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Individualizing Patient Pathways through Modularization: Design and Evaluation of Healthcare-Specific Modularization Parameters

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Abstract

Some classes of person-oriented services such as healthcare services require individualization to be effective. Individualizing services and corresponding patient pathways are costly. To provide such services in an individualized, but also efficient manner, service modularization is known as a solution. Until now, modularization parameters that take healthcare specificities into account are missing. This paper closes this gap. Following a design science research approach, we iteratively build and evaluate a set of healthcare-specific modularization parameters. For requirements elicitation, refinement of the modularization parameters and their evaluation, we conduct interviews with domain experts from patient pathways in oncology care as well as with service design and business development experts. As main theoretical contribution, this paper provides design knowledge for the modularization of healthcare services. For practice, the set of parameters assists healthcare providers in the efficient provision of individualized, patient-centric solutions and patient pathways.

Keywords: service modularization, modularization parameters, healthcare services, patient pathways, design science research

1. Introduction

Healthcare systems worldwide are working at capacity and during different stages of the Covid-19 pandemic, the pressure further increased dramatically. The importance of efficient provision of healthcare services is undisputable and cost pressure is part of the everyday issues in hospitals and healthcare facilities. On the contrary, research has shown that individualized healthcare leads to improved quality of healthcare treatments and results in better healthcare outcomes (Birkhäuer et al., 2017).

This individualization can be represented by tailored patient pathways that specifically address the individual patient needs while following evidence-based medical treatment procedures. In this context, a "patient pathway a is a tool to plan and manage the care process of patient groups with complex, long-term conditions to support mutual decision-making by a multidisciplinary care team and patients" (Richter et al., 2021). Still, individualizing healthcare is known to be costly.

When it comes to realizing individualization of services in an efficient manner, service modularization has been discussed as solution and proven to be effective (C. Peters, 2020). Basically, service modularization comprises the decomposition of an object (here: a service, decomposed into processes) into decoupled individual components with specified interfaces (here: service modules) that can be combined to form new individual components (here: modular services) (Böhmann & Krcmar, 2006). For actually realizing service modularization and to arrive at corresponding service modules and modular service portfolios, dependencies between service processes are to be assessed so that the typical module characteristics of high module-internal cohesion and loose intra-module coupling (Stevens et al., 1974) are achieved. In this context, existing research (C. Peters, 2014) has introduced modularization parameters which can be used for the systematic assessment of process interdependences that allow the actual creation of modules. Modularization parameters are a set of criteria by which processes are assessed. They determine whether and how processes are combined in one module or not (C. Peters, 2014, Peters et al. 2013). So far, no set of modularization parameters for service modularization exists that a) has been rigorously built and evaluated and b) that considers the specificities of the healthcare domain. This is why we pose the

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following research question that guides our design science research paper at hand:

Research question: How do healthcare-specific modularization parameters look like?

Figure 1 illustrates this paper's underlying understanding of how healthcare services, healthcare service processes, healthcare service modules, and modularized healthcare services as individualized patient pathways relate to each other. It transfers the general service modularization understanding and concepts as described by C. Peters (2016) to the application domain of healthcare services. The following example helps reading the figure from top to bottom. A set of healthcare services form the un-modularized service portfolio (first layer). In the example represented, a comprehensive cancer care network offers services for patients such as colorectal cancer patients. Each service can be drilled down to its underlying healthcare service processes (second layer). They are the basis for assessments and for actually performing service modularization. Using the healthcare service processes, a portfolio of healthcare service modules is created (third layer). The modules of the portfolio are used to create individual patient pathways (modular healthcare services) according to the needs and preferences of patients (fourth layer). In a modularized service portfolio comprising modular healthcare services, service modules are an integral part of services. Reuse of these service modules over several patient pathways is an important and intended effect of service modularization. This is depicted with the module from the service portfolio being reused in both patient pathway A and B of the modularized healthcare services of the fourth layer.

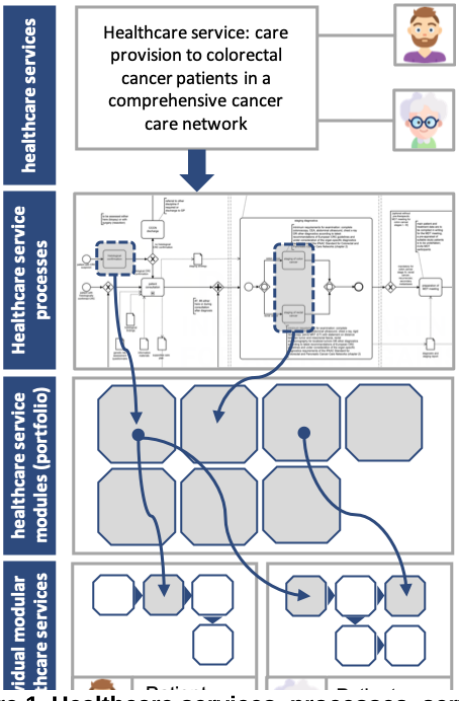

Figure 1. Healthcare services, processes, service modules, individual modular services and their interdependencies.

2. Methodology

2.1. Design science research approach

The objective to develop and assess a healthcare-specific set of modularization parameters is addressed applying a design science research (DSR) approach. DSR is suitable to support service design research in developing both rigorous and relevant research artifacts (Teixeira et al., 2019). We cover the main phases along a classical DSR process, i.e., analysis, artifact design, evaluation, and communication (Offermann et al., 2009; Peffers et al., 2007). By following the step-by-step approach for DSR service design research proposed by Teixeira et al. (2019), we explicitly ensure the rigor and relevance of the design artifact in an iterative design and evaluation manner. In Figure 2, the research process and how it is grounded in the existing service design knowledge base on modularization as well as the empirical base on service design in real-world healthcare settings are outlined. As part of the rigor cycle, literature reviews were carried out to identify the state of the art of modularization in general and explicitly in the field of healthcare services (rigor cycle).

For the relevance cycle, interviews were conducted to elicit healthcare-specific requirements for the modularization parameter intended. For the evaluation of the parameter set designed, we followed two focal points: First, experts' feedback concerning the general service modularization approach in healthcare for individualization purposes was

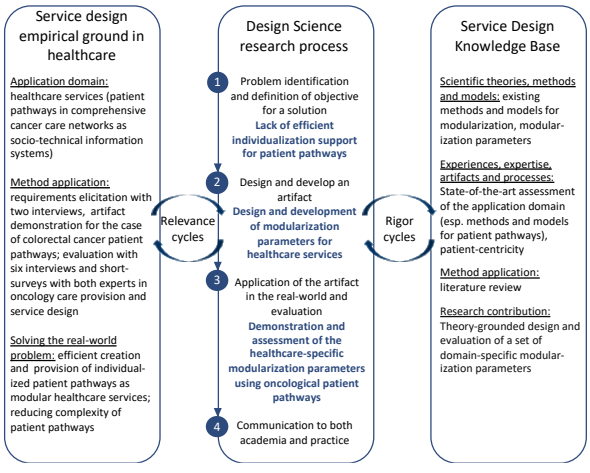

Figure 2. Overall research approach instantiating DSR for service design from Teixeira et al. (2019).

collected. In this regard, we also demonstrate individualization of patient pathways using modular healthcare services with a use case and personas from colorectal cancer care using mock-up like visualizations of example service modules and modular patient pathways. Second, expert's feedback regarding the DSR artifact itself, i.e. the modularization parameters, was collected. For these evaluation purposes, interviews and short surveys were conducted. Thus, the evaluation is centered around the Proof-of-Concept and Proof-of-Value (Nunamaker et al., 2015). The assessment of parameter usability in practice (Proof-of-Use) is not in the of the scope of this paper.

2.2. Literature review

The literature review comprised a title and abstract search for modularization in healthcare services in Pubmed, Ebsco Academic Search Elite, and Web of Science. The search string used was ((modularity OR modularisation OR modularization OR module OR modular) AND TI (healthcare service OR health care service OR care process OR "care pathway" OR "clinical pathway" OR "patient pathway")). During the screening of results all articles which presented healthcare modules, modularization approaches, applications or parameters were included. We excluded articles focusing on e-learning/ teaching/ educational/ training modules and genomics modules. This led to an inclusion and analysis of 14 articles.

2.3. Interviews and short survey

To also empirically ground the design of the healthcare-specific set of modularization parameters, we elicited healthcare service-specific requirements with the conduction of semi-structured interviews with two providers of digital (personal online treatment via video app) and at-home healthcare services (home dialysis) for patients. The interviews were qualitatively analyzed and coded with regard to relevant parameters and justification for their relevance (or irrelevance). Table 1 gives examples of how interviewee statements contributed to the definition of modularization parameters.

For the evaluation and critical assessment of the set of modularization parameters developed, we conducted semi-structured online interviews with four domain experts from patient pathways in oncology care working in comprehensive cancer care networks and national public health institutes in Germany and Poland as well as with two service design and business development experts. For the domain experts from oncology care, the interviews comprised four areas of interest which were (I) entry questions on the understanding, practice, and representation of individualization of care services, (II) questions on particular examples of healthcare service individualization using two colorectal cancer patient personas, (III) feedback on the demonstration use case of modular healthcare services with colorectal cancer care patient pathways, and (IV) short survey questions rating statements about modular, individualized patient pathways on a 5-point-Likert scale.

Table 1. Exemplary interview statements and coding for modularization parameters.

Interview statement	Parameter coded
"Personal interaction, i.e., processes that take place directly with the customer or patient, is clearly also relevant."	Personal patient encounter dependency
"There are processes that are based on the same device or system."	Device/ system dependency
"Certain processes run in parallel and others are performed in a staggered manner. This time variable must certainly be relevant."	Time-critical path dependencies

For the service design and business development experts, the interview focused on the evaluation of the set of healthcare-specific modularization parameters. First, the evaluation was performed on a parameter-by-parameter basis. The modularization parameters and their corresponding short descriptions were introduced using screensharing within the videoconference call, the specific question that is used to assess the interdependence of processes in regard to this modularization parameter was also outlined. They assessed how easy to understand, unambiguously described, and useful (i.e., reflecting a measure of interdependency between processes that is likely to be relevant in forming healthcare service modules) they are. This was done using a 5-point Likert scale. Also, there was room to discuss questions or unclarities or to suggest improvements. Second, there was an evaluation of the overall modularization parameter set. Again, a 5-point-Likert scale was used and the set was evaluated regarding completeness, understandability, quality of description, transferability to other real-world (health) contexts, utility (by using the set, one can modularize services), ability to leverage modularization effects, i.e., reuse, of modules, module-wide innovation, faster development, rapid reconfiguration, and potential to provide individualized services in an efficient manner.

3. Design and development of modularization parameters

The design and development of this paper's DSR artifact is grounded in both the existing service design knowledge base on modularization parameters and the empirical base from real-world on service design in healthcare settings. In the following, we described how the rigor and relevance cycles of the DSR process are constituted and the artifact is designed.

3.1. Obtaining rigor – the state of the service design knowledge base on modularization parameters

The design and development of the set of health-care specific modularization parameters is based on existing literature on service modularization, especially modularization parameters and interviews with service design experts in the healthcare domain.

As in our consideration, service modularization is often done based on service processes (Tuunanen & Cassab, 2011). While modularization of services has been studied for quite some time (Dörbecker & Böhmann, 2013), C. Peters (2014) is the first to suggest the concept of modularization parameters. These modularization parameters are introduced for the domain-independent use but are suggested for and capable of modularization of complex services. To the best of our knowledge, there is no further research on modularization parameters that can be built on.

In addition, we reviewed existing modularization approaches and parameters in healthcare. None of the existing literature explicitly defines modularization parameters for healthcare services. Instead, the majority of the literature describes disease-specific service modules in the sense of essential care intervention elements or building blocks of care provision for a specific patient population. For example, Hagen et al. (2019) describe 33 intervention modules for the therapy of children with anxiety, depression, trauma and conduct problems. Cardoso et al. (2021) describe and test a modular ontology for the automatic processing of textual data to describe the care pathway of patients with a neurodegenerative disease, covering four domain modules (core, medical, socio-environmental, coordination) and a consolidation module. Overall, healthcare service modules presented in the literature reviewed were developed based on data collected with case studies, interviews, practice observations, or document analyses. No systematic modularization method was applied. We used and analyzed the modules described in the literature to derive potential healthcare-specific modularization parameters. For example, the modular service architecture from a patient's perspective proposed by V. Peters et al. (2020) – covering modules such as "getting rid of health complaints" or "improving skills" – was used to justify the specification of a parameter describing patient needs dependencies (see section 4.3.1.). Interview quotes from the literature further supported the evidence grounding of the modularization parameters development. E.g., the case study on interface types in healthcare service provision by de Blok et al. (2014) was useful to identify dependencies concerning necessary know-how of care providers or personal interactions with patients (e.g., "it is very important that the same person will take care of the client, so the wound is taken care of in the same manner").

3.2. Obtaining relevance – empirical ground on healthcare service design in oncology care

3.2.1. Colorectal cancer care services. Cancer is an often protracted, highly complex disease - worldwide one of the most common and costly diseases as well as a leading cause of death (Sung et al., 2021). To meet the high requirements of specialized, interprofessional and interinstitutional care for cancer patients, Comprehensive Cancer Care Networks (CCCNs) are being established. CCCNs shall offer a wide service range customized to the evolving needs and preferences of cancer patients and their relatives (Zonneveld et al., 2018). Multidisciplinary and tumor-specific care teams of several organizational units work together, covering the whole continuum of cancer care, i.e., prevention, diagnosis, treatment, follow-up, rehabilitation and supportive care to palliative and end-of-life care as well as clinical research (Albreht et al., 2017). Although evidence-based recommendations for the treatment of specific cancer patient types are already prepared in a highly standardized manner and provided in clinical practice guidelines (CPGs), the individual journey of patient in a CCCN remains complex and is not centrally organized. To support the implementation of CPGs recommendations in practice and to provide cancer services of a uniformly high quality, patient pathways are being promoted (Richter et al., 2021). For care provision to colorectal cancer patients, a patient pathway template was developed and tested in several European pilot CCCNs by adapting them to national, regional, and local contexts (Richter & Schlieter, 2021). Given these existing developments and the fact that the adaptation of patient pathways to individual patient contexts, needs, and preferences remains challenging, cancer care in CCCNs is a highly suitable domain for service modularization.

3.2.2. Personas of colorectal cancer patients. We created two personas of colorectal cancer patients (one example represented in Figure 3) as reliable and realistic representations of key target audience of individualized healthcare services in a network of care providers. Their development was based on the knowledge gained by one of the authors in previous pathway research and development projects in the domain of comprehensive cancer care, the exchange with a patient representative and cancer patients. The personas described represent two people diagnosed with colorectal cancer who are in significantly different life and health situations. Correspondingly, they show different needs and preferences that must be considered in therapy decisions and for their course of treatment. Thus, an efficient and patient-centered mode of healthcare requires to individualize the services offered and provided to both of them. In the following, we demonstrate service modularization as a means to this end and use these personas for demonstration purposes of the modularization parameter set developed.

Figure 3. Colorectal cancer persona example.

3.3. Modularization parameters for healthcare services

In the following, we present a set of healthcare domain-specific modularization parameters which was developed based on the current knowledge and evidence on service modularization in healthcare and in general (as described in sections 3.1. and 3.2.). They are divided into the four areas of patient-related, healthcare system-related, technology-related, and general parameters as represented in Table 2. For each parameter, the meaning and context, modularization aim and a particular question (in italics) guiding the modularization process in the sense of the respective parameter are described in the following.

Table 2. Modularization parameters and categories.

Modularization parameter category	Modularization parameter (process dependencies with regard to…)
Patient-related	Personal patient encounter Patient engagement Patient needs
Healthcare system-related	Care network partner Regulations Remuneration
Technology-related	Devices/ systems Documents Information/ data IT-support/ (semi-) automation
General	Locality Time criticalities Know-how

3.3.1. Patient-related modularization parameters. Patient-centeredness is essential considering the overall aim of individualizing patient pathways by modularization. Thus, the following parameters focus on patient-related interrelations between processes.

Personal patient encounter dependency. Many processes of a patient pathway rely on personal encounters between service providers (e.g., doctors, nurses, therapists) and patients. Personal encounters make up a high fraction of value-creating moments along the patient pathway (e.g., anamnesis, surgery, pastoral care). This parameter represents direct, visible personal interaction. *Do the processes require the same personal encounter with a patient?*

Patient engagement dependency. Patients can be involved in service provision with self-management and self-care activities (V. Peters et al. 2020), e.g., educational/counselling self-management or home exercises. Shared decision-making, as essential element of patient-centered care, is a typical approach to implement patient engagement. Modularization performed in awareness of this parameter checks for processes with the same level of patient engagement potential. Depending on whether patients want to be actively involved in their own care process, they may take advantage of this potential. Giving patients the choice to also not get involved, not get informed or follow recommendations by doctors is partly patient-centered care as well. *Do the processes rely on the same type and degree of patient engagement?*

Patient needs dependency. Certain processes of a patient pathway help to satisfy a specific patient need (e.g., connect with other patients, get informed about own disease, not be in pain, get fit). Especially supportive care needs, i.e. physical, psychological,

social, informational, spiritual support, are relevant in this regard. Also, individual preferences and context such as getting care at home instead of the hospital or difficulties for patients to visit a clinic on a regular basis are to be considered here. If two processes contribute to the same patient need, they are interdependent in the sense of this modularization parameter. *Please consider the specific patient need for the processes first. Do the processes contribute to satisfying the same patient need?*

3.3.2. Healthcare system-related modularization parameters. The following modularization parameters are highly specific to the domain of integrated healthcare delivery, especially in a network of care providers - whether they simply share the same mission of care for a particular type of patient or are part of a coordinated care network.

Care network partner dependency. There are processes of a patient pathway which highly depend on the cooperation with other healthcare providers of the care network, e.g., an interdisciplinary tumor board meeting or a surgery. Other processes are independent of partners and other care disciplines. Modularization performed in awareness of this parameter aims at coupling those processes which do not depend on any other partners (self-dependency) or on a small number of the same partners. With this, coordination efforts in case of re-configuration can be reduced. *Are the processes integrating the same external partners?*

Regulatory dependency. There are varying levels of commitment to a process of a patient pathway. Good clinical practice obligates the implementation of the latest scientific findings, e.g., summarized as recommendations in CPGs. Internal protocols also require commitment. Moreover, there are processes of a patient pathway which are relevant for certification, e.g., ISO 9001 quality certification or certification of a comprehensive cancer care network committing to comply with certification standards. Other parts of a pathway might be required by law. Modularization performed in awareness of regulatory dependencies aim at reducing module updating efforts as well as increasing re-configurability and development times in case of changes necessary. *Do the processes underlie the same regulations or (own or external) standards?*

Remuneration dependency. In healthcare, there are different modes of remuneration of processes along a patient pathway. Modularization in awareness of this parameter aims to bundle processes according to the remuneration and mode of co-payment available, e.g., privately paid, co-funded, covered by health insurance, voluntary services. This can help with reducing complexity and providing transparency for patients in terms of remuneration of their care provision. *Do the processes have the same mode of remuneration?*

3.3.3. Technology-related modularization parameters. Modular healthcare services in terms of patient pathways are provided in a network of care providers. These networks can be regarded as socio-technical information systems. Thus, besides people- and system-related dependencies as described before, healthcare service processes can also show technology-related dependencies.

Device/ system dependency. Especially diagnostic and therapeutic processes of a patient pathway are linked to specific medical devices, application systems (e.g., patient data management system) or equipment. Modularization performed in awareness of this parameter aims to couple such processes to avoid patient burden, unnecessary multiple device usage (e.g., of an x-ray), and media discontinuity. *Do the processes use the same devices or application systems?*

Document dependency. Processes of a patient pathway use certain documents or are activated by them as inputs (e.g., doctor's letter or tumor board recommendation letter received). If processes are based on the same documents, they are dependent with respect to this parameter. They are also dependent if a process contains a document and thereby activates a next process. *Are the processes using the same documents?*

Information/ data dependency. For the majority of processes in the patient pathway, specific information or data are needed (e.g., patient family anamnesis, lab results, genetic test results). If a process passes certain information/data (object) to another process or vice versa, they are dependent on each other. *Do the processes require a mutual exchange of information/data?*

IT-support/ (semi-)automation potential. Potentials for IT-support and (semi-)automation of processes within a patient pathway shall be checked. Especially commodity services qualify here – e.g., appointment scheduling and notification, patient information provision, patient tracking. This parameter is important when it comes to cost reduction and efficiency improvement purposes. *Can the processes be (semi-) automated within the same automation sequence (also applies if already the case)?*

3.3.4. General modularization parameters. Service modularization literature already offers general modularization parameters independent from a specific application domain. Such can be suitably

applied to the context of healthcare services. Therefore, we selected and adapted general modularization parameters from C. Peters (2014), which relate to the geographical setting, timely manners of service provision, devices and application systems used, and know-how needed for service delivery.

Local dependency. There are processes of a patient pathway which require to take place in a specific care surrounding (e.g., hospital, operating room, examination room, laboratory) and which cannot be performed independent from the environment (e.g., general physical examination or consultation at patient home or GP practice). Especially the lanes of a pathway model indicate dependencies with this regard. *Are the processes performed at the same location?*

Time-critical path dependency. There are processes within a patient pathway which must be carried out in a specific sequence and in a mandatory manner (e.g., anesthesia before surgery or informed consent before treatment beginning) or which must start within/ after a defined timeframe (e.g., max. 14 days between tumor board recommendation for treatment and beginning of treatment). *Are the processes necessarily performance in a direct sequence?*

Know-how dependency. There are processes within a patient pathway which require a specific knowledge or qualification from the care service provider (service provider specificity). Less know-how-specific processes could also be delegated to other specialists (e.g., from doctors to physician assistants or nurses), allowing to couple such in one service module and avoid care interruptions for patients due to visits of several providers. An example of a process with high know-how specificity is a surgery. An example of a process with lower know-how specificity is the collection of a patient's vital data (e.g., blood pressure, oxygen saturation). *Do the processes require the same (level of) knowledge or qualification?*

4. Demonstration and assessment

We present the results of the Proof-of-Concept and Proof-of-Value with regard to both the assessment of the overall service modularization approach in healthcare for modular, individualized patient pathways (see section 4.1) and the evaluation and respective refinement of the modularization parameter set (design artifact) (see section 4.2). Therefore, we demonstrate the overall service modularization approach using mock-up like visualizations of example service modules and modular patient pathways for colorectal cancer patients.

4.1. Demonstration and assessment of modular healthcare services in oncology care

For demonstration purposes of the modular service approach in the use case of oncology care, we created an exemplary healthcare service portfolio. It is based on the contents of the existing patient pathway processes for colorectal cancer care in comprehensive cancer care networks (referring back to section 3.2.1.) and represented in Figure 4. For the purposes of clarity and better comprehensibility for the interviewees, the service modules were clustered and colored accordingly. The clusters chosen also illustrate different emphases with regard to the modularization parameters. For example, modules addressing "informational needs of patient" (colored yellow) or "supportive care needs" (colored purple) include processes of the colorectal cancer patient pathway which show high dependencies regarding patient needs. In contrast, the processes underlying modules for "diagnostic options" (colored green) and "therapy and recovery options" (colored orange) show a strong regulatory dependency since all of them refer to recommendations of colorectal cancer CPGs. The modules represent examples and are not derived

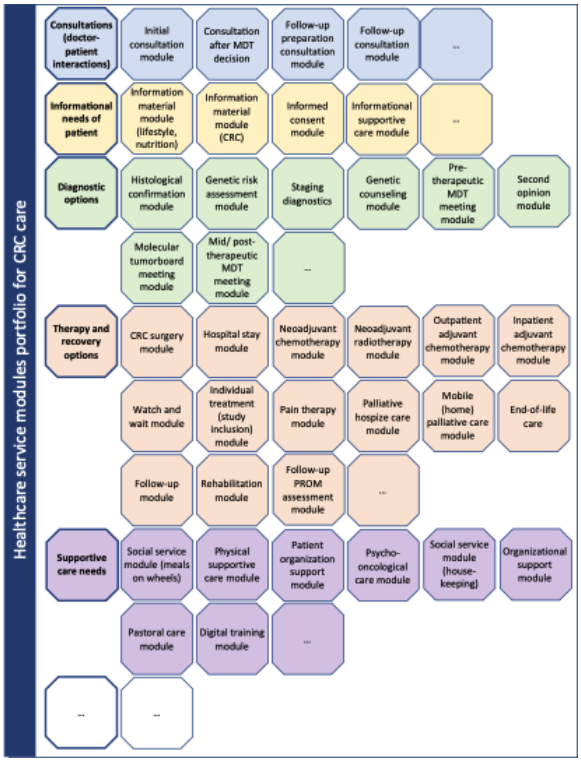

Figure 4. Demonstration of a service modules portfolio for colorectal cancer (CRC) care.

systematically (e.g., applying the method proposed in (C. Peters, 2016)). This approach was agreed to be sufficient for the Proof-of-Concept and Proof-of-Value purposes. Using this service modules portfolio, relevant modules satisfying the specific needs and preferences of the two personas (referring back to section 3.2.2.) can be chosen to build the individual patient pathway. This is demonstrated with Figure 5.

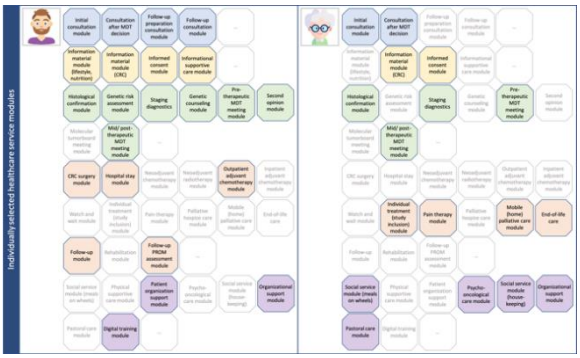

Figure 5. Demonstration of individual service module selection for the CRC personas.

The domain experts interviewed uniformly stressed that in the selection process, the clinically meaningful options should always be offered to patients first. Then, the individually appropriate ones should be selected in a joint discussion. Automatic module selection should be avoided, whereas IT-supported suggestions in the form of configuration proposals depending on the patient's needs and preferences are certainly welcome. It was pointed out, that tumor boards (treatment planning in an interdisciplinary care team) along the patient pathway are milestones for (re-) configuration of a forthcoming care episode. Figure 6 demonstrates how the service modules selected for one of the personas could ultimately form the patient pathway.

The overall assessment of the modular patient pathway approach by the oncology domain experts interviewed was positive. They confirmed its usefulness, especially for the individualization of care. Also, re-use of healthcare service modules was confirmed to be a sustainable way of providing individualized patient pathways. Modular patient pathways are expected to contribute to patient-centered healthcare. A relevant statement that was made by all interviewees is that a new, modular representation of patient pathways could encounter acceptance problems among physicians. The traditional representation of patient pathways as BPMN process models cannot and should not be replaced by modular representation. However, since it represents the patient pathway in a much clearer and easier to understand way, it may be a suitable form of pathway representation for patients.

4.2. Evaluation and refinement of the healthcare-specific modularization parameters

As described in the methods section, our main DSR artifact, the healthcare-specific modularization parameters, has been iteratively designed and evaluated. For the resulting set of modularization parameters, we outline the final version parameter-by-parameter in section 3.3. Now, we want to highlight insights gained and obstacles identified during earlier iterations of the artifact design and evaluation, e.g., from the interviews conducted. We further illustrate how these insights and previously existing obstacles led to major improvements and increased clarity as represented in the final version of parameters.

It can be reported that the quality of each evaluation activity can be considered very high due to high expertise-level of interviewees and their focused feedback. Within the parameter-based evaluation, 11 out of 14 modularization parameters, the evaluation regarding ease of understandability, unambiguous description and utility was assessed very high. For the three others, this was also the case despite the criterion unambiguous description. For each of these three parameters, improvements were proactively provided by the interviewees. For information / data dependency, the question arose whether this includes data objects or data fields (interviewee 1: "the dependency of data seems highly relevant, but so far superficially described. For the assessment of this parameter, you might want to clarify whether you ask for data object dependency or data fields dependencies"). The first is the case and this is now clarified. For IT-support/ (semi-) automation potential,

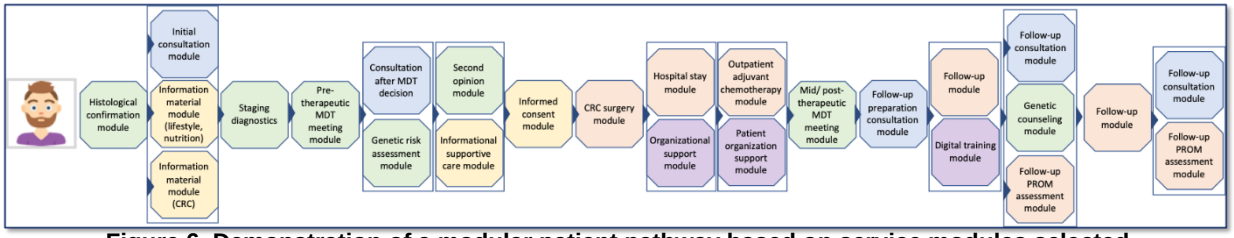

Figure 6. Demonstration of a modular patient pathway based on service modules selected.

the scope of one automation sequence in which the processes could be automated had to be defined which is now implemented. For patient needs dependency, it has to be noted that this parameter has a slightly different way of assessment. While all other parameters can be easily assessed by looking at the processes of question, for the assessment of patient needs dependency one has to also consider the actual patient need first, e.g., information needs of patients, and then can assess whether it is the same single patient need for all to-be assessed processes. This is now considered by including "please consider the specific patient need for the processes first" in the parameter description. As positive outcome of the evaluation, it can be reported that all of the refinements and suggestions of improvements could be implemented and are now reflected in the final set of parameters as described above. Furthermore, the experts' feedback explicitly emphasized the importance of a specific modularization parameter, e.g., domain experts from oncology mentioned time-critical path dependency as crucial.

5. Discussion

In regards to the existing modularization literature, we contribute with introducing a set of modularization parameters which a) represent the glue between decomposed services on a process-level and modular services and b) provide explicit design knowledge in regards to the module creation process. This built-and-evaluated artifact of the modularization parameters can be used to guide the modularization process itself and represent the rationale why certain processes might be part of highly cohesive modules or not. Each individual service modularization parameter is a measure of interdependence between a couple of services, the set of parameters enables the module creation (due to a sufficiently high interdependence of a group of services forming the module).

The modularization parameters represent a first building block for a nascent design theory contribution (Gregor & Hevner, 2013). They represent the glue that combines processes into modules. Tuunanen et al. (2022) propose that design principles could be used as a basis for feature/combination of features level modularization. Currently, we consider the existing service processes as basis for modularization. To further improve effective modular healthcare IS design, future research could focus on developing and adopting design principles as basis for feature-level modularization. The modularization parameters and categories form a suitable starting point for such aim.

The modularization of services can help in providing individualized healthcare services in an efficient manner. As described above, this not only assists in realizing more patient-centricity as such, it helps providing better healthcare from a medical treatment perspective as individualized healthcare provision is proven to be more effective (Birkhäuer et al., 2017). In the context of Covid-19 and seeing healthcare systems worldwide working to capacity, modularity of healthcare services and patient pathways can also help in identifying modules that can be provided at home or at least outside of hospital and facility units that are particularly busy.

Naturally, a highly important aspect in the context of service modularization is its result: modularized services and a portfolio of modularized services at the service provider's side that enables leveraging the intended modularization effects such as reuse, rapid reconfiguration, etc. While the illustration of the resulting modular portfolio or the resulting modular patient pathways cannot be considered resulting artifacts of the conducted design science research process, they still are important side products of our research activities. According to the experts, the intuitive overview of the modular portfolio and its color-coding as well as the persona-based illustration of individualized pathways that are obviously built in a modular fashion, are considered extremely useful. The interviews revealed that it most likely assists in explaining the individual patient journey to patients and their relatives. From the provider side, it further has potential to improve communication within multi-stakeholder healthcare ecosystems and nurtures the identification of strategically important modules for module-wide innovation efforts for each stakeholder as well as for stakeholders that collaboratively innovate modules.

For the most effective use of modularization parameters, tools supporting the modularization process should be developed that integrate the set of modularization parameters by-design. This was also mentioned by the experts. Further design-oriented research might be needed that supports corresponding theory-driven tool development. This could facilitate and fasten the process of service modularization significantly and might impact corresponding business models (Peters et al. 2015). Digital or even bot-based workflow support might further increase the tool's digital support capabilities.

The consolidated four modularization parameter categories can be useful for the further development of parameters in other domains than healthcare. The categories also facilitate decisions on whom to involve in the modularization process, i.e., in the parameter-by-parameter assessment of service processes leading to the forming of service modules.

6. Conclusion

This paper iteratively designs and evaluates healthcare-specific modularization parameters following a DSR approach. Thereby, we assist in providing modular healthcare services in an efficient manner while realizing individualized services in terms of patient pathways. As healthcare services represent one class of services that require individualization to be effective, this can be seen as a highly relevant contribution in a domain of increasing societal relevance. Furthermore, we assist healthcare providers to modularize their services and service portfolios and to leverage intended modularization effects such as reuse, module-wide innovation, faster development and rapid reconfiguration.

The paper makes one major theoretical contribution: the resulting set of modularization parameters. This artifact of our DSR approach has been systematically designed and evaluated following (Teixeira et al., 2019) using several relevance and rigor cycles each. By doing so, we extend the knowledge base by providing design knowledge for service modularization in the form of the evaluated set of modularization parameters. For practice, we not only provide the modularization parameters as such, but also their unambiguous descriptions as well as precisely formulated questions that help in assessing each parameter. Furthermore, we suggest ways of visually representing the resulting modular service portfolios and modular patient pathways.

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