We transcribed, coded, and analyzed the interviews utilizing the Miles and Huberman approach. The consolidated criteria for reporting qualitative research (COREQ) were applied in this study.

Results

In all six Downteams studied, the modular package for Down syndrome patients (i.e., the visit to the Downteams) could clearly be divided into modules (i.e., the separate consultations with the various professionals), and into different components (i.e., sub-elements of these consultations). These modules and components were linked by different types of customer-flow and information-flow interfaces. These interfaces allowed patients to flow smoothly through the system and allowed for information transfer, respectively.

Conclusion

Our study shows a modular perspective is applicable to analyzing chronic healthcare for a heterogeneous patient group like children with Down syndrome. The decomposition of the various Downteams into modules and components led to mutual insight into each other's professional practices, both within and across the various Downteams studied. It could be used to increase transparency of delivered care for patients and family. Moreover, it could be used to customize care provision by mixing-and-matching components. More detailed research on chronic modular care provision for patients with DS is needed to explore this.

Keywords: Service modularity; Healthcare; Interfaces; Down syndrome

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[8](#)

3.1 Background

Down syndrome (DS) is a complex congenital condition. Individuals with DS share a typical appearance, intellectual disability, and delayed motor development. However, each individual with DS is affected differently by those characteristics. In addition, many individuals with DS experience various DS-related comorbidities. Examples are problems of hearing and vision, autoimmune diseases, airway infections, and heart defects (Weijerman & de Winter, 2010). The prevalence and severity of these comorbidities vary, making patients with DS a very heterogeneous patient group, despite their common genetic background (trisomy 21).

Providing adequate healthcare and interventions in the early life of individuals with DS improves their physical and intellectual abilities (Weijerman et al., 2008; Bull, 2011). Typically, a multitude of healthcare providers is involved in the care of a child with DS (van den Driessen-Mareeuw et al., 2017). In the Netherlands, numerous pediatric outpatient clinics organize multidisciplinary team appointments (so-called “Downteams”) for children with DS, including a visit to the pediatrician, speech therapist, physiotherapist and others (van den Driessen-Mareeuw et al., 2017). These teams differ in their composition and work practices. The extent to which these differences have an influence on healthcare provision is unclear. Besides, various other external healthcare professionals and organizations deliver parts of the required healthcare. This shows the complexity of the care patients with DS have to deal with. Healthcare providers increasingly look for ways to reorganize current DS healthcare provision, while at the same time extending options for adaptation to individual needs.

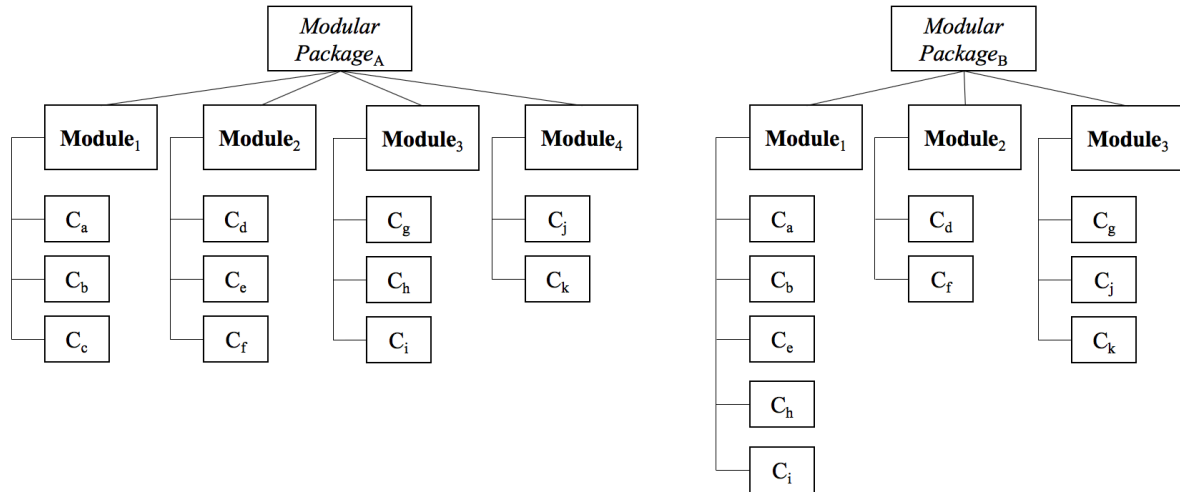
Modularity promises to relieve problems of complexity in service systems, by its ability to enable efficient customization and responsiveness to individual requirements. Modularity involves the decomposition of a product or service into modules that can be mixed and matched to individual needs, so that each patient receives an *individualized* service package (Baldwin & Clark, 1997; Schilling, 2000). Modularity has increasingly gained attention in the field of healthcare and studies have been carried out in areas such as elderly care (de Blok et al., 2010), mental care (Soffers et al., 2014) and to a lesser extent hospital care (Silander et al., 2017). We addressed the applicability of modularity in chronic DS healthcare provision as an example of complex care in a heterogeneous patient group. We studied whether the dimensions of modularity can be recognized within the service delivery for this type of healthcare, with the potential to make use of modularity theory to meet current demands for reorganization in mind.

3.2 Theoretical background

Modularity originates from the operations management domain. It is a strategy that enables organizations to (re)organize their complex products and services in an efficient way (Baldwin & Clark, 1997). Modularity concerns the decomposition of these complex products and services into independently functioning modules, each of which consist of separate components. We consider *modules* (M) as separate, relatively independent parts of a service offering with a specific function that can be offered individually, or in combination (Rajahonka, 2013). Within these modules, standardized *components* (C) can be distinguished, the smallest elements in which a service offering can be meaningfully divided (de Blok et al., 2014). The mixing-and-matching of various components is referred to as a *modular package* (MP); in healthcare, a modular package is the individualized healthcare package for a patient (de Blok et al., 2010). Such a modular package can result in an individualized service: the provided modules or components within modules can be adapted to the needs of each

individual patient, without necessarily having to change the other parts of the modular package (Figure 1).

Figure 1. Example of possible modular packages.



Interfaces are important elements of modular services; they provide interaction between modules and between components, how they fit together, and how they connect and interact within the modular package (Voss & Hsuan, 2009; Peters, Meijboom & de Vries, 2018). Interfaces play a major role as linkages in the configuration of modular service provision: they ensure the formation of a functional, coherent whole when *mixing-and-matching* the modules and the components (Baldwin & Clark, 1997). In services, one can make a distinction between two types of interfaces: information-flow and customer-flow interfaces. *Information-flow* interfaces guide the exchange of information and stimulate information transfer about the (changed) patient situation between the different modules involved in the healthcare provision. *Customer-flow* interfaces enable patients to flow smoothly through the system, which is necessary to provide continuity of care (Meyer, Jekowski & Crane, 2007). This is achieved through coordination of activities between providers, and between providers and patients (de Blok et al., 2014).

Interfaces are especially important in service settings. Elements of (healthcare) services are typically consumed at different points in time, and at different locations (Eissens-van der Laan et al., 2016). Furthermore, modular packages often need reconfiguration, for instance due to patients' changing healthcare needs. Both the service use at different times and locations, and the potential need for reconfiguration stress the necessity to align the different elements of the service, i.e. the different components and modules. Failing to do so may have serious consequences for quality of care and for the patient's quality of life (van Bilsen, 2008). Another characteristic of services is the central role of people: modules and the modular package come into being because of the interaction between service providers (i.e., healthcare professionals) and customers (i.e., patients). The people allow for smooth (re)combinations, thereby acting as interfaces themselves; they play a vital role in healthcare service provision (Voss & Hsuan, 2009).

Modularity is a relatively new concept in the field of healthcare. However, it has great potential because of its possibilities for cost reductions in combination with individualization (Vähätalo, 2012). Especially the latter is considered important. The possibility to provide

healthcare adapted to each individual can potentially contribute to a person-centered approach (Singer et al., 2011; Walker, Stewart & Grumbach, 2016). This approach, in which healthcare provision is responsive to individual patient preferences, needs, and values, is widely advocated in the Dutch healthcare system (Centraal Planbureau, 2016).

However, healthcare modularity studies are limited and are mostly conducted in the Netherlands and Finland. In the Netherlands, studies focused on elderly care (de Blok et al., 2010; de Blok et al., 2013; de Blok et al., 2014; Broekhuis, van Offenbeek & van der Laan, 2017) and mental care (Soffers et al., 2014). In Finland, studies focused on hospital services (Silander et al., 2017) and the conceptual implications of modularity in health and social services (Vähätalo, 2012; Vähätalo & Kallio, 2015). These studies showed that service modularity may increase customization and efficiency in healthcare, but evidence of these effects in hospital services remains scant. We for the first time applied modularity theory for heterogeneous patient groups in a hospital context by examining whether the dimensions of modularity can be recognized within chronic DS healthcare provision.

3.3 Methods

3.3.1 Setting of the study

In this paper, we have limited our focus to chronic DS healthcare provision for children in the Netherlands. During childhood, chronic healthcare for individuals with DS is generally coordinated by a pediatrician, preferably as coordinator of a specialized multidisciplinary Downteam (de Goor, 2011). In the Downteam, the pediatrician collaborates with different medical, paramedical and non-medical specialists (Borstlap et al., 2011). These different ‘members’ of the Downteam provide subsequent consultations for children with DS, so that they can visit multiple specialists with knowledge of their condition in one day. Healthcare provided by Downteams is generally focused on stimulating the development of the child, physically as well as mentally, and around screening for and coordinating treatment of the various potential comorbidities.

3.3.2 Study design

We carried out a qualitative, exploratory single case study to test modularity theory in chronic DS healthcare provision for children in the Netherlands. Considering that the topic of study is still in its formative stage, qualitative research in the form of a case study was conducted (Saunders, Lewis & Thornhill, 2009). Case study research enables one to understand the process, and to answer “how”, “why” and “what” questions (Yin, 2014), which are central in this study. Another advantage of this method is the opportunity to research the study topic in its real-life context (Eisenhardt, 1989; Yin, 2014); this can contribute to understanding whether a modular approach is feasible in the context of chronic healthcare provision for a heterogeneous patient group.

3.3.3 Case selection

We took the chronic healthcare provision for children with DS, provided by Downteams, as our case. This type of care serves as an example of chronic care by its wide range of healthcare professionals and largely heterogeneous patient group. Currently, there are 22 Downteams in the Netherlands (Stichting Downsyndroom, n.d.), located at different hospitals and geographically dispersed over the country. Their set-up and working methods differ from team to team. Best practices for the organization of these teams have not been identified yet; a

multidisciplinary guideline with recommendations for the content of the delivered (para)medical care is available, developed under the auspices of the Dutch Pediatric Association (Borstlap et al., 2011); the guideline forms the starting point of healthcare delivery for all Downteams in the Netherlands.

3.3.4 Data collection

We first collected relevant documents of all 22 Downteams in the Netherlands. We aimed to select a range of Downteams varying in working methods and geographic locations in order to select a representative set of participating Downteams. Based on this aim, the availability of Downteams and by using information from the collected documents, we deliberately selected six out of the 22 Downteams to include in our research. These six Downteams are well-known in the field and provide a good representation of all Downteams in the Netherlands. They were chosen carefully, so that they demonstrated variety in their set-up, working methods and geographic location, leading to a comprehensive view on chronic Down syndrome care. We contacted these six Downteams in writing and by telephone. For these Downteams, we conducted observations and interviews in addition to the documents we collected. The data retrieved from the six Downteams was sufficient for our goal to explore the applicability of modularity principles. The remainder of this section is based on the order in which we retrieved the types of data.

3.3.4.1 Documentation

We collected relevant documentation that was open to the public (e.g., online information brochures on the Downteams, national guideline (Borstlap et al., 2011), and internal documentation of the Downteams (e.g., planning schemes, medical protocols). The collected documents gave valuable information in terms of the set-up and working methods of the Downteam. Hence, documents were assessed first, so that observations and interviews could focus on clarification of the working methods of Downteams and on more detailed topics, such as possibilities for individualization.

3.3.4.2 Observations

In total, two researchers (LF & VP) conducted six observations which lasted half a day, one at each Downteam during consultations of children with DS. We followed a patient at each of his/her (consecutive) consultations (e.g., consultation with pediatrician, consultation with speech therapist). This allowed us to get a better understanding of the care provision. We received oral approval from parents of children with DS and healthcare professionals prior to our observations. The observations were unstructured and focused on the question “*Which dimensions of modularity can be recognized within the service delivery of this Downteam?*”, with the observer as participant. Our aim was to play a neutral role as much as possible. This was appropriate because this type of observation allows the researcher to completely focus on the research and take notes immediately (Saunders et al., 2009). During those observations, the observer made field notes and theoretical memos that allowed us to summarize the data and collect potential interpretations and relations.

3.3.4.3 Interviews

Interviewees were selected using purposive sampling. We conducted interviews with coordinators (in all cases the pediatrician) from the six selected Downteams. The potential

participating coordinators were, prior to the interview, contacted in writing and by telephone. We deliberately chose to interview the coordinators of these Downteams as they had expertise and experience in the field of chronic healthcare provision for children with DS and knowledge on the set-up and working methods of the respective Downteams.

Generally, reaching saturation, meaning new interviews do not yield new data on the interview topics, is considered sufficient for validity (Saunders & Townsend, 2016). In the case of exploratory studies, a limited amount of interviews can be sufficient (Guest, Bunce & Johnson, 2006) in order to get a reliable sense of thematic exhaustion and variability within our data set. In our study, data saturation happened after six interviews, as no new themes emerged from the data gathered between interview five and interview six.

The interviews were semi-structured and lasted approximately 30 minutes. This was sufficient, as the interviews mostly appeared to confirm the information obtained during document analyses and observations of the Downteams. The semi-structured nature of the interviews allowed us to make sure that important topics were addressed while leaving room for the interviewees to tell their story (Saunders et al., 2009). In the case that a respondent said something interesting and relevant to our study objective, or the respondent's answer to our question was not clear, we asked the respondent to clarify the answer. The topic list for the interviews was compiled based on a literature review on (healthcare) modularity and on the collected documentation. See Supplementary file 1 for the overview of our complete topic list. Because the interviewees were not familiar with the vocabulary of modularity, the wording of questions was adapted to topics relevant to healthcare provision by Downteams. For example, we asked, "*What consultations does the Downteam offer?*" instead of "*Which modules can be distinguished in the Downteam?*" in order to get acknowledged with the specific type of healthcare. In addition, a question like "*To what extent is healthcare provision adapted to the specific patient?*" helped us to check for possibilities of individualization. Interviews were audio-recorded and transcribed.

3.3.5 Data analysis

The final data consisted of documentation, theoretical memos from the observations and transcripts of the interviews, which we integrated in our analysis. A thematic analysis of the content was carried out using the three steps method described by Miles and Huberman (1994): 1) data reduction; 2) data display, and 3) drawing conclusions/verification. This is a systematic data reduction process building on the reading of transcripts, document summaries and observation notes, segmentation of sentences and phrases, codification of text segments, generation of themes and categories, and identification of relationships (Miles & Huberman, 1994). The thematic analysis was guided by our preliminary coding framework and based on definitions derived from modularity literature (See Supplementary file 2) (Voss, Tsikriktsis & Frohlich, 2002). Those initial deductive codes were useful in the segmentation and early coding phase of the data analysis. By combining the information from the interviews, observations and document analysis with the theoretical framework, we applied a modular view to the data retrieved. For instance: when the interviewee had mentioned that a consultation with a physiotherapist was also offered independently from the Downteam, we considered this part of the service delivery as a module, as per our definition of modules. The applied framework was continuously discussed and tested during the coding of the interviews (Voss et al., 2002). Text segments were compared and contrasted, and codes were assigned. During the analytical phase, all authors of this paper had frequent contact and discussed and

assessed the outcomes of the analysis. For example, sometimes it was unclear whether a text segment could be related to the code 'module' or the code 'component'. In order to solve these issues, we used guiding criteria (e.g., what is the respective role of an element in care provision) to determine which text segments belong to a module and belong to a component (Dörbecker & Böhmman, 2015). Next, data were displayed and compared using data displays (see Results section) that proved useful to see patterns in the collected data. For instance: we collected all the available guidelines for each Downteam in a chart. This helped us to see what is happening and provided opportunities to gain additional in-depth understanding of the data in a convenient way (Voss et al., 2002). Based on those displays, a comparison with existing literature was made and conclusions were drawn.

3.3.6 Quality of the research

To assure internal validity, various measures were taken. First, the concept of modularity and the purpose of the study were extensively explained at the beginning of each interview. As such, interviewees were assisted to provide information relevant towards the goal of the research, increasing the internal validity of the study (Saunders et al., 2009). Second, the transcripts of the interviews and field notes of the observations were returned to the respondents and we received no comments or corrections. This increased validity because our data was checked by the respondents from whom the data were originally obtained. Third, cross-verification was achieved by using multiple methods (documents, observations and interviews) to analyze the same topic. In that way, different aspects of the topic could be retrieved, hence increasing the validity (Yin, 2014). Last, reaching data saturation increased the validity of our study (Guest et al., 2006). LF and VP determined that this happened after six interviews, because the new interview did not yield new results or adaptations to our coding scheme. With respect to reliability, several measures were taken. First, the COREQ criteria list for qualitative research (Tong, Sainsbury & Craig, 2007) was used to guide our analysis that was inspired by Miles and Huberman (1994). In doing this, we constantly moved back and forth within the data, the coded extracts of data that we analyzed and the analysis of the data we produced (See Supplementary file 3 for the complete list). Second, all interviews were conducted in the same manner, by the same person (LF). Moreover, the confidentiality of the information provided by the interviewees was assured at the beginning of the interview. This was done in order to let the interviewee feel at ease and create a comfortable atmosphere. Last, we made use of peer review to assess the quality of our findings (Creswell & Miller, 2000): another researcher (VP) analyzed the data independently. The coding results were almost identical, discrepancies were resolved based on the discussion of the researchers. These measures were aimed at decreasing the observer error, and hence increasing the external validity (Saunders et al., 2009).

3.4 Results

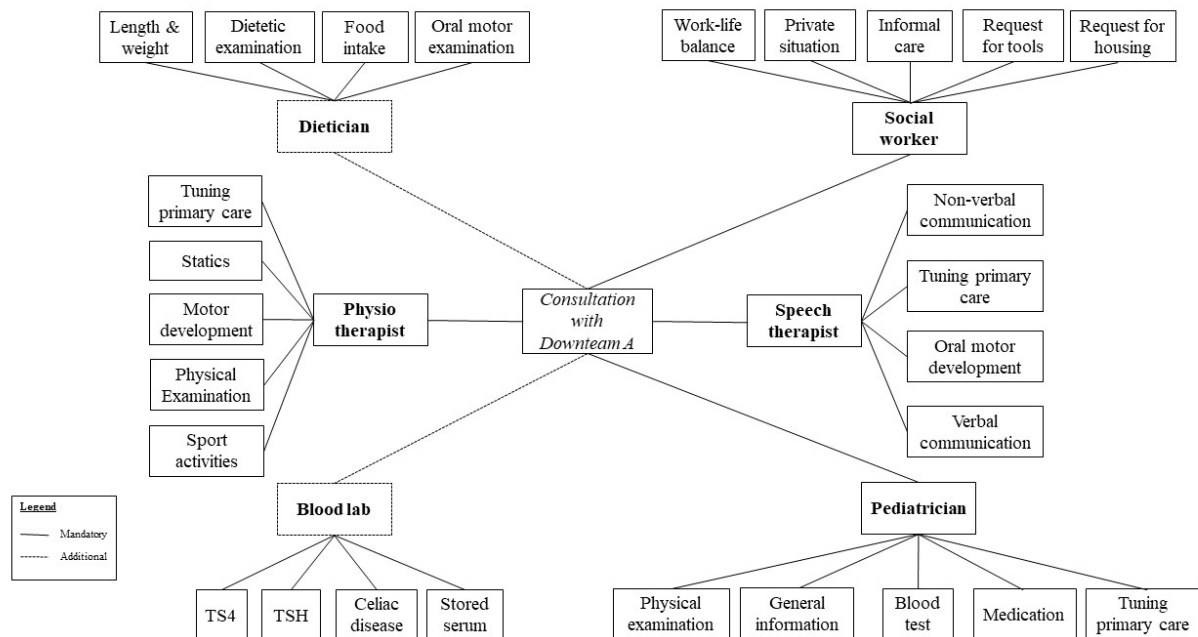
During a visit to the Downteam, the patient with DS subsequently meets various (para)medical specialists belonging to the Downteam, within one given part of the day. All Downteams offered a range of consultations from different healthcare professionals to each patient. The teams varied in the duration of the consultations (ranging from 15 to 45 minutes), the number (ranging from four to eight) as well as the profession of participating healthcare professionals. In three Downteams (A, B & C), all patients visited the same professionals; in the remaining three Downteams (D, E & F) each patient had one or two mandatory

consultations with professionals, complemented with consultations with professionals depending on their current needs. Interestingly, the interviewees mentioned that they were not aware of the observed differences between Downteams. They assumed that each Downteam was organized in the same way. Supplementary file 4 provides a description of the set-up of the participating Downteams.

3.4.1 Recognizing modularity in the Downteams' service provision

Based on the information from the documentation, observations and interviews, we were able to describe practices executed by Downteams in modular terms, using the definitions and coding of the text fragments, theoretical memos and documentation as basis. From a modular perspective, the combined consultations of one visit to the Downteam can be seen as the *modular package*, i.e. the healthcare package that each patient with DS visiting the Downteam is provided with. Within this package, the separate consultations with the various healthcare providers form the *modules*. They are indeed independent, as they can also be offered separate from the Downteam. *Components* are elements of the healthcare delivery that have a function on their own but cannot function independently: they are offered as part of the module, in this case, the consultation. The components are based on, for instance, national guidelines set by the Dutch Pediatric Association (Borstlap et al., 2011), but can also be based on the Downteam members' own insights. Examples are 'physical examination', 'oral motor development', and 'blood test'. The Downteams studied offered 4 to 8 different modules, wherein various components could be distinguished (a complete picture to illustrate this is shown for Downteam A in Figure 2; a detailed description of all Downteams is shown in Supplementary file 4). The content of the components is omitted in Figure 2, but can be found in Supplementary file 5.

Figure 2. Graphical presentation of a modular package delivered by Downteam A.

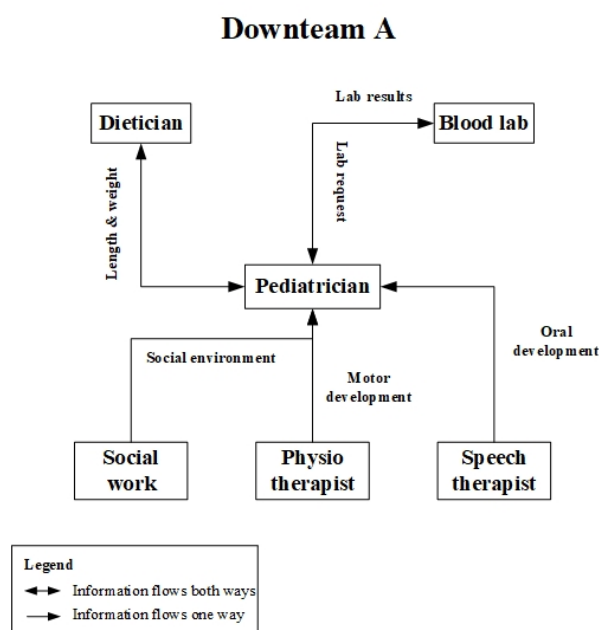


3.4.2 Interfaces within Downteams

We found several communication mechanisms that connected the modules (i.e., the different consultations). From a modular perspective, these various ways of communication and connection between the modules can be considered as interfaces. In the Downteams, the planning scheme leading to a convenient order of the modules and the consultation scheme for a particular day are clear examples of customer-flow interfaces. In some Downteams, a letter was sent to patients with DS prior to the visit, asking the parents or relatives of the patient with DS to indicate their preferences with regard to the consultations. By means of this interface, the modular packages were customized to meet the needs of individual patients, guided by professional judgment in the selection of the appropriate modules and components.

The majority of identified interfaces contributed to information-flow in the modular package. They helped to manage the interaction between the service providers involved in the modular package. Regular multidisciplinary discussion, shared electronic health record (EHR) reports, care plans, direct communication lines and a summarizing letter are clear examples of information-flow interfaces. For example, the shared EHR ensures that the different professionals of the Downteam can read the information reported by other members. The other two interfaces that we observed, a clearly stated work schedule and work protocol, are internal arrangements that allow for predictable interactions between professionals, based on a clear specification of tasks and responsibilities. Figure 3 shows an example of observed communication lines and relevant information that is being shared through these interfaces. The communication lines illustrate the interdependency of the professionals involved in the multidisciplinary setting of DS healthcare provision. For example, the length and weight of the patient is exchanged between the pediatrician and the dietician; it serves as input for general health and growth assessment for the pediatrician, and as input for the analysis of the nutritional status for the dietician.

Figure 3. Sample of various communication lines between modules of the modular package of Downteam A.



3.5 Discussion

Our study shows a modular perspective is applicable to analyzing chronic healthcare for a heterogeneous patient group. The modular perspective enabled us to decompose the complex healthcare in the observed Downteams into modules, components and interfaces, and to perform a comparative analysis between these teams, even though they differed considerably. This decomposition creates possibilities to mix-and-match standardized components in order to create individualized modular packages. This implies that every patient can be offered a different combination of components and thus each is treated as unique (de Blok et al., 2010). In this way, modularity could create a customized service from standardized components. As such, modularity could potentially support person-centered care provision.

Strikingly, the coordinators and other service providers were hardly aware of the different ways in which their and other Downteams are organized. We observed this when we returned our transcripts and results to the interviewees to check for accuracy and resonance with their experiences (Birt et al., 2016). Beforehand, they had expected identical results per case, based on the guidelines provided by the Dutch Pediatric Association (Borstlap et al., 2011). The differences we observed were very insightful for them, because the decomposition of the various Downteams into modules and components led to mutual insight into each other's work practices, both within and across the Downteams we studied. This triggered plans to evaluate and consider restructuring their Downteam, as best practices from other Downteams as well as overlaps and gaps regarding the delivered components within their own team became apparent to every service provider. The modular perspective also increased awareness of the challenges involved in delivering such a complex service: the service providers were not aware of the diversity in interfaces through which the relevant patient information was exchanged.

The modular perspective can also provide transparency to patients and caretakers: it becomes easier to understand the overall healthcare delivery, and where they can best ask their questions. If this perspective is offered to them by means of e.g. a communication map, they can prepare their visit to the Downteam even better.

3.5.1 Implications for future research

Our exploratory study has some limitations. First, we focused on chronic DS healthcare provision for children in the Netherlands. More studies in other complex care contexts and other countries are needed to assess the external validity of our results.

Second, we only interviewed the coordinators of the Downteams. The remaining involved healthcare professionals (e.g., speech therapist, physiotherapist), patients and their caretakers might have provided additional relevant information into the modular perspective on chronic DS healthcare provision. This could lead to a more comprehensive modular view on this type of complex care. A follow-up study could address this.

Last, we observed a great variety of interfaces in the chronic healthcare provision for patients with DS. This is an important observation to explore further, as a tight fit between the complementary components and the professionals involved will prevent gaps as well as duplications in service provision. This tight fit is achieved through interfaces (Peters et al., 2018). Our study has paved the way for more research on this topic, especially on how their dynamics influence care provision.

3.6 Conclusions

In conclusion, we examined whether the dimensions of modularity, a concept from the field of operations management, could be recognized within chronic healthcare service delivery in a heterogeneous patient group (in our case: for children with DS). This was the case: a modular perspective enabled decomposition of the complex healthcare delivered by Downteams into modules and components which could be compared between different Downteams. In this way, this study serves as a first exploration of modularity for a heterogeneous patient group. Future research is needed to assess further potential to individualize care for each patient while also properly linking and aligning interfaces.

List of abbreviations

DS Down syndrome

EHR Electronic health record

Declarations

Ethics approval and consent to participate

The study protocol was discussed within the research team and it was checked with the Ethics Review Board of the School of Social and Behavioral Sciences of Tilburg University whether Medical Research Involving Human Subjects approval from a Medical Ethics Committee was necessary. The Ethics Review Board determined that this was not the case for this study and that further ethics approval was not required. All respondents were informed about the study and their rights as participants in scientific research. We asked for oral approval, which we received from all respondents (written approval was not considered mandatory by the University Ethics Board).

Consent for publication

Not applicable.

Availability of data and material

The datasets generated and analyzed during the current study are not publicly available due to confidentiality but are available from the corresponding author on reasonable request. The data are stored on the secure server of Tilburg University. This server is automatically backed up every 24 hours. Backups are stored for two weeks.

Competing interests

No potential conflict of interest was reported by the author(s).

Funding

Not applicable.

Authors' contribution

LF designed the study, searched literature, collected, coded and analyzed data and drafted the manuscript. VP designed the study, searched literature, collected, coded and analyzed data and drafted the manuscript. BM and EV initiated the study, guided, supervised and approved the (development of the) study design, supervised coding and data analysis and critically

reviewed, edited and revised the manuscript. All authors agreed to be accountable for all aspects of the work and read and approved the final version of the manuscript before submission.

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Chapter 4. Providing person-centered care for patients with complex healthcare needs: A qualitative study

Abstract

Background

People with chronic conditions have complex healthcare needs that lead to challenges for adequate healthcare provision. Current healthcare services do not always respond adequately to their needs. A modular perspective, in particular providing visualization of the modular service architecture, is promising for improving the responsiveness of healthcare services to the complex healthcare needs of people with chronic conditions. The modular service architecture provides a comprehensive representation of the components and modules of healthcare provision. In this study, we explore this further in a qualitative multiple case study on healthcare provision for children with Down syndrome in the Netherlands.

Methods

Data collection for four cases involved 53 semi-structured interviews with healthcare professionals and 21 semi-structured interviews with patients (the parents of children with Down syndrome as proxy). In addition, we gathered data by means of practice observations and analysis of relevant documents. The interviews were audio-recorded, transcribed verbatim and analyzed utilizing the Miles and Huberman approach.

Results

Our study shows that the perspectives on healthcare provision of professionals and patients differ substantially. The visualization of the modular service architecture that was based on the healthcare professionals' perspective provided a complete representation based on (para)medical outcomes relevant to the professionals' own discipline. In contrast, the modular service architecture based on the patients' perspective, which we define as a person-centered modular service architecture, provided a representation of the healthcare service that was primarily based on functional outcomes and the overall wellbeing of the patients.

Conclusion

Our study shows that visualization of the modular service architecture can be a useful tool to better address the complex needs and requirements of people with a chronic condition. We suggest that a person-centered modular service architecture that focuses on functional outcomes and overall wellbeing, enables increased responsiveness of healthcare services to people with complex healthcare needs and provision of truly person-centered care.

Keywords: Complex healthcare needs; Modular service architecture; Person-centered care; Down syndrome; Qualitative research

4.1 Background

An increasing number of people are living with complex healthcare needs resulting from multiple chronic conditions (van der Heide et al., 2018; Kuipers, Cramm & Nieboer, 2019). This increase poses a challenge to adequate healthcare provision. Most healthcare services continue to focus predominantly on single diseases or prioritize medically oriented care (medical outcomes) over socially oriented care (functional outcomes). As a result, these healthcare services do not adequately respond to the complex healthcare needs of people with chronic conditions; current healthcare provision is not optimally tailored to their needs (van der Heide et al., 2018; Fransen et al., 2019). Also from a societal perspective, it is important that healthcare services become more responsive to the complex needs and requirements of these people.

Down syndrome (DS), also known as trisomy 21, is the most common form of intellectual disability among newborn infants. At different ages, a variety of physical problems can arise and necessitate screening, prevention, and treatment (Skotko, Davidson & Weintraub, 2013; Haddad et al., 2018; Kinnear et al., 2018). The different health professions most frequently involved are pediatrics (celiac disease, growth, hypothyroidism, leukemia), cardiology (congenital heart defects), optometrist and ophthalmologist (visual acuity and squint), ENT-physician (chronic ear infections, hearing defect, and sleep apnea), orthopedics (hip dysplasia and dislocation), speech therapy (speech delay and disturbed oral motor function), dietetics (obesity and malnutrition), and physiotherapy (motor retardation and screening of development) (Weijerman & de Winter, 2010; Bull, 2011). Although each separate clinical problem is well known, it is the personal tailoring of the screening, prevention and treatment in a patient with DS which makes the organization and delivery of person-centered care complex.

The complexity of healthcare services, an example of knowledge-intensive professional services, stems from multiplicity and diversity in their service offering (von Nordenflyght, 2010; Lewis & Brown, 2012; Zou, Brax & Rajala, 2018). Multiplicity refers to the growing number of involved providers, components and interactions in service provision (Kreye, Roehrich & Lewis, 2015; Zou et al., 2018) and is demonstrated by the various professionals, from different units or departments, who deliver a high number of components for the treatment of patients with complex healthcare needs. This highly professionalized workforce needs to collaborate, something that could contradict the professional autonomy of the professionals (von Nordenflyght, 2010; Silander et al., 2017) and, consequently, increase the complexity of healthcare services. Diversity refers to the growing variety of providers, components and interactions that are required to fulfill diversified patient needs (Zou et al., 2018). Each patient has an individual constellation and combination of health problems which implies that multiple professionals are required to address these health problems. In addition, the steep information asymmetry between professionals and patients, a characteristic that is inherent in knowledge-intensive professional services (von Nordenflyght, 2010), can result in ambiguously expressed healthcare needs and increases the complexity of healthcare services.

An approach based on service modularity, a concept from the operations management domain, has the potential to reduce service complexity and increase responsiveness to complex healthcare needs (Baldwin & Clark, 1997). Service modularity involves the decomposition of a complex service into modules and components. Modules are independent parts of a service with a specific function that can be offered individually, or in combination (Rajahonka, 2013). Within these modules, standardized components can be distinguished.

These are the smallest elements in which a service can be meaningfully divided (de Blok et al., 2014). The decomposition of a complex service into modules and components is captured in the modular service architecture (MSA) and is defined as “the way that the functionalities of the service system are decomposed into individual functional elements to provide the overall services delivered by the system” (Voss & Hsuan, 2009, p. 546). The MSA is an intelligible visualization of all modules and components of a service and provides a comprehensive modular representation of a service offering (Voss & Hsuan, 2009). It allows for the mixing-and-matching principle of modularity: (re)combining components and modules to create individualized modular packages. This principle ensures that each customer can be offered a selection of components and is treated as unique (de Blok et al., 2010; Fransen et al., 2019). As a result, services can be optimally tailored to the needs and preferences of individual customers.

Despite the potential of MSA to provide services that are responsive to the complex needs and requirements of customers, empirical evidence on the application of MSA is rare (Brax et al., 2017). Although previous research provides examples of modular decomposition of healthcare services such as home care for the elderly (de Blok et al., 2010), residential mental healthcare (Soffers et al., 2014) and cancer care (Gobbi & Hsuan, 2012), these studies do not provide the complete MSA of these healthcare services. This results in an incomplete representation of the service offering and limits the potential of MSA to mix-and-match components and create truly individualized modular packages for each patient. Since only a few studies have addressed the applicability of MSA in complex services (Bask, Merisalo-Rantanen & Tuunanen, 2014; Broekhuis, van Offenbeek & van der Laan, 2017; Silander et al., 2017), there is still ambiguity around how to decompose a service offering into components and how to determine which of these components, alone or together, can be assigned as modules (Salvador, Forza & Rungtusanatham, 2002; Eissens-van der Laan et al., 2016; Bartels et al., 2020). Dörbecker & Böhmann (2015) have developed questions that can guide the identification of components and modules for the creation of MSA, but these are only applied to a limited extent (Fransen et al., 2019). In addition, the few studies that do address the applicability of MSA are traditionally conducted from the professional’s perspective (Bask et al., 2014; Broekhuis et al., 2017; Silander et al., 2017), which is surprising given the indispensable involvement of the customer in service provision (Cook et al., 2002; Lewis & Brown, 2012; Kreye et al., 2015).

In healthcare, the professional’s perspective mainly reflects the provision of healthcare services aimed at improving medical outcomes (Broekhuis et al., 2017; Silander et al., 2017; van der Heide et al., 2018) and does not respond to the individual situations of people with complex healthcare needs. As a result, care is often not optimally tailored to their needs. The medical outcomes are often not the most relevant from a patient’s perspective; patients often attach greater value to functional outcomes and overall wellbeing (van der Heide et al., 2018; Kuipers et al., 2019). However, it is increasingly acknowledged that insight into the patient’s perspective is becoming more important, especially for tailoring care to the needs and preferences of patients (Phelps et al., 2012; van der Heide et al., 2018; Kuipers et al., 2019), quality of care (Minnes & Steiner, 2009; van den Driessen Mareeuw et al., 2020), and coordination of care (Miller et al., 2009; Singer et al., 2011). These are all considered essential elements of person-centered care (Häkansson Eklund et al., 2019). Our aim is therefore twofold. First, we provide the complete modular service architecture of healthcare provision for people with complex healthcare needs. This allows for the creation of

individualized modular healthcare packages and supports the provision of person-centered care. Second, we provide insight into the patient's perspective on MSA and explore how their perspective can support the provision of person-centered care. By doing so, we respond to the call for further empirical study on the application of MSA (Brax et al., 2017) and the call for more insight into the patients' perspective on complex (modular) healthcare services (Brax et al., 2017; Håkansson Eklund et al., 2019; Bartels et al., 2020).

We address these gaps in a multiple case study where we explore the applicability of MSA in healthcare provision for people with complex healthcare needs. We explore this from the perspective of patients as well as from that of the healthcare professionals. We used chronic healthcare for children with DS as an example, and focused on the question whether MSA can support the provision of person-centered care.

4.2 Methods

4.2.1 Ethical considerations

Ethical approval for this study was obtained from the Ethics Review Board of Tilburg University [EC-2017.60t]. Written informed consent was obtained prior to participation from all participants (the professionals and the parents of the children with DS).

4.2.2 Study design

We carried out a qualitative multiple case study to explore the applicability of MSA in chronic healthcare provision. A multiple case study design was chosen because this enabled us to explore differences within as well as across cases (Yin, 2014). The consolidated criteria for reporting qualitative research (COREQ) (Tong, Sainsbury & Craig, 2007) were used as guideline for the study design and the data analysis (S1 File).

4.2.3 Context

In the Netherlands, pediatric outpatient clinics organize multidisciplinary team appointments for children with DS, including a visit to medical, paramedical, and non-medical specialists, all on the same day (van den Driessen Mareeuw et al., 2017). These teams are called Downteams. We aimed to achieve a range of available Downteams in the Netherlands that vary in their composition and working methods in order to achieve a representative set of Downteams. We used purposive sampling logic and carefully selected four out of the 22 Downteams in the Netherlands (Stichting Downsyndroom, n.d.) to include in our research. These four Downteams are well-known in the field and demonstrate variety in their composition, working methods and geographic location, resulting in a comprehensive view on chronic healthcare for children with DS. As such, they provided a good representation of all Downteams in the Netherlands.

4.2.4 Participants

Recruitment of participants was carried out by the coordinators (the pediatricians) of the Downteams based on purposive sampling logic. In the summer of 2017, using e-mail, face-to-face requests, and telephone, they invited all the healthcare professionals in their Downteam and potentially interested parents of children with DS. The parents of the children with DS were considered as proxy for the children with DS (hereafter referred to as 'patients'); this is common practice in pediatric research, especially in children with intellectual disability (Eiser & Varni, 2013). The e-mail included an invitation with a detailed explanation of the study.

The potential participants were given as much time as needed to consider whether they wished to participate and, in the case of a positive decision, were asked to reply to the pediatrician and give consent for their contact details to be disclosed to the first author who then contacted the participants and scheduled the interviews. In total, 74 people agreed to participate; six people refused to participate due to time constraints (two professionals, four patients).

4.2.5 Data collection

The data were collected by researcher VP through semi-structured interviews, observations and collecting documentation. From September 2017 until January 2018, 53 healthcare professionals and 21 patients were interviewed, each interview lasting from 45 to 75 minutes (Table 1). No significant changes in the health system or in staffing during the data collection period occurred. The interview questions were made up of a range of open-ended questions which aimed at an understanding of which healthcare elements were provided by each respective healthcare professional and helped us to acquire information on the patient's perspective on healthcare provision (S2 File). The same topics were discussed with both healthcare professionals and patients; questions were adapted to the perspective of the participant. Interviews were audio recorded and transcribed verbatim in a Word document. Data saturation was met after 65 interviews; however, for the sake of completeness the researchers agreed to perform the remaining scheduled interviews. Participants were asked to review their own transcript to improve the reliability of our interpretations; they provided additional information through follow-up emails.

Researcher VP also conducted 12 unstructured practice observations, three at each Downteam. Each observation lasted half a day and took place during a consultation of children with DS at a Downteam. Researcher VP followed a child with DS and their parents at each of their (consecutive) consultations (e.g., consultation with pediatrician, consultation with physiotherapist). This allowed us to get a better understanding of the daily practice of care provision. The observations focused on the questions "*What elements of healthcare does the healthcare professional provide during the consultation and are there opportunities for patient input during healthcare provision?*" Researcher VP made field notes and theoretical memos which helped to understand potential interpretations of the observations.

Last, researcher VP collected relevant documentation that was available both externally (e.g., national guideline (Borstlap et al., 2011), folders containing information about the Downteam) and internally (e.g., planning schemes, minutes from multidisciplinary meetings).

4.2.6 Data analysis

The final data consisted of transcripts of the interviews, field notes and theoretical memos from the observations and documentation. The different types of data were complementary to each other: interviews helped us to acquire information on the professional's and patient's perspective on care provision, observations allowed us to get a better impression of the daily practice of care provision, and the documents collected gave valuable information with regard to the composition and working methods of the Downteams. The data analysis was conducted in two stages: within-case and cross-case (Barratt, Choi & Li, 2011). A thematic analysis of the content was carried out, using the three steps method described by Miles and Huberman (2014): 1) data reduction; 2) data display, and 3) drawing conclusions.

Table 1. Study participants.

Case A	Case B	Case C	Case D
Dietician	Dietician	Audiology assistant	Child psychologist
Doctor for the mentally handicapped (2x)	Doctor for the mentally handicapped	Contact parent	Doctor for the mentally handicapped
ENT-doctor (2x)	ENT-doctor	Dietician	ENT-doctor
Ophthalmologist	Medical social worker	Doctor for the mentally handicapped	Occupational therapist
Parent (6x)	Ophthalmologist	ENT-doctor	Ophthalmologist
Pediatrician (2x)	Orthoptist	Orthoptist	Parent (5x)
Physiotherapist (2x)	Parent (5x)	Ophthalmologist	Pediatrician
Secretary	Pediatrician (2x)	Parent (4x)	Physiotherapist
Social worker	Physiotherapist	Pediatrician	Preverbal speech therapist
Speech therapist (2x)	Secretary	Physiotherapist	Secretary
	Specialized nurse	Secretary	Speech therapist
	Speech therapist	Speech therapist	
	Rehabilitation doctor	Social worker	
	Youth healthcare physician		

The participants did not express themselves in modularity terms, but instead we used modularity as a perspective that guided interpretation of the data. By combining the information from the interviews, observations and documentation, we were able to describe and interpret the practices provided by healthcare professionals in modular terms. For example: we used the national guideline (Borstlap et al., 2011) to assign distinct parts of the consultation from each individual professional as modules, as per our definition of modules (Rajahonka, 2013). The transcripts, field notes and theoretical memos were then used to corroborate the parts assigned as modules. We used guiding questions (e.g., for what are the modules used?, who will use these modules?) (Dörbecker & Böhmman, 2015) to validate our interpretation of modules. If this differed from our interpretation, we reconsidered how the modules had been assigned. As a result, we went back and forth with all the collected data. We returned to our participants to prevent potential errors of interpretation (Birt et al., 2016). The participants recognized the modular perspective in their way of working. Analysis began with the coding of three interviews by one researcher (VP) using the initial coding scheme that was developed based on theoretical constructs. The codes were discussed among three researchers (VP, BM and EV). For the next ten interviews, two researchers (VP and BM) coded the interviews independently and then compared and discussed their codes. During this process, initial codes were altered and new codes were added. The three researchers (VP, BM and EV) discussed and assessed the outcomes of the coding until consensus was reached. The remaining interviews were then coded by one researcher (VP) using the final version of the coding scheme. The quotes from interviewees resulting from the analysis are presented in the text of the Results section; we illustrate the modular perspective in the quotes in square brackets.

4.3 Results

4.3.1 Within-case analysis

We created detailed descriptions for each of the four cases. Based on the information from the interviews, observations, and documentation, we described in modular terms the practices undertaken by the healthcare professionals in the four Downteams, using our coding of the text fragments as a basis. We assigned the distinct parts of the consultations from the various individual professionals as modules (e.g., Dietetic examination, Language production). The professionals explained that each module has specific meaning for their consultation and is based on the national DS guideline developed by the Dutch Pediatric Association (Borstlap et al., 2011).

“The healthcare parts [modules] I offer have specific meaning for the child and his/her parents: disorders, wellbeing and development.” (Pediatrician A)

“My consultation is based on the national DS guideline and my discipline specific protocol. Those are the parts [modules] I offer during my timeslot.” (Physiotherapist B)

We identified the components of the care currently provided by the professionals as elements of healthcare provision belonging to a certain module (e.g., Oral motor examination as an element of the module Dietetic examination, Analysis of used gestures as an element of the module Language production). These components are based on guidelines, protocols, and screening forms used in healthcare provision. For example, the ENT-doctor always evaluates the throat (a module on its own) but does not provide all of the components potentially belonging to that module.

“I do the mandatory screening for these children [with DS]. I do not have many options for mixing care parts [modules] related to my consultation, but sometimes I can leave out a small element [component] of the consultation.” (ENT-doctor A)

“Based on my screening form, I know which elements [components] belong to a specific care part [module] of my consultation. For example, if a patient suffers from celiac disease [module], certain elements [components] belong to that specific care part [module].” (Dietician C)

Having allocated the different aspects of the professionals' work, it turned out that different individual modules contained identical components. Since the content of their healthcare provision was not prescribed in detail for each professional, different professionals ended up doing the same thing. For example, overlap occurred when two professionals both measured the height and weight of a patient and the professionals were not aware of this duplication. Also, at times professionals were under the impression that their colleagues were dealing with issues related to food and drink, for example. When these professionals met after their respective consultations, it turned out that none had dealt with those issues, with a resultant gap in healthcare provision. The MSA approach can assist in identifying overlaps and gaps in healthcare provision. Both professionals and patients expressed the need for this:

“It would be great to remove duplicate elements [components] of our consultations. But I am not fully aware of what the other healthcare professionals do. In order to remove

something [components] from my consultation, I need that insight. Otherwise those elements [components] might be missing.” (Physiotherapist D)

“We are used to discipline-oriented working, I hardly know what my colleagues are doing.” (Physiotherapist A)

“I am not aware of what, for example, a speech therapist can offer me during a consultation. And I am not the only parent facing this problem.” (Parent B)

“[...] It would be great to have some kind of overview of what we can expect from the Downteam [...]” (Parent C)

We constructed the MSA visualizations based on the identified modules and components of each case. To illustrate this, the MSA of case A is shown in Fig 1. The MSAs of the other three cases are presented in S1 Fig.

Although the healthcare professionals did not express themselves in modular terms, they could recognize their way of working when presented with the MSA visualization. The MSAs based on the perspective of the healthcare professionals working in each Downteam show that the professionals are mainly focused on (para)medical conditions relevant to their own discipline. This led to consultations that are focused on (para)medical outcomes. This is not always the most relevant approach from the patients’ perspective, as explained below.

4.3.2 Cross-case analysis

For the cross-case analysis, we combined the detailed descriptions from each of the four cases. In each case, patients argued that current healthcare provision did not fully reflect their needs and requirements. The patients actually attached greater value to functional outcomes and overall wellbeing as opposed to (para)medical outcomes.

“[...] I don’t care which medication my child needs, I want him to get better and perform to the maximum of his capacity [...]” (Parent C)

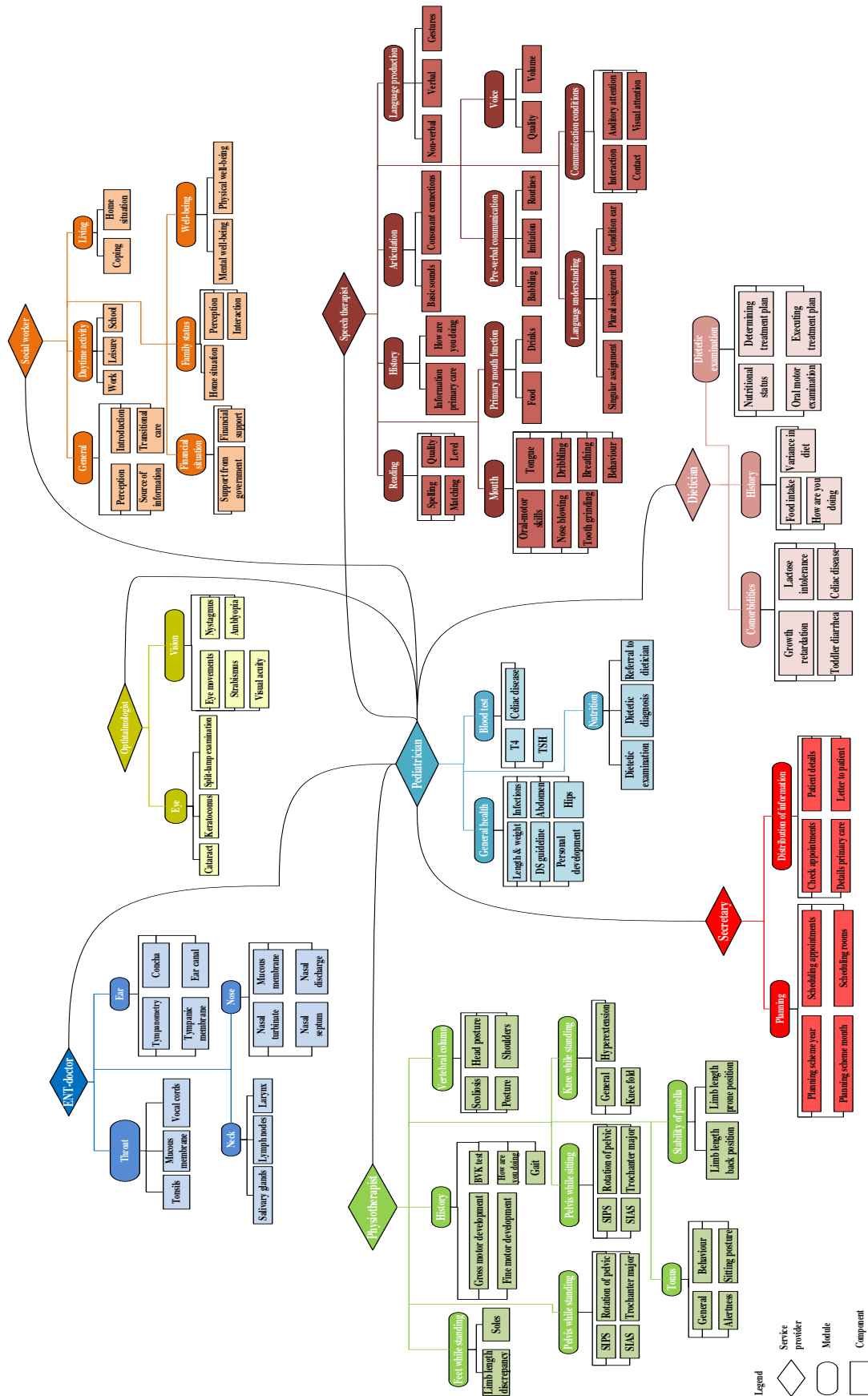
“The consultations are often not in line with what I require for my child. I do not know where to ask questions about eating and drinking.” (Parent A)

“Sometimes I leave the Downteam and I still do not have the answers to my questions, as I did not know where to ask them.” (Parent A)

“I do not understand why I always need to visit all the disciplines in the team. If my child has no problems related to the physiotherapist, why should we visit him? If I am not sick, I don’t go to a general practitioner!” (Parent B)

Therefore, we returned to our initial participants with the idea of presenting healthcare provision from the patients’ perspective. We used the MSAs that were built from the healthcare professionals’ perspective (Fig 1 and S1 Fig) as our starting point. The modules and components were reshaped in a way that reflected the intended patient needs i.e. functional outcomes and overall wellbeing. For instance, we suggested ‘Participating in society’ instead of ‘Activities of daily living’ and ‘Getting rid of complaints’ instead of ‘Medical examination’.

Figure 1. Modular service architecture based on the healthcare professionals' perspective: Case A.



Interestingly, we observed a clear difference between the medical specialists and the other healthcare professionals. Paramedical specialists, non-medical specialists and patients were very enthusiastic about this approach. In particular, patients stressed that the reshaping might look like a minor difference, but that this was crucial for engaging in meaningful conversations with the healthcare professionals. It reflected the patients' actual needs and requirements.

“Framing healthcare [modules and components] in a patient-centered way is mainly a different way of thinking, and does not necessarily change my way of working. If this is what patients want, I believe this is what we should offer.” (Speech therapist C)

“[...] this way of reframing healthcare for our child is fully recognizable and appealing [...]” (Parent A)

“This [person-centered approach] feels like we [parents] are being heard. Finally, we are not talking about what type of therapies my child needs, but what he is capable of.” (Parent C)

The medical specialists were more reluctant. They expressed their concern about parents' capacity to know what is important to screen, because many problems are not easy to recognize based only on their symptomatology in DS.

“An important function of our consultation is early detection of less desirable health situations that can occur more often in children with DS, without direct complaints (screening for problems to come). The question remains whether you can tackle these types of problems with demand-driven healthcare.” (ENT-doctor D)

We dealt with this by engaging in conversations with the medical specialists and explaining to them that our suggestion does not imply changing their way of working, but rather changing their way of thinking: providing optimal healthcare to patients remains their responsibility. Presenting healthcare in a way that reflects patient needs and requirements does not harm the professional autonomy of medical specialists. It is a matter of changing presentation, not practice. These conversations helped to overcome the reluctance of the medical specialists.

The patients and professionals also reflected on the level of detail in which healthcare provision should be described. Patients argued that extensive descriptions of possible healthcare provision might cause them to lose track in the jungle of all possible components.

“[...] I want to know what options I have before and during a consultation, but I do not need an extensive list. I need a sense of what I can expect or what I can ask [...]” (Parent C)

“With all due respect, I don't care what exact medical issue my child has. If I observe that his/her [child] skin is itchy, I want them [healthcare professionals] to get rid of the itch.” (Parent A)

These comments inspired us to group individual components under umbrella headings. Components were only grouped if they fulfilled the same type of patient need. For example, we grouped components like 'Eczema' and 'Acne' under the umbrella component 'Skin disorder'. We also did this for the module 'Dealing with laws and regulations'. Specific types

and forms of arrangements and regulations were grouped under four components ‘Financial arrangements’, ‘Legal arrangements’, ‘Organizational arrangements’, and ‘Guardianship, administration and mentorship’. This made the MSA visualization more comprehensible for both patients and professionals.

Finally, we constructed the MSA visualization based on the patients’ perspective (Fig 2). It takes the individual needs and requirements of children with DS as starting point for the provision of healthcare and not the fields of expertise of the healthcare professionals. In doing so, it focusses on the functional outcomes and overall wellbeing as opposed to the (para)medical outcomes.

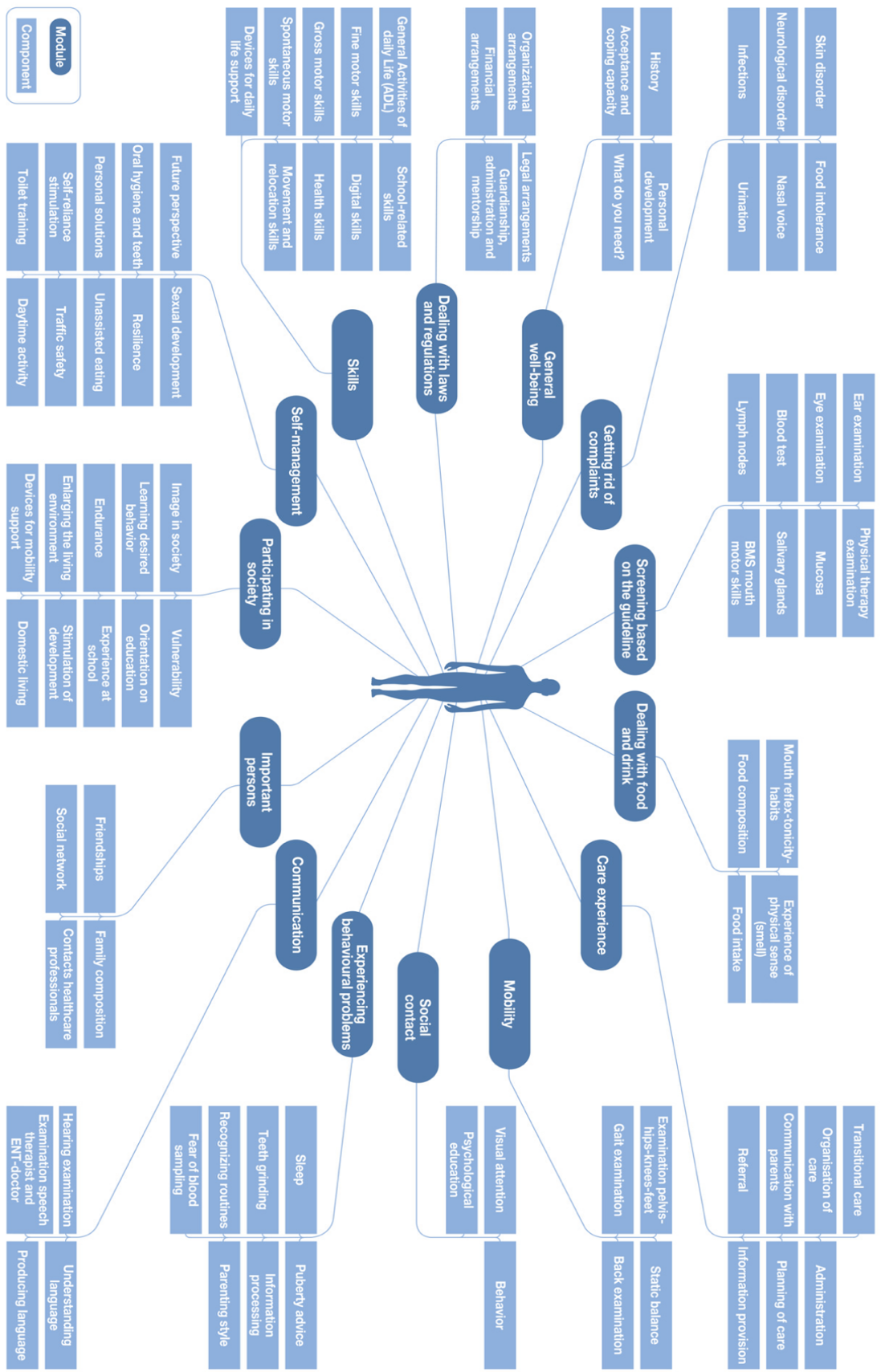
4.4 Discussion

We explored the applicability of MSA visualization in chronic healthcare provision for children with DS from the perspective of patients alongside that of healthcare professionals. The modular perspective enabled us to fully decompose the healthcare provision into modules and components. Previous studies only provided partial modular decompositions of healthcare services (de Blok et al., 2010; Gobbi & Hsuan, 2012; Soffers et al., 2014) which limited the potential of modularity to reduce service complexity and increase responsiveness to complex healthcare needs (Baldwin & Clark, 1997). Our results show that the MSA proved to be very illuminating for professionals and patients since it led to insight into the work practices of each professional, which increased transparency on services offered for both professionals and patients. In addition, the MSA revealed gaps and overlaps in healthcare provision, and provided opportunities to deal with unnecessary duplications and blind spots.

Moreover, we show that MSA visualization provides possibilities for mixing and matching components and modules to address individual needs and, as such, increases the responsiveness of healthcare services to people with complex healthcare needs. This demonstrates that MSA supports service customization (de Blok et al., 2010; Lewis & Brown, 2012; de Blok et al., 2014), which can consequently lead to truly person-centered care provision (Häkansson Eklund et al., 2019; Bartels et al., 2020). As such, the MSA visualization provides a means of dealing with the complexity (i.e., multiplicity and diversity) of knowledge intensive professional services (von Nordenflyght et al., 2010; Zou et al., 2018). As distinct from previous studies on MSA (Bask et al., 2014; Broekhuis et al., 2017; Silander et al., 2017), we have incorporated the patients’ perspective on MSA into our study and show that their perspective is essential for fulfilling the needs and preferences that are considered relevant by patients. The indispensable role of customers has been acknowledged in the extant service literature (e.g., Cook et al., 2002; Lewis & Brown, 2012; Kreye et al., 2015), but the literature on service modularity has mostly overlooked this (Brax et al., 2017). Our study shows that the patient’s perspective is essential to mix-and-match components in such a way that modular healthcare packages are created that are truly responsive to the needs and requirements of people with complex healthcare needs. As such, the service offering can be customized effectively (Brax et al., 2017) and the provision of person-centered care is supported (Häkansson Eklund et al., 2019; Bartels et al., 2020). Furthermore, the results revealed the similar and contrasting viewpoints of healthcare professionals and patients.

We show that the MSA built from the perspective of the patients differs substantially from the MSA built from the perspective of the healthcare professionals.

Figure 2. Modular service architecture based on the patients' perspective.



The MSA based on the perspective of the professionals provided a complete representation of the healthcare service based on (para)medical outcomes relevant to their own discipline: they focus on ‘What-can-we-offer?’ As such, it is an example of more traditionally oriented healthcare organized around single diseases within separate silos (Porter & Lee, 2013). This introduces the risk that healthcare provision is focused on the (para)medical outcomes of the separate diseases instead of functional outcomes for the patients. This is in accordance with the findings of other researchers (Lugtenberg et al, 2011; van der Heide et al., 2018; Kinnear et al., 2018; Kuipers et al., 2019; van den Driessen Mareeuw et al., 2020). Current developments, however, focus more and more on the needs and requirements that are considered relevant by patients. In other words, the needs and requirements of patients with complex healthcare needs should serve as the starting point for their healthcare provision (Skotko et al., 2013; van der Heide et al., 2018).

The MSA that is based on the perspective of patients represents healthcare provision in a more person-centered way, as it focuses on ‘What-do-I-need?’. For example, we reorganized components as ‘Enlarging the living environment’, ‘Experience at school’ as part of the person-centered module ‘Participating in society’ and the components ‘Traffic safety’ and ‘Sexual development’ as part of the person-centered module ‘Self-management’. This person-centered MSA visualization provides a complete representation of the healthcare service based on functional outcomes and overall wellbeing and shows that insight into the patients’ perspective is important for the delivery of person-centered care (Miller et al., 2009; Minnes & Steiner, 2009; van den Driessen Mareeuw et al., 2020). While previous studies on modular decompositions implicitly assume that they fulfill patients’ needs and preferences (de Blok et al., 2010; Soffers et al., 2014), we show that the person-centered MSA can be used as a tool to ensure the complex healthcare needs of people with chronic conditions are fulfilled. It offers patients and professionals the possibility of mixing and matching person-centered modules and components to create individualized person-centered care packages without ignoring the professional role of the healthcare professionals. The extent to which each patient can create their own modular package is debatable: while some patients are clearly capable of this, it may be more difficult for others (von Nordenflyght, 2010; Silander et al., 2017). It would be difficult for patients with limited advocacy skills to create and arrange their own healthcare services (van den Driessen Mareeuw et al, 2020). The person-centered MSA ensures that it is the patients’ needs that guide medical decisions and implies that each patient can be offered a modular package that fits with their needs and requirements (Broekhuis et al., 2017), a promising development for people with complex healthcare needs, that is not yet standard practice (Kinnear et al., 2018).

For healthcare professionals, it can be challenging to deliver person-centered care. MSA can serve as a tool to increase their understanding of people’s complex healthcare needs and identify duplications and gaps in their healthcare provision. The MSA also helps to remind them why they are in the caring profession and how they can provide patients with what they want and need. Previous research has shown that tools, like care mapping, have the potential to support the provision of person-centered care (Chenoweth et al., 2009; Crotty et al., 2015; Young et al., 2019). The MSA encourages reflection on the working methods of healthcare professionals and draws attention to the social situation of a patient, enabling healthcare professionals to provide person-centered care. Our person-centered MSA approach can be applied by others by following three steps: 1) detailed identification of all individual healthcare parts and elements (modules and components) in collaboration with patients and

professionals, 2) labelling and reshaping these parts from the patients' perspective, thereby focusing on functional outcomes and overall wellbeing when combining and grouping components and modules, and 3) selection of appropriate modules and components for person-centered healthcare provision. Previous research has shown that – once established – applying a person-centered approach does not require additional time from professionals; it even leads to more efficient care (Stewart et al., 2000). Our proposed person-centered approach provides more clarity on how to identify the individual parts of a service offering and which part(s) can be considered as components or as modules, which is crucial for the modular decomposition of services (Salvador et al., 2002; Dörbecker & Böhmman, 2015; Eissens-van der Laan et al., 2016; Bartels et al., 2020). By applying our approach, future studies can demonstrate the modular composition of their case under study and the insights obtained can become more relevant for theory as well as for practice.

We have not yet implemented our findings in one or more of the Downteams under study. Doing this would be the next step, as would conducting a follow-up study to show whether the person-centered approach is truly feasible in current healthcare settings. Our suggested person-centered MSA approach can also be used as a basis for future healthcare design (Chenoweth et al., 2019). These findings could be applicable to other patient groups with complex healthcare needs (e.g., diabetes, oncology, geriatrics) with little adjustments.

Our study has some limitations. First, the results were obtained in the Downteams of Dutch hospitals. Interpretations for other patient groups with complex healthcare needs is dependent on the similarity between their needs on an organizational level. We believe that the MSA approach is also applicable for patients with more variable multi-morbidity, but a similarity in their healthcare needs, such as patients with cancer. Cancer is a complex condition manifesting in many different forms for which treatment usually requires various combinations of chemotherapy, radiotherapy, immunotherapy and/or surgery, leading to different forms and differing severity of side effects of the treatment options (Gobbi & Hsuan, 2012; Cortis et al., 2017). However, on an organizational level, there is much similarity in cancer treatment. Therefore, MSA approaches are also likely to be useful for cancer patients. MSA can be useful in such situations because it ensures that professionals are aware of the full range of care and service components and patients are fully informed about treatment and support options. We also believe that the MSA approach is applicable in many other types of complex services such as legal services or higher educational services. For example, when clients face a legal conflict (divorce, termination of employment etc.) they can make use of a variety of providers in dealing with their conflict. Each provider is responsible for providing a subset of services for the client and collectively the providers offer the service that fits with the client's needs and wishes. Approaching legal services from a modular perspective allows for the decomposition into components and modules, resulting in transparency on the supply side of legal services. The modular perspective is also relevant for clients because although accurate information about legal services becomes increasingly available online (Giannakis et al., 2018), the clients are not fully aware of what each legal provider can offer them. This results in legal services that are not completely tuned to the needs and requirements of clients. In higher educational services in many countries there has been an increasing focus on individualized instructions, despite the increasing number of students (Goldschmid & Goldschmid, 1973). As a result, there is a need to make higher education services available to large number of students and, at the same time, offer an individualized learning package for each student. A modular approach could help in dealing with this issue, as it provides

opportunities to offer curricula or interdisciplinary programs that are designed based on modules, where each student's program is tailored to their individual needs and wishes (Turnbull, Burton & Mullins, 2008). Future research should test whether the MSA approach is feasible in these complex service settings. Second, we did not include healthcare professionals from primary care (e.g., general practitioner, youth healthcare physician) in our study, because they have a very limited role in chronic DS healthcare in the Netherlands. This could be different for other chronic diseases and countries. Third, parents were considered as proxy for the children with DS in our study. Although parents are often used as proxy in pediatric care, differences between children and parent proxy have been described (Eiser & Varni, 2013).

Future research could include the perspectives of healthcare professionals from primary care and children themselves in order to fully capture the modular perspective on chronic healthcare provision for people with complex healthcare needs. Furthermore, future studies are required to address the coordination of our person-centered MSA approach. A lack of coordination could lead to increased health risks for people with complex healthcare needs, for instance when patients receive conflicting treatments or unnecessary duplications from multiple healthcare professionals. Coordination of healthcare is, therefore, of great importance for people with complex healthcare needs (Singer et al., 2011; van der Heide et al., 2018). In modular healthcare services, coordination is achieved by interfaces. Interfaces allow for the interaction and communication between modules, components, and people (patients and professionals) involved in healthcare provision (Peters, Meijboom & de Vries, 2018). These interfaces can provide a tight fit between modules, components and people and, as such, can reduce the risk of conflicting treatments or unnecessary duplication in healthcare provision. Further research should address the role of interfaces in healthcare provision for people with complex healthcare needs. Lastly, we did not measure the value of the MSA approach. Future research could examine whether Downteams with a person-centered MSA approach are associated with better outcomes on process-indicators (e.g., adherence to guidelines, access to care) and outcome indicators (e.g., safety of care, patient satisfaction) compared with Downteams that use a traditional approach.

4.5 Conclusion

We performed a qualitative multiple case study to explore the applicability of MSA visualization in healthcare provision for people with complex healthcare needs, using chronic healthcare for children with DS as our proof-of-concept. To our knowledge, this is the first empirical study that explores the applicability of MSA in healthcare services from the perspective of the patients besides that of the healthcare professionals. Our modular perspective allowed us to provide a complete representation of their healthcare provision. Our reshaping of the results into a person-centered MSA visualization, focusing on functional outcomes and overall wellbeing instead of (para)medical outcomes of separate disease entities, enables provision of truly person-centered care. This person-centered MSA approach can thereby contribute to increased responsiveness of healthcare services for people with complex healthcare needs.

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Chapter 5. Elaborating on modular interfaces in multi-provider

contexts

Abstract

Purpose: This study examines how modular interfaces manifest in multi-provider contexts and how they can improve coordination and customization of services. The aim of the study is to describe interfaces in multi-provider contexts and elaborate on how they support the delivery of integrated patient care.

Design: A qualitative, multiple case study was conducted in two multi-provider contexts in healthcare services: one representing paediatric Down syndrome care in the Netherlands and one representing home care for the elderly in Finland. Data collection involved semi-structured interviews in both contexts.

Findings: This study provides insight into several types of interfaces and their role in multi-provider contexts. Several inter- and intra-organizational situations were identified in which the delivery of integrated patient care was jeopardized. This study describes how interfaces can help to alleviate these situations.

Originality: This study deepens the understanding of interfaces in service modularity by describing interfaces in multi-provider contexts. The multi-provider contexts studied inspired to incorporate the inter-organizational aspect into the literature on interfaces in service modularity. This study further develops the typology for interfaces in modular services by adding a third dimension to the typology, that is, the orientation of interfaces.

Keywords: Interfaces; Service modularity; Integrated patient care; Health services

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5.1 Introduction

Services are increasingly delivered by a multitude of service providing entities producing service components (Avlonitis & Hsuan, 2017; Brax et al., 2017). In these multi-provider contexts, rapid and effective coordination and communication among the service providing entities is crucial (de Blok et al., 2014; Brax et al., 2017) for the delivery of service packages that meet the needs and requirements of customers. This is especially important because responsibilities are shared between multiple autonomous entities and each entity has different resources and practices that need to be aligned (Auschra, 2018). A promising approach for the delivery of coordinated yet customized services in multi-provider contexts is service modularity (Brax et al., 2017). Modularity refers to the decomposition of a complex service system into smaller subsystems (Baldwin & Clark, 1997). By recombining independently functioning subsystems a variety of customer needs and requirements can be fulfilled.

Interfaces make sure that the independent subsystems are coordinated (Voss & Hsuan, 2009). They are the linkages in the configuration of modular services and allow for interaction and communication. Interfaces allow for the mixing-and-matching of subsystems and ensure the formation of a functional, coherent whole (Baldwin & Clark, 1997). Without interfaces, a service offering would simply collapse (Peters, Meijboom & de Vries, 2018). This is certainly true for multi-provider contexts in which services are delivered over a long period of time and typically involve multiple service providing entities (Tax, McCutcheon & Wilkinson, 2013; Avlonitis & Hsuan, 2017). Interfaces are especially important in healthcare services because the treatment of patients requires input from multiple healthcare professionals and organizations (Meijboom, Schmidt-Bakx & Westert, 2011). Poor coordination and communication could potentially lead to health risks for patients in terms of overlapping or missing treatments (Singer et al., 2011).

Furthermore, patients underline the need for their voices to be heard and they call for healthcare services tailored to their needs (Silander et al., 2017; Minvielle, 2018). This can be achieved by setting the patient at the centre of care provision (Berwick, 2009) and engaging in customization, which can be defined as the development of tailored services to meet customers' diverse needs (Minvielle, 2018). However, this is challenging due to the necessary involvement of multiple service providing entities in healthcare services. In modular services, individualized modular packages can be created by mixing-and-matching subsystems by means of interfaces (Voss & Hsuan, 2009). As a result, a customized modular package can be provided that is tailored to the needs of each individual. In doing so, interfaces enable coordination and customization in modular services. Coordination and patient-centredness are key elements in the delivery of integrated patient care (Singer et al., 2011) and modular services.

This study examines modular interfaces in multi-provider contexts to improve the coordination and customization of services. As such, the aim of the study is to describe interfaces in multi-provider contexts and elaborate on how they can support the delivery of integrated patient care in multi-provider contexts. Thus, this study addressed the following two research questions:

RQ1. How can interfaces be described in a multi-provider context?

RQ2. How can interfaces support the delivery of integrated patient care in a multi-provider context?

A multiple case study into multi-provider contexts in two healthcare contexts was conducted: one representing paediatric Down syndrome (DS) care in the Netherlands, and one representing homecare for the elderly (HCE) in Finland. These contexts were chosen because of the modular nature of the cases, meaning that the cases make use of a structure that enables them to combine a large variety of independently functioning care and service components into customized care packages (Fransen et al., 2019). In this study, the words ‘patient’ and ‘customer’ are used synonymously since theory uses the word customer and patient simultaneously.

The contribution of our study is two-fold. First, this study contributes to the service modularity literature by explicating the importance of interfaces in multi-provider contexts. We specifically make a contribution by adding a third dimension, the orientation of interfaces (inter-organizational versus intra-organizational), to the existing interface typology of de Blok et al. (2014). This moves the discussion on interfaces in service modularity from an intra-organizational level (single-provider context) to an inter-organizational level (multi-provider context). Second, we empirically investigate the implications of modular interfaces for the delivery of integrated patient care in multi-provider contexts. As such, this study responds to calls for research on service modularity in multi-provider contexts (Brax et al., 2017).

The paper is structured as follows. We first review the relevant literature on interfaces in service modularity and integrated patient care and provide a conceptual synthesis of these two concepts. Next, we explain the case study methodology. We then describe our empirical results and offer a discussion of the findings while developing propositions for future research. Finally, we present our conclusions, including scientific and managerial implications.

5.2 Theoretical background

Modularity is essentially related to the decomposition of a complex service system into independent modules (Baldwin & Clark, 1997). Each of these modules consists of separate components: the smallest elements in which a service can be meaningfully decomposed (de Blok et al., 2014). The components and modules can be flexibly configured into unique modular packages without losing functionality (Baldwin & Clark, 1997). The compatibility of the modular package is enabled by means of interfaces, since they manage interaction and communication within the modular package (Voss & Hsuan, 2009). In previous years, studies have concentrated on product interfaces while the literature concerning interfaces in service modularity remains scarce (Peters et al., 2018). Two complementary interface dimensions are distinguished: interfaces at the content dimension and interfaces at the people dimension (Voss & Hsuan, 2009). The people dimension distinguishes interfaces in services from interfaces in products. The interface typology in modular services by de Blok et al. (2014) elaborates on the suggested dimensions of Voss and Hsuan (2009).

The typology of de Blok et al. (2014) is based on two dimensions: interface entity and interface aim. The interface entity refers to the decomposition level – content (components/modules) or people (service providers) – while the interface aim can be either providing variety or coherence (de Blok et al., 2014). By combining the two dimensions – interface aim and interface entity – a typology of four interface categories is created. Variety on the component level creates open-customer interfaces and allows for reconfiguration of service packages and strives for individual adaptation. Coherence on the component level is related to closed-customer interfaces aiming at the customer’s safe and smooth flow within

service processes. Open-information interfaces enhance the variety of service providers and aims to guide the dissemination of information among them. Finally, closed-information interfaces ensure coherence between service providers by means of standardized arrangements and reduces the amount of information to be exchanged (de Blok et al., 2014). The four interface categories enhance the flow of information and customers in modular service provision; they enable interaction and communication between the components and providers involved.

The current literature on interfaces in service modularity does not acknowledge that most services cannot be provided by the same service provider (Peters et al., 2018; de Pourcq et al., 2020) despite the acknowledgement of the emergence of multi-provider contexts (Brax et al., 2017). Service providers can create modular packages where all service components are delivered by the same service provider (single-provider context). However, most services are provided by two or more service providing entities (Tax et al., 2013; Brax et al., 2017) who produce service components for the delivery of a modular package (multi-provider context). When two or more service providing entities (e.g., hospital and paramedical practice) are involved, rapid and effective coordination and communication becomes even more important (Brax et al., 2017). Delivering uncoordinated services could lead to inefficient service provision and unnecessary duplications, in terms of gaps or overlap in service delivery. Conceptually, interfaces have the potential to manage and guide interactions among service providing entities in a multi-provider context. However, the role of interfaces in multi-provider contexts has been overlooked in the present service modularity literature (Peters et al., 2018). Previous research provides clues for the potential of interfaces in these contexts, but also points out that certain characteristics of multi-provider contexts can constrain the potential of interfaces (Broekhuis, van Offenbeek & van der Laan, 2017; Silander et al., 2017; de Pourcq et al., 2020). Research demonstrates that standardization is a prerequisite for modular services (Silander et al., 2017), but the number and the heterogeneous nature of different service providers in multi-provider contexts could constrain the standardization of interfaces (Broekhuis et al., 2017; Silander et al., 2017).

5.2.1 Integrated patient care

Healthcare is considered a multi-provider context since it consists of multiple providers, possibly stemming from different organizations with professionals representing different specialties and disciplines (Meijboom et al., 2011; Vähätalo & Kallio, 2015). As a result of the involvement of multiple providers, health services have been accused of being fragmented (Stange, 2009). Fragmentation causes ineffectiveness, resulting in low customer satisfaction and low outcome quality. The integration of services is often put forward as the opposite of service fragmentation and is said to have multiple benefits, for example greater efficiency (Kodner, 2009). In health services, integration is described by means of the concept of integrated care. Essential elements of integrated care are coordination and cooperation between providers participating in care provision and the aim of integration is to provide customers an experience of continuous, comprehensive, and flexible services (Kodner & Kyriacou, 2000; Somme et al., 2014). Leadership and managerial related issues, such as multidisciplinary teamwork and staffing professionals, has been widely recognized as crucial in organizing integrated health services (González-Ortiz et al., 2018). However, it is not only important to have services organized fluidly; it is essential to put the patient at the centre of care provision (Berwick 2009; Singer et al., 2011; Minvielle, 2018). For this reason, we

address the fact that health services are typically delivered by multiple professionals and organizations, and we follow Singer et al. (2011) in suggesting integrated patient care should be “*coordinated across professionals, facilities, and support systems; continuous over time and between visits; tailored to the patients’ (and family members’) needs and preferences; and based on shared responsibility between patient and caregivers for optimizing health.*” (p. 113).

Singer et al. (2011) emphasize the aspects of coordination and patient-centredness and acknowledge that it is challenging to achieve both in delivering integrated patient care. Even more so in multi-provider contexts where different organizations, providers, and disciplines are involved (Sun et al., 2014). Challenges in these contexts are related to, for example, regulations, lack of collective interests, communication, technical standards, different professions being involved, and issues of confidentiality (Auschra, 2018).

5.2.2 Theory synthesis: Modular interfaces in integrated patient care

We elaborate on the concepts of interfaces in service modularity and integrated patient care. In doing so, we address how interfaces can support the delivery of integrated patient care in multi-provider contexts.

5.2.2.1 Coordination of care

Singer et al. (2011) argue that coordination refers to the interaction across professionals, facilities and support systems within and across organizations. The aim of coordination is to deliver consistent and informed patient care. Singer et al. (2011) argue that the coordination of care often seeks to achieve automation, efficiency, and simplicity. This form of coordination is closely related to the concept of coherence (de Blok et al., 2014; Broekhuis et al., 2017). We argue that closed-information interfaces and closed-customer interfaces can improve coordination across professionals, facilities, and support systems by standardizing the flow of information between components and service providers (Silander et al., 2017; de Regge, Gemmel & Meijboom, 2019), which is also an essential aim of integrated patient care (Somme et al., 2014). As a result, these interfaces support coherence and unity both among people and among components within modular packages (de Blok et al., 2014). Both interface types diminish the amount of information exchange required, since the interactions between professionals or components can be prescribed via these types of interfaces (de Blok et al., 2014; Silander et al., 2017). This is especially important in multi-provider contexts (Brax et al., 2017) because there is a higher probability for uncoordinated care when care is delivered by two or more organizations (Meijboom et al., 2011). Based on the ability of both interface types to provide predictability and coherence, we argue that they can improve coordination across professionals, facilities, and support systems.

5.2.2.2 Continuous proactivity and familiarity

Care that is continuous over time is linked to the extent to which service providers are continuously familiar with the patient’s current needs (continuous proactivity) as well as their medical history (continuous familiarity) (Singer et al., 2011). Continuous familiarity includes, but is not limited to, each provider’s familiarity with the care they and others have provided to the patient. When providers update care plans, they should account for factors contributing to previous hospitalizations and the treatments at discharge. However, this requires standardized interfaces between information systems as well as established documentation protocol

(Silander et al., 2017; de Regge et al., 2019). Moreover, familiarity also assesses the extent to which patients receive outreach, including phone calls and home visits, to ensure appropriate follow-up (Berwick, 2009). Closed-information interfaces is related to continuous familiarity as these interfaces ensure that all professionals have access to the information they need to provide coherent services; interfaces guide and stimulate information exchange about the patients' situation (Fransen et al., 2019). Continuous proactivity enables responsiveness of service providers to incoming requests from patients and this helps to identify gaps in care. Internal arrangements that allow for predictable interactions in the modular package could support this responsiveness (Fransen et al., 2019). When such arrangements are in place, providers could act proactive based on standardized actions (Silander et al., 2017). The closed-customer interfaces could account for this by ensuring a safe and smooth patient flow.

5.2.2.3 Tailored to the patients' needs and preferences

Tailoring care to the patient's needs and preferences can be supported by fluent information exchange between the service provider and the patient, as well as between providers (Silander et al., 2017; Fransen et al., 2019). Mixing-and-matching standardized components with help of interfaces is a way of responding to customer's individual needs and preferences (Pekkarinen & Ulkuniemi, 2008; de Blok et al., 2010). Moreover, it is important to develop or build a good relationship between the service provider and the patient (Gulliford, Naithani & Morgan, 2006) to get a better understanding of the needs and preferences of patients. Open-information interfaces can support this process, since they allow for the recognition of (changes in) patients' needs and preferences and makes adaptations possible (de Blok et al., 2014; Soffers et al., 2014).

5.2.2.4 Shared responsibility between patient and provider

Patients and providers may indicate some changes during care delivery. The extent to which patients are informed and engaged by providers in making care-related decisions determines whether the desired changes can be truly addressed (Berwick, 2009; Singer et al., 2011). When the desired changes have been indicated, open-customer interfaces can support realizing these changes. These interfaces provide a structure that enable the (re)combination of components (de Blok et al., 2014); it enables adaptation of the modular package to the patient's desired changes based on an aligning rather than a rigid structure (Soffers et al., 2014). Such interfaces ensure that providers can better present the available components to patients and could allow patients to make better informed decisions (Fransen et al., 2019). As a result, patients and providers are better informed and share responsibility about making changes.

To conclude, we posit that interfaces can support the delivery of integrated patient care in multi-provider contexts and we use our empirical data to support our reasoning. Table 1 provides an overview of the concepts from the modularity and integrated patient care literature and is used as starting point for the analysis of our empirical data. Our two empirical cases are not used for comparative purposes, but instead they both provide illustrative examples of how interfaces can support the delivery of integrated patient care in multi-provider contexts.

Table 1. Interface types supporting the delivery of integrated patient care.

Interface type	Dimension of integrated patient care
Open-information interface	<ul style="list-style-type: none"> • Tailored to patients’ needs and preferences
Closed-information interface	<ul style="list-style-type: none"> • Coordination across professionals (representing different organizations, disciplines and specialities); • Continuous familiarity (about patients’ medical history, including family situation)
Open-customer interface	<ul style="list-style-type: none"> • Shared responsibility between patient and professionals (representing different organizations, disciplines and specialities)
Closed-customer interface	<ul style="list-style-type: none"> • Coordination across facilities (representing information systems, enterprise resource planning, administrative practice) and support systems (representing voluntary workers, family members, community resources) • Continuous proactivity

5.3 Methodology

We used a qualitative multiple case study design to describe modular interfaces in the delivery of integrated patient care in multi-provider contexts. Case study research design was chosen since this method is the most appropriate when, amongst other things, contextual conditions are believed to be very pertinent to the phenomenon being studied (Yin, 2003). We identified two general theories, service modularity and integrated patient care, which we used to approach our empirical contexts. This methodological approach to case research is defined as theory elaboration (Ketokivi & Choi, 2014). We elaborate on these theories by conducting an investigation of the relationships – interfaces in service modularity and dimensions of integrated patient care – among the concepts.

5.3.1 Study context

For the purpose of this study, we used theoretical sampling and chose two different cases which both are extreme examples of multi-provider contexts (Eisenhardt, 1989; Gummesson, 2000). Both cases represent a context where a number of services are offered by providers representing multiple disciplines and organizations. In both cases, the providers’ aim is to respond to heterogeneous and constantly changing needs of customers. Multi-provider characteristics of both cases are described in more detail below and in Table 2. Consequently, the multi-provider characteristic is particularly transparently observable in both cases (Eisenhardt, 1989). To evaluate the trustworthiness of the results, we deliberately chose the healthcare provision for children with DS in the Netherlands and HCE in Finland. Collecting two datasets from different patient groups and from different countries supported the transferability of the results and consequently, increased the trustworthiness of the study (Eriksson & Kovalainen, 2008). The uniqueness of each case is presented in more detail in the paragraphs below to show how each case serves as an extreme example of a multi-provider context (Eisenhardt, 1989).

DS is a complex congenital condition. Individuals with DS share a typical appearance, intellectual disability, and delayed motor development (Weijerman & de Winter, 2010). However, each individual with DS is affected differently. In the Netherlands, paediatric outpatient clinics organize multidisciplinary team appointments. These so-called Downteams include a visit to various healthcare professionals, all on the same day (Fransen et al., 2019). The different ‘professionals’ of the multidisciplinary team provide subsequent consultations

for the children with DS, so that they can visit multiple professionals on a single day. These specialists represent different specialties (e.g., ophthalmology, pediatrics) and different types of organizations (e.g., hospital, paramedical practice).

HCE consists of services aiming to support living at home as long as possible. Many of the elderly have multiple health problems as well as age-related frailty. However, each combination and severity of problems is unique and requires customization of service packages. Although rehabilitation is undertaken, the need for assistance is likely to increase over the years. The services supporting elderly people who live at home are numerous and are delivered by multiple providers, representing not only different types of organizations (e.g., public, private and NGO) but also represent various types of services (e.g., pharmacy, housing, psychological support). In addition, the customer's family and relatives are typically involved in care provision.

Given the above-mentioned case descriptions, greater service needs combined with functional difficulties make children with DS and HCE ideal populations for studying integrated care. It is also said that people with chronic illnesses and disabilities are the ones who benefit most from integrated care (Kodner & Kyriacou, 2000; Sun et al., 2014).

5.3.2 Data collection

We collected our main data by interviewing providers who conduct and manage care for children with DS and HCE. We used documentation as secondary data in both cases. It was obtained by collecting relevant internal and external documents and consisted of printed and electronic documents such as care plan sheets and forms used, process descriptions and service descriptions. These documents were used to complement the interviews and provided a better understanding of existing practices. The triangulation of primary and secondary data strengthened the reliability of the study as it offered possibilities to cross-check information (Eriksson & Kovalainen, 2008) and provided stronger substantiation of the propositions presented based on the results (Eisenhardt, 1989).

In the DS case, data was collected from one Downteam in the Netherlands. This Downteam was chosen based on its availability and the fact that this team is well known in the field. We conducted a total of 15 interviews by means of purposive sampling of the interviewees. We conducted interviews with all healthcare professionals involved in the Downteam and with the carers of children with DS who visit the Downteam. We reached data saturation, meaning that marginal utility after additional interviewees became low (Gummesson, 2000), after 14 interviews, but decided to include one more interview for confirmation sake.

In the HCE case, data was collected from one municipality in Finland. In this municipality, HCE is mainly delivered by public providers and supplemented by private and NGO providers. As this is the most common way of organizing care for the elderly in Finland, this municipality was considered suitable for the purposes of the study. In addition, one of the researchers had access to it. Interviewees represented providers from different disciplines and different organizations. First, four interviewees were suggested by the top manager in service provision for the elderly. From that point, in order to ensure the representativeness of the sample, interviews continued on the basis of the snowball technique to involve other public providers, NGOs and private providers. HCE case interviews were conducted mainly with one interviewee at a time, although some interviews involved two or three colleagues from the

same organization. Data saturation was reached after 24 interviews. The interviewees of both cases are represented in Table 2.

Table 2. Participants interviewed.

Case: Down syndrome		Case: Home care for the elderly	
<i>Interviewee</i>	<i>Organization</i>	<i>Interviewee</i>	<i>Organization</i>
Audiology assistant	Paramedical practice	Assistant Nurse	Public home care unit
Contact parent	National patient organization	CEO and 1 assistant	National rheumatism association
Dietician	Hospital	CEO and 2 assistant nurses	Company offering cleaning services for elderly
Doctor for the mentally handicapped	Healthcare organization for people with an intellectual disability	CEO and 2 assistant nurses	Support for Elderly Association
Ear, Nose and Throat doctor	Hospital	CEO and 2 counsellors	The Alzheimer society Finland
Ophthalmologist	Hospital	CEO and 2 social workers	Carers Finland association
Orthoptist	Hospital	Deacon	Local church
Parent of child with Down syndrome	-	Founder of the voluntary work unit	Public voluntary work
Parent of child with Down syndrome	-	Geriatrician	Public hospital
Parent of child with Down syndrome	-	Head of voluntary work unit	Public voluntary work
Parent of child with Down syndrome	-	Pharmacologist	Pharmacy
Pediatrician	Hospital	Preventive care nurse	National heart association
Physiotherapist	Hospital	Preventive care nurse	Company offering home nursing services
Speech therapist	Paramedical practice	Registered nurse	Company offering home nursing services
Secretary	Hospital	Registered nurse	Public preventive care unit
		Registered nurse	Company offering cleaning and home help services
		Registered nurse	Public home care unit
		Service coordinator	Public home care unit
		Service coordinator	Public home care office
		Social worker	Public social office
		Supervisor	Public home care office
		Top manager	Public home care office
		Voluntary work coordinator	Red cross
		Voluntary work organizer	Public preventive care unit

In both cases, we applied a semi-structured interview approach which enabled us to address topics that had to be covered while leaving room for interviewees to tell their own story. The topic list for the interviews was compiled as a result of our literature review on interfaces in service modularity and integrated patient care. Interviewees were asked first about the content that made up the services (e.g., ‘*Could you tell us about your role and the service you provide*

in your team?’) and how these services were coordinated (‘e.g., *Which important handovers take place within your team and beyond?*’). Questions related to continuous familiarity explored how well providers knew patients’ history (e.g., ‘*Is the information that is shared between providers available, sufficient, up-to-date, and accurate?*’), whereas questions related to continuous proactivity concentrated on follow-up of care (e.g., ‘*How are the appointments/examinations for patients planned?*’). The tailoring of services was investigated with questions related to the customization of services (e.g., ‘*Which parts of the service are standardized and which are customized?*’). The questions related to shared responsibility focus on the patient’s role in care provision (e.g., ‘*How do patients participate in care planning?*’). Interviews were audio-recorded and transcribed verbatim.

To meet ethical concerns related to data collection, ethical approval for the Dutch case was obtained from the Ethics Review Board of Tilburg University [EC-2017.60t]. In the Finnish case, ethical approval was obtained from the head of the public health services. Written and oral informed consent was obtained from all respondents prior to participation.

5.3.3 Data analysis

Data analysis was conducted using abductive reasoning, which starts with reference to the general theories (service modularity and integrated patient care) while leaving room to discover new ideas and information that emerge from the data (Ketokivi & Choi, 2014). The data analysis of the two cases was conducted using the three-steps method as described by Miles and Huberman (1994): 1) data reduction; 2) data display; and 3) drawing conclusions. This is a systematic data reduction process built on the reading of transcripts, document summaries and theoretical memos, segmentation of sentences and phrases, codification of text segments, generation of themes and categories, and identification of relationships (Miles & Huberman, 1994). In the HCE case, NVivo12 software was used for codification of the text segments while the software was not used for further analysis. The data in the DS case was coded manually. To increase the transparency of our data analysis, examples of this process are presented in Table 3 for RQ1 and RQ2. To illustrate: we used the interface description by Voss and Hsuan (2009) for identifying possible interfaces: “*Interfaces are the linkages between subsystems that allow interaction and communication between those subsystems*” (p. 186). When we identified all the individual interfaces, we collated them as a generic interface and allocated the specific interface type, based on de Blok et al. (2014) to the generic interface. In Table 3, the first column presents an authentic quote, the second column presents the individual interface/observed challenge and the third column presents the generic interface/challenge. By showing the logical link between our observations and categories in Tables 3, we aim to increase the credibility of the results (Eriksson & Kovalainen, 2008). For confirmability purposes, the link between findings and interpretations are presented with authentic quotes in the empirical results section (Eriksson & Kovalainen, 2008).

Author 1 coded all the transcribed interview data from the Finnish case, Authors 2 and 4 coded all the data from the Dutch case. The coding for both datasets was guided by our preliminary coding framework. This framework was discussed continuously and tested during the coding of the interviews. During the analytical phase, Authors 1, 2 and 3 discussed and assessed regularly the outcomes of the analysis.

Table 3. Coding examples with exemplary quotes for the data analysis for RQ1 and RQ2.

Interfaces in multi-provider context		
Quote	Interface	Interface collated
<p>“I go there alone and suggest that the customer invites their relatives to join, and often they will. I interview the customer and carry out some tests, then I discuss, first with the relative and then all together, what services would be best for the customer.” (Care coordinator)</p> <p>“We go to a new customer and knowing that they haven’t yet been provided with any services, we immediately start to put the service puzzle together, not only concentrating on loneliness.” (NGO worker)</p>	Initial care plan meeting at home	Multidisciplinary meeting
<p>“I make the care plan which I type up on the computer and send to the home care team ... then within the month, when the nurses to be responsible for this particular customer have been chosen, they go through the care plan and evaluate whether it is still valid and if something has changed or needs to be added.” (Care coordinator)</p>	Care plan evaluation meetings	
<p>“If there is a care meeting at the ward, there is a doctor, nurses from the ward, relatives and me. If it is necessary, we discuss [about services] when discharging from the ward to home.” (Care coordinator)</p> <p>“After the child has visited all the members of the Downteam, we come together and discuss the outcomes of the separate visits. In doing so, we combine all our knowledge and make sure nothing has been forgotten.” (Physiotherapist)</p>	Meetings at ward	
<p>“I participate every six months, or sometimes more often, in their team meetings and we discuss home care customers and whether they [the team] need my help in deciding how to cope with the customer.” (Care coordinator)</p>	Home care team meeting	
<p>“We have a meeting in which all the care coordinators participate and we discuss our practices or have some training, for example about the criteria for moving a customer to housing services.” (Care coordinator)</p> <p>“Every six months I sit together with my team and I look at what is going well and what can be improved. We evaluate ourselves” (Paediatrician)</p>	Team evaluation meeting	
Challenges relates to the delivery of integrated patient care		
Quote	Observed inter/intra-organizational challenge	Observed inter/intra-organizational challenge collated
<p>“When customers talk about the services they need, they do not talk about our home care or social services but services for day-to-day living, such as a hairdresser, shopping, transportation. We professionals do not know about these services.” (Social worker)</p> <p>“We could always use more information, there is never enough.” (Public home care worker)</p> <p>“You are not aware of the kind of activities that other disciplines perform.” (ENT-doctor)</p> <p>“I once did not want to visit the physiotherapist because my son does not have any issues related to this discipline. However, this was not possible and we found it inconvenient.” (Carer)</p>	Missing overview of care content	Lack of transparency

For example, sometimes it was unclear whether a piece of text was part of the ‘between components in care package’ code or ‘between service providers in care package’ code. These issues were resolved through discussion until agreement was achieved among the researchers. The fact that multiple authors participated during the analysis had two advantages. First, multi-author team has complementary insights which provides opportunity to catch the novelty and richness of the data. Second, convergence of the observations supports the credibility of the findings while simultaneously conflicting perceptions between team members prevented a premature closing of the analysis (Eisenhardt, 1989). We created data displays (see Results section; Tables 4 and 5) that helped to identify patterns in the data. Credibility of the results was supported by the observation that only minor differences in interfaces occurred between two contexts (Eriksson & Kovalainen, 2008).

5.4 Empirical results

In both the DS case and the HCE case, service providers typically offer their patients a modular care package that consists of care and related services, including components and modules that concern medical needs (e.g., taking medication, wound care), social care (e.g., financing, housing) and psychological concerns (e.g., loneliness, depression), among others. Since each patient differs in their care needs and preferences, each modular care package is unique. The needs and requirements of patients are likely to alter as a result of the chronic condition of the patients. As such, the modular care package needs to be consistent with each individual’s needs and requirements and it requires to be coordinated over time. Interfaces should be in place that guide interaction and communication in healthcare provision and make sure that the modular care package is coordinated and meets the needs and requirements of patients.

5.4.1 Interfaces in multi-provider setting

We recognized various examples of interfaces and we classified them in Table 4. To illustrate the interfaces found in both cases, we provide examples of each cell in the sections below. In this section we do not distinguish between inter- and intra-organizational interfaces. This is in line with RQ1, because we elaborate on how interfaces can be described in multi-provider contexts according to the typology of de Blok et al. (2014). In Section 5.4.2, we take the inter- and intra-organizational perspective into account as we describe the interfaces supporting the delivery of integrated patient care.

5.4.1.1. Open-customer Interface

The national guidelines set by the Dutch Paediatric Association and for elderly care by The Finnish Ministry of Social Affairs and Health serve as examples of open-customer interfaces. The different sections of the guidelines can be used to adapt care in collaboration with customers according to their individual needs and wishes. In other words, the modular package for each patient can be adjusted, so that the different needs of individual patients can be accounted for. In HCE, a vast number of services are available from different providers and organizations for different purposes. In order to respond to heterogeneous needs and let the customer arrange their own care, home care workers stated that they “... *always carry leaflets about all service providers and their numbers. We [home care workers] leave it [the leaflet] for them [the customer] and with the help of their close relatives they start to call*”. Interviewees highlighted that they provided information about services, social benefits, health

promotion etc. and customers made the relevant decisions, often together with their relatives. The open-customer interfaces highlight the importance of service transparency in supporting the possibility of providers and customers creating appropriate service packages.

Table 4. Interfaces identified in each case.

		Interacting entities			
		<i>Between components</i>		<i>Between service providers</i>	
Aim	<i>Variety</i>	<i>O-C interfaces</i>		<i>O-I interfaces</i>	
		<u>DS case</u> <ul style="list-style-type: none"> • Guideline • Protocol • Screening form 	<u>HCE case</u> <ul style="list-style-type: none"> • Law and national recommendations • List of associations and their services • List of private providers and their services • List of public providers and their services 	<u>DS case</u> <ul style="list-style-type: none"> • Electronic health record • Multidisciplinary team meeting • Transition letter 	<u>HCE case</u> <ul style="list-style-type: none"> • Electronic health record • Care plan • Multidisciplinary meeting • Telephone consultation
	<i>Coherence</i>	<i>C-C interfaces</i>		<i>C-I interfaces</i>	
		<u>DS case</u> <ul style="list-style-type: none"> • Planning rules • Planning scheme • Checklist 	<u>HCE case</u> <ul style="list-style-type: none"> • Check-up call • Check list • Enterprise resource planning • Telephone consultation • Process description • Work description 	<u>DS case</u> <ul style="list-style-type: none"> • Electronic health record • Division of labour • Multidisciplinary team meeting • Work schedule 	<u>HCE case</u> <ul style="list-style-type: none"> • Background and other information form • Care plan • Informal progress book • Electronic health record • Enterprise resource planning • Work description

5.4.1.2 Open-information interfaces

The multidisciplinary team meeting serves as an example of an open-information interface. It allows providers to discuss the outcomes of their individual consultations and further tailor the care according to the customer's individual needs. The information gathered by all the disciplines and providers involved is discussed and leads to a joint outcome. Within HCE, multidisciplinary team meetings are organized mostly by the public providers while NGOs and private providers are not always invited. However, they are consulted by phone. The identified open-information interfaces illustrate the importance of obtaining and transferring information across the organizations and providers involved, while tailoring the services and changing components within the service packages.

5.4.1.3 Closed-customer interfaces

The planning scheme and the consultation scheme are examples of closed-customer interfaces. These schemes are structured in such a way that a continuous flow of patients is created by matching the agreements of the various providers involved: *“For the eye drops to kick in, it takes about three quarters of an hour. In the meanwhile, another professional could provide his consultation, making sure that the patient doesn’t have to wait.”*

(Ophthalmologist). This ensures that the patient flows smoothly through the system. The enterprise resource planning (ERP) system represents a planning scheme in which the public provider creates the date and time for each service. The aim is to distribute all services delivered by different providers evenly in each day, as a care coordinator described: *“Meal service is one visit more to check that everything is all right. Our meal drivers are so caring that if customer does not open the door, or if they detect something unusual, they call and ask if we can go and check the situation.”* Evenly allocated services also serve the purpose of alleviating the loneliness of elderly, as illustrated by a church deacon in the following extract: *“We [NGOs and public providers] try to organize so that we do not all go at the same time but providers should be allocated evenly, particularly for lonely customers”*. The ERP planning scheme is available only for public-service home care workers but, for each customer, an individual care plan is agreed upon in a multidisciplinary meeting or providers are informed in other ways, for example by phone. The closed-customer interfaces described above illustrate the way in which service components are coordinated across care teams representing different disciplines and different organizations, as well as across support systems such as community recourses (e.g., voluntary workers).

5.4.1.4 Closed-information interface

The work schedule and division of labour are examples of closed-information interfaces. They serve as internal arrangements that allow for predictable interactions between providers, based on a clear specification of tasks and responsibilities. Additionally, the electronic health record (EHR) reduces the amount of information that needs to be transferred between the providers, making sure that a coherent service is offered. In HCE, customers have an individual care plan on the basis of which the care is implemented. This individual care plan is a combination of EHR and ERP and it allows providers to check the care plan at any time. The care plan is structured and well-established and serves particularly well for coordination purposes among public home care teams and also among other public providers (social worker, hospital etc.), while less so among private and NGO providers. The EHR ensures that all public providers can be aware of a patient’s medical and service history. Since not all providers, such as NGOs, have access to EHR, an informal progress book at the home of the elderly person serves the same purpose and works as a closed-information interface, as the following quote illustrates: *“Often there is a notebook at a customer’s home. Voluntary workers write what they have done with the customer and whether the customer is having a good day. Some relatives are really active and write in detail, and they ask that home care workers record some particular observations.”* (Care coordinator). The identified closed-information interfaces show how providers coordinate care across different professionals and support each other’s familiarity with a customer’s situation.

5.4.2 Interfaces supporting the delivery of integrated patient care

The respondents in our study mentioned a number of inter- and intra-organizational situations in which the delivery of integrated patient care was jeopardized. We elaborate on examples of inter- and intra-organizational challenges, as well as the way in which these challenges are related to the dimensions of integrated patient care. The corresponding challenges are presented in square brackets, both in text and in Table 5. We also provide improvements, i.e. examples of how interfaces can alleviate these challenges (Table 5), which were suggested by the respondents.

5.4.2.1 Challenges related to coordination across facilities and support systems

In both cases, it appeared that interactions between providers take place on the basis of their professional work experiences, but not substantively on the basis of protocols or guidelines [Lack of protocols]. As a result, providers have expectations about certain service processes or service content but find out that they have been changed according to providers' professional experience. Sometimes also the lack of protocols and guidelines leads to unstandardized behaviour, as the following quotation from HCE illustrates: *“Client, relatives and home care workers cancel the visits of voluntary workers [if customer is sent to hospital] but these checkup call volunteers are sometimes forgotten.”* (Public worker coordinating voluntary work). It is also the case that proceeding on the basis of experience and not protocols has led to overlapping services [Overlap in services]. This challenge becomes even more severe if the same facilities, such as information systems, are not communicating. For example, if the content of the work was not described properly or could not be seen by everybody, different providers would end up doing the same thing, as illustrated by the following quote: *“It is possible that a deacon from the church, a voluntary helper from the Red Cross, and a private physiotherapist are all visiting the customer and doing same thing without knowing it.”* (Top manager HCE). We also observed this in the DS case, when overlap occurred when two providers were measuring the weight and height of a patient. This certainly does not enhance efficiency. One way of addressing this challenge is to introduce several closed-customer interfaces: planning rules, planning schemes, work descriptions and service descriptions. This ensures that providers are well-informed about what every provider is doing, when they are doing it, and why they are doing it.

5.4.2.2 Challenges related to coordination across professionals

We observed that coordination between providers was often lacking due to information being missing. Currently, information about the patient is not readily accessible, since, for example, the EHR of the general practitioner is not accessible to the paediatrician [Lack of information transfer]. Interfaces like e-mail or formal letters can be used to overcome this lack of information transfer. Information transfer was also restricted when several different EHR systems are applied by different providers and the relevant information about the customer is not available for all providers. Challenges related to information flow had led to various problems such as poor continuity of care. Although it is extremely important to guarantee the security of medical and social records, changes made in relation to the legislation governing information transfer practices could enhance information flow. Challenges related to coordination between providers from different organizations can be alleviated by closed-information interfaces, like national IT protocols and open software, since that would allow providers access to information systems.

Table 5. Observed challenges in the delivery of integrated patient care.

Observed challenge in integration of services	Dimension of integrated patient care	Type of interface	Interface orientation	Interface supporting integration of services
[Lack of protocols] Lack of protocols for interaction between service providers	Coordination across facilities and support systems	<ul style="list-style-type: none"> • C-C interface • C-C interface 	<ul style="list-style-type: none"> • Intra-organizational • Intra-organizational 	<ul style="list-style-type: none"> • Planning rules • Planning scheme
[Overlap in services] Not enough knowledge about other service providers causing overlapping	Coordination across facilities and support systems	<ul style="list-style-type: none"> • C-C interface • C-C interface 	<ul style="list-style-type: none"> • Inter-organizational • Inter-organizational 	<ul style="list-style-type: none"> • Work description • Service description
[Lack of information transfer] Lack of tools for information transfer	Coordination across professionals	<ul style="list-style-type: none"> • C-I interface • C-I interface 	<ul style="list-style-type: none"> • Inter- and intra-organizational • Inter-organizational 	<ul style="list-style-type: none"> • National IT protocol • Open software
[Lack of proactive actions] Service providers do not actively check with customers whether services are still up to date	Continuous proactivity	<ul style="list-style-type: none"> • C-C interface • C-C interface 	<ul style="list-style-type: none"> • Inter-organizational • Inter-organizational 	<ul style="list-style-type: none"> • Check-up call • Needs assessment
[Lack of awareness] Service providers are not aware of the medical history of a customer	Continuous familiarity	<ul style="list-style-type: none"> • O-I interface 	<ul style="list-style-type: none"> • Inter-organizational 	<ul style="list-style-type: none"> • Multidisciplinary meeting
[Lack of shared professional language] The information exchanged is documented in a language that is not understood by other service providers involved	Continuous familiarity	<ul style="list-style-type: none"> • O-I interface 	<ul style="list-style-type: none"> • Inter-organizational 	<ul style="list-style-type: none"> • Standard documentation format
[Lack of common goal] Lack of common goals for care across the providers	Tailored to the patient's needs and preferences	<ul style="list-style-type: none"> • O-I interface • O-I interface 	<ul style="list-style-type: none"> • Inter-organizational • Inter-organizational 	<ul style="list-style-type: none"> • Shared care plan • Multidisciplinary meeting
[Lack of transparency] Overview of care content is missing	Shared responsibility	<ul style="list-style-type: none"> • O-C interface 	<ul style="list-style-type: none"> • Inter- and intra-organizational 	<ul style="list-style-type: none"> • Overview of available components and modules

5.4.2.3 Challenges related to continuous proactivity

Although in the HCE case continuous proactivity was achieved by check-up calls, this was not so clear in the DS case [Lack of proactive actions]. Customers argued that they would appreciate it if providers would check with them, before the consultation, whether they had specific needs or requirements. Also, a lack of proactivity was observed and attributed to there being little interaction between the providers from secondary care (e.g., pediatrician)

and providers from primary care (e.g., general practitioner). This could lead to situations where the needs and requirements of the patient are unknown prior to the consultation. Both healthcare professionals and carers expressed this: “*There is actually no contact between our speech therapist in primary care and the speech therapist of the Downteam. When we visit the Downteam, we have to explain what our own speech therapist is working on*” (Carer) and “*I often only hear during the consultation whether the child has had speech therapy and if there is any possible information available from this speech therapist*” (Speech therapist). A check-up call and needs assessment, which we define as closed-information interfaces, would help providers to be better prepared for care provision and ensures that the needs and preferences of patients are retrieved.

5.4.2.4 Challenges related to continuous familiarity

Furthermore, it became apparent that the providers are not always aware of the (medical) history of the patient [Lack of awareness]: “*I know the last time I visited the ENT-doctor, I thought that he was not quite familiar with what he had done before. Because [patient’s name] had tubes and he asked how long he had been using them*” (Carer). Although open-information interfaces can ensure improvements in this respect, for instance a multidisciplinary meeting prior to the consultations, better preparation by the specialists themselves is also required. Moreover, in relation to the information documented and exchanged across providers, it is important that the information exchanged is documented in a language that is also standardized and can therefore be understood by other relevant providers [Lack of shared professional language]: “*If the ophthalmologist writes about plus and minus, I do not know exactly what the consequences for the visual acuity or depth perception are.*” (Physiotherapist). A similar problem occurred in HCE. As pointed out in the following comment, home care workers did not always keep records in the manner recommended by the standardized Finnish Care Classification: “*Home care workers could write summaries every now and then, there are too many entries which are not clear.*” (Geriatrician). The expectation is that the development of two interfaces, multidisciplinary team meetings and standard documentation formats, will lead to providers being better acquainted with the medical history and needs of patients.

5.4.2.5 Challenges related to tailoring services according to patients’ preferences

Service packages in HCE were not always tailored by involving all of the providers delivering the care. The result is a lack of common goals for care delivery when it comes to the customer’s care package. [Lack of common goal]. Typically, public providers were the ones to organize care meetings, for example when customers were discharged from the hospital. However, it was mainly public sector providers who participated in these meetings and NGOs or private providers were not always invited. This was usually justified by citing the confidentiality of information, but often invitations were just forgotten. Confidentiality problems are illustrated as follows: “*Discharging is complicated because of privacy protection issues. We can invite public home care workers but can we invite a private provider? And what we can tell them about the patient? Tricky questions.*” (Hospital’s social worker). Due to this, information that would have been useful for tailoring services, was not received from all providers. This gap was partially compensated for with phone calls, but it was often the case that poor collaboration resulted in several care plans being created by each provider, with a single shared care plan not produced. The same challenge was observed in

DS where providers only had multidisciplinary meetings after the patient had left the hospital. In these meetings, they often said that they wished they had been in possession of certain information beforehand. To illustrate: “...*During the consultation I heard that the child had issues at school. If I had known that beforehand, I could have tailored my consultation towards this issue...*” (Contact parent). This information could have been shared if a multidisciplinary meeting had taken place before the patient arrived at the hospital. If this had been the case, all providers could have been quickly briefed about prevailing issues and they could have adapted their consultations accordingly. Challenges related to tailoring services to patients’ preferences could be alleviated by introducing multidisciplinary meetings and common care plans, which serve as examples of open-information interfaces.

5.4.2.6 Challenges related to shared responsibility

It was unclear to both providers and customers exactly what services they could choose from because there was no overview of the services available. This demonstrated a lack of transparency in terms of service or work descriptions and information folders: “...*you are not fully aware of the kind of activities that other disciplines perform...*” (ENT doctor). If the healthcare elements are not clear for the providers involved, that is, if the transparency of service offerings is poor, it leads to a situation where providers have insufficient knowledge about services available [Lack of transparency] and it becomes impossible to make health-related decisions together with the customers. Home care workers stated that they “*could use more information, it is not enough*” (Public home care worker). Transparency was particularly poor over so-called supportive services such as lawn mowing and relief of loneliness: “*When customers talk about services they need, they do not talk about our home care or social services but services for day-to-day living, such as hairdresser, shopping, transportation. We professionals do not know about these services*” (Social worker). Also, it is not always clear to patients and relatives why they need to visit certain providers. One relative stated: “*I once called the secretary to make adjustments to the schedule. They said that this was not possible, because this schedule is mandatory. I felt frustrated, because I should be the one to decide what my child needs.*” (Carer). Shared responsibility is not promoted, and it should therefore be clear for patients why such requests are denied. The introduction of an open-customer interface, namely an overview of the available components and modules of the providers involved, would promote service transparency. If this were to be done, this interface could support patients and providers make care-related decisions together.

5.5 Discussion

This study had a two-fold agenda. First, the study described interfaces in multi-provider contexts. Second, we analysed how interfaces can support the delivery of integrated patient care in multi-provider contexts. Based on these insights, we offer directions for future research in the form of tentative propositions.

5.5.1 The role of interfaces in multi-provider contexts

We have described interfaces in two multi-provider contexts in health services. Most of the interfaces identified in this study were in line with those identified by de Blok et al. (2014), such as planning rules (closed-customer interface) and work division (closed-information interface). Something that was not mentioned by de Blok et al. (2014), but which is observed in our study, is that interfaces can simultaneously cover both types of interface entities

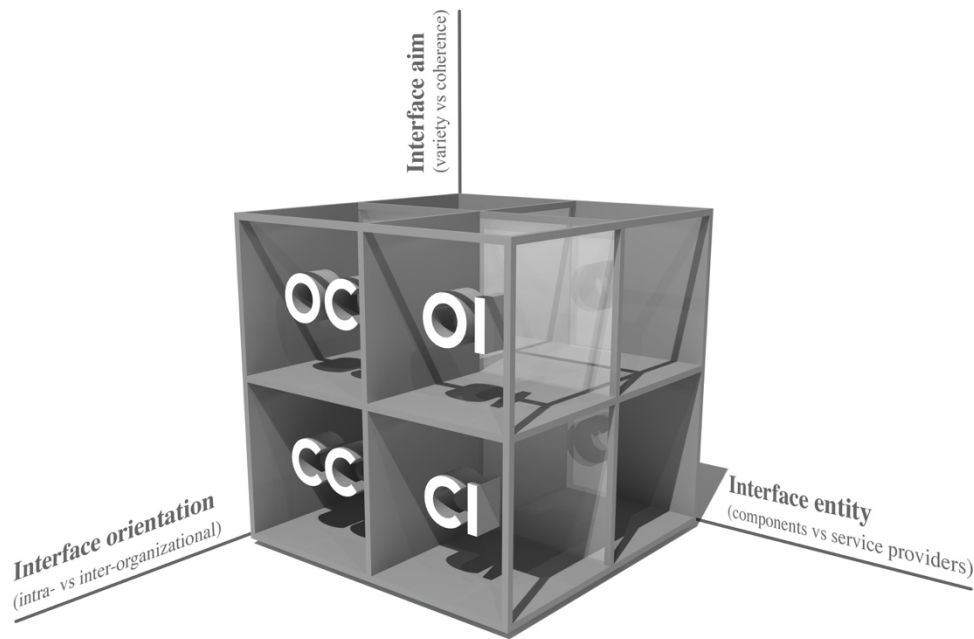
(components and providers) and both types of interface aims (variety and coherence). In that sense, the interface categories do not rule each other out: in other words, they are not mutually exclusive. The care plan, for example, is created in multidisciplinary meetings and has the aim of creating tailored service packages for customers (open-information). However, once done, it serves the further aim of diminishing the need for information exchange between providers (closed-information). Therefore, the care plan first serves as an open-information interface by allowing for reconfiguration of care packages and individual adaptations which is considered as an essential element in service modularity (Pekkarinen & Ulkuniemi, 2008; Fransen et al., 2019). Second, the care plan serves as a closed-information interface. This interface type directs the flow of information and is mentioned as typical for interfaces in service modularity (Voss & Hsuan 2009). We also observed this phenomenon in relation to interface entities. On one hand, the ERP contains the predefined information about the order of the service components (closed-customer). On the other, it also automatically creates the schedule for providers and reduces the need for information exchange i.e. the need to negotiate the distribution of work among the providers (closed-information). This dual role of interfaces needs to be taken into account when describing them. Based on the above, we formulate the following proposition:

Proposition 1. Interfaces can cover both interface entities and interface aims and in doing so can serve a dual role in service provision.

We propose that in multi-provider contexts, interfaces coordinate and manage interactions on three analytically distinct dimensions. The first two dimensions, interface entities (Figure 1. x-axis: components or service providers) and interface aims (Figure 1. y-axis: variety or coherence), are captured in the typology of de Blok et al. (2014). The third dimension, which we define as the interface orientation (Figure 1. z-axis: inter-organizational or intra-organizational), explains whether interfaces manage interactions within the same organization or across organizations. This shows that modular packages can be created either 1) when all service components are delivered by the same service provider, which requires intra-organizational interactions (single-provider context) or 2) when service components are delivered by two or more service providing entities which requires inter-organizational interactions between the service entities involved (multi-provider context). The current typology of de Blok et al. (2014) does not capture the interface orientation dimension. Although there is a vast amount of literature in the operations and supply chain management domain that acknowledges the importance of intra- and inter organizational relationships (e.g., Das & Teng, 1998; Vanneste & Puranam, 2010; Zhang, van Donk & van der Vaart, 2016; Halkjær & Lueg, 2017), this is overlooked in the literature on interfaces in service modularity. By adding a third dimension, we further develop the existing typology by de Blok et al. (2014). In doing so, we move the discussion on interfaces in service modularity from an intra-organizational level (single-provider context) to an inter-organizational level (multi-provider context).

Figure 1 presents a classification of eight interface categories. The first four intra-organizational interface categories are unchanged. The last four interface categories (inter-organizational open-customer, inter-organizational open-information, inter-organizational closed-customer, and inter-organizational closed-information) are the newly discovered interface categories in multi-provider contexts.

Figure 1. A three-dimensional typology of interfaces in service modularity.



First, inter-organizational open-customer interfaces provide a structure that enables combination and adaptation of components and modules across organizations. They support the transparency of service provision because they describe precisely the available services that each organization can deliver (Brax et al., 2017). This offers providers opportunities for specialization, which is especially important for healthcare organizations since they feel pressure to increase specialization (Halkjær & Lueg, 2017). Second, inter-organizational open-information interfaces offer a structure that brings service providers together from different organizations, and in doing so, enables information exchange across organizations. These interfaces can enable gains from specialization (Halkjær & Lueg, 2017), because in multi-provider contexts the formation of inter-organizational open-information interfaces can be motivated when less efficient in-house operations are abandoned and are able to be substituted by other providers (Hoetker, 2006). For example, a hospital can decide to hire a certain specialist because they do not possess that type of in-house knowledge. In this way, service providers can be relatively easily replaced by others, allowing for efficient mixing-and-matching of the service offering. This kind of lateral exchange of competencies is possible in integrated supply chains (Vanneste & Puranam, 2010). Hoetker (2006) has already shown the possibilities of this in the laptop industry. Third, inter-organizational closed-customer interfaces arrange components and modules so that they can work together in a predictable way, making sure that the customer can flow between one organization and another without hindrance. These interfaces make the impact of actions taken in one organization on another as predictable as possible, so that mutual adjustment can take place in a coherent way, relying on rules, procedures, and standards instead of discussion and negotiation. In doing so, they provide clear descriptions of the adequate outputs of each service provider and each organization, which can help in terms of reducing overlap in services. Last, inter-organizational closed-information interfaces diminish the amount of information exchange between service providers from different organizations by making

interactions predictable. This requires standard information transfer practices which also facilitate the interoperability of services in multi-provider contexts (Zhang et al., 2016). These interfaces require the electronic sharing of information between different information systems and service providers, improving the ease with which providers can offer and coordinate their services and customers can move smoothly through the system (Auschra, 2018). An example of such an interface can be a cross-organizational information system (e.g., interoperable electronic health record). Summarized, we developed the following proposition:

Proposition 2. While inter-organizational interfaces make inter-organizational coordination easier, they are more difficult to specify than intra-organizational interfaces.

5.5.2 Matching modular interfaces and integrated patient care

We empirically investigated the implications of modular interfaces for the delivery of integrated patient care in multi-provider contexts. By applying the typology on modular interfaces in healthcare by de Blok et al. (2014) and combining this with the dimensions of integrated patient care by Singer et al. (2011) we were able to show how modular interfaces support the delivery of integrated patient care. Although these theoretical perspectives, modular interfaces and integrated patient care, use different concepts, they reflect two sides of the same coin. First, integrated patient care emphasizes coordination whereas interface typology speaks of coherence. Both of them aim at supporting fluidity of services and smooth flow of customers in service processes. Second, integrated patient care highlights patient-centredness whereas interface typology addresses it as variety. Both of them focus on allowing choices to be made to deliver a customized service offering that fits the needs and requirements of the customer. Customization is a highly topical issue in healthcare because customers increasingly expect customization in their services (Berwick, 2009; Minvielle, 2018). The interface typology aims to meet this requirement by pointing out the linkage between subsystems, namely interfaces, which support variety and customization of services. Integrated patient care also considers customization important and introduces practices to tailored care and the engagement of patients in planning their services (Singer et al., 2011).

The results of this study shed a light on the discussion in healthcare between standardization and customizations. We found several guidelines and protocols that were missing, their absence causing confusion among providers and even uncoordinated services. Furthermore, although guidelines and protocols existed in some cases, providers did not always follow them. This caused even more confusion when unexpected practices were encountered and outcomes of procedures unexpected. In these cases, providers were acting on the basis of their professional work experience and not on the basis of protocols, something also observed in other healthcare modularity studies (Silander et al., 2017). The needs of individual customers are highly heterogeneous and might change unexpectedly (Vähätalo & Kallio, 2015). Adapting protocols to changing situations requires good professional knowledge and long clinical experience which both are essential elements of professionalism. Standard guidelines and protocols would be particularly beneficial in multi-provider contexts where predicting professionals' behaviour across disciplines is highly challenging (de Regge et al., 2019). However, the extent to which standardization in multi-provider contexts is possible can be questioned, since standardizing too extensively might jeopardize important adaptations of services based on professional work experience. We formulate the following proposition:

Proposition 3. Extensive interface standardization in multi-provider contexts jeopardizes customization based on professional expertise.

5.6 Conclusion

This study offers a detailed perspective on modular interfaces in multi-provider contexts in healthcare services. Our case research provides insight into several types of modular interfaces in multi-provider contexts. Furthermore, we provide examples of inter- and intra-organizational situations in which integrated patient care was jeopardized and how modular interfaces can support the delivery of integrated patient care. Future research is needed to assess the further potential of our findings in the wider context of service operations.

5.6.1 Theoretical contribution

This study applies the typology for interfaces by de Blok et al. (2014) for explicating the importance of interfaces in multi-provider contexts. Although the typology of de Blok et al. (2014) provided a useful framework for scrutinizing interfaces in modular services, it did not capture the inter-organizational element of multi-provider contexts. By adding a third dimension, the orientation of interfaces (intra-organizational versus inter-organizational), to the typology of de Blok et al. (2014) we specifically contribute by further developing the typology for interfaces in modular services. In doing so, we move the discussion on interfaces in service modularity from an intra-organizational level (single-provider context) to an inter-organizational level (multi-provider context). This is essential for improving the theoretical underpinnings of service modularity (Brax et al., 2017). Furthermore, this study investigated the implications of modular interfaces for the delivery of integrated patient care in multi-provider contexts. These implications provided more insight on the complicated nature and role of interfaces in multi-provider contexts. As such, we address the call for more research on service modularity in multi-provider contexts (Brax et al., 2017).

5.6.2 Managerial and practical implications

Despite all the existing research, many managerial and operational challenges related to the delivery of integrated patient care remain unsolved (González-Ortiz et al., 2018). Although these challenges might vary from context to context, the general idea of modular interfaces provides a holistic approach and helps managers to understand the importance of interfaces in health services that are delivered by a variety of professionals and organizations. We identified various interfaces that allow for interaction and communication in multi-provider contexts and showed that these interfaces can help managers to overcome managerial and operational challenges. By highlighting the available interfaces and introducing work and service descriptions that are available for every professional, functional silos can possibly be broken down. This can lead to less fragmentation between professionals and organizations and increased common goals. Moreover, we point out that inter-organizational interfaces (e.g., shared EHR) are particularly important when enhancing coordination and patient-centredness in the delivery of integrated patient care. Inter-organizational interfaces ensure a safe and smooth patient flow and allow for tailored services across healthcare organizations. In other words, the patient will not experience any hindrance, in terms of missing or overlapping treatment, while moving from one organization to the other. The results of this study can inspire managers to invest resources in developing and improving interfaces in multi-provider contexts. In this way, they have the opportunity for realizing the full potential

of integrated patient care. Our results could also be relevant for many other types of services (e.g., legal services, tourism services) that operate in a multi-provider context.

5.6.3 Limitations and future research

The results of this study were based on two cases representing multi-provider contexts in two different countries. Although countries are different, they both represent publicly financed healthcare systems. This can be considered a limitation, because the findings in other types of healthcare systems might be different. For example, it would be worth studying whether the organizational background of healthcare providers has an effect on the creation of interfaces and their functioning. In both of our cases, services were provided by public, private, and NGO providers which are all different, for example, having different institutional logics. Cultural differences are likely to impede collaboration among providers (Auschra, 2018). Although, these differences were not central to our study, previous literature indicates that it would be worth studying whether different organizational backgrounds affect the functioning of interfaces. Last, despite the fact that the customer's role in services is increasing, we did not incorporate interfaces with customers into our study. As such, this study might not provide an accurate representation of the customer's role in multi-provider contexts. We suggest that future research should address interfaces between service providers and customers in multi-provider contexts. This will further improve our understanding of interfaces in service modularity.

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Chapter 6. Interfaces in complex modular healthcare services

Abstract

Interfaces guide and manage interactions in complex modular services. However, there is little understanding of the actual role of interfaces in complex modular services, and interfaces between service providers and customers are overlooked in the literature. This is remarkable, given the strong need for customer centeredness in most complex modular services. We address this gap in a combined theoretical and empirical approach. We conducted a qualitative, multiple case study. Data collection involved 74 semi-structured interviews, 12 unstructured observations, and secondary data in so-called 'Downteams' in the Netherlands (these teams provide chronic healthcare for Down syndrome children). We identified a wide variety of interfaces in this example of complex modular healthcare provision. Based on our theoretical elaboration and our empirical data, we distinguish six interface classes that each serve a distinct role in complex modular services. These interface classes make sure that all the service providers involved are properly informed, that the delivery of complex modular services is coordinated, and that the identification of individual customer needs and preferences is ensured. In addition, we are the first to focus on interfaces between service providers and customers and, as such, we present a refinement of existing theory on interfaces in service modularity.

Keywords: Interface; Modularity; Customer-centered; Healthcare; Case study

6.1 Introduction

Services are becoming increasingly complex due to growing heterogeneous customer needs. Ensuring that these needs are met requires the involvement of multiple, often highly specialized service providers, offering a diversity of components (Bask et al., 2011; Brax et al., 2017). Besides the involvement of multiple service providers, who operate either as individual professionals or as employees in organizations, the wide variety of components is indispensable for satisfying the increasingly diversified needs of customers in complex services (Bask et al., 2011; Zou, Brax & Rajala, 2018).

Modularity has the potential to reduce the complexity of service systems (Simon, 1962) because it allows for the decomposition of a complex service system into smaller subsystems. These subsystems can be designed independently yet function together as a whole (Baldwin & Clark, 1997). By using the modularity principle of recombining independently functioning subsystems, a variety of heterogeneous customer needs can be addressed (de Blok et al., 2014). However, these subsystems need to be *coordinated* in order to function as a coherent whole; this is the role of interfaces. Interfaces prescribe how subsystems in a modular system mutually interact (Salvador, 2007). They are the linkages that allow interaction and communication between these subsystems (Voss & Hsuan, 2009). More specifically, Voss and Hsuan (2009) describe interfaces in two distinct dimensions: 1) interfaces in the *content* dimension connecting individual components and/or modules and managing possible interactions between their contents, and 2) interfaces in the *people* dimension connecting the various people involved in service provision and allowing them to exchange information with and about customers.

Interfaces are especially important in modular services in healthcare (Greenhalgh & Papoutsi, 2018). Modular healthcare services are complex because care provision requires multiple healthcare providers with different specialized backgrounds – and often from multiple organizations – to provide dissimilar healthcare modules and components (de Blok et al., 2010; Vähätalo, 2012). Coordination therefore becomes important. In addition, patients increasingly emphasize that they want their voices to be heard; they call for services that are tailored to their needs (Silander et al., 2017). This requires healthcare providers to interact with patients in order to understand their needs and the associated requirements. Unfortunately, most healthcare services do not adequately respond (Vähätalo & Kallio, 2015). For that reason, more focus is required on delivering healthcare that is *patient* instead of provider centered (Singer et al., 2011). Delivering patient-centered care requires that care providers shift from viewing patients as passive recipients to viewing them as active participants. To make this shift, interactions between patients and healthcare providers are essential, because only patients know whether their needs and preferences have been fully considered and whether they have received sufficient information and opportunities to allow them to participate in their care provision (Berwick, 2009; Singer et al., 2011).

Conceptually, interfaces in service modularity have the potential to manage and guide interactions in complex modular services (de Blok et al., 2014). However, a recent literature review revealed that we have very little understanding of the actual role of interfaces in complex modular services (Peters, Meijboom & de Vries, 2018), especially those that guide interactions *between people* involved in complex modular service provision. Further elaborations of interfaces in the people dimension in the literature only address the mutual interactions between service providers (e.g., de Blok et al., 2014; Broekhuis, van Offenbeek &

van der Laan, 2017); interfaces between service providers and customers are not addressed. This gap in our understanding of interfaces needs to be filled.

We have taken up that challenge and explore the role of interfaces in complex modular services, presenting a refinement of the existing theory of interfaces in service modularity in the people dimension. To achieve this, we addressed the following research questions: *What is the role of interfaces in complex modular services? And to what extent are they customer centered?* Empirically, we used the chronic healthcare provided by Downteams in the Netherlands as an example of complex modular service provision in healthcare.

Our contribution to the field is twofold. First, we advance the understanding of interfaces in complex modular services. We identified six distinct interface classes in complex modular healthcare provision: data entry and work arrangement in the content dimension, bidirectional information exchange and unidirectional information exchange in the people dimension between service providers, and substantive information exchange and procedural information exchange in the people dimension between service providers and customers. Second, our interdisciplinary approach, in which we combine the domains of operations management and health services, allowed us to get a more advanced understanding of the possible interactions between service providers and customers in complex modular service provision. Based on these insights, we included the customer in the conceptualization of interfaces in the people dimension and posit that interfaces between service providers and customers are indispensable in complex modular service provision. Without these interfaces, it is not possible to deliver services that truly match with customer needs and preferences.

This paper is divided into six sections. The Introduction briefly introduces the topic of this study. The Literature review provides an overview of existing literature on complex services and interfaces in service modularity. The section on Methodology describes the multiple case study methodology we used. The Results section presents the within- and cross-case analysis and is followed by the Discussion where we discuss the theoretical and managerial implications of our case findings. The Conclusion section sets out the findings from our study.

6.2 Literature review

6.2.1 Modularity theory

Modularity is rooted in general systems theory and is assumed to deal with complexity of service systems (Simon, 1962). Modularity involves the decomposition of a complex service into independent modules (Baldwin & Clark, 1997). Modules are separate, relatively independent parts of a service and fulfill a specific function (Rajahonka, 2013). Each of these modules itself consists of separate components. Components are defined as “the smallest elements in which a service offering can be meaningfully divided” (de Blok et al., 2014, p. 176). Interfaces manage the interactions and connections within the service offering. While combining and connecting various components, interfaces make sure that components function as a coherent whole (Baldwin & Clark, 1997). This ‘mixing-and-matching’ of components leads to a modular package. The delivery of modular packages can lead to individualized services: components can be easily substituted to match individual customer needs, without changing the modular package as a whole (Fransen et al., 2019).

The concept of modularity has been applied in various types of complex services like construction services (Doran & Giannakis, 2011), health services (de Blok et al., 2014; Soffers et al., 2014), legal services (Giannakis et al., 2018), and tourism services (Avlonitis & Hsuan, 2017). By recombining independently functioning modules, a variety of

heterogeneous customer needs could be addressed in these complex modular services. Although service providers assumed that they fulfilled customers' needs, in these studies it turned out that customer needs were only partially fulfilled. In order to gain a better understanding of their customers, and fulfill needs that are considered relevant by customers, service providers should put emphasis on attending to the customers' needs and preferences. To achieve that, complex modular services are trying to become more customer centered. This is important given the indispensable involvement of the customer in service provision (Cook et al., 2002; Sampson & Froehle, 2006). Although some scholars argue that service production may be carried out without customer participation (Lovelock & Gummesson, 2004), most scholars agree that customers are seen as active participants in creating, producing, and delivering services, thus co-creating the service (Bitner et al., 1997; Vargo & Lusch, 2004; Sampson & Froehle, 2006). As such, customer participation is a central feature of service production (Sampson, 2000; Vargo & Lusch, 2004; Sampson & Spring, 2012). Thus, because of the inseparability of services, service delivery is typically characterized by interactions between customers and providers (Gittell, 2002). These interactions should enable service providers to gain a better understanding of customers and their respective needs and would allow them to become more customer centered.

6.2.2 Patient-centered care in complex modular care services

The movement towards becoming more customer centered is especially important in complex modular care services. Most care services do not respond adequately to increasing numbers of patients with multiple chronic diseases and complex care needs (Kuipers, Cramm & Nieboer, 2019) and as a result, current care delivery is not tailored to the needs of those patients. Making care more patient centered as opposed to provider oriented may be the way forward. Patient-centered care has the potential to make care more tailored to the needs of patients (van der Heide et al., 2018; Ko et al., 2019). It can be defined as providing care that is respectful of and responsive to individual patient preferences, needs, and values and ensures that patient values guide all care-related decisions (Institute of Medicine, 2001).

Some aspects of patient-centered care are more important than others in fulfilling the needs and preferences of patients with complex care needs. First, care providers need to take patients' individual needs and preferences as a starting point for the development and provision of care (van der Heide et al., 2018). Care provision should be more than just meeting the patients' needs and preferences, it should emphasize them (Berwick, 2009). Care providers should actively involve patients in care provision to retrieve needs and preferences that are considered relevant by patients. For this reason, patients should be well informed about the care and treatment options they have. Their preferences with regard to these options should guide all care and treatment decisions (van der Heide et al., 2018).

Second, all relevant care providers should be adequately informed in and the delivery of multidisciplinary care should be coordinated. The treatment of patients with complex care needs often requires input from multiple care providers with different specialized backgrounds (Meijboom, Schmidt-Bakx & Westert, 2011). When multiple providers are involved in care provision, coordination becomes even more important. A lack of coordination could lead to inefficient care and health risks, for example when patients receive conflicting treatment or medication from different care providers (Singer et al., 2011; van der Heide et al., 2018). Coordination of multidisciplinary care is therefore of great importance for people with complex care needs.

In sum, the literature shows that a patient-centered care approach can help modular care services to become more responsive to the needs and requirements of patients with complex care needs. We argue that modular care services should therefore focus on delivering care that is patient centered in addition to being coordinated.

6.2.3 Interfaces in complex modular services

Conceptually, interfaces in service modularity should be able to provide modular services that are both coordinated and patient centered. Interfaces have an important role in modular services because they allow for interaction and communication within the modular service offering (Voss & Hsuan, 2009). They allow for the mixing-and-matching of components and ensure that components function as a coherent whole (Baldwin & Clark, 1997). As such, interfaces can enable both coordination and customization in modular service provision. In services, Voss and Hsuan (2009) distinguish two complementary interface dimensions: 1) interfaces in the *content* dimension that connect individual components and/or modules and manage possible interactions between their contents, and 2) interfaces in the *people* dimension that connect the various people involved in service provision and allow them to exchange information with and about customers. Eissens-van der Laan et al. (2016) describe the latter dimension more precisely: “the people dimension refers to the interactions between the service provider and the customers” (p. 310). The service modularity literature emphasizes the importance of interfaces (Peters et al., 2018), but only a few studies explicitly focus on interfaces in complex modular services. Given the central role of customers in complex services, when reviewing the literature we focused on interfaces in the people dimension (Table 1).

Voss and Hsuan (2009) were the first to discuss interfaces between service providers and customers. They argue conceptually that it is interfaces that connect the various people involved in service provision and allow them to exchange information about – but also with – customers. They conclude that there is a need for empirical study on interfaces in service modularity. De Blok et al. (2014) argue that interfaces in services connect different service providers as well as service providers and customers, but the authors only provide characteristics and examples of interfaces between service providers. Spring & Santos (2014) assert that, in modular service provision, interfaces should focus on interactions between service providers and customers but they do not provide empirical data. Soffers et al. (2014) suggest that it is the interfaces between people that guide information exchange among service providers and among service providers and customers. They identify a large number of interfaces in the people dimension and recognize that conversations with customers could be seen as interface between providers and customers. However, they do not explore this further. Broekhuis et al. (2017) posit that the presence of organizational interfaces between providers and customers within a service offering would provide a basis for configuring customer-specific services, but do not discuss this in their study. In a recent study, we have argued that interfaces play an important role in the customization and coordination of complex modular health services (Fransen et al., 2019). We have suggested that future research should involve customers as well as service providers in order to get a more comprehensive view on interfaces in complex modular services.

Table 1. Chronological overview of literature on interfaces in service modularity.

Author (year)	Interface types	Interfaces between people (as reported in the identified papers)
Voss & Hsuan (2009)	Interface in content dimension Interface in people dimension	Interfaces in services can include people, information, and rules governing the flow of information. Communication with the customer is especially important, given the active role of customers
Vähätalo (2012)	Interface between components Interface between people	Interfaces between people are needed in order to construct the service entity that meets the changing needs of customers
de Blok et al. (2014)	Open-Customer interface Closed-Customer interface Open-Information interface Closed-Information interface	Interactions within the service package are required to connect the various providers involved in service delivery and allow them to exchange information about customers
Spring & Santos (2014)	Structural interface Procedural interface	Procedural interfaces focus on integration of the people dimension of service offerings and relate to the interaction between the service provider and the customer
Soffers et al. (2014)	Interface between modules Interface between people	Interfaces between people guide information exchange among service providers and between service providers and customers
Broekhuis et al. (2017)	Functional interface Organizational interface	Organizational interfaces between modules coordinate the activities among providers and between providers and customers
Fransen et al. (2019)	Information-flow interface Customer-flow interface	Customer-flow interfaces allow for coordination between providers, and between providers and customers

It is striking that the predominant interest in interfaces in the service modularity literature is primarily focused on mutual interactions between service providers rather than interactions between service providers *and their customers*. This finding is even more remarkable given the fact that service providers need to deal with growing heterogeneous customer needs (Bask et al., 2011). Interactions between service providers and their customers are necessary to determine whether customer needs have been truly met; only customers know whether their needs and requirements have been fully considered and addressed. We therefore argue that interfaces should include interactions between service providers and customers in order to deliver services that are both coordinated and meet customer needs. The interfaces between service providers and customers complement the previously identified interfaces in the people dimension.

To fill this gap in the literature, this study presents a multiple case study in healthcare that focuses on the role of interfaces in complex modular service provision. Also, we explicitly include customers in the conceptualization of interfaces in the people dimension, in line with the theory initially proposed by Voss and Hsuan (2009). In doing so, we aim to gain a more advanced understanding of the possible interfaces between customers (patients) and service providers (healthcare providers) in complex modular healthcare services, and of the extent to which these interfaces are patient centered.

6.3 Methodology

The aim of the study is to add new knowledge to the theory regarding interfaces in service modularity by focusing on interactions in complex modular service provision. A qualitative, multiple case study research design was chosen because this enabled us to explore differences within, as well as across, cases (Barratt, Choi & Li, 2011). We used existing concepts and models to collect data that would refine existing theory, an approach defined as theory elaboration (Ketokivi & Choi, 2014; Fisher & Aguinis, 2017). We started with a partially explained phenomenon – interfaces in service modularity – and collected data to elaborate on this theoretical construct. Based on constructs from interfaces in the service modularity literature, we empirically examined interactions in both the content and people dimensions in complex modular service provision.

6.3.1 Study context

The methodological approach of our study is qualitative case research (Yin, 2014) in complex healthcare provision for children in the Netherlands with DS. DS, also known as trisomy 21, is the most commonly known medical cause of intellectual disability. Individuals with DS experience various comorbidities with varying severity such as problems of hearing and vision, heart defects, and auto-immune diseases. Each individual with DS is affected differently (Weijerman & de Winter, 2010). As such, DS provides an example of a patient group with complex healthcare needs. The greater service needs, combined with functional difficulties, make children with DS an ideal population for assessing the degree to which healthcare provision is functioning in a coordinated and patient-centered way (Phelps et al., 2012). Multidisciplinary pediatric outpatient clinics have been established in the Netherlands and organize team appointments for children with DS. Each child visits medical, paramedical, and non-medical specialists, all on the same day (van den Driessen Mareeuw et al., 2017). These teams are referred to as ‘Downteams’.

The suitability of the chosen study context follows from its highly modular setup. This means that the cases make use of a structure that enables them to combine a large variety of independently functioning healthcare components into customized healthcare packages (Fransen et al., 2019) for each patient that are then provided to the patient and their carer by a multidisciplinary team. We analyzed the interactions between components, modules, service providers, and customers.

6.3.2 Case selection and unit of analysis

Currently, there are 22 Downteams located at different hospitals in different parts of the Netherlands (Stichting Down Syndroom, 2018). We followed a purposive sampling strategy. This led to the inclusion of four Downteams that were representative of all the Downteams in the Netherlands. The four Downteams included are geographically dispersed, demonstrate variety in their set-up and are well-known in the field, as such, provide a comprehensive view of chronic DS healthcare in the Netherlands. The teams were pseudonymized to protect the hospitals’ identities. The unit of analysis was the interaction between components/modules, service providers (i.e., healthcare professionals), and customers (i.e., patients and their carers). This allowed us to gain in-depth knowledge on the use of interfaces that was focused on the content as well as the people dimension in this example of complex modular service provision.

6.3.3 Data collection

Seventy-four semi-structured interviews with healthcare professionals ($n = 53$) and carers of children with DS ($n = 21$) were conducted (Table 2), lasting from 45 to 75 minutes. The carers of the children with DS were considered as proxy for the children with DS (hereafter referred to as “patients”); this is common practice in pediatric research, especially in children with intellectual disability (Eiser & Varni, 2013). The topic list (Supporting information I) was compiled based on a literature review on interfaces in service modularity (Peters et al., 2018). The semi-structured interviews ensured that we adhered to the predetermined topics and allowed us to go into these topics in more depth when necessary. The same topics were discussed with both healthcare professionals and carers, but the wording of the questions was adapted to the perspective of the participant. Questions were focused on the interactions taking place between components, modules, healthcare providers, and patients (“*Which types of information exchange take place within the Downteam and outside it? Can you give some examples?*”) as well as on the actual mechanisms to support the information exchange (“*Who is responsible for communication with and information provision to the patient?*”). Furthermore, a question like “*How do you feel about the coordination between the care providers in your Downteam?*” helped us to acquire information on the patient’s perspective on interactions in healthcare provision. The interviews were recorded and transcribed. We returned the interview transcripts to each respective participant, allowing them to review what they had said and add more information if they wanted to (Birt et al., 2016). After analyzing 65 interviews we reached data saturation because we noticed that no new themes were emerging.

Moreover, we collected relevant secondary data for each case that was available both externally (e.g., national guideline, brochures containing information about the Downteam) and internally (e.g., planning schemes, protocols) and that could lead to additional insights into the interfaces present. Last, we conducted 12 unstructured observations at the Downteams, three for each case, each of them lasting half a day. We joined patients and their carers during their visit with the Downteam (e.g., consultation with pediatrician, consultation with physiotherapist). The observations focused on the question “*What kind of interactions take place during healthcare provision and what kind of mechanisms are available to support interactions in healthcare provision?*” During the observations, the observer made theoretical memos which helped with understanding potential interpretations of the observations.

6.3.3.1 Ethics approval and consent to participate

Ethical approval was obtained from the Ethics Review Board of Tilburg University [EC-2017.60t]. Written informed consent was obtained prior to participation from all participants.

6.3.4 Data analysis

The data analysis was conducted in two stages: within-case analysis and cross-case analysis (Barratt et al., 2011). The thematic analysis approach of Miles, Huberman and Saldaña (2014) was performed in each stage. This approach consists of three steps: 1) data reduction, 2) data display, and 3) drawing and verifying conclusions. It is a systematic data reduction process based on the reading of transcripts, documents and theoretical memos, coding of sentences, collating and categorizing codes, and identifying mechanisms among the codes (Miles et al., 2014). The COREQ criteria list for qualitative research (Tong, Sainsbury & Craig, 2007) was used to guide us. This list made sure that our research adhered to the standard of good

qualitative research, as we report the important aspects of the research, study methods, context of the study, findings, analysis, and interpretations (Supporting information I).

Table 2. Participants interviewed.

Case A	Case B	Case C	Case D
Dietician	Dietician	Audiology assistant	Child psychologist
Doctor for the mentally handicapped (2x)	Doctor for the mentally handicapped	Contact parent	Doctor for the mentally handicapped
ENT-doctor (2x)	ENT-doctor	Dietician	ENT-doctor
Ophthalmologist	Medical social worker	Doctor for the mentally handicapped	Occupational therapist
Parent (6x)	Ophthalmologist	ENT-doctor	Ophthalmologist
Pediatrician (2x)	Orthoptist	Orthoptist	Parent (5x)
Physiotherapist (2x)	Parent (5x)	Ophthalmologist	Pediatrician
Secretary	Pediatrician (2x)	Parent (4x)	Physiotherapist
Social worker	Physiotherapist	Pediatrician	Preverbal speech therapist
Speech therapist (2x)	Secretary	Physiotherapist	Secretary
	Specialized nurse	Secretary	Speech therapist
	Speech therapist	Social worker	
	Rehabilitation doctor	Speech therapist	
	Youth healthcare physician		

Coding started from our preliminary coding framework that was developed using our theoretical conceptualizations as a basis for the interview topic list. The preliminary coding framework was tested at the very beginning of the data analysis. The deductive codes were discussed and this led to some adaptations to the coding framework. This resulted in a definitive coding scheme (Appendix I). In total, three researchers were involved in the coding process; two researchers (BM & EV) each coded a subsample of interviews and documents, and one researcher (VP) coded all the interviews, documents, and theoretical memos to warrant consistency. The coding of the interviews was compared and discussed within the research team until consensus was reached. We started with the identification of possible interfaces, using the interface description by Voss and Hsuan (2009) as our guiding principle: *“Interfaces are the linkages between subsystems that allow interaction and communication between those subsystems”* (p. 186). We then discussed in which dimension these interfaces were in play: the content dimension or the people dimension, the latter split “between healthcare professionals” and “between healthcare professionals and patients/carers” subgroups. After the coding process, we bundled text fragments with similar codes and systematically analyzed them to reveal the mechanisms used as interfaces. For each case, we presented the findings to the pediatricians for validation. These informants confirmed our findings and suggested only minor modifications. For the cross-case analysis, we collected the text fragments with similar codes from the individual cases and bundled them. This allowed us to classify the identified interfaces from the within-case analysis based on their role in healthcare provision. We compared our classification of interfaces, which is a form of data

display (Miles et al., 2014), with the existing literature and drew conclusions based on the analyses.

6.4 Results

A modular package for patients with DS at a given point in time typically consists of different components and modules (e.g., physical examination, oral motor development), which are provided by various service providers (e.g., pediatrician, speech therapist) in the Downteam (Fransen et al., 2019). In order to make sure that the patient's modular package is consistent with their needs and requirements and is coordinated over time, interfaces should be in place that guide interaction and communication between healthcare components and modules, healthcare providers, and patients/carers involved in modular healthcare provision (Fransen et al., 2019). The interviews, documents, and observations revealed a large number of such interfaces. While analyzing the data, we observed high consistency among the interfaces we identified for each case. Therefore, we condensed these interfaces into a description that holds for all. However, we also identified interfaces that were case specific. We provide more detail on these case specific interfaces in Sections 6.4.1.1–6.4.1.4. A complete overview of all the identified interfaces per case is presented in Table 3.

6.4.1 Within-case analysis

We identified a large number of interfaces in the content dimension that connect components and modules: checklists, guidelines, protocols, and screening forms are used to guide decisions and criteria regarding diagnosis, management, and treatment of patients. They describe appropriate components and modules that can be selected to deal with the specific health-related conditions that a patient is facing. These interfaces support healthcare providers with substantive recommendations for the provision of healthcare. Interfaces such as a multidisciplinary workbook, work schedule, and consulting room schedule provide rules on where, when, and by whom which components or modules should be provided. These interfaces enable healthcare providers to be informed of the other healthcare providers' tasks and responsibilities. However, healthcare providers indicated that they are accustomed to discipline-oriented working and are largely unaware of what their colleagues are doing. This was sometimes problematic because certain outputs of healthcare providers serve as input for other involved healthcare providers (e.g., the output of the ENT doctor is relevant input for the speech therapist).

Several interfaces in the people dimension were identified that allow for interaction and communication between healthcare providers. We identified two separate types of multidisciplinary meetings: multidisciplinary healthcare meetings and multidisciplinary team evaluation meetings. The multidisciplinary healthcare meetings are held to coordinate the actual provision of healthcare and used to discuss and combine the outcomes of the consultation with each healthcare provider. This ensures that any follow-up treatments are provided in a coherent way and emphasizes the multidisciplinary nature of the care provision. The multidisciplinary team evaluation allows healthcare providers to reflect on their way of working and provide feedback to each other. The healthcare providers emphasized the importance of such meetings, as they stimulate them to reflect on their day-to-day practices.

Table 3. Identified interfaces per case.

CASE A					
Content	Quote	People	Quote	People	Quote
<i>Between components or modules</i>		<i>Between service providers</i>		<i>Between service providers and customers</i>	
<ul style="list-style-type: none"> Annual planning Guideline ENT-doctor History form dietician History form doctor for the mentally handicapped History form ophthalmologist History form physiotherapist History form social worker History form speech therapist Nationwide multi-disciplinary guideline Protocol pediatrician Screening form physiotherapy Work schedule 	<p>“The nationwide multi-disciplinary guideline serves as the starting point of care delivery. I use it to focus on specific components relevant for each patient.” (Pediatrician)</p> <p>“I use the history form as a tool to collect the necessary information about a patient. As soon as I have the information, we start discussing about the financial, legal, and organizational arrangements.” (Social worker)</p>	<ul style="list-style-type: none"> Consent form Electronic health record E-mail Laboratory form Multi-disciplinary team meeting Notes Referral general practitioner Referral letter Report audiology Report from primary care Team evaluation Telephone 	<p>“The multidisciplinary team meeting is used to put our heads together, discuss the patient’s medical history and specific actions to be performed. By doing this, we are immediately up-to-date about a patient’s situation.” (Physiotherapist)</p>	<ul style="list-style-type: none"> Admission letter E-mail Information letter Patient portal Summary letter 	<p>“The information letter does not inform me at all. I require detailed information about the distinct consultations and what kind of questions I can ask them. If the information letter would contain this information, it would be useful.” (Carer)</p>
CASE B					
Content	Quote	People	Quote	People	Quote
<i>Between components or modules</i>		<i>Between service providers</i>		<i>Between service providers and customers</i>	
<ul style="list-style-type: none"> Checklist doctor for the mentally handicapped Checklist pediatrician Consulting room schedule Dietary journal Division of work Guideline ENT-doctor History form dietician History form ophthalmologist History form specialized nurse Nationwide multi-disciplinary guideline Multi-disciplinary work book 	<p>“We are used to discipline oriented working and I hardly know what my colleagues are doing.” (Speech therapist)</p> <p>“It is useful if I have a general sense of what the speech therapist is doing, because my output should serve as input for their consultation. Right now I only provide my general output.” (ENT-doctor)</p>	<ul style="list-style-type: none"> Declaration form E-mail Electronic health record Intercollegiate meeting Multi-disciplinary team meeting Notes Referral letter Report from primary care Summary letter Team evaluation Transition letter 	<p>“Twice a year we meet with a group of healthcare providers from primary care in which we discuss what we should do in the coming half year; e.g. is it necessary to take education together?” (Rehabilitation doctor)</p> <p>“The team evaluation is important as it stimulates us to reflect on our working methods. Due to the issues of the day, we cannot do this on a daily basis.” (Pediatrician)</p>	<ul style="list-style-type: none"> Admission letter E-mail Guide for social services List of primary care providers Patient portal Questionnaire Summary letter Telephone appointment Telephone consultation 	<p>“For my last visit to the Downteam, I did not want to visit the ENT-doctor and speech therapist, because I did not need them. The Downteam arranged this and made sure that I had a convenient visit.” (Carer)</p> <p>“If parents inform us in advance about their requests, either medical or non-medical, we can both use this to our advantage.” (Secretary)</p> <p>“The specialized nurse guides us through the maze of our healthcare system. She is proactive in her way of working and</p>

<ul style="list-style-type: none"> • Protocol medical social worker • Protocol speech therapist • Screening form physiotherapist 					<p><i>makes sure our problems are being answered before, during or after our visit to the Downteam.”</i> (Carer)</p>
CASE C					
Content	Quote	People	Quote	People	Quote
<i>Between components or modules</i>		<i>Between service providers</i>		<i>Between service providers and customers</i>	
<ul style="list-style-type: none"> • Checklist doctor for the mentally handicapped • Checklist pediatrician • Consulting room schedule • Division of work • Guideline ENT doctor • History form dietician • History form ophthalmologist • History form physiotherapist • History form speech therapist • Nationwide multi-disciplinary guideline • Protocol audiology assistant • Protocol dietician • Screening form physiotherapist • Work schedule 	<p><i>“There is a consulting room schedule, making sure that providers are in the right room at the right time.”</i> (Secretary)</p> <p><i>“My consultation is often scheduled after the consultation with the contact parent, while our consultations often run late. It would be better if our consultations are not scheduled one after the other.”</i> (Physiotherapist)</p> <p><i>“The physical examination is mainly focused on the motor skills and the mobility of the joints. This expertise is really linked to my discipline.”</i> (Physiotherapist)</p>	<ul style="list-style-type: none"> • Electronic health record • Multi-disciplinary team meeting • Notes • Referral letter • Report from primary care • Summary letter • Team evaluation • Telephone • Transition letter 	<p><i>“I often only hear during the consultation whether the patient visits a speech therapist in primary care and if there is any possible information available from this speech therapist. I would prefer to have this information beforehand.”</i> (Speech therapist)</p> <p><i>“I literally need the length and weight of the pediatrician’s consultation. I search in the EHR for the identified length and weight of a patient.”</i> (Dietician)</p> <p><i>“The patients are not here for me, they are here for you. Everything pediatrician X can do, I can do it to. You [other healthcare providers] make the difference.”</i> (Pediatrician)</p>	<ul style="list-style-type: none"> • Admission letter • E-mail • Information folder for parents • Information folder for patients • Patient portal • Patient reminder letter • Social domain folder • Summary letter • Telephone consultation • Transition folder 	<p><i>“...Since we only visit the Downteam once a year, my child has no clue what we will be doing in the hospital. The folder helps us to prepare for the visit, as he sees some pictures of the care elements and a photograph of the doctor. Children with DS are very visually oriented, so the folder is really of added value...”</i> (Carer)</p>

CASE D					
Content	Quote	People	Quote	People	Quote
<i>Between components or modules</i>		<i>Between service providers</i>		<i>Between service providers and customers</i>	
<ul style="list-style-type: none"> Action list Annual planning Consulting room schedule Guideline ENT doctor History form ophthalmologist History form preverbal speech therapist Nationwide multi-disciplinary guideline Patient overview Protocol child psychologist Protocol pediatrician Screening form physiotherapist Screening form speech therapist Screening form occupational therapist Screening form preverbal speech therapist Work schedule 	<p><i>There are various conditions a patient may face. However, from all these conditions, the protocol helps me to select the module that matches the needs of the patient"</i> (Preverbal speech therapist)</p>	<ul style="list-style-type: none"> Electronic health record E-mail Laboratory form Multi-disciplinary team meeting Notes Referral letter Report from primary care Summary letter Team evaluation Telephone Transition letter Transition meeting 	<p><i>"Sometimes we face medical problems we simply cannot deal with on our own and then there is always the possibility to refer a patient, by means of a referral letter, to another specialist within the hospital."</i> (Speech therapist)</p> <p><i>"After the consultations all of us meet in the pediatrician's room and present what we noticed and how we should act upon it."</i> (Occupational therapist)</p>	<ul style="list-style-type: none"> Admission letter Consultation scheme E-mail Patient portal Patient satisfaction survey Questionnaire Summary letter Telephone appointment Telephone consultation 	<p><i>"If we inform and communicate with patients to the best of our ability, it will result in us being informed to the best of our ability about their wishes and needs."</i> (Pediatrician)</p> <p><i>"The patient portal gives me the opportunity to look at the medical history of my child and give input for the next visit. But, I feel we could do way more with this added service."</i> (Carer)</p>

They would prefer to do this more often, but due to time constraints this is not possible. Another type of people interface connecting healthcare providers was identified: established forms of media (e.g., telephone, electronic mail, electronic health record (EHR), and notes). They enable information exchange in healthcare provision and make sure that healthcare providers interact fairly easily and as quickly as possible. For example, the EHR ensures that all content is stored in one place in one organization. The pediatrician records the height and the weight of the patient in the EHR. The dietician, who also has access to the EHR, can find the height and the weight of the patient in the EHR without interacting with the pediatrician. As such, the EHR allows for consistent and predictable interaction between the healthcare providers involved.

We also identified interfaces in the people dimension that support information exchange between healthcare providers and patients/carers. Admission letters, summary letters, and information letters serve as examples. These letters contain information about what a visit to the Downteam entails (e.g., the various providers a patient will visit, and what a patient needs to bring with them) and information about results and possible follow-ups from the visit. However, carers expressed the view that these letters often have little added value. For example, they argued that the information letter provides partially redundant information. The patient portal allows patients/carers to access their personal medical file and makes sure that they can pose questions before their visit to the Downteam. It gives patients/carers the opportunity to provide input for the next visit, which is appreciated, but they questioned the

usefulness of this interface. They felt that they could make much more use of the patient portal than in the current situation. Phone appointments and questionnaires provide patients/carers with the opportunity to express their needs and preferences and allow healthcare providers to adjust their consultation in a way that matches the patients' needs and preferences.

6.4.1.1 Case A

A multidisciplinary meeting that takes place before the patient's visit was specifically identified in case A. It has a different purpose from the meeting that takes place after healthcare provision and serves to pro-actively adjust healthcare provision based on the medical history of the patient and identification of the patient's needs. A physiotherapist emphasized the importance of this meeting: *"The meeting is used to put our heads together, discuss the patient's medical history and specific actions to be performed. By doing this, we are immediately up-to-date about a patient's situation."* (Physiotherapist).

6.4.1.2 Case B

In case B, a specialized nurse has a prominent role in healthcare provision. She always schedules a telephone appointment with carers a few weeks before a visit to the Downteam. She takes stock of specific requests and preferences from patients before their visit. Those requests can be medical issues, but also organizational issues such as a convenient planning of consultations. The specialized nurse is very important for patients/carers, mainly for questions of a non-medical nature. She has a prominent role in healthcare provision because she guides patients and carers through the maze of the healthcare system.

6.4.1.3 Case C

In case C, a patient information folder and carer information folder were identified as interfaces that connect healthcare providers and patients. They make sure that both patient and carer are aware of the tasks and roles of each healthcare provider involved. The Downteam have made sure that the folders are adapted for the patient population at hand, as they contain a photograph of each healthcare provider and include icons of the healthcare components delivered by each healthcare provider. This ensures that both patients and carers feel more at ease during their visit to the Downteam and are better prepared for the visit.

6.4.1.4 Case D

In case D, a patient satisfaction survey is distributed, providing patients/carers with the opportunity to provide feedback on healthcare provision. Healthcare providers can act upon the feedback received and improve provision. Providers argued that if patients inform them in advance, it results in them being well informed and, as a result, they can provide healthcare that is better adapted to patients' needs and preferences. We also identified a specific type of interface that connects healthcare providers in case D. Transition meetings take place in which the responsibility for all or some aspects of care for a patient is transferred from the pediatric to the adult healthcare provider. This exchange of information seems straightforward, but it was often unclear which information exactly needed to be exchanged. Healthcare providers argued that, despite the physical presence of both providers during the transfer, the exchange of information is often incomplete.

6.4.2 Cross-case analysis

For the cross-case analysis, we expanded our initial coding list to include emerging codes. When we bundled the text fragments stemming from the cases with similar codes within the respective dimensions (content or people), this provided further insight in terms of different classes of interfaces and their roles. For example, all the different types of history forms were collated under the emerging code “history form”. This type of interface is used, among others, as a specific form of data entry in the EHR. We continued this process (collating and categorizing) for all the other interfaces identified in the within-case analyses. A more detailed overview of this process is presented in Supporting information III. Table 4 and the sections below provide more detailed information on the identified interface classification.

Table 4. Summary of cross-case analysis: interface classification.

Content <i>Between components or modules</i>	People	
	<i>Between service providers</i>	<i>Between service providers and customers</i>
Data entry Checklist Guideline History form Protocol Screening form	Bidirectional information exchange Intercollegiate meeting Mail Multidisciplinary healthcare meeting Multidisciplinary team evaluation meeting Telephone	Substantive information exchange Needs assessment Patient portal Summary letter Telephone consultation
Work arrangement Annual planning Consulting room schedule Division of work Multidisciplinary workbook Work schedule	Unidirectional information exchange Consent form Electronic health record Laboratory form Notes Report from primary care Referral letter Summary letter	Procedural information exchange Admission letter Consultation scheme Information letter Information folder Patient reminder letter Patient evaluation survey

6.4.2.1 Interfaces in the content dimension

Interfaces identified in the content dimension provide information on the possible applications of components and modules and their feasibility with respect to various comorbidities and disabilities. In doing so, they guide component and module selection for the modular healthcare packages delivered. We observed that these interfaces are standardized formats that either guide the medical content of care leading to data entry in the EHR, or make sure that internal processes are arranged supporting work arrangements.

Data entry

Checklists, guidelines, history forms, protocols, and screening forms are all interfaces that eventually lead to data entry in the EHR. While some of them are used to complete the medical history of a patient (e.g., history form), others are used to add information following from the physical examination of a patient (e.g., screening form). “*The history form is used to*

make sure that my information is up-to-date based on a patient's health, while the screening form helps me during the consultation to examine the patient. All the data gathered is eventually entered in the EHR." (Physiotherapist). We observed that these interfaces have in common the embodiment of a particular subject for data entry in the EHR, but the data that needs to be entered is not specified in advance. This offers healthcare providers the opportunity to shape their consultation based on their professional judgement and patient preferences, while the results of the consultation are entered in predefined areas of the EHR, mainly related to the healthcare provider's professional background. We found that, at times, data entry was impossible, as some types of healthcare providers did not have access to the EHR or specific parts of the EHR. *"Although we are part of the Downteam, we do not have access to the hospital EHR. We have to send our results [to the coordinator] (via e-mail) manually"* (Social worker). This limits the interface potential of the EHR with respect to accessibility of information for every healthcare provider. Some of the interfaces (e.g., checklists and protocols) also serve as memory aids for the healthcare providers: *"...I manually extracted bullet points from the nationwide guideline and created a personal checklist in the EHR. I do not have to memorize the entire guideline, but I use the checklist as a memory tool..."* (Pediatrician). This illustrates that the checklist in itself does not guide the data entry, but is used as a memory aid to collect data from the patient and later on for data entry in the EHR. In one case it was possible to incorporate interactive checklists in the EHR, leading to a dashboard that indicates compliance to individual items of the prevailing guideline. This facilitates insight into adherence to that guideline and provides information on whether each patient receives the same quality of healthcare.

Work arrangements

Annual planning, consulting room schedule, division of work, multidisciplinary workbook, and work schedule are interfaces aimed at supporting work arrangements. They are formalized by the Downteams and state exactly which components and/or modules are to be provided where, when and in which order, which gives them a well-specified and standardized character: *"I create an annual plan – an overview of which patients visit the Downteam in which month – that I send to all the members of the Downteam. Each healthcare provider can act on it and is aware of the patient's visit months in advance.* (Secretary). These strict and prescribed interfaces ensure that components and modules are executed in the right order. An ophthalmologist emphasized this: *"...because we know in advance when each patient will visit us, we are able to adapt our schedule and make sure that the right provider treats the right patient..."* (Ophthalmologist). This is useful for healthcare providers in arranging a visit that is convenient for both themselves and for patients. Furthermore, multidisciplinary workbooks make sure that healthcare providers are aware of the components and modules that need to be provided by them and those that need to be provided by their colleagues. These interfaces ensure that components and modules are aligned and reduce possibilities of overlap in treatment or of missing treatments, as this could be dangerous from a safety point of view (e.g., in case of conflicting medication): *"Only recently we started working with a workbook, but it helps in getting a better understanding of each other's work methods and work practices"* (Pediatrician).

6.4.2.2 Interfaces in the people dimension: between service providers

Some of the interfaces identified allow for information exchange between service providers about patients and healthcare provision. We observed that the information flow in these interfaces was either unidirectional or bidirectional, and that this had different implications for the complex modular healthcare provision. We classified them accordingly.

Bidirectional information exchange

Intercollegiate meetings, multidisciplinary healthcare meetings, and multidisciplinary team evaluation meetings are interfaces aimed at bidirectional information exchange. They connect healthcare providers and involve direct, mutual exchange of information. These interfaces require simultaneous activity, either through physical presence or long-distance contact (e.g., telephone). Physical presence, in particular, can provoke substantive discussions among the healthcare providers involved: *“When everyone is physically present at our team meeting, we have a much livelier discussion than when information is exchanged by means of a letter”* (Pediatrician). These interfaces emphasize the multidisciplinary nature of the healthcare provision and lead to shared knowledge and understanding of the work of others, both within the team and outside the team, across all the healthcare providers involved. These meetings have a pre-established structure for discussing patients that allows them to share information effectively and adapt care delivery accordingly.

Unidirectional information exchange

Referral letter, summary letter, and report from primary care are interfaces aimed at unidirectional information exchange. They connect healthcare providers, but only transmit information in one direction: from a sender to a receiver. These interfaces comprise established forms of media like letters, forms, mails, files, and notes that guide swift information exchange. The healthcare providers do not have to be simultaneously active and often the interface delivers information for later use. A physiotherapist stated: *“A report from primary care makes sure that I have all the necessary information to complete a patient’s medical history. It is not information that I require immediately, but I can use it at a later point in time”* (Physiotherapist). This is especially useful when information is exchanged across organizational borders, as these interfaces make sure that healthcare providers have access to information, regardless of time and place.

6.4.2.3 Interfaces in the people dimension: between service providers and customers

Some of the interfaces identified create interactions between service providers and customers in complex modular care provision. Interestingly, we observed that three cases (B, C & D) were more active in this regard than the other case (A). While all interfaces aimed at a streamlined flow of information between providers and customers, we observed that the way providers interact with customers could be characterized by the type of information exchanged between them. We therefore classified the interfaces between service providers and customers based on the type of information exchanged: substantive information exchange or procedural information exchange.

Substantive information exchange

The patient portal, summary letter, telephone consultation, and needs assessment are interfaces aimed at substantive information exchange. Their aim is to inform healthcare

providers and customers about medical facts or questions. This enables healthcare providers to provide care that is tailored to the patient's needs. Healthcare providers do approach patients, often with a needs assessment, in order to get a better understanding of a patient's needs and preferences. A secretary mentioned: *"We send out a relatively simple questionnaire to patients on which they can indicate what their needs and wishes are for their next visit. This helps us to get a sense of their problems"* (Secretary). In a similar fashion, the telephone consultation was described in this way: *"A few weeks in advance the specialized nurse calls me about our visit to the Downteam. She explores our needs and thinks about things we do not think about. This helps us, but also the team, to be better prepared for the healthcare provision"* (Carer). Based on this information, healthcare providers can decide to rearrange providers or components of a modular package based on the individual needs and preferences of patients.

When a patient leaves the Downteam, the summary letter and telephone consultation make sure that the outcomes of the visit to the Downteam are communicated to the patient: *"...A few weeks after the patient's visit to the Downteam, I schedule a telephone consultation with them and discuss the outcome of the visit and ask if there was anything unclear in the summary letter..."* (Pediatrician). Since multiple healthcare providers are involved, it is important that information is actively exchanged so they have up-to-date information about the patient's situation. The summary letter and telephone consultation are useful in this regard: *"I do not completely remember everything that is being said at the Downteam when I visit the physiotherapist in primary care. I just give him the summary letter instead"* (Carer). These interfaces help to share the outcomes and recommendations of the Downteam with the other healthcare providers involved.

Procedural information exchange

The information folder, patient satisfaction survey, and information letter are interfaces aimed at procedural information exchange when patient and healthcare provider are temporally or spatially separated. They manage the complexity of modular healthcare provision by increasing transparency. The patient's understanding of available healthcare components and modules is crucial in this regard. However, we found that most of the cases do not have an overview of available healthcare components and modules for their patients. To illustrate: *"In the previous situation we had no information folder available – the overview of what we could expect during the visit to the Downteam – and I had less understanding of the healthcare provision. With the introduction of the information folder, I am aware of the role of each healthcare provider and I know where to direct my questions"* (Carer). Occasionally, evaluation surveys are sent to patients to obtain feedback on healthcare provision, leading to an understanding of the patients' perspective on modular healthcare provision. This can provide a means of improving healthcare provision: *"Based on the recommendations of parents, we were able to make adaptations to our care provision"* (Physiotherapist). It was observed that not all cases actively engage in getting feedback from their patients. To illustrate: *"We actually know very little of how patients experience care provision and are happy with how we are doing it. We have a gut feeling, but we cannot build on that"* (Pediatrician).

6.5 Discussion

The study allowed us to identify a wide variety of interfaces in the two dimensions of complex modular services: content and people. We discuss the theoretical and managerial implications of our findings, limitations, and future research directions.

6.5.1 Theoretical implications

Our case findings provide more detailed understanding of interfaces in complex modular service offerings. In our multiple case study on complex modular service provision in healthcare, we identified six distinct interface classes in the content and people dimensions. These are conceptualized to general modular service theory in Table 5.

Table 5. Conceptual classification of interfaces.

Content	People	
<i>Between components or modules</i>	<i>Between service providers</i>	<i>Between service providers and customers</i>
<p>Data entry Provides particular formats for service providers that lead to data entry into information and communication systems</p>	<p>Bidirectional information exchange Ensures a mutual exchange of information between two or more service providers. This requires simultaneous activity and creates an interactive process</p>	<p>Substantive information exchange Ensures that needs of customers are retrieved, supporting the providers and customers involved to stay informed before, during, and after service provision</p>
<p>Work arrangement Supports the organization of work, by stating exactly which components or modules are to be provided where, when, and in which order</p>	<p>Unidirectional information exchange Ensures that information is exchanged between one service provider and another, preventing information from going missing</p>	<p>Procedural information exchange Manages complexity of the service offering, by providing customers and service providers with transparency and guidance about the service offering</p>

In the content dimension, the data entry interfaces identified embody particular formats that facilitate data entry into information or communication systems such as an EHR or enterprise resource planning system. These interfaces guide the technical interactions between components. This is especially relevant given the fact that many organizations turn to information and communications systems in order to reduce the complexity of their service offering (Dobrzykowski & Tarafdar, 2015; Zou et al., 2018). The work arrangement interfaces identified describe how complex modular service provision is arranged; they serve as mechanisms that structure services internally in order to arrange convenient service provision. Compliance with these interfaces is required to ensure that components and modules are aligned and put into a fixed order for service provision (de Blok et al., 2014). As such, the data entry and work arrangement interface classes identified promote coordination in complex modular services.

In the people dimension between service providers, bidirectional and unidirectional information exchange interfaces ensure that information can be exchanged, even if information needs to cross functional or organizational borders. Since complex modular services are delivered by multiple providers, possibly from multiple organizations (Brax et al., 2017), it is important that all the service providers involved have access to information,

regardless of time and place. However, service providers often do not specify in advance how to interact with each other (Peters et al., 2018). This limits the coordination of complex modular services and could lead to deficiencies in collaboration between the service providers involved (Gittell, 2002; Vähätalo, 2012), for example, causing problems in the transition from pediatric to adult care services. Eventually, the lack of coordination increases the possibility of incomplete or inaccessible information and this could lead to risks like waiting times, delays for customers, and loss of information, among others (Meijboom et al., 2011). Our identified interface classes enable service providers to share information effectively, either through direct or indirect interaction, and prevent services from being uncoordinated. As such, the identified bidirectional and unidirectional information exchange interface classes make sure that all involved service providers are informed and the delivery of complex modular services is coordinated. This constitutes one of the aspects of patient-centered care that is especially important in order to fulfill the needs and preferences of patients with complex care needs (Gill et al., 2014).

In this study, in the people dimension, particular attention is paid to interfaces between service providers and customers. To our knowledge, this is the first study to deal with these interactions between service providers and customers in the context of service modularity. By allowing for the exchange of information, these interfaces make sure that customers of modular service provision are genuinely involved. Substantive information exchange interfaces ensure that needs and preferences of customers are retrieved and that all the providers are kept informed. These interfaces support service providers in becoming more responsive to the needs and requirements that the customers consider to be relevant. The increased responsiveness helps service providers in delivering a modular package that changes alongside the customer's relevant needs. Earlier research arguing that providers who establish strong interactions with customers can better understand their needs and adapt service provision accordingly (Sampson, 2000; Gittell, 2002; Dobrzykowski & Tarafdar, 2015) is now further elaborated for the domain of complex modular services. These interfaces can ensure that service providers shift from viewing customers as passive recipients to viewing them as active participants in their service delivery (Singer et al., 2011). In doing so, service providers are able to construct a modular package by mixing-and-matching components and modules that meet the needs and embody preferences that are considered relevant by customers. This responds to the call for more patient-centeredness in healthcare by scholars (Berwick, 2009; Singer et al., 2011) and leading healthcare organizations (Institute of Medicine, 2001; WHO, 2015). It also relevant to the call for more customer centeredness in other complex service settings such as construction services (Doran & Giannakis, 2011), legal services (Giannakis et al., 2018), and tourism services (Avlonitis & Hsuan, 2017). When customers are actively involved in modular services, they implicitly influence the design of modular service delivery, taking on the role of component suppliers as well as design engineers (Sampson & Spring, 2012). The role of design engineer, in particular, is considered more and more significant in delivering customized modular services. For example, Bombard's (2018) review of healthcare services shows that engaging patients in the design and delivery of services is very fruitful, both from a societal and a scientific perspective.

Procedural information exchange interfaces provide transparency and guidance on complex modular service provision for service providers as well as customers. These interfaces make sure that customers are well informed about the options (modules and

components) available to meet their needs. Their preferences with regard to these options should guide decisions related to service delivery and can contribute to shared decision making, an important aspect in the delivery of patient-centered care (Singer et al., 2011). The interfaces are essential for complex modular service provision because they increase transparency about healthcare providers and their work practices and improve the patients' access to information. The lack of transparency and information has been highlighted many times by other scholars (Harris & Buntin, 2008; Dobrzykowski & Tarafdar, 2015; Ko et al., 2019). Furthermore, the procedural information exchange interfaces also make sure that customers are able to provide feedback on service delivery in a standardized manner. Again, this can be used to improve future service delivery (Avlonitis & Hsuan, 2017). This is especially useful in chronic healthcare, where individuals require similar services on a recurrent basis (de Blok et al., 2010). It is important to note that feedback is often directed at procedural aspects of service delivery and not necessarily on substantive aspects. For instance, customers often comment on the inconvenient sequence of delivered components rather than the actual delivered content of the components (Tax, McCutcheon & Wilkinson, 2013). By providing feedback, customers take on the role of quality assurer (Sampson & Spring, 2012). They contribute to quality, satisfaction, and to the value of the service, and they ensure that the quality of the service is acceptable (Vargo & Lush, 2004). This is increasingly relevant because customers are becoming more critical and more demanding, not only on the outcome of service provision, but also on how it is delivered (de Blok et al., 2013).

The six identified interface classes support service providers in managing complex modular services and making sure that the modular service provided is both coordinated and fulfills the customers' needs and preferences. However, customers increasingly want to manage their own service provision and while doing so, they need to take responsibility for the selection and coordination of service providers and their activities so as to create the modular service they want (Maulil, Geraldi & Johnston, 2012). This suggests the importance of the "intelligent" customer (Maulil et al., 2012), who is assumed to have sufficient knowledge of the services provided. The extent to which the customer can do this effectively is questionable: while some customers are clearly capable of this, it may be more difficult for others (Silander et al., 2017). By giving sufficient attention to the customer's needs and preferences, adapted to the customer's capabilities, the service provider can achieve the best possible customer satisfaction.

6.5.2 Managerial implications

Our research provided the organizations in the case studies with insight into the various interfaces that allow for interactions in complex modular care provision. Other organizations can also take advantage of our findings. We recommend paying close attention to information exchange and communication, both between healthcare providers, and between providers and patients. Although only demonstrated in one of the case study organizations, the transition meeting serves as a very good example of how information exchange and communication can be facilitated between healthcare providers, even across organizations borders. This idea could be implemented to advantage in the other case organizations. Our research indicates the importance of interfaces in healthcare delivery in order to make sure that healthcare is coordinated and patient centered. Not unexpectedly, interfaces between patients and care providers are particularly important in the provision of patient-centered care and organizations

need to realize this. Interfaces between patients and healthcare providers can be more fully exploited. For example, current use of the patient portal could be improved by all of the case organizations. We hope this study can support them in shifting from the perspective that casts patients as passive recipients to regarding them as active participants in service provision. This may sound complicated, but making this shift only requires a different way of *thinking*, rather than a completely different way of working.

6.5.3 Limitations and directions for future research

This study is not without limitations. First, our results were obtained in Downteams in Dutch hospitals. Further study is needed to know whether our results hold for multidisciplinary teams focused on other patient groups, or in other service domains. Second, we did not include the quality and nature of the interpersonal interaction between providers and customers in our study. It is known that the responsiveness to individualized interactions, also defined as personalization (de Blok et al., 2013), can help in tuning interactions and communication to the specific and individual needs of customers in order to better match their needs. Further studies could explore the concept of personalization in complex modular service offerings. Last, we only interviewed the healthcare providers and proxies of patients. Although our results provide a first perspective on interfaces between providers and customers in complex modular services, there is a critical need to consider complex modular services from the customers' perspective (Tax et al., 2013). This would allow us to recognize what a customer sees as the relevant interfaces and, from there, develop interfaces that are even more relevant for the customer. The customer journey method as proposed by Lemon and Verhoef (2016) could provide guidance for this.

6.6 Conclusions

This is the first comprehensive study exploring the role of interfaces in complex modular services. We conducted a multiple case study on chronic healthcare for children with DS as an example of complex modular service provision. We were able to identify a refined classification of interfaces in complex modular service offerings and thus contribute to elaborating modular service theory. The interface classes identified present six distinct roles that interfaces play in complex modular service provision: data entry and work arrangement in the content dimension, bidirectional information exchange and unidirectional information exchange in the people dimension between service providers, and substantive information exchange and procedural information exchange in the people dimension between service providers and customers. The latter two interfaces are especially relevant for providing complex modular services that are respectful of and responsive to individual customer needs and preferences. We are the first to focus on interfaces between service providers and customers and, as such, we present a refinement of the existing theory of interfaces in service modularity. We also explored to what extent these interfaces were patient centered. Our study shows that interfaces support the informing of service providers, the coordinated delivery of complex modular services, and the identification of relevant individual patient needs and preferences. These are important aspects of patient-centeredness. Not only is this relevant for complex modular health services, but we believe these findings could also contribute to customer centeredness in other complex modular service settings.

Conflict of interest

All authors declare that there is no conflict of interest

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Chapter 7. Discussion

Healthcare services are increasingly provided by a network of healthcare professionals and organizations (Singer et al., 2011; Haggerty, 2012). Even when focusing on a specific disease (e.g., diabetes) or target group (e.g., children), multiple professionals and organizations are often necessary in the provision of healthcare (D'Amour et al., 2008; Chung et al., 2012). Intensive collaboration and coordination between the various professionals and organizations involved is required for adequate healthcare provision. However, this is often lacking or far from functioning satisfactorily which could result in ineffective and unsafe care (Manser et al., 2010; Meijboom, Schmidt-Bakx & Westert, 2011). In addition, patients are becoming more demanding and call for healthcare services that are tailored to their needs. Healthcare providers increasingly recognize this call and acknowledge that they need to become more responsive to the individual needs and preferences of patients (Berwick, 2009).

These observations are especially important for patients with complex chronic care needs because these people often have care needs that extend beyond medical needs like social care (financing, housing) and psychological concerns, among others (Cortis et al., 2017). Meeting these complex needs requires the involvement of multiple healthcare providers, possibly stemming from multiple organizations. Coordination between the involved healthcare providers is crucial in preventing health risks in terms of overlapping or missing treatments (Singer et al., 2011). Since most healthcare services are organized around single diseases, they are often not sufficiently responsive to patients with complex care needs (van der Heide et al., 2018). As a result, healthcare services are not optimally tailored to patients' needs and preferences.

Patient-centered care has the potential to better tailor care for patients with complex care needs (Kuipers, Cramm & Nieboer, 2019; van der Heide et al., 2018). Patient-centered care has been defined as providing care that is respectful of and responsive to individual patient preferences, needs and values, and ensuring that patient values guide all care-related decisions (Institute of Medicine, 2001). Previous studies have shown that emphasizing patients' needs and preferences and the coordination of care are especially important in the provision of patient-centered care for people with complex care needs (Gill et al., 2014; van der Heide et al., 2018). Thus, it is important for healthcare professionals to provide care that is both coordinated and responsive to these individual needs and preferences. In this doctoral thesis, we address these challenges from a modular perspective.

Service modularity involves the decomposition of a complex service into components and modules (Baldwin & Clark, 1997). The components and modules can be mixed-and-matched to individual needs and preferences, so that each patient receives a tailored modular package (Voss & Hsuan, 2009). Interfaces have an important role because they make sure that the combined components and modules form a functional, coherent modular package (Baldwin & Clark, 1997). Because of its potential to provide coordinated yet customized services, modularity is applied in a variety of service settings, like construction services (Doran & Giannakis, 2011), legal services (Giannakis et al., 2018) and tourism services (Avlonitis & Hsuan, 2017). Healthcare services provide another setting with great potential for exploiting the benefits of modularity, but evidence on the applicability of modularity in complex healthcare services is very limited.

In this doctoral thesis, we contribute evidence on the feasibility of modularity in complex healthcare services. We used chronic healthcare provision for children with Down syndrome (DS) in the Netherlands as an example of complex service provision in healthcare. Individuals

with DS suffer from a wide variety of health problems with varying severity. As a result, they have complex healthcare needs (van den Driessen Mareeuw et al., 2020). Since each individual with DS is affected differently (Weijerman & de Winter, 2010), they embody a very diverse and heterogeneous population from an early age. Many different healthcare professionals (e.g., pediatrician, general practitioner, ENT-specialist) and organizations (e.g., hospitals, paramedical practices) are potentially required to provide the necessary healthcare components for treatment and support of children with DS. The unique complex care needs, combined with the functional difficulties of these children, make chronic DS healthcare provision a very suitable case for exploring the potential of modularity in complex healthcare services. The modular perspective enabled us to explore the extent to which healthcare provision for children with DS was functioning in both a coordinated and patient-centered way (Phelps et al., 2012). To this end, five studies were conducted: a literature review, a pilot study and three empirical studies, each of which is presented in a separate chapter of this doctoral thesis.

We started with a scoping review on interfaces in service modularity (Chapter 2) to get a better understanding of the numerous definitions, conceptualizations and implications of interfaces in service modularity. The pilot study (Chapter 3) was crucial for this doctoral thesis as it evaluated the feasibility of the modular perspective for my future research plans in healthcare service provision. We conducted a single case study in which we examined whether the concepts related to modularity (e.g., components, modules, interfaces) could be recognized within chronic DS healthcare provision. This was the case: the modular perspective enabled decomposition of this type of complex healthcare into components, modules and interfaces. Moreover, the decomposition led to mutual insight into work practices of the involved healthcare providers and triggered plans to evaluate and restructure healthcare provision. The theoretical and practical implications from this pilot study strengthened our conviction that the modular perspective is applicable to this type of complex healthcare provision. The combined insights from the scoping review and the pilot study provided direction for the three empirical studies in which we further elaborated on the application of modularity in chronic healthcare provision. To determine more precisely how modularity can contribute to coordination and responsiveness to individual needs and preference in this type of healthcare, it was essential to know exactly which different types of care components and modules were necessary for treatment and support of children with DS and which healthcare providers (professionals and/or organizations) were responsible for the provision of these components and modules. In other words, we had to characterize current chronic healthcare provision for children with DS from a modular perspective. For this purpose, we conducted a multiple case study in four multidisciplinary teams (Downteams) in hospitals in the Netherlands to collect empirical data on chronic healthcare provision for children with DS. Data collection involved 51 interviews with healthcare professionals, 23 interviews with parents of children with DS, 12 observations at Downteams and a large amount of secondary data. This helped us in getting a better understanding on chronic healthcare provision for children with DS and ensured that we could create a complete modular representation of the full range of different types of care components and healthcare professionals involved. This modular representation provides a comprehensive view on modular healthcare provision for children with DS (Chapter 4) and is defined as the modular service architecture (MSA) of a service offering (Voss & Hsuan, 2009). The MSA made it possible to identify interfaces and explore their role in modular healthcare provision. We

identified a wide variety of interfaces between content (components and modules) and people (service providers and customers) involved in modular healthcare provision. The results of the two empirical studies on interfaces (Chapter 5 & 6) offer a more detailed perspective on interfaces in complex modular services by: 1) providing more insight on interfaces that cross organizational borders, 2) addressing the role of interfaces, especially those between service providers and customers, and 3) exploring to what extent these interfaces are customer centered. The findings of these five studies have different implications for theory, managers and society. In the remainder of this discussion, we present a theoretical reflection (Section 7.1), managerial reflection (Section 7.2) and societal reflection (Section 7.3) on the findings of this doctoral thesis.

7.1 Theoretical reflection

In this doctoral thesis, we demonstrate the application of service modularity in complex healthcare provision, an example of complex service provision. The concept of interfaces is central in this doctoral thesis, given the potential of interfaces to manage interactions and communication in a modular service offering (Voss & Hsuan, 2009). Interfaces make sure that independent modular parts can form a coherent, functional whole (Baldwin & Clark, 1997). Without interfaces, a complex system would simply collapse. Given this importance of interfaces, we conducted a scoping review on the literature on interfaces in service modularity. We identified 12 papers for inclusion in the review and each of these papers used a different definition or conceptualization of interfaces. We created a comprehensive overview of the various definitions and conceptualizations of interfaces in service modularity to create a better understanding of the role of interfaces, and to align the various conceptualizations. We found that interfaces either played a role in the *content* dimension of a modular service offering (interactions between components and modules) or in the *people* dimension of a modular service offering (interactions between service providers and customers). We recommended that future research should make use of this alignment in order to reduce the numerous approaches in definitions and conceptualization of interfaces. This would promote more rigorous studies on the subject and further increase the conceptual clarity of interfaces. In turn, supporting the development of the field of service modularity in general (Brax et al., 2017). We also found that two aspects of interfaces are overlooked in the literature. First, the literature on interfaces in the people dimension only addressed the mutual interactions between service providers (e.g., de Blok et al., 2014) but not the interactions between service providers and their customers. Second, there was no explicit attention to interactions between service providers that cross organizational borders. Since modular services are increasingly provided as part of a complex system involving multiple providers (Brax et al., 2017), often even stemming from different organizations, the importance to manage interactions between these multiple providers is growing. Conceptually, interfaces have the potential to manage these interactions, but little is known about interfaces between service providers from multiple, autonomous organizations in a modular service offering. The findings of our review improve the general understanding of interfaces and underline their importance in modular services, but, more importantly, it resulted in an agenda for our future research.

Previous researchers (e.g., Carlborg & Kindstrom, 2014; Heikka, Frandsen & Hsuan, 2018) implicitly assume that their cases under study are modular by nature. They do not address whether or why this is true; it is often simply assumed that services are modular

(Baldwin & Clark, 2000). There are only a few studies that actually demonstrate the modular (de)composition of their cases (Bask, Merisalo-Rantanen & Tuunanen, 2014; Broekhuis, van Offenbeek & van der Laan, 2017). Without providing evidence that a service can be considered a modular service, the obtained insights from these studies become less relevant for theory as well as practice. The potential of modularity, providing coordinated yet customized services, and the evidence from previous empirical studies on healthcare modularity (e.g., Soffers et al., 2014; Silander et al., 2017) strengthened our beliefs that a modular perspective is applicable to complex chronic healthcare provision. However, in order to substantiate our beliefs, we first performed an empirical pilot study (Chapter 3) to examine whether several modularity related concepts (components, modules, interfaces) could be recognized when researching complex chronic healthcare provision. The outcome of this study provided evidence that chronic healthcare provision for children with DS can be considered modular, showing that the modular perspective is a feasible one, also for more complex healthcare services.

Previous research has underlined that instead of implicitly assuming modularity of a service, it is important to pay extra attention to understand the modular service *architecture* (MSA): the underlying arrangement of components and modules that can be selected and combined to compose modular packages (Pekkarinen & Ulkuniemi, 2008; Voss & Hsuan, 2009). However, (empirical) investigations on MSA are rare (Frandsen, 2017) and only a few studies have been conducted on this topic (Bask et al., 2014; Broekhuis et al., 2017; Silander et al., 2017). Differently, we actually explored and thus problematized the applicability of MSA in chronic healthcare provision for children with DS and this enabled us to fully decompose the healthcare provision into components and modules. By selecting a combination of components and modules that fulfill the needs and preferences of patients from the MSA, every patient can be offered an individualized modular package. In this way, modularity creates a customized healthcare service from a standardized set of components and modules.

Although the modular decomposition of the four cases required an incredible amount of work, the resulting MSA from each case proved to be very insightful for both healthcare providers and patients. The analysis showed that both providers and patients were hardly aware of the work practices of the (other) involved providers in healthcare provision. This sometimes led to gaps and overlaps in healthcare provision. The revealed MSA offered greater transparency to providers and patients by providing a clear overview of the available components and modules. At the same time, while doing the analysis we encountered that the MSA composed from the perspective of the patients differed substantially from the MSA composed from the perspective of the healthcare providers. The MSA from the perspective of the providers led to a complete representation of healthcare provision based on (para)medical outcomes relevant to their own discipline. This perspective was consistent with how previous studies described components and modules (Bask et al., 2014; Soffers et al., 2014). This description is supply-driven, focused on ‘*What-can-be-offered?*’. In healthcare, this is an example of more traditionally oriented healthcare: single disease oriented within separate silos (Porter & Lee, 2013). This approach introduces the risk that the needs and preferences of individual customers are overlooked. The MSA based on the perspective of the patients, however, represents healthcare provision in a more person-centered way. It focusses on ‘*What-do-I-need?*’ and provides a complete representation of the healthcare service in terms of the functional outcomes and overall wellbeing of patients. The creation of this person-

centered MSA required reconsidering module and component descriptions in terms of customer's expressed or implied needs rather than clinical expertise as available from the supply-driven MSA. Together with the respondents, we constructed components and modules such as 'Important persons' (e.g., Social network, Family composition), 'Getting rid of complaints (e.g., Skin disorder, Food intolerance)', 'Participating in society' (e.g., Enlarging the living environment, Experience at school), and 'Self-management' (e.g., Traffic safety, Sexual development). In this way, we ensure that patient's needs and preferences form the starting point of healthcare provision; this person-centered MSA approach should lead to the provision of more patient-centered care. Broekhuis et al. (2017) argued that "a customer-centered decomposition, by describing and labelling customer-centered modules, would enable customers to participate in composing their service package" (p. 758). We elaborated on this statement by showing that the mixing-and-matching of patient-centered modules, selected from a demand-driven/person-centered MSA can be carried out to create different customer-specific configurations of service provision, without losing functionality, while better matching the needs and preferences of the customer. We propose that a demand-driven MSA should be defined as "*the way that customer needs and preferences are expressed in the individual decomposed elements that together comprise the overall service offering provided by the service providers*". In this way, the needs and preferences of the customer are at the center of attention in contrast to the supply-driven approach in which the expertise of the professional takes center stage.

The MSAs allowed us to identify interfaces involved in modular healthcare provision. We studied interfaces that cross organizational borders in two examples of chronic care provision in Chapter 5: home care for the elderly and DS care. In Chapter 6, we focus on interfaces between service providers and customers in chronic healthcare for children with DS. In addition to the current literature on interfaces in service modularity, we found in Chapter 5 that interfaces in chronic healthcare provision manage interactions both within the same organization as well as across organizations. We defined this as the interacting orientation of interfaces, i.e. intra-organizational versus inter-organizational orientation. Based on this finding, we were able to extend the interface typology by de Blok et al. (2014) by adding the interacting orientation of interfaces to the typology. This resulted in a three-dimensional typology of interfaces in service modularity and moved the discussion on interfaces from an intra-organizational level to an inter-organizational level. In accordance with the alignment of the various conceptualizations of interfaces in service modularity (Chapter 2), we identified that interfaces managed inter-organizational interactions in both the *content* and the *people* dimension. Inter-organizational interfaces in the content dimension (e.g., workbooks, cross-organizational information systems) support coordination in complex modular services and inter-organizational interfaces in the people dimension (e.g., intercollegiate meetings, joint needs assessments) support customization in complex modular services. This finding underlines the potential of modularity to provide coordinated yet customized services, also in the context of complex healthcare services.

In addition to the literature on interfaces in modular healthcare services (de Blok et al., 2014; Soffers et al., 2014), we argue that interfaces can simultaneously cover either types of interface dimensions (content or people) or either types of interface aims (variety and coherence). These interface categories are not mutually exclusive. The electronic health record is an example of an interface that allows for the (re)configuration of modular packages and individual customer adaptations as well as for the direction of the flow of information

between the people involved. This shows that interfaces can serve a dual role in modular service provision. This dual role of interfaces is particularly relevant during the specification and construction of modular packages. In this specification process, coherent modular packages need to be constructed that consider individual customer needs and preferences over time (de Blok et al., 2010). Future research could further explore the (dual) role of interfaces in this process.

In order to consider individual customer needs and preferences, interfaces between service providers and their customers should be in place. The role of customers in services has been identified as one of the distinguishing features of services (Cook et al., 2002; Sampson & Froehle, 2006) and it has been emphasized that service provision is typically characterized by interactions between customers and providers (Gittell, 2002). Previous research also showed that only customers themselves know whether their needs and preferences have been fully considered and addressed (Gittell, 2002). As such, it is even more remarkable that interfaces between service providers and customers have been largely overlooked in the literature on service modularity. The findings of this doctoral thesis confirm that interfaces between service providers and customers are indispensable for the provision of services that meet the needs and preferences that are considered relevant by customers. In the past, service providers were confident that ‘they knew what the customer wanted’ and argued that they were fulfilling their customers’ needs. However, customers are becoming more demanding and call for services that are truly tailored to *their* needs and preferences (Silander et al., 2017). Companies need to acknowledge this and become more customer-centered in order to address needs and preferences that are truly relevant for customers. Providing customer-centered services requires that service providers shift from viewing customers as passive recipients to viewing them as active participants (Tax, McCutcheon & Wilkinson, 2013). One way of realizing this is by involving the customer in the design and provision of services. Interfaces have the potential to guide interactions between the various service providers and customers leading to more customer involvement. In this doctoral thesis, we identified two distinct interface classes between service providers and customers in complex modular services: substantive information exchange and procedural information exchange interfaces. These interfaces allow for the interactions between service providers and customers and ensure that customers of modular service provision are genuinely involved. Previous research has shown that close interactions between customers and service providers are essential for tailoring services to the needs of individual customers (Cook et al., 2002; Gittell, 2002). This doctoral thesis demonstrates that this also holds true for complex modular services. The increased responsiveness helps service providers in providing a modular package that can change according to the customer’s emerging needs. Furthermore, these interfaces ensure that customers are well informed about the options (i.e., components and modules) available to meet their needs and preferences. We provide evidence on interfaces between providers and customers and show these are relevant for providing complex modular services that are respectful of and responsive to individual customer needs and preferences.

Besides the identification of two interface classes between service providers and customers, we identified another four interface classes (Chapter 6). Each of the six identified interface classes has its own distinct role in complex modular service provision, together they support service providers in managing complex modular services, ensuring that the modular service is both coordinated and fulfilling the customer’s needs and preferences. These are

important aspects of patient-centeredness (Berwick, 2009), but also more generally speaking of customer-centeredness of services (Gulati & Oldroyd, 2005).

Over the course of this doctoral thesis, it became clear that adequate interfaces between service providers and their customers can contribute to shared decision making, an important aspect in the provision of patient-centered care (Berwick, 2009; Singer et al., 2011) and customer-centered services in general. Shared-decision making can only be realized when both patients and providers actively exchange information (Barry & Edgman-Levitan, 2012). Interfaces allow healthcare providers to better present their treatment and support options to patients, and allow patients to express their needs and preferences to providers (Barry & Edgman-Levitan, 2012). As a result, patients and providers are better informed and share responsibility in the decision on how to proceed.

7.1.1 Limitations and directions for future research

Each study has its limitations and leaves room for future research and so does this doctoral thesis. To complement the limitations of each chapter in this doctoral thesis, we address the limitations of this doctoral thesis as a whole and provide suggestions for future research in the two sections below.

7.1.1.1 Research limitations

First, a modular way of working was not deliberately chosen by the cases included in our study. The interviewees did not consider their care provision and services as being modular, nor did they express themselves using modularity concepts. Instead, we used modularity as a perspective that guided interpretation of the way of working used in our cases. This meant that when analyzing our data, the data had to be interpreted in modularity terms and labels. To deal with potential interpretation errors and prevent researcher bias, we used the member check technique to counter these potential errors (Birt et al., 2016). The member checks revealed that interviewees did recognize aspects and concepts related to modularity in their way of working and this warranted the quality of our research.

Second, given the theoretical state-of-the-art of service modularity we opted for a case study research approach. Although we consider our research approach as appropriate, since case study research is particularly appropriate for areas where research and theory are at their early and formative stages (Eisenhardt, 1989), we acknowledge that our research approach has led to a strong emphasis on theory building and theory elaboration in the field of service modularity, rather than theory testing. We have to be careful that we do not only focus on theory building because the case under study is ‘new and interesting’ (Colquitt & Zapata-Phelan, 2007), but these theories also need to be tested at a certain point. This doctoral thesis presents opportunities to test the theories we built and elaborated on in the form of quantitative studies. We elaborate on those quantitative studies in Section 7.1.1.2.

Third, data collection involved interviews with healthcare professionals that are part of a Downteam and interviews with parents of children with DS who visit a Downteam. We did not include healthcare professionals from primary care in our sample. This was a deliberate choice since these professionals play a limited role in chronic DS healthcare in the Netherlands. However, they might have provided additional information on healthcare provision and could have potentially led to an even more comprehensive modular perspective on healthcare provision for children with DS.

Fourth, although our results provide first insights on the customer's perspective on modular services, it is based on proxies of customers. Even though proxies are considered common practice, especially for children with intellectual disabilities (Eiser & Varni, 2013), proxies may not capture the exact experience as perceived by customers. As a result, we may not have fully captured the customers' service experience and this could lead to a distorted view on modular services from the customers' perspective. It could be worthwhile to explore other ways to obtain information from customers who are not able to provide customer reported information. We discuss this in more detail in the next section.

7.1.1.2 Future research

First, future research could implement changes based on our findings in practice and determine the true potential and feasibility of modularity in complex healthcare services. For example, one or more of the Downteams in the Netherlands could implement the person-centered MSA approach (recalling Chapter 4). A follow-up study could be conducted to examine the implementation of the person-centered MSA in one of the Downteams. Action research could be a particular relevant research design for this study as it focuses on taking action and creating knowledge or theory about that action (Coughlan & Coughlan, 2002). As such, action research can enable in-depth understanding of the translation of modularity principles in practice (Broekhuis et al., 2017). This type of study could provide evidence on whether a person-centered MSA approach is better at tailoring care to the needs and preferences of patients than the supply-driven MSA. Such studies can provide a significant contribution to the field of service modularity because they provide evidence on the potential of actual implementation of modular services, in addition to providing evidence from studies using a modular perspective (Brax et al., 2017).

Second, future research could present a quantitative validation of our qualitative results. The service modularity function (SMF) as proposed by Voss and Hsuan (2009) could be applied to measure the degree of service modularity embedded in services. The SMF is a mathematical function that measures the degree of modularity deriving from services and the degree to which the modules can be reused across a variety of services (Voss & Hsuan, 2009). The SMF has a range of 0 to 1, where $SMF = 1$ represents a perfectly modular service and $SMF = 0$ represents a service that is not modular at all (Voss & Hsuan, 2009). The SMF can be applied to measure the extent to which a service can be considered a modular service (Prockl & Hsuan, 2016; Frandsen & Hsuan, 2017). The degree of modularity would allow scholars to compare modular services and such comparisons could help to emphasize the relevance and suitability of modularity in the context of complex services. The degree of modularity provides possibilities to draw conclusions based on whether a modular service with an SMF of .8 performs better or worse on compared to a modular service with an SMF of .6. In other words, future research could examine if health services with a higher degree of modularity are associated with better numbers on process-measures (e.g., adherence to guidelines, idle time) and/or outcome-measures (e.g., timeliness of care, effectiveness of care) compared to health services with lower degrees of modularity. In addition, future research could examine if health services with higher degrees of modularity are associated with higher levels of Patient Reported Experience Measures (PREMs) and Patient Reported Outcome Measures (PROMs). These measures address patient experiences regarding healthcare processes and outcomes of treatments related to patient functioning (Manary et al., 2013). They are considered as robust measures for the quality of life of patients. These measures

could help in getting a better understanding of the patient's perspective on modular health services.

Third, the results of this doctoral thesis stem from our empirical evidence on chronic care provision for children with DS. Although we strongly believe that our results can be extrapolated to different forms of complex chronic healthcare or other types of complex services due to a similar multiplicity and diversity in customer needs, it is important to investigate this. Important work in this regard is already being carried out in the field of cancer care (Gobbi & Hsuan, 2012; Meijboom et al., 2018; Bartels, Meijboom & de Vries, 2019). Besides, it would be interesting to observe whether there are similar or divergent results when you compare different complex service settings. For example, future research could compare complex modular services with comparable emotional experiences (e.g., legal services, healthcare services) or compare complex modular services with differing emotional experiences (e.g., higher educational services, tourism services).

Fourth, our focus on the customers' perspective on modular service provision is new. Future studies should further explore the role of customers in modular services. The customer journey method as proposed by Lemon and Verhoef (2016) could be employed for this purpose because it will support the mapping of modular service provision from the customer's perspective. This perspective can support providers in identifying overlaps and gaps in service provision, for example when a customer moves from one organization to another and in helping to overcome these overlaps and gaps to create seamless service provision. The customer's perspective is becoming ever more important since customers emphasize that they want their voices to be heard. As a result, there is increased attention for models and theories such as service delivery networks (Tax et al., 2013), value-co creation in multi-actor systems (Sweeney, Danaher & McColl-Kennedy, 2015; Vargo & Lush, 2015) and experience-based service designs (Patrício et al., 2011; Lemon & Verhoef, 2016) which describe service delivery through the eyes of the customer.

Last, both healthcare professionals and parents expressed that the transition of individuals with DS from pediatric to adult care deserves more attention. When we asked the professionals and parents about how they experienced coordination and information exchange in healthcare provision, they indicated that they often felt lost when their children moved from pediatric to adult care and this is confirmed in literature (e.g., Bindels-de Heus et al., 2013; Jensen & Davis, 2013). The transition of care is complicated by the fact that pediatric Downteams are not accessible anymore for adults with DS and adult Downteams are rare in the Netherlands. When the transition of care is not properly organized and coordinated, continuity of care is at risk. This can result in poor health outcomes on the long-term (Jensen & Davis, 2013). Conceptually, interfaces have the potential to properly deal with the transition of care. Chapter 5 of this doctoral thesis has shown that interfaces have the potential to manage and guide interactions on both the inter- and intra-organizational level, indicating that the modular perspective could be useful for improving the transition of care. Therefore, we recommend that future research should focus on the transition from pediatric care to adult care and examine this process in more detail.

7.2 Managerial reflection

Chronic healthcare provision for children with DS proved to be a good setting for exploring the potential of modularity in complex healthcare services. The modular perspective allowed us to identify the full range of components, modules and interfaces that are offered in

healthcare provision for children with DS. This modular decomposition supported the healthcare professionals in creating a modular care package that fulfilled the unique complex care needs of children with DS. Interfaces made sure that the modular care package was coordinated and could change along the relevant needs and preferences of children with DS. By providing coordinated yet customized services, modularity showed its potential in chronic healthcare provision for children with DS. More importantly, the modular perspective allowed us to bring a novel perspective into the Downteams we studied. Based on the results of this doctoral thesis, we recommend healthcare professionals in chronic DS healthcare provision to pay particular attention to the following points in order to support the provision of patient-centered care by means of modularity.

First, we advise healthcare professionals to be more aware of each other's work practices. Our modular perspective showed that there was sometimes overlap in the provision of components, because healthcare professionals were not aware of the fact that another professional already provided a certain care component. On the other hand, the modular perspective revealed possibilities for missing treatments because healthcare professional X expected that healthcare professional Y had already offered that component. To illustrate: both the pediatrician and the physiotherapist might consider the DS patient's hips and feet. In modularity terms this entails that the component 'considering hips and feet' is offered twice. Thus, since the content of healthcare provision is not described in detail, different professionals ended up doing the same thing. This duplication of care, that is made explicit by the modular perspective, does certainly not enhance efficiency in healthcare provision. On the other hand, the duplication of care also serves a dual purpose because it ensures that the advice of the healthcare professionals is aligned. The MSAs that were created for each of the four cases provide a complete overview of the possible components and modules that each healthcare professional can provide. This could lead to more mutual insight into each other's (healthcare professionals) work practices, both within and across the Downteams, and can thereby increase transparency on healthcare provision. It can reduce the duplication of care and therefore I recommend healthcare professionals to use these MSAs in daily practice.

Second, patients and carers were insufficiently aware of healthcare professional's work practices. Due to the involvement of the various professionals, they lost track of what each professional could offer them. As a result, they were often not aware of the available care components and this sometimes resulted in patients and carers leaving the Downteam without all their needs being addressed. We recommend Downteams to invest in communication tools like information brochures that contain a short description and image of each healthcare professional involved in the Downteam and incorporating the information from these brochures in their patient portal. The MSAs can serve as a starting point for the creation of these brochures. Doing so will improve the patients' and carers' access to information and ensures that patients and carers will be better prepared for their visit to the Downteam.

Third, patients and carers expressed that their needs and preferences were not always addressed, because professionals tend to focus on medical outcomes that belong to their own discipline. These medical outcomes are sometimes considered as partially relevant by the patients and carers resulting in healthcare provision not fully meeting their needs and preferences. For example, patients place more emphasis on their quality of life and societal participation rather than on the specific medical problems they have. Therefore, we would recommend healthcare professionals to take the functional outcomes and overall wellbeing of patients as starting point for healthcare provision. The modular decomposition from the

patient's perspective is particularly helpful in this respect, because it represents healthcare provision in a more patient-centered way. We developed a three-step method to achieve a patient-centered modular decomposition of healthcare (Chapter 4). The first step concerns the identification of all individual healthcare parts (components and modules) in close collaboration with patients and professionals. This will result in a complete overview of the total range of healthcare components and modules. The second step involves labelling and reshaping these parts from the patient's perspective, thereby focusing on functional outcomes and overall wellbeing. The last step includes the selection of components and modules that match with the needs and preferences of each individual patient. This can result in the provision of patient-centered healthcare and is a promising development for complex healthcare provision. The person-centered MSA approach could even be used as support for future healthcare design, for example in the revision of the current national DS guideline as developed by the Dutch pediatric association (Borstlap et al., 2011). It is important to express that this approach requires a different way of thinking, rather than completely changing the professional's way of working. Previous research has shown that providing patient-centered care does not require additional time from professionals; it even leads to more efficient care, greater quality of life and well-being of patients and increased quality and safety of care (Stewart et al., 2000; Rathert, Wyrwich & Boren, 2013).

Fourth, due to the involvement of multiple healthcare professionals in chronic DS healthcare provision, close attention needs to be paid to the coordination of the involved healthcare professionals. A lack of coordination could result in incomplete or inaccessible information. Different types of interfaces manage and guide information exchange between healthcare professionals and allow them to share information effectively, either through direct or indirect interaction, and could prevent healthcare from being uncoordinated. Identifying these interfaces is important, because this research showed that healthcare professionals were not aware of all the different mechanisms through which relevant patient information was exchanged. It turned out that some professionals did not always make use of already available interfaces and invented workarounds to exchange information. This does not enhance efficiency. In addition, we observed that some of the identified interfaces were case specific (e.g., transition meeting). The coordinators of the Downteams and/or policy makers could explore whether these interfaces could also be applied in their own Downteams/hospitals.

Fifth, we would advise healthcare professionals to give special consideration to information exchange across organizational borders. The provision of chronic DS care does not only involve healthcare professionals from the Downteam itself, but also involves professionals from different organizations (e.g., general practitioners, schools). It is important that all the professionals involved have access to patient information, regardless of time and place, to ensure continuity of care. We observed that information was often not actively exchanged between professionals from different organizations which resulted in a loss of information. This could lead to deficiencies in the follow-up of care. Therefore, we emphasize the importance of inter-organizational interfaces, advising policy makers to invest resources (money and personnel) in defining and specifying those interfaces.

Sixth, we recommend healthcare professionals to devote particular attention to information exchange between patients and professionals. Patients emphasized that they wanted their voices to be heard, especially before and after their visit to the Downteam. Interfaces between professionals and patients allow for interactions between them and make sure that patients are genuinely involved in healthcare provision. These interfaces ensure that needs and

preferences of patients are retrieved and support professionals in becoming more responsive to these needs and preferences. This is especially important in addressing the call for providing more patient-centered care. We advise professionals to exploit the already available interfaces more fully: the current use of the patient portal could be improved by all of the Downteams and the patient evaluation survey could be deployed by more than one Downteam in order to retrieve valuable feedback on healthcare provision.

Seventh, and last, we would like to draw the attention of healthcare professionals to the fact that patients increasingly want to manage their own healthcare provision. Information about their healthcare provision becomes more easily available online, which can support this. Professionals need to face and overcome this new reality. By offering healthcare as a collection of components and modules, patients can decide to select specific components and modules from independent professionals. They can create and manage their own modular care package by selecting, for example, module 1 from professional X, module 2 from professional Y and module 3 & 4 from professional Z.

7.2.1 Extrapolating towards cancer care

The proposed modular perspective is applicable in different forms of complex chronic healthcare due to the similar multiplicity and diversity in patient needs. This is reflected in the various types of providers and organizations involved in healthcare provision. The results of my research in chronic DS care can be extrapolated to offer directions for dealing with multiplicity and diversity in other complex healthcare provisions, for example cancer care. Cancer is a complex condition which usually requires the input of multiple care professionals to meet a patient's cancer-related needs and preferences (Cortis et al., 2017). Meeting these needs and preferences requires collaboration and coordination from a broad collection of care providers (e.g., oncologists, pathologists, surgeons) and organizations (e.g., hospital, hospice, home care organization). Despite the increasing recognition that cancer care should become responsive to people with complex care needs (Cortis et al., 2017), most cancer care professionals are not working collaboratively with other care professionals and as a result, care is not optimally tailored to the patient's needs and preferences. Modularity is assumed to deal with these issues and previous research has provided first clues for the potential of modularity in cancer care (Gobbi & Hsuan, 2012; Meijboom et al., 2018; Bartels et al., 2019).

Since a multitude of healthcare professionals are involved in cancer care, they need to be aware of the full range of cancer care and service components of each professional in order to prevent missing treatments or overlap in treatments, possibly resulting in health risks. A decomposition of healthcare provision into components and modules, displayed in an MSA, would result in an increased awareness and understanding of the supply side of cancer care provision. Patients are often unaware of the various different treatment and support options offered by the various professionals (Bartels et al., 2019). As a result, they are not fully informed. Providing patients with an overview (MSA) of the different treatment and psychosocial support options (components and modules) would lead to more awareness and understanding of these different options, which would increase the patient's ability to actively participate in the decisions made regarding treatment. This overview should take the individual patient's cancer-related needs and preferences as starting point for the provision of healthcare. In other words, instead of taking existing treatment and support as given, the patient's needs and preferences are put at the center of interest. The medical needs remain the same, but more emphasis can be placed on the non-medical and personal needs of patients.

Such a patient-centered modular decomposition can be beneficial for professionals as well because previous research has shown that providing patient-centered care leads to more positive outcomes like greater job satisfaction and improved quality of care (Rathert et al., 2013).

The coordination of cancer care is emerging as an important challenge in healthcare provision (Cortis et al., 2017) because healthcare professionals, organizations and patients need to closely interact to ensure that cancer care packages meet the patient's needs and preferences. Interfaces can take care of these interactions in the provision of modular cancer care (Gobbi & Hsuan, 2012). Interfaces between professionals are required to be well informed about the patient's situation. These interfaces are especially important when professionals from various organizations are involved. For example, the treatment of a rectal cancer includes both chemotherapy, radiotherapy and surgery but radiotherapy is often only available in a specialized institution, which results in the patient going back and forth between two different institutions. Interfaces should be in place that guide information exchange between the professionals from independent organizations involved in radiotherapy and surgery. This is important from a safety point of view, for example in case of incorrect follow-up treatments. For the patient, this can result in a disjointed care experience (Cortis et al., 2017) or the need for a considerable effort to personally manage their care provision, which may be beyond their capabilities. Even more important, interfaces between professionals and patients are required to ensure that all needs and preferences of patients are considered and that patients are well informed about the options (components and modules) available. Professionals need to realize that patients have needs besides their medical needs and therefore they need to carefully monitor both. Previous research in this context has shown that patients may well have preferences with regard to certain non-medical needs (Meijboom et al., 2018). For example, they want to have digital or phone-call consults instead of face-to-face consults. Interfaces could ensure that professionals become more responsive to both the medical and non-medical needs and preferences that are considered relevant by patients. In this way, professionals may know what options a patient might favor, what kind of information patients expect and what further needs to be considered in cancer care provision.

7.2.2 Extrapolating towards legal services

The proposed modular perspective can also be applied in many other complex services. The results of our research in complex healthcare services can also be extrapolated to, for example, legal services. Previous research has provided first proofs for the potential of modularity in legal services (Giannakis et al., 2018). We deliberately chose legal services due to similarities in emotional experience of clients in legal conflicts as compared to patients who require treatments in healthcare services.

When clients face a legal conflict (e.g., divorce, customer conflicts, termination of employment) they can make use of a variety of providers for dealing with their legal conflict (Regan & Heenan, 2010). Each provider is responsible for providing a set of services that contributes to dealing with the legal conflict. The providers should have a complete overview of each other's activities to ensure that they collectively offer a legal service that fits with a client's needs and wishes. Approaching legal services from a modular perspective allows for the decomposition into components and modules, resulting in transparency on the supply side of legal services. This modular decomposition is also relevant for the clients themselves because although accurate information about legal services becomes increasingly available

online (Giannakis et al., 2018), they do not know exactly what each legal provider can offer them, which results in legal services not completely tuned to the needs and requirements of the client. The overview of all the possible components and modules can help to better match supply and demand.

The clients dealing with a conflict can have different needs and requirements and it is important that service providers take these needs into account. These clients have problem-focused needs but also social-emotional needs (van Dijk, Giebels & Zebel, 2016). The first type of needs relates to information on legal procedures, rights and obligations, help in structuring the issues, and finding possible solutions. The second type entails the need for listening, showing understanding, allowing space for venting and the sharing of experiences. Providers must ensure that their services are tailored to the expressed needs of clients. Various different providers (e.g., attorney, mediator, notary) and organizations (e.g., court, tribunal, law firm) are required in the process of dealing with a legal conflict. Information exchange between the involved providers, organizations and clients is especially important. A lack of coordination can result in missing information during the legal process (van Dijk et al., 2016). For example, the attorney must have access to all the available information about the legal conflict. If the attorney lacks information from, for example, a witness it could harm the lawsuit and result in a negative outcome for the client. Therefore, interfaces between the providers, organizations and clients should be in place to prevent such issues. Specifying in advance how these parties can interact can prevent uncoordinated legal services. For example, interfaces like an unambiguous job description and standard contractual clauses can help to structure legal activities for providers to arrange more convenient legal service provision. Interfaces between providers and clients help clients in getting access to justice and legal information by means of for example online protocols of communication with clients. Moreover, they support providers in retrieving and dealing with the problem-focused and social-emotional needs of clients by means of for example standard forms for client needs assessments (Giannakis et al., 2018). As a result, providers are better able to tailor legal services to the needs and requirements of clients and the legal conflict can be dealt with in a more effective manner.

7.3 Societal reflection

Doing scientific research is an iterative process involving several partners from both academia and society. The outcomes of this doctoral thesis are not only the result of scientific research, but rather the result of interactions between the research team, the healthcare professionals in the field of Down syndrome care and the parents of children with Down syndrome. This “co-production of knowledge” between the research team, the healthcare professionals and the parents, also known as co-creation (van de Mheen, 2019), resulted in both scientific results and societal impact. Societal impact is generally understood as the exploitation of scientific results beyond the world of academia (van de Mheen, 2019) – and is often defined as “the short- and long-term contribution of scientific research to changes in, or development of, social sectors and social challenges” (Royal Netherlands Academy of Arts and Sciences, 2018). In a systematic literature search, van de Mheen (2019) identified ten characteristic elements which are presumed to be essential and a key to success for co-creation: 1) a structured, long term partnership, 2) equality and reciprocity among all partners involved, 3) mutual trust, 4) mutuality, 5) personal contact, 6) blurring boundaries between research and

societal partners, 7) knowledge exchange, 8) improvements to everyday practice and scientific output, 9) the research process is key, and 10) co-creation takes time.

When I started my doctoral thesis, I had to get acquainted with the field of Down syndrome care since I was unfamiliar with this specific field. In order to do so, I attended consultations of children with DS at various Downteams in the Netherlands. At the same time, the ‘Expertisenetwerk Downsyndroom Brabant’ was being established and this provided an interesting opportunity getting to know the participating healthcare professionals and organizations better; resulting in the beginning of long-term relationships with pediatricians from four Downteams. At first, I encountered resistance from the healthcare professionals from the Downteams, because they were not used to collaborate with people beyond the medical discipline. They found it unusual that someone with a background in operations and supply chain management conducted his doctoral thesis within a healthcare setting. As a result, not every healthcare professional was eager to participate. I had to demonstrate the added value of my research project in order to gain their trust. By providing them with tangible deliverables (e.g., improved planning schemes) that concerned improvements to everyday practice, I was able to show the added value of operations management concepts in healthcare. As a result, healthcare professionals began to trust me and allowed me in their daily practice. This opened doors for me that were previously closed, and a feeling of equality and reciprocity arose between the professionals and me. The professionals became more open minded and started to share knowledge with me about their own work practices, resulting in mutual trust. Garretsen et al. (2007) described this process as the professional’s readiness to change. Besides conducting interviews with healthcare professionals, I also conducted interviews with parents of children with DS. Parents were very eager to participate and invited me in their homes for interviews. Although the stories of the parents were sometimes very emotional, the parents were happy to share their experiences with me. They could express themselves about their experiences with healthcare provision of their child, either positive or negative, without being judged. This created a feeling of mutual trust between us without losing my scientific independence. During the course of this doctoral thesis, I informed these parents about the progress of my research and the developed products for users in everyday practice (e.g., information brochures and transition letters). Parents appreciated this very much because they had the impression that their input led to output for their own children and other children with DS. The perspectives of the parents and the healthcare professionals were vital in order to develop a comprehensive view on healthcare provision for children with DS.

This approach resulted not only in scientific output like publications and presentations at scientific conferences, but also resulted in practical output. For instance, facilitation of the first conference of the ‘Expertisenetwerk Downsyndroom Brabant’ (van den Driessen Mareeuw et al., 2018), participation in the revision of the nationwide multidisciplinary guideline (Section ‘Organization of care’) under supervision of the Dutch Pediatric Association, and practical products for the participating Downteams (i.e., manuals and folders). Moreover, some of the practical products were developed in collaboration with motivated students from the master’s program ‘Supply Chain Management’ at Tilburg University. In the context of their Master thesis projects, which lasted six months, students worked with healthcare professionals and parents of children with DS on topics related to the scope of this doctoral thesis, for instance the transition of individuals with DS from pediatric to adult care (de Beer, 2019; van Rooij, 2020), substitution of DS care from secondary to primary care (van Bergen, 2018) and multidisciplinary DS care provision (Barendregt, 2018).

By delivering solid research results, these Master thesis projects contributed valuable and essential knowledge which enabled to close the gap between science and everyday practice. It also enabled me to enhance the connection between education and research in the ‘Supply Chain Management’ master program at Tilburg University.

The knowledge resulting from this doctoral thesis is the result from co-creation between science and society. I collaborated with a wide variety partners from academia (e.g., scholars and institutions) and society (e.g., healthcare professionals, parents) over the last four years. This resulted in both scientific impact and societal impact and as such it will have greater impact (van de Mheen, 2019). It is knowledge that matters!

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Summary

For each patient, coherence in healthcare provision is a must. This is even more important for patients with complex care needs resulting from multiple chronic conditions. Since multiple professionals and/or organizations are often indispensable to fulfil a patient's healthcare needs and preferences, the establishment of well-connected links between them are of crucial importance. This is very well illustrated in healthcare for children with Down syndrome (DS). DS is a complex congenital condition leading to developmental delay and an array of comorbidities that seriously influence a patient's life. This deliberately requires adequate collaboration and coordination between a collection of healthcare professionals (e.g., pediatrician, general practitioner) and organizations (e.g., hospital, paramedical practices). In the Netherlands, pediatric outpatient clinics are therefore organized in multidisciplinary teams (Downteams) offering appointments for children with DS. However, patients and their carers told us that, in practice, this approach does not yet truly fulfil their needs and preferences. Making care more patient-centered is the way forward, but it is a challenge to provide care that is both coordinated and patient-centered at the same time.

In this doctoral thesis, the abovementioned challenge of providing care that is both coordinated and patient-centered is addressed from a modular perspective. This modular perspective means that we describe the working methods and practices executed by healthcare professionals in modular terms. Service modularity involves the decomposition of a complex service into components and modules. Components are the smallest elements into which a service can be divided, whereas modules comprise a collection of components with a specific function. For example, the module physical examination consists of components like movement skills. The components and modules can be mixed-and-matched to individual needs and preferences, so that each patient receives a tailored modular package. Interfaces have an important role in the delivery of these modular packages, because they make sure that the combined components and modules form a functional, coherent modular package. The concept of interfaces is central in this doctoral thesis, given the potential of interfaces to manage interactions and communication in a modular service offering. In other words: without interfaces, a system would simply collapse. Since modularity is able to provide coordinated and customized services, we explored healthcare provision for children with DS, an example of complex healthcare provision, from a modular perspective and explored to what extent this perspective can support the provision of coordinated and patient-centered care provision. To this end, five studies were conducted: a literature review, a single-case study and three multiple case studies.

In **Chapter 1**, we present a brief overview of the background of this doctoral thesis. First, we introduce the problems faced in providing patient-centered healthcare for people with complex healthcare needs. Second, we describe the chronic healthcare provision for children with DS in the Netherlands and address the complexity surrounding this type of healthcare. Last, we introduce the theory on modularity and its related concepts and explain how a modular perspective can support the provision of patient-centered healthcare.

Given the importance of interfaces in complex modular services, we conducted a scoping review of the literature on interfaces in service modularity in **Chapter 2**. We created a comprehensive overview of the various definitions and conceptualizations of interfaces in

service modularity to create a better understanding of the role of interfaces in modular services. We aligned the various conceptualizations and showed that interfaces play a role in two distinct dimensions of modular services. First, interfaces connect individual components and/or modules in the content dimension. Such interfaces manage and support interactions between components and modules; an example is a guideline. Second, interfaces connect the various people involved in modular services in the people dimension. Such interfaces allow for interactions between service providers and enable information exchange about customers. Furthermore, we found that two aspects of interfaces are overlooked in the current literature: the literature on interfaces in the people dimension only address the mutual interactions between service providers, and not the interactions between service providers and their customers. Second, there is no explicit attention to interactions that cross organizational borders. This results in limited understanding about collaboration and coordination between two or more organizations. To conclude: the findings of the review improve the general understanding of interfaces and underline their importance in complex modular services, and also resulted in an agenda for our future research.

In **Chapter 3**, we conducted a single-case study to examine whether several modularity related concepts (components, modules, interfaces) could be recognized in complex chronic healthcare provision for children with Down syndrome. This pilot study was crucial for this doctoral thesis as it evaluated the feasibility of using a modular perspective in studies on chronic healthcare provision in Downteams. Downteams are pediatric outpatient clinics that organize multidisciplinary team appointments for children with DS, including a visit to the pediatrician, physiotherapist, speech therapist and others. The outcome of this study provided evidence that chronic healthcare provision for children with DS can be considered modular, showing that the modular perspective is feasible, also for more complex healthcare services. The combined theoretical and practical implications from the scoping review (Chapter 2) and the pilot study (Chapter 3) strengthened our conviction that a modular perspective is applicable to study this type of complex healthcare provision. To further increase our understanding on how healthcare provision for children with DS functions in a coordinated and patient-centered way, we conducted a multiple case study in four hospitals in the Netherlands to collect empirical data on healthcare provision for children with DS, provided by Downteams.

The multiple case study allowed us to get a better understanding of the complete collection of different types of care components necessary for treatment and support of children with DS and the providers responsible for delivering them. In other words, we characterized chronic healthcare provision delivered by Downteams from a modular perspective in **Chapter 4**. The scheme in which this is presented is called the modular service architecture (MSA). The MSA provides healthcare professionals and patients with a complete overview of all different types of care components necessary for treatment and support. We show that the MSA built from the perspective of the patients differs substantially from the MSA built from the perspective of the healthcare professionals (the service providers). The MSA from the provider's perspective focusses on medical outcomes (What-can-we-offer?) whereas the MSA from the patient's perspective focusses on functional outcomes and well-being (What-do-I-need?).

The MSAs provided a comprehensive representation of healthcare provision in terms of modules, components, and providers. Only with such a complete modular representation, it is possible to identify the interfaces involved in complex modular service provision. In **Chapter 5**, we identified a wide variety of interfaces in two cases: home care for the elderly and chronic healthcare provision for children with DS. Both cases represent a setting in which a number of healthcare services are offered by providers representing multiple disciplines and organizations. The home care for the elderly case was chosen based on an international collaboration with a scholar from Turku University in Finland. We observed that interfaces are required to coordinate the various dissimilar healthcare modules and components originating from multiple care professionals with different specialized backgrounds, from multiple organizations. We also observed that interfaces crossed organizational borders. The fact that interfaces take care of interactions across organizations is defined as the interacting orientation of interfaces, i.e. intra-organizational versus inter-organizational orientation. This moved the discussion on interfaces to an inter-organizational level. As a result, we show that interfaces support coordination and customization within and across organizational borders. Although Chapter 5 showed that interfaces promote coordination and customization in complex modular services, we also observed that interactions with patients were overlooked.

In **Chapter 6**, we show that interfaces between service providers and customers are indispensable for the provision of modular services that meet the needs and preferences as considered relevant by customers. Only patients know whether their needs and preferences have been fully considered and whether they have received sufficient information and opportunities to allow them to participate in their care provision. We identified two interface classes that allow for information exchange between service providers and customers: First, substantive information exchange interfaces, for example the patient portal, ensure that needs and preferences of customers are retrieved and that all the providers are kept informed. Second, procedural information exchange interfaces like an information folder make sure that providers and customers are well informed about the options (modules and components) available to meet their needs. Moreover, we identified four additional interface classes in complex modular services: data entry interface, work arrangement interface, bidirectional information exchange interface and unidirectional information exchange interface. These four interface classes make sure that interactions between components, modules and providers are coordinated and predictable. Each of the six identified interface classes has a complementary role in complex modular service provision, but only all six interface classes together support service providers in fully managing complex modular services. This ensures that the complex modular service provided is both coordinated and truly fulfills the customer's needs and preferences.

The last chapter of this doctoral thesis, **Chapter 7**, presents a reflection of the five studies (one literature review, one single-case study and three multiple case studies). Each of these studies has different implications for researchers, for managers, and for society as a whole. With regard to theory for researchers, we are the first to explore the potential of modularity in complex healthcare provision and show how modularity can contribute to coordination and patient-centeredness of services. Besides, our focus on the customers' perspective on modular service provision is new. From a managerial point of view, the results of our research in chronic DS healthcare can be extrapolated to offer directions for dealing with multiplicity and

diversity in other complex healthcare provision, like cancer care. Also, the modular perspective seems applicable for other complex services. A comparable example is legal services due to similarities in emotional experience of clients in legal conflicts, as compared to patients who require treatments in healthcare services. With regard to society, we collaborated extensively with four hospitals during this doctoral thesis. This created a structural interaction with healthcare professionals in the field of DS healthcare and parents of children with DS. Our research led to impact on society in various ways: we were strongly involved in the establishment of the 'Expertisenetwerk Downsyndroom Brabant' and we facilitated its first ever conference with the aim of sharing knowledge on organization of work processes with healthcare professionals. Furthermore, we will contribute to the revision of the nationwide multidisciplinary DS guideline as developed by the Dutch Pediatric Association by writing the section 'Organization of care'. Moreover, we created various hands-on tools for Downteams like a communication map and a flowchart for transition of healthcare. The results of this doctoral thesis led to adjustments, recommendations and improvements for the daily practice of healthcare provision for children with DS. We are proud that our scientific results could be translated into policy and action.

Appendices

Supplementary file 1. Topic list of Chapter 3.

Modularity topic	Indicative questions
Service set-up	What consultations does the Downteam offer?
	How are the consultations organized?
	What standardized practices does each member of the Downteam apply?
Service provision	Do all patients visit the same members? If not, how is it determined which patient visits which members?
	Do all patients visit the Downteam with the same frequency? If not, how is it determined how often each patient visits the Downteam?
Interfaces in set-up	Is healthcare provision adapted to the specific patient?
	In what ways do the members of the Downteam collaborate?
	Do discussions on ad hoc basis take place?
	Does a multidisciplinary discussion take place, during which all patients are discussed? If so does this discussion take place before, after, or separate from the Downteam? If so, are all members present at this discussion?
	Does the Downteam provide a letter in which all members discuss their findings? If so, is there a standard format used for this letter?

Supplementary file 2. Coding list of Chapter 3.

Code	Sub code	Example quotes
Standardization	Standardization in care	"The procedures are very standardized.", "All patients visit the same members at each visit.", "All patients visit the pediatrician and the ophthalmologist, those are standard.", "With our team, you can either participate in all consultations, or in none of them.", "All consultations have the same duration.", "Care is very uniform."
	Standardization in frequency visits	"All patients visit the Downteam yearly."
Components	-	<i>All quotes regarding practices within each consultation, e.g.</i> , "I always check the length and weight of the patient."
Modules	-	<i>All quotes regarding the available consultations for patients, e.g.</i> , "Every patient visits the pediatrician, physiotherapist,....,,....", "The members of our Downteam are the,,"
Modular package	-	<i>All quotes regarding the way that the consultations are combined (i.e., construction of modular package) and all quotes on all consultations that patients (can) have, e.g.</i> , "All patients visit the same professionals:,,,.." "[our case manager] sends a letter to parents, where parents can [...] and they can indicate whom [which professionals] they want to speak to."
Interface-practices Downteams	O-C interfaces	"[Our case manager] sends a letter to parents, where parents can [...] and they can indicate whom [which professionals] they want to speak to."
	O-I interfaces	"The EPF gives me information on the consultations with others [members of the Downteam] and, sometimes, I adapt my consultation to that.", "We organize a multidisciplinary discussion, at which every member is present. We discuss each patient separately."
	C-C interfaces	"My [pediatrician's] consultation is always scheduled after that of the physiotherapist.", "At the beginning of the visit, patients are provided with a consultation schedule."
	C-I interfaces	"We adhere to the national guidelines.", "The EPF stores all information in one place.", "After the multidisciplinary consultation, the secretary forms a letter for which every professional [member of Downteam] writes a part. Next, I [pediatrician] write a conclusion.", "Because we are so close to each other, it is easy to just drop by at another member's office and discuss the patient.", "The standard format of the letter is that everyone [each member of Downteam] writes their own part."

**Supplementary file 3. A 32-item checklist for reporting qualitative studies
(COREQ) of Chapter 3.**

Item	Description	Check (page number)
Domain 1: Research team and reflexivity		
<i>Personal characteristics</i>		
1. Interviewer	Which author/s conducted the interviews and/or observations?	Fransen and Peters
2. Credentials	What were the researcher's credentials?	MSc and MSc
3. Occupation	What was their occupation at the time of the study?	Master student and PhD-student
4. Gender	Was the researcher male or female?	Female and male
5. Experience and training	What experience or training did the researcher have?	Both researchers took a course on Qualitative Research Methods at Tilburg University and had previous experience during thesis writing
<i>Relationship with participants</i>		
6. Relationship established	Was a relationship established prior to study commencement?	One of the authors (EV) suggested potential respondents based on her experience in the field of DS healthcare
7. Participant knowledge of the researcher	What did the participants know about the researcher?	The personal interest of the researchers and purpose of the study was explained before the data collection started
8. Researcher characteristics	What characteristics were reported about the researcher?	Interest in research topic, occupation, reason for research
Domain 2: Study design		
<i>Theoretical framework</i>		
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study?	Thematic analysis
<i>Participant selection</i>		
10. Sampling	How were participants selected?	Purposive sampling
11. Method of approach	How were participants approached?	In writing and by telephone
12. Sample size	How many participants were in the study?	Six
13. Non-participation	How many people refused to participate or dropped out?	0
<i>Setting</i>		
14. Setting of data collection	Where was the data collected?	Workplace
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	The patient was present during the observations
16. Description of sample	What are the important characteristics of the sample?	Occupation: Pediatrician
<i>Data collection</i>		
17. Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	The topic list is added to the manuscript as supplementary material
18. Repeat interviews	Were repeat interviews carried out? If yes, how many?	No
19. Audio recording	Did the research use audio recording to collect the data?	Yes
20. Field notes	Were field notes made during and/or after the interview or observation?	Yes
21. Duration	What was the duration of the interviews or observation?	Interviews: 30 minutes Observation: half-day
22. Data saturation	Was data saturation discussed?	Data saturation was discussed within the research team
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	We asked the respondents to review the data we collected. We received no comments and/or corrections
Domain 3: Analysis and findings		
<i>Data analysis</i>		

24. Number of data coders	How many data coders coded the data?	Two (LF and VP)
25. Description of the coding list	Did authors provide a description of the coding list?	The coding list is added to the manuscript as supplementary material
26. Derivation of themes	Were themes identified in advance or derived from the data?	Themes were identified in advance
27. Software	What software, if applicable, was used to manage the data?	N/A
28. Participant checking	Did participants provide feedback on the findings?	We asked the respondents to review the researchers' interpretation of the interview data
<i>Reporting</i>		
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified?	We made use of examples from the interviews and observations to show the richness of the data
30. Data and findings consistent	Was there consistency between the data presented and the findings?	We present an analytic story where we highlight the key concepts of the study and how our findings shed light on the concepts
31. Clarity of major themes	Were major themes clearly presented in the findings?	We used headers in the text to indicate the major themes
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	We used sub sections in the text to indicate the minor themes

Supplementary file 4. Disciplines and consultations in the various Downteams of

Chapter 3.

Downteam	A	B	C	D	E	F
Mandatory consultation(s)	Pediatrician, physio-therapist, speech therapist, social worker	Pediatrician, physiotherapist , speech therapist, social worker	Pediatrician, physiotherapist, speech therapist, contact parent, ENT-doctor, ophthalmologist , orthoptist, dietician, social worker, audiologist	Pediatrician, ophthalmologist	Pediatrician	Pediatrician, physiotherapist
Optional consultations	Dietician, blood lab	N/A	N/A	ENT-doctor, ophthalmologist , orthoptist, physiotherapist, rehabilitation doctor, speech therapist	ENT-doctor, ophthalmologist , orthoptist, physiotherapist, rehabilitation doctor, speech therapist	Speech therapist, special education generalist, dentist, ENT-doctor, ophthalmologist , contact parent
Duration of consultations	20 minutes each	20 minutes each	20 minutes each	30 minutes each	15-45 minutes each	30 minutes each

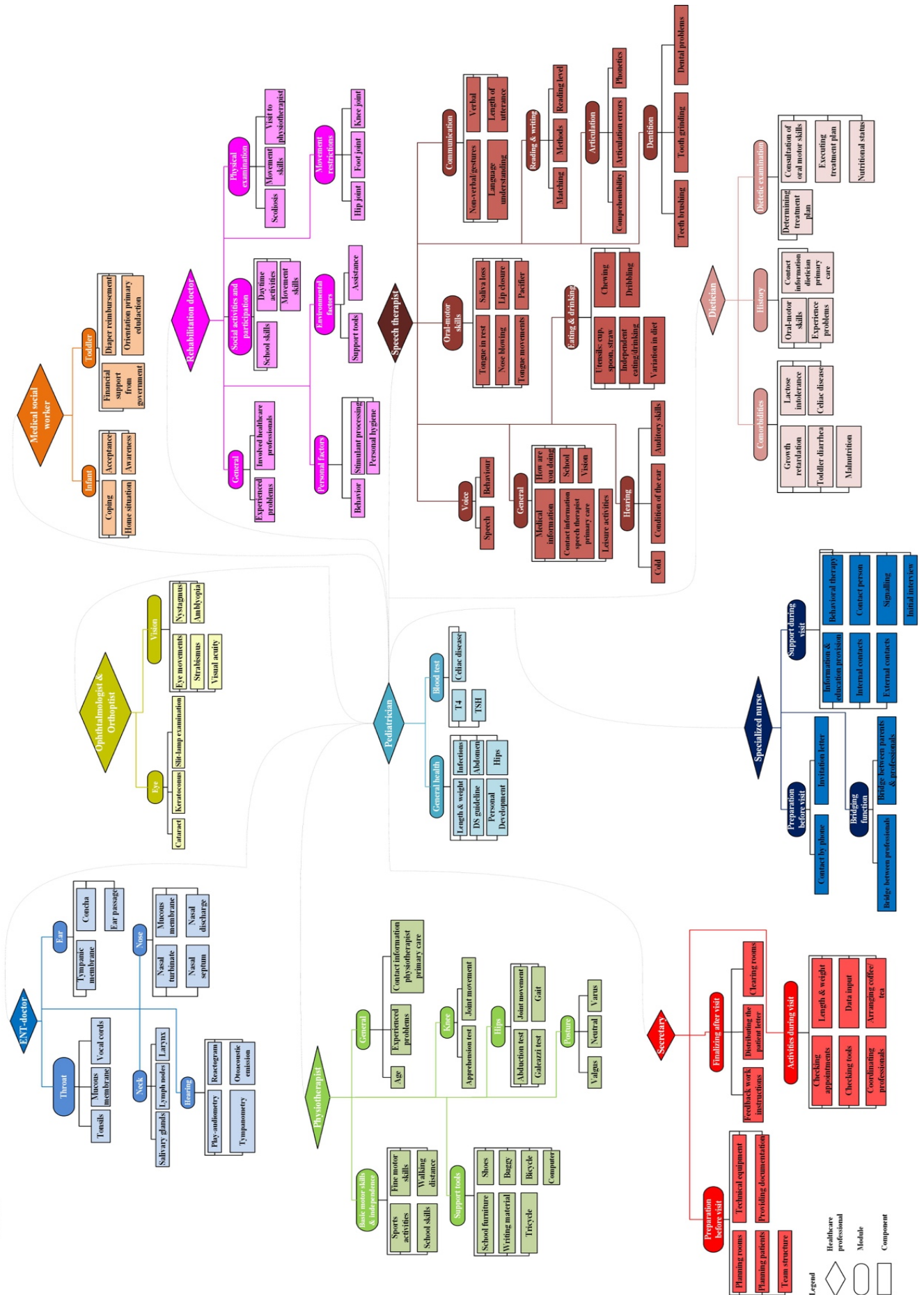
Supplementary file 5. Explanation of the modular perspective on Downteam A of

Chapter 3.

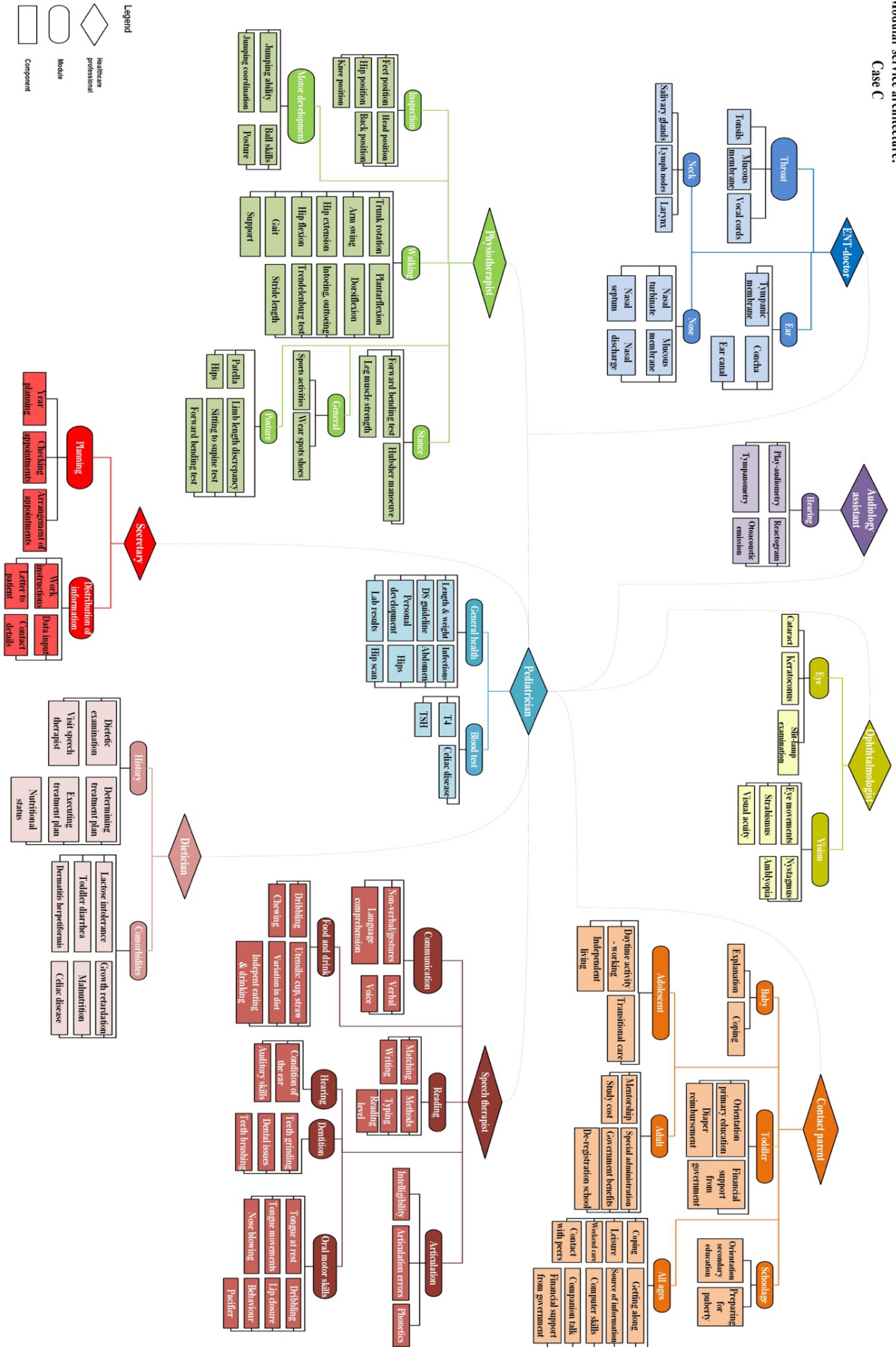
Modular package	Module	Component	Explanation
Consultation with Downteam A	Pediatrician	General information Physical examination Blood test Medication Tuning primary care	Provides the pediatrician with the information necessary to follow the overall growth of a patient Investigates the body of the patient (e.g. back, feet) Concerns the discussion on blood samples Concerns the medication of a patient (e.g. usage, results) Coordinating and facilitating primary care (e.g. dentist, general practitioner)
	Physio-therapist	Physical examination Motor development Statics Sport Tuning primary care	Investigates the body of a patient (e.g. back, feet) Concerns the development of the motion of the patient Concerns the position and posture of the body of the patient Concerns issues regarding sporting activities Coordinating and facilitating with physiotherapist in primary care
	Speech therapist	Oral motor development Communication (non-verbal) Communication (verbal) Tuning primary care	Concerns the oral skills necessary for proper speech and feeding development Concerns the way the patient communicates in a non-verbal manner Concerns the way the patient communicates in a verbal manner Coordinating and facilitating with speech therapist in primary care
	Social worker	Work-life balance Private situation Informal care Requests for tools Requests for housing	Concerns the balance between work and life issues and whether the family is able to take care of themselves Concerns any issues regarding the private situation of the patient and his/her family Concerns the use of informal care by relatives Concerns any form of procedural issues the patient and his/her family are dealing with regarding tools and housing
	Dietician	Length and weight Dietetic examination Food intake Oral motor examination	Concerns the measurement of length and weight of the patient Concerns the examination of the patient based on his nutritional problem Concerns the food intake of the patient Concerns the oral skills necessary for proper speech and feeding development
	Blood lab	T4 TSH Celiac disease Stored serum	Concerns the test for T4 Concerns the test for TSH Concerns the test for Celiac disease Concerns the test for Stored serum

S1 Figure. Modular service architecture Case B – D of Chapter 4.

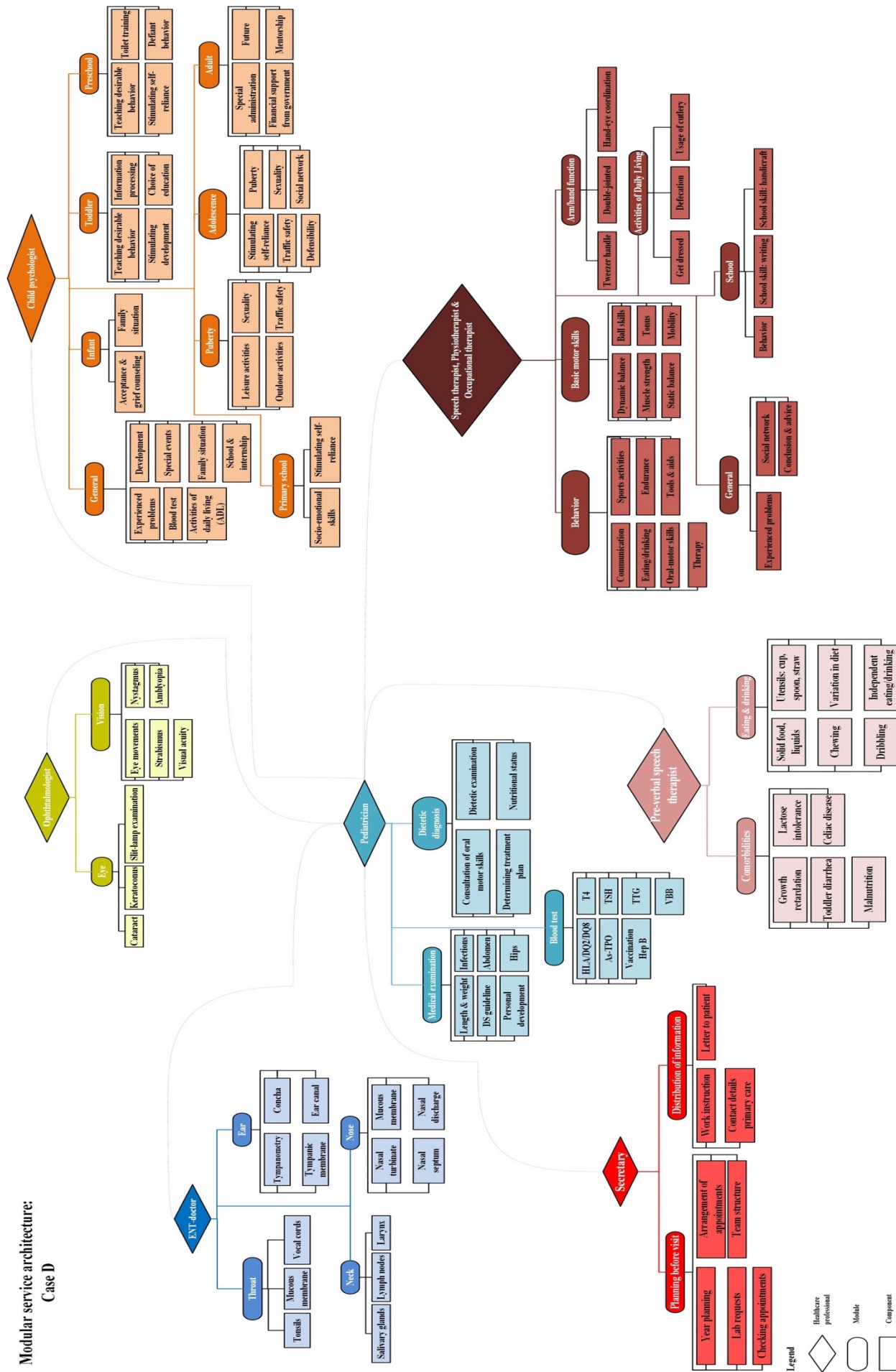
Modular service architecture:
Case B



Modular service architecture:
Case C



**Modular service architecture:
Case D**



S1 File. A 32-item checklist for reporting qualitative studies (COREQ) of Chapter

4.

Item	Description	Check
Domain 1: Research team and reflexivity		
<i>Personal characteristics</i>		
1. Interviewer	Which author/s conducted the interviews and/or observations?	VP
2. Credentials	What were the researcher's credentials?	MSc
3. Occupation	What was the occupation at the time of the study?	PhD-student
4. Gender	Was the researcher male or female?	Male
5. Experience and training	What experience or training did the researcher have?	Courses on Qualitative Research Methods at Tilburg University and previous experience during thesis writing
<i>Relationship with participants</i>		
6. Relationship established	Was a relationship established prior to study commencement?	Yes, VP established a relationship with the case informants (pediatricians) ahead of the research
7. Participant knowledge of the researcher	What did the participants know about the researcher?	The personal interest of the researchers and purpose of the study was explained before the data collection started
8. Researcher characteristics	What characteristics were reported about the researcher?	Interest in research topic, occupation, reason for research
Domain 2: Study design		
<i>Theoretical framework</i>		
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study?	Within- and cross-case thematic analysis
<i>Participant selection</i>		
10. Sampling	How were participants selected?	Purposive sampling
11. Method of approach	How were participants approached?	Telephone, face-to-face, e-mail
12. Sample size	How many participants were in the study?	74
13. Non-participation	How many people refused to participate or dropped out? Reasons?	6 people refused to participate due to time constraints
<i>Setting</i>		
14. Setting of data collection	Where was the data collected?	Workplace (hospital) and at participants' home
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	No
16. Description of sample	What are the important characteristics of the sample?	Gender, occupation, respective role
<i>Data collection</i>		
17. Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	The topic list is added to the manuscript as appendix; the topic list was pilot tested and discussed with an expert on this topic
18. Repeat interviews	Were repeat interviews carried out? If yes, how many?	No repeat interviews were carried out, but we sent out a follow-up e-mail
19. Audio recording	Did the research use audio recording to collect the data?	Yes
20. Field notes	Were field notes made during and/or after the interview or observation?	Yes
21. Duration	What was the duration of the interviews or observation?	Interviews: 45-75 minutes Observation: half-day
22. Data saturation	Was data saturation discussed?	Data saturation was discussed within the research team and achieved after 65 interviews
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	Transcripts were returned to participants. We received comments

		and corrections from a few participants
Domain 3: Analysis and findings		
<i>Data analysis</i>		
24. Number of data coders	How many data coders coded the data?	Two (VP and BM)
25. Description of the coding list	Did authors provide a description of the coding list?	The coding list is described in the methods section
26. Derivation of themes	Were themes identified in advance or derived from the data?	Themes were identified in advance, but we also made use of a code called 'other' in which relevant other themes were categorized
27. Software	What software, if applicable, was used to manage the data?	Microsoft Word, Microsoft Excel and Microsoft Visio
28. Participant checking	Did participants provide feedback on the findings?	We asked the participants to reflect on the findings of the study
<i>Reporting</i>		
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified?	We used various quotations from our participants. Moreover, we created several figures to illustrate our results
30. Data and findings consistent	Was there consistency between the data presented and the findings?	We present an analytic story that is interpretive and insightful
31. Clarity of major themes	Were major themes clearly presented in the findings?	We present major themes in both the within-case and cross-case analysis
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	We distinguish between a within-case and cross-case analysis. In these distinct paragraphs, we describe both major and minor themes

S2 File. Topic list of Chapter 4.

1. General questions

- 1.1 What is your name and age?
- 1.2 Can you briefly describe your current job and your role in the Downteam?

2. Modular organization

- 2.1 Can you explain how the Downteam works?
 - What (care) components does your discipline comprise?
 - What parts of the care that you provide can also be provided by other specialists in the Downteam?
 - What do you think of the current multidisciplinary organization of your Downteam?
- 2.2 What processes have been more or less standardized in the care for people with DS?
- 2.3 What components of your role would you describe as being more standardized, and which ones would you describe as more tailored to the patient?
 - In which way do you attempt to provide patient-centered care?
- 2.4 Which healthcare professionals are not part of the Downteam, but are connected to the Downteam?
- 2.5 Which important information transfers take place within the Downteam and outside it? How do these take place? Can you give some examples?
 - How does the information transfer from the Downteam to primary care take place?
 - How does the information transfer from the Downteam to a care organization take place?
- 2.6 How is the electronic health record (EHR) employed? Who has access to the EHR? What communication outside of the EHR is important to ensure a good provision of care?

3. Information exchange

- 3.1 How would you describe the information exchange within the Downteam? By this I mean whether the information is complete, accurate and up to date.
- 3.2 How would you describe the information exchange between the Downteam and primary care organizations? By this I mean whether the information is complete, accurate and up to date.
- 3.3. Whom or what has been designated as responsible for the coordination of the care for people with DS? If so, how did this happen?
- 3.4 Would the designation of a single organization or person to bear responsibility for the coordination of care for people with DS influence the coordination of activities?
- 3.5 How do you experience the contact with other caregivers/specialists within the Downteam?
 - How do you experience the contact with other specialists outside of the Downteam?
 - How do you experience the contact with primary care?
- 3.6 How are work processes and activities coordinated between your specialization and primary care?
- 3.7 On a scale from 1 to 10, how would you rate the degree of coordination in the care for people with DS at this moment?
 - What are your reasons for this rating?
- 3.8 Do you see any room for improvement with regard to the coordination of activities between the Downteam and primary care?

- 3.9 Who schedules the appointments/examinations for patients? Who checks whether these have indeed taken place?

4. Patient centeredness

- 4.1 Are patient discussions or progress discussions held outside of the multidisciplinary consultation, in which the patient's care plan is discussed?
- 4.2 To what extent is the care tailored to the specific needs of patients (e.g. age, personal preferences etc.)?
- 4.3 Who is responsible for communication with and information provision to the patient?
- 4.4. To what extent do you consult the information in the patient's medical history?
- 4.5 Please elaborate on the following statement: The patient and/or the patient's parents are capable of taking on a coordinating role
- Which things that patients have a need for are given insufficient attention?
 - How do patients get the opportunity to express their needs, wishes or demands when they visit the Downteam?
 - Do you see possibilities for (more) patient participation? Why/why not?

Appendix I. Coding list of Chapter 6.

General code	Deductive codes	Inductive codes	Example quotes
Interfaces on the content dimension (Voss & Hsuan, 2009)	Interaction between components or modules	Data entry	<p>“I use a standardized protocol for my consultation. Based on that protocol, I enter the data in the HER.” (ENT-doctor)</p> <p>“A checklist pops up in the EHR which helps me to shape the consultation. When the consultation has ended, I click on the checklist and I indicate what has been done.” (Pediatrician)</p>
		Work arrangements	<p>“I have an overview of children and I create an annual planning for them. I share it with all the specialists involved so that they know this immediately and can adjust their agenda.” (Secretary)</p> <p>“We also have a multidisciplinary workbook entailing everyone’s work methods. In doing so, we at least have something overarching. For example, if you break your leg, or something else, we have a back-up.” (Pediatrician)</p>
Interfaces on the people dimension (Voss & Hsuan, 2009)	Interaction between providers	Bidirectional information exchange	<p>“We always have the multidisciplinary team meeting where you actually give everyone feedback about what has not been discussed or what should have been shared. In doing so, you do not miss any information from each other.” (Specialized nurse)</p> <p>“I try to do a team evaluation on a six-monthly basis with the complete Downteam. It would be great if parents could also join us in order to exchange information and reflect on how we are doing and what to improve.” (Pediatrician)</p>
		Unidirectional information exchange	<p>“I always receive a letter from the pediatrician explaining what has happened over the past 18 years. In this way he closes the pediatric phase.” (Doctor for the mentally handicapped)</p> <p>“In the EHR I can check which tests have been done by the ophthalmologist, by the ENT-doctor and their conclusions.” (Speech therapist)</p>
	Interaction between providers and customers	Substantive information exchange	<p>“Our specialized nurse makes sure to call the parents a few weeks before the visit to the Downteam in order to be aware of potential problems.” (Secretary)</p> <p>“It would be nice to send our specific questions a few days/weeks in advance to the Downteam, so they can prepare and have answers to our questions.” (Carer)</p>
		Procedural information exchange	<p>“A few weeks in advance I receive an invitation letter from the Downteam indicating who, when and where I will visit each specialist.” (Carer)</p> <p>“We send an evaluation survey to patients after their visit in order to gather feedback on how they experienced care provision.” (Secretary)</p>

Supporting information I. Topic list of Chapter 6.

1. General questions

- 1.1 What is your name and age?
- 1.2 Can you briefly describe your current job and your role in the Downteam?

2. Modular organization

- 2.1 Can you explain how the Downteam works?
 - What (care) components does your discipline comprise?
 - What parts of the care that you provide can also be provided by other specialists in the Downteam?
 - What do you think of the current multidisciplinary organization of your Downteam?
- 2.2 What processes have been more or less standardized in the care for people with DS?
- 2.3 What components of your role would you describe as being more standardized, and which ones would you describe as more tailored to the patient?
 - In which way do you attempt to provide patient-centered care?
- 2.4 Which healthcare professionals are not part of the Downteam, but are connected to the Downteam?
- 2.5 Which important information transfers take place within the Downteam and outside it? How do these take place? Can you give some examples?
 - How does the information transfer from the Downteam to primary care take place?
 - How does the information transfer from the Downteam to a care organization take place?
- 2.6 How is the electronic health record (EHR) employed? Who has access to the EHR? What communication outside of the EHR is important to ensure a good provision of care?

3. Information exchange

- 3.1 How would you describe the information exchange within the Downteam? By this I mean whether the information is complete, accurate and up to date.
- 3.2 How would you describe the information exchange between the Downteam and primary care organizations? By this I mean whether the information is complete, accurate and up to date.
- 3.3. Whom or what has been designated as responsible for the coordination of the care for people with DS? If so, how did this happen?
- 3.4 Would the designation of a single organization or person to bear responsibility for the coordination of care for people with DS influence the coordination of activities?
- 3.5 How do you experience the contact with other caregivers/specialists within the Downteam?
 - How do you experience the contact with other specialists outside of the Downteam?
 - How do you experience the contact with primary care?
- 3.6 How are work processes and activities coordinated between your specialization and primary care?
- 3.7 On a scale from 1 to 10, how would you rate the degree of coordination in the care for people with DS at this moment?
 - What are your reasons for this rating?
- 3.8 Do you see any room for improvement with regard to the coordination of activities between the Downteam and primary care?

- 3.9 Who schedules the appointments/examinations for patients? Who checks whether these have indeed taken place?

4. Patient centeredness

- 4.1 Are patient discussions or progress discussions held outside of the multidisciplinary consultation, in which the patient's care plan is discussed?
- 4.2 To what extent is the care tailored to the specific needs of patients (e.g. age, personal preferences etc.)?
- 4.3 Who is responsible for communication with and information provision to the patient?
- 4.4. To what extent do you consult the information in the patient's medical history?
- 4.5 Please elaborate on the following statement: The patient and/or the patient's parents are capable of taking on a coordinating role
- Which things that patients have a need for are given insufficient attention?
 - How do patients get the opportunity to express their needs, wishes or demands when they visit the Downteam?
 - Do you see possibilities for (more) patient participation? Why/why not?

Supporting information II. A 32-item checklist for reporting qualitative studies (COREQ) of Chapter 6.

Item	Description	Check
Domain 1: Research team and reflexivity		
<i>Personal characteristics</i>		
1. Interviewer	Which author/s conducted the interviews and/or observations?	VP
2. Credentials	What were the researcher's credentials?	MSc
3. Occupation	What was the occupation at the time of the study?	PhD-student
4. Gender	Was the researcher male or female?	Male
5. Experience and training	What experience or training did the researcher have?	Courses on Qualitative Research Methods at Tilburg University and had previous experience during thesis writing
<i>Relationship with participants</i>		
6. Relationship established	Was a relationship established prior to study commencement?	Yes, VP established a relationship with the case informants ahead of the research
7. Participant knowledge of the researcher	What did the participants know about the researcher?	The personal interest of the researchers and purpose of the study was explained before the data collection started
8. Researcher characteristics	What characteristics were reported about the researcher?	Interest in research topic, occupation, reason for research
Domain 2: Study design		
<i>Theoretical framework</i>		
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study?	Within- and cross-case analysis
<i>Participant selection</i>		
10. Sampling	How were participants selected?	Purposive sampling
11. Method of approach	How were participants approached?	Telephone, snowballing, face-to-face, e-mail
12. Sample size	How many participants were in the study?	74
13. Non-participation	How many people refused to participate or dropped out? Reasons?	6 healthcare providers refused to participate due to time constraints
<i>Setting</i>		
14. Setting of data collection	Where was the data collected?	Workplace (hospital)
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	No
16. Description of sample	What are the important characteristics of the sample?	Gender, occupation, respective role
<i>Data collection</i>		
17. Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	The topic list is added to the manuscript as appendix. The topic list was pilot tested and discussed with an expert on this topic
18. Repeat interviews	Were repeat interviews carried out? If yes, how many?	No repeat interviews were carried out
19. Audio recording	Did the research use audio recording to collect the data?	Yes
20. Field notes	Were field notes made during and/or after the interview or observation?	Yes
21. Duration	What was the duration of the interviews or observation?	Interviews: 45-75 minutes Observation: half-day
22. Data saturation	Was data saturation discussed?	Data saturation was discussed within the research team and achieved after 65 interviews
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	Transcripts were returned to participants. We received comments

		and corrections from a few participants
Domain 3: Analysis and findings		
<i>Data analysis</i>		
24. Number of data coders	How many data coders coded the data?	Two
25. Description of the coding list	Did authors provide a description of the coding list?	The coding list is added to the manuscript as appendix
26. Derivation of themes	Were themes identified in advance or derived from the data?	Themes were identified in advance, but we also made use of a code called 'other' in which relevant other themes were categorized
27. Software	What software, if applicable, was used to manage the data?	Microsoft Word, Microsoft Excel
28. Participant checking	Did participants provide feedback on the findings?	We asked the participants to reflect on the findings of the study
<i>Reporting</i>		
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified?	We used various quotations from our participants. Moreover, we created tables to illustrate our results
30. Data and findings consistent	Was there consistency between the data presented and the findings?	We present an analytic story where we highlight the key concepts of the study and how our findings shed light on the concepts
31. Clarity of major themes	Were major themes clearly presented in the findings?	We present major themes in both the within-case and cross-case analyses
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	We distinguish between within-case and cross-case analyses. In these distinct sections, we describe both major and minor themes

Supporting information III. Overview of all identified interfaces for all cases of

Chapter 6.

Interface type	Interface collated	Interface description	Interacting entities	Interface class	When in service provision	Direction of the interface
<ul style="list-style-type: none"> Action list Checklist pediatrician Checklist doctor for the mentally handicapped 	Checklist	A form containing a list of actions to be performed by a provider to ensure that no action will be forgotten	Content	Data entry	During	N/A
<ul style="list-style-type: none"> Guideline child psychologist Guideline ENT-doctor Guideline pediatrician Nationwide multidisciplinary guideline 	Guideline	A document with the aim of guiding decisions and criteria regarding diagnosis, management and treatment of a patient	Content	Data entry	During	N/A
<ul style="list-style-type: none"> Dietary journal History form dietician History form doctor for the mentally handicapped History form ophthalmologist History form physiotherapist History form preverbal speech therapist History form social worker History form specialized nurse History form speech therapist 	History form	A form that is used to collect information to complete the medical history of a patient	Content	Data entry	During	N/A
<ul style="list-style-type: none"> Protocol audiology Protocol dietician Protocol medical social worker Protocol pediatrician Protocol speech therapist 	Protocol	A document containing standardized information on the specific elements of a consultation	Content	Data entry	During	N/A
<ul style="list-style-type: none"> Screening form physiotherapist Screening form occupational therapist Screening form preverbal speech therapist 	Screening form	A form that is used to guide examination during a consultation	Content	Data entry	During	N/A
<ul style="list-style-type: none"> Annual planning 	Annual planning	A document showing which	Content	Work arrangement	Before	N/A

<ul style="list-style-type: none"> • Patient overview 		patients will visit the hospital in each month				
<ul style="list-style-type: none"> • Consultation scheme • Consulting room schedule 	Consulting room schedule	A scheme showing the planning of consecutive consultations for each patient	Content	Work arrangement	Before	N/A
<ul style="list-style-type: none"> • Division of work • Multidisciplinary workbook 	Division of work	A document containing descriptions of working methods of each healthcare professional	Content	Work arrangement	During	N/A
<ul style="list-style-type: none"> • Work schedule 	Work schedule	A standardized schedule including information on when each professional has to visit each child	Content	Work arrangement	During	N/A
<ul style="list-style-type: none"> • Intercollegiate meeting • Transition meeting 	Intercollegiate meeting	A meeting in which professionals with different specialisms from different organizations meet to share information	People	Bidirectional information exchange	During	Bidirectional
<ul style="list-style-type: none"> • Mail exchange 	Mail	A electronic form of written information exchange between healthcare professionals	People	Bidirectional information exchange	During	Bidirectional
<ul style="list-style-type: none"> • Multidisciplinary team meeting before consultation • Multidisciplinary team meeting after consultation 	Multidisciplinary team meeting	A multidisciplinary meeting in which the healthcare professionals discuss the individual results of the consultations and discuss the follow-up for the patient	People	Bidirectional information exchange	During	Bidirectional
<ul style="list-style-type: none"> • Team evaluation 	Team evaluation	A meeting in which the healthcare professionals evaluate the functioning of the team as a whole	People	Bidirectional information exchange	After	Bidirectional
<ul style="list-style-type: none"> • Telephone call 	Telephone	A tool to exchange information between healthcare professionals	People	Bidirectional information exchange	During	Bidirectional

<ul style="list-style-type: none"> • Consent form • Declaration form 	Consent form	A form in which patients indicate that healthcare professionals are allowed to share personal data with other healthcare professionals	People	Unidirectional information exchange	Before	Unidirectional
<ul style="list-style-type: none"> • Electronic health record 	Electronic health record	A digital format in which real-time, patient records are available, which make information available instantly and securely to authorized healthcare professionals	People	Unidirectional information exchange	During	Unidirectional
<ul style="list-style-type: none"> • Laboratory form 	Laboratory form	A form that is used to indicate which blood counts should be measured	People	Unidirectional information exchange	During	Unidirectional
<ul style="list-style-type: none"> • Notes 	Notes	A form of written information exchange between healthcare professionals	People	Unidirectional information exchange	During	Unidirectional
<ul style="list-style-type: none"> • Report from primary care • Report from audiology 	Report from primary care	A letter from healthcare professionals in primary care containing information about the patient's medical history	People	Unidirectional information exchange	Before	Unidirectional
<ul style="list-style-type: none"> • Referral general practitioner • Referral letter • Transition letter 	Referral letter	A letter that is used to refer to healthcare specialists that are not part of the Downteam	People	Unidirectional information exchange	During	Unidirectional
<ul style="list-style-type: none"> • Summary letter 	Summary letter	A letter containing a summary of the results of each specialist and follow-up (if necessary)	People	Unidirectional information exchange	After	Unidirectional
<ul style="list-style-type: none"> • Patient portal 	Patient portal	A website on which the patient can access his/her appointments and his personal care dossier	Customer	Substantive information exchange	Before, after	Bidirectional
<ul style="list-style-type: none"> • Questionnaire 	Needs assessment	A questionnaire containing questions about the needs and	Customer	Substantive information exchange	Before	Unidirectional

		wishes of patients				
<ul style="list-style-type: none"> Summary letter 	Summary letter	A letter containing a summary of the results of each specialist and follow-up (if necessary)	Customer	Substantive information exchange	After	Unidirectional
<ul style="list-style-type: none"> Telephone consultation Telephone appointment 	Telephone consultation	A form of verbal information exchange in which the professional asks questions to retrieve the needs and wishes of the patient	Customer	Substantive information exchange	Before	Bidirectional
<ul style="list-style-type: none"> Admission letter 	Admission letter	A letter each patient receives from the hospital before his/her visit to the Downteam	Customer	Procedural information exchange	Before	Unidirectional
<ul style="list-style-type: none"> Consultation scheme 	Consultation scheme	A scheme showing the planning of consecutive consultations for each patient	Customer	Procedural information exchange	Before	Unidirectional
<ul style="list-style-type: none"> Information letter 	Information letter	A letter that each patient receives prior to the visit showing what the visit to the Downteam looks like	Customer	Procedural information exchange	Before	Unidirectional
<ul style="list-style-type: none"> Guide for social services Information folder for caretakers Information folder for patients List of primary care providers Social domain folder Transition folder 	Information folder	A folder containing information about what they can expect during the visit to the Downteam.	Customer	Procedural information exchange	Before, after	Unidirectional
<ul style="list-style-type: none"> Patient reminder letter 	Patient reminder letter	A letter used to remind the patient about his next visit to the hospital	Customer	Procedural information exchange	Before	Unidirectional
<ul style="list-style-type: none"> Patient satisfaction survey 	Patient satisfaction survey	A survey used to evaluate patient satisfaction	Customer	Procedural information exchange	After	Unidirectional

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Modularity involves the decomposition of a service into components and modules that can be mixed and matched to individual needs, so that each customer receives an individualized modular package. As such, every customer can be offered a different combination of components and modules and thus each is treated as unique. This is especially important in healthcare since patients are becoming more demanding and call for healthcare services that are tailored to their needs. However, evidence on the applicability of modularity in complex healthcare services, for example on healthcare for people with complex care needs, is missing.

This doctoral thesis is composed of five studies to advance knowledge on service modularity in complex healthcare provision and explore to what extent service modularity can support the provision of patient-centered service provision. These studies characterized chronic healthcare provision for children with Down syndrome from a modular perspective and show how modularity, and specifically interfaces, can contribute to the delivery of coordinated and patient-centered care provision. In general, this doctoral thesis contributes to the service modularity literature, and in particular to interfaces in service modularity, as well to the practice of delivering patient-centered care for patients with complex care needs, such as individuals with Down syndrome.

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