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HOW LIGHTWEIGHT TECHNOLOGIES SUPPORT DIGITAL INNOVATION IN THE CONTEXT OF PATIENT-CENTERED CARE

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How lightweight technologies support digital innovation in the context of patient-centered care

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Abstract

A central challenge for healthcare is technology innovation. The literature has reported on the many challenges to IT innovation efforts in hospitals and in digital health services in general. Recently, the increased use of mobile apps, personal devices, web interfaces – so-called lightweight technology – has introduced a novel innovation logic where recombinability seems to emerge as a core capability to enable innovation. However, we still know little about how recombinability supports digital innovation in healthcare. Specifically, we explore the recombinability of lightweight technologies in the context of digital innovation for patient-centeredness. Our research builds on a comparative analysis of two case studies in Scandinavia. The two cases show that recombinability is crucial to enable flexible personalization. We discuss different strategies of recombinability to enable digital innovation for patient-centered health practice.

Keywords: digital innovation, lightweight, recombinability, design, patient-centered care.

1 Introduction

There is a strong need for innovation in healthcare. An aging population is challenging the sustainability of the current healthcare system. The elderly and those with chronic illnesses account for more than 80 % of healthcare spending in the in Sweden and in Norway it is estimated that the cost of elderly care may rise by 38% for the next generation of elderly (Vårdanalys 2014; The Norwegian Institute of Public Health 2016). Today's system was not designed for this situation and consequently it is unable to deliver in accordance with these demands.

There are several different initiatives addressing these challenges. One of them leverages the capabilities of digital technologies to move towards patient-centric healthcare. Patient-centric healthcare entails re-organising the healthcare systems to address patients' illness profile and personal needs rather than the needs of health providers (Davis et al 2005). As a result, care becomes more personalized improving the patient experience and increasing his engagement (Ekman et al., 2011). Studies show that a patient-centric approach reduced hospital length of stay between 50 and 70%; that lifestyle interventions reduced costs by 12 % and that self-management services reduced hospital admissions by 57% (Horne et al., 2013). The shift towards patient-centric healthcare requires care services to become adaptable and flexible, and it needs digital technologies and infrastructure that support the same flexibility and adaptability (Lindroth et al, 2018; Von Korff et al 2002: von Thiele Schwarz, 2016).

Prior research has shown, however, that digital technologies and infrastructures in healthcare have traditionally been designed prioritising stability, homogeneity, and risk minimization (Aanestad et al., 2017; Greenhalgh et al., 2017; Magnusson et al., 2019). Over the years, large investments have been made into increasingly complex and specialized hospital systems such as Electronic Patient Records, systems for patient admittance and billing. As a result, investments are geared for efficiency rather than innovation which results in rigid systems and infrastructures (Magnusson et al., 2019; Vårdanalys 2019; SOU 2019:42; Gandhi et al. 2016; Romanov et al. 2012).

In this paper, we argue that the adoption of digital technologies supporting patient-centric healthcare requires a different approach. We build on the recent work by Bygstad (2016) and his distinction between heavyweight IT (e.g. the traditional hospital systems), and lightweight IT (e.g. apps). Specifically, we examine the role of lightweight IT and its recombinatorial capability in relation to personalization in digital infrastructure for healthcare. The notion of recombinability refers to how digital resources such as code, user-oriented technologies, services or products are 'building blocks' that can be combined and recombined in various ways (Henfridsson et al., 2018). Lightweight and heavyweight are not just two different types of technologies, but represent two knowledge regimes (Bygstad, 2017). This means that they include "the network of key actor groups (such as IT professionals, users, vendors), work practices, certain technologies and the shared knowledge on the appropriate development and use" (Bygstad, 2017, p. 181). The research on lightweight/heavyweight has primarily focused on the generative relationship between the different regimes. Differently, in this study, we unpack different aspects of the lightweight regime, and investigate how these aspects can leverage the capability for recombinability to support personalization of care. In this paper, we address the following research question: *How does recombinability of lightweight technologies support digital innovation in the context of patient-centered care?*

To address our research question, we have conducted a comparative study of two cases of digital innovation in healthcare. In both cases novel digital lightweight technologies are introduced to address current challenges in the existing patient-health provider communication and information practices, with the aim to facilitate a patient-centred approach. The first case is set in the context of elderly chronic care in Norway, the second case is in cancer rehabilitation in Sweden. Both cases are about the design, implementation and use of digital solutions to improve the personalization of care, and in both cases a recombinatorial strategy played a crucial role (Grisot et al, 2019; Grisot et al, 2020). In this paper, we build on, and develop our previous research by unpacking recombinability further. This article further develops the two logics of generic and tailorable recombinability by drawing on the concept of Lightweight IT (Bygstad, 2017).

The structure of the paper is as follows: we first present the lightweight/heavyweight perspective. This is followed by a presentation of the recombination concept. This is followed by the research methodology and provides details about the two cases. In working with the case material, we present our findings in section 4, and conclude the analysis section by summarising the key findings from the comparative analysis. Discussion and conclusion follow.

2 Theoretical background

2.1 Lightweight vs heavyweight IT

Bygstad (2017) conceptualises lightweight and heavyweight IT as two different knowledge regimes. A knowledge regime is the overarching perspective on how IT can be used in a work practice, and the collective conventions of appropriate use. While heavyweight IT is characterized by vertical silo systems, driven by traditional software engineering approaches, lightweight IT is driven by competent users' need for solutions and realized through innovation processes. Thus, while heavyweight develops at a slower pace and becomes increasingly complex and specialized over time, lightweight enables change and fast innovation. Lightweight IT uses consumer-oriented technologies such as smart phones, tablets, apps and social media. The lightweight regime prioritizes usability and adaptability before rigidity and homogeneity. Examples of strengths with lightweight IT are mobile apps that enables swift purchase of metro tickets, apps to improve service work as well as improved welfare technology solutions (Bygstad and Iden 2017). The lightweight IT sits on top of the heavyweight IT in a layered architecture enabling innovation through its combinatorial features. Earlier studies have demonstrated lightweight IT's promising potential for finding solutions to the "silo problem" and the lack of horizontal information support as well as process improvement in hospitals (Øvrelid, 2018; Bygstad, 2016; Hertzum and Simonsen 2013). However, the combinatorial features of lightweight IT are less understood. In this study we aim to understand how these features can support patient patient-centric care.

2.2 Recombination in Digital Infrastructures

In this study we focus on recombinability as a central capability of digital technologies. Recombination is at the core of innovation (Henfridsson et al., 2018). Digital innovation is about "combining digital technology in new ways or with physical components that enables socio-technical changes and creates new value for adopters" (Osmundsen et al., 2018). According to Yoo et al (2013), digital technologies possess more innovative potential than their analog counterparts as digital services, applications and content can be reused and recombined (Tilson et al. 2010; Yoo et al., 2010). Thus, digital innovation implies that digital technology evolves in a 'recombinant' or 'combinatorial' manner (Nylén & Holmström, 2015). This applies to the way hardware circuits, lines of code and other forms of digital resources are configured to interact in new ways.

However, it is also a broad term which points to issues of malleability and adaptability of a digital product or a set of products, as well as their flexibility. Recent research has pointed out that not all digital infrastructures enable recombinability (Øvrelid and Kempton, 2019), and that this is particularly difficult to achieve in the public sector (Holgersson et al., 2017) and in healthcare specifically (Bygstad and Hanseth, 2018).

In management and innovation literature, the recombination perspective is well known, and it is argued that recombination is central in innovation processes. Innovation, in this view, derives from combining components which were previously unconnected, or by finding new ways of combining already associated elements.

In IS, Henfridsson et al (2018) distinguish between *design recombination* and *use recombination*. Design recombination is a firm-centric view on recombination assuming that a firm design for recombination as it is defined as "the activity of generating a value path by connecting digital resources as a value offer to users" (p.92). Use recombination is about how the design can be recombined at the point of use, which means that recombination is performed in use: "the activity of generating an individual value path by connecting digital resources in use" (p.92).

Originally, the concept of innovation as recombination is based on the work of Schumpeter (1934) who emphasised that innovation, as a process, is often a matter of reconfiguring what exists. In his work on the evolution of technology and how combination work in design, Arthur also identified the central role of recombination and argues that technology is an assemblage of practices and components where some form a core central assembly (Heavyweight IT), and other have supporting functions (Lightweight IT) (Arthur 2009).

3 Research methodology

This paper is based on two studies of digital innovation in healthcare and specifically on the introduction of two novel digital tools for telecare used in clinical practice by nurses in the context of chronic care. The studies follow an interpretive approach (Walsham 1995; 2006) and are based on qualitative data. In both cases data were collected over an extended period of time through interviews, ethnographic observations and document analysis (Silverman and Marvasti, 2008; Wolcott, 2005). Details on data collection are given in section 31. and 3.2. The study brings together two cases where telecare solutions are introduced for patient-health provider communication. The solutions enable patients to generate data while at home as part of the care service, while nurses in clinical settings have access to the data and use them for clinical decisions and for patient counselling. In addition, the digital technologies in both cases enable patients to access their data which includes graphical visualizations of data over time, and messages from the nurse. The cases present also interesting differences. In case 1, the tool supports the generation of data in a continuous way for remote patient monitoring in the context of primary care. In case 2, the tool is used by patients for a limited period of time and ahead of specialist visit. The case settings, context, and data collection methods are described in the following two sections. The similarities and differences of the two cases are summarised in figure 3.

3.1 Case 1: digital innovation in elderly care

In Case 1, the research reported is based on a case study on the use of a telecare system for patients affected by cardiac diseases, diabetes and COPD. The study started in January 2017 and ended in April 2018. The focus of the study is a pilot project where a private IT company (the vendor of the telecare software) run a remote care center in partnership with the primary care services of a small municipality. The pilot is organized in the framework of the national Norwegian program for remote care technologies which started 2016 and is still ongoing. The pilot was run for two years (2016-2018), and during this period the center was staffed with four nurses and cared for ca. 150 patients. Specifically, we were interested in understanding how nurses and patients used the telecare solution in addressing the specific needs of the patients.

Data were collected via interviews and observations. A total of 23 interviews and 27 hours of observation were conducted. This paper builds mainly on data from the interviews with the nurses at the remote monitoring center, the management team and the developers at the company. We asked nurses to describe how they instructed patients in using the devices and the app for data reporting, how they made sense of the measurements received in the system, how they wrote messages to patients, how they in general interacted with patients based on the received data. We did not have access to the data in the system, patient records, and we could not interview patients.

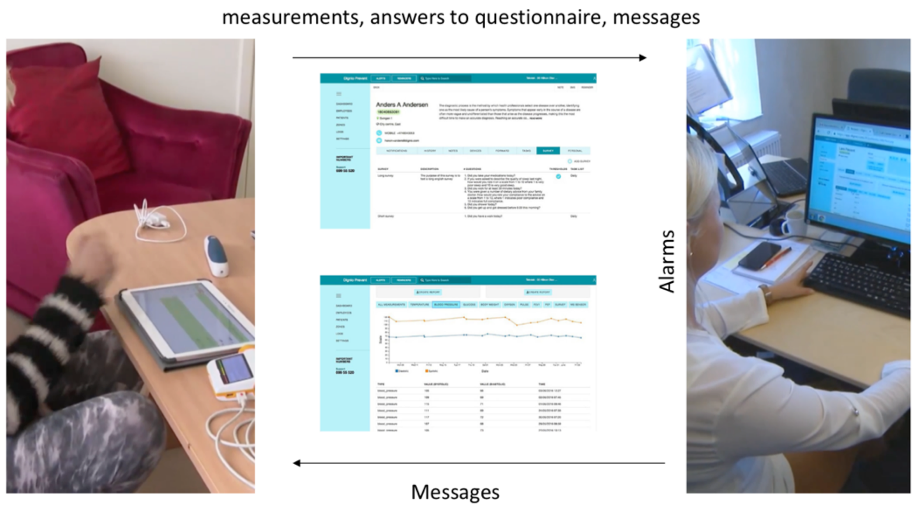

Figure1. The system set up (patient on the left and nurse of the right) with two illustrative screenshots.

Figure 1 illustrates how the telecare system works. ProAct is a telecare system which works as a patient record and as a communication system. It is accessed by the patient via the ProAct app on the tablet, and by the nurses via a web view on their computers. ProAct runs on a secure cloud platform and collects data from measurements taken by patients in their homes with a set of personal digital devices. When enrolled in the service, the patients receive a set of devices according to their disease and the data that need to be tracked. For instance, patients with COPD are equipped with a digital spirometer which measures the volume of air inspired and expired by the lungs (FEV 1 and PEF); a digital pulsometer which measures the pulse (frequency of heart beats per minute) and the oxygen saturation; a digital thermometer which measures body temperature; and a digital scale which measures body weight. In agreement with the nurses, the patients are expected to use the devices and take measurements (e.g. every morning, or in the morning and evenings). Each time they take a measurement, the device sends the data to the app and to the system. Data are collected in the patient record and displayed to the nurses as alert messages which are colour coded (green, yellow or red depending on how the new measurement relates to the set thresholds for each type of value). In the nurses' view, each record contains a number of tabs showing the patient profile (e.g. personal information, diagnosis, medicines, comments), incoming measurements, graphical visualization of the measurements, personal setup of the devices, messages between nurses and patients, and a personalized questionnaire. Nurses receive an alert also when patients send messages, answers to the structured questionnaires, and also in case measurements are missing. When patients are enrolled in the service, they receive a home visit from one of the nurses who delivers the devices and explains how to use them.

3.2 Case 2: digital innovation in cancer rehabilitation

In Case 2, the research reported is based on a study of the design and implementation of a digital infrastructure for nurses and patients in cancer rehabilitation (see author, 2019). The site of the study is a clinic specialised in cancer rehabilitation at a major university hospital in Sweden. The clinic receives patients, mostly women, who have been treated for cancer in the lower pelvic area and who suffers from chronic survivorship diseases (consequences of the cancer treatment including radiation, chemotherapy and surgery). The focus of the study has been on understanding the design and use of the various components in the digital infrastructure (an App, a website, an on-line patient forum, a FB page) to address the specific needs of the patients. The study is based on qualitative data from interviews and non-participants observations of the work practices of the nurses at the clinic. In total, 20 nonparticipant observation days, four semi-structured interviews and seven individual interviews with patients were conducted. The aim of the fieldwork was to understand the information and communication practices between nurses and patients in the treatment process at the clinic. For instance data collection has focused on documenting the different data-collection steps, how nurses set up the treatment plan, how they interact when they meet the patient and what they talk about. In addition, data about the use of the digital infrastructure consists of the following: (1) interviews with patients who had used the app and the webpage, directly after a video or telephone consultation with a nurse and (2) ten recorded telephone consultations between patient and nurse where data from the app were discussed during the call; (3) App log-data on the number of clicks in the app for each patient, number of seconds to add data to the app and (4) ten weekly observations of the activities in the online community, its progression and the ongoing conversations.

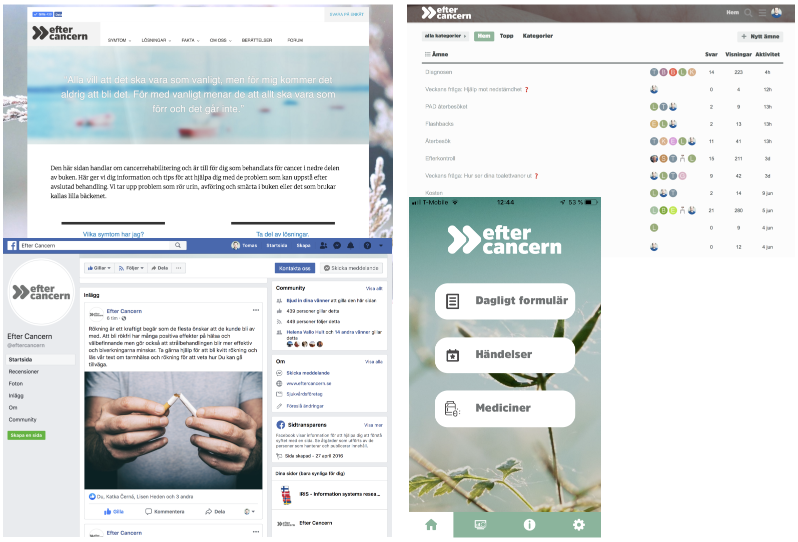

Figure 2. Screenshots from the four digital components: webpage (top left), patient forum (top right), facebook page (bottom left), app (bottom right).

The digital infrastructure is made of various digital components: an app for patient-reported data with a web interface for nurses, a secure patient forum, an open webpage, and a Facebook page. The infrastructure was developed to respond to the different information and communication needs of the health practitioners at the clinic. The App is intended to aid patients in reporting accurate data about their everyday experiences of living with their health conditions. For instance, with the app, patients can report the number of toilet visits, level of pain, and use a standard scale which is a diagnostic medical tool (the Bristol scale) to classify the form of faeces. The patient is expected to use the app and log measurements for two weeks prior to a face-to-face consultation. The information is then accessible to the nurse via a web interface as they are reported. In this way, nurses no longer have to reconstruct the patient's experiences and symptoms by asking questions during the consultation, but have direct access to the reported patient data. This reduces the risk of memory bias and the uncertainty surrounding the quality of the data, and also makes the conversation during the face to face visit more meaningful.

The open webpage and the FB page are intended to reach out with quality information to patients not enrolled at the clinic (for instance those living in other areas in Sweden), and also to health providers caring for patients with side effects of cancer treatments. On the webpage, nurses publish information about diagnosis, symptoms, problems and advice on how to address them. The webpage is also intended to be an information source for the patients at the clinic. The webpage is built on the Open Source, WordPress Content Management System (CMS). The webpage is linked to a Facebook page. This is not used for content generation, but only for its capability to spread information to new patients. Nurses and the project's cancer communication expert post links that redirect back to the webpage. Between February 2016 and October 2017 this generated 2700 returning visitors out of 9000 total visits. The secure patient discussion forum is intended for peer-support among patients and in the interaction with nurses. In the forum patients can share experiences and tips and receive responses from nurses specialized in oncology. The forum is based on Discourse which is an open source Internet forum management software. At present there are over 100 patients active in the forum.

To reach out to new patients,

	Targeted health condition	Goal	Technology	Data	Communication	Communication content	Temporality	Materiality	Interpretative complexity
Case 1	Hearth failure, diabetes, COPD.	Long term monitoring to avoid exacerbation and support patient to self-manage.	Telecare software, telecare app on tablet with a series of connected digital devices: e.g. thermometer, spirometer.	Data from measures by medical devices. Visualizations of data for both parties. Data from structured questionnaire.	Mainly text messages, occasional phone calls.	Patients' personal experience of the illness and daily concerns. Nurses' feedback and questions for data interpretation and for reflection.	Asynchronous text messages, real time daily measured data, continuous use, daily use (e.g. morning, evening)	Physical medical devices occupying space in patients home. Possible to transport, but not without frictions.	Medium to high complexity of a combination of measurments.
Case 2	Cancer related radiation induced diseases: fecal leakage, loose stools, sexual dysfunction.	Titrate medication and adjust diet, support patient to self-manage.	App on patients' personal mobile phone, web-based interface for nurses. Information portal, online peer-support community.	Data estimated by the patient. Visualizations of data for both parties. Forum posts.	Phone calls, occasional face-to-face visits. Online peer-support	Patients' personal experience of the illness and daily concerns. Questions about the meaning of data to increase mutual understanding.	Synchronous phone every second week or less, and measurements everyday for two weeks. Measuremens takes up to 20 times a day. Weekly forum posts.	Patients own mobile phone. Mostly digital environments. Highly mobile.	Medium to low complexity of data. Medium to low complexity of forum posts.

Figure 3. Similarities and differences across the two cases.

The data were analysed in various steps. First, we focused on understanding the information and communication practices of nurses and patients. We used the notes from the observation sessions to create narratives of the nurse-patient interactions. For instance we described how nurses work with the data they receive from patients, and what actions they take in response. We also relied on the interviews with the nurses and the patients to understand how they use the technologies and what they perceive the benefits and challenges are. Second, we focused on the need for personalized care: despite having similar diagnosis, each patient has a specific history, life situations, home context, personal needs. Thus, we coded our data looking for instances of personalization, and focused on singling out how nurses used digital resources to accommodate for the specific needs of each patient. For instance, in the remote care case, nurses dedicated time to write the message to each patient differently (e.g. direct questions, messages divided in short chunks of text, bold formatting of certain words). We paid specific attention to how the different digital resources were used. At this stage, comparing results across the two cases, we identified two different overall ways of combining digital resources for personalization in the context of a lightweight regime. We defined these two as logics of recombinability - generic and tailored - and we proceeded our analysis by specifying the characteristic of each logic in relation to personalization.

4 Findings: two logics of recombinability for personalization

In this section, we present the findings from our study. We describe the two logics of recombinability of digital resources in the two cases: a generic use recombinant logic and a tailored use recombinant logic. By analyzing the different logics, we build a foundation for the discussion in section 5. In both cases, digital resources were used to support patient-health provider interaction, and the need for recombinability emerged both in design and in use and for the different actors involved in the care process.

4.1 Generic recombinability

In the cancer rehabilitation case - case 2 - the need for recombinability emerged from the local practice at the clinic and the information and communication needs of nurses, as well as from the patient everyday situations. These needs are varied and heterogeneous, and require a combination of different digital tools. At the clinic, the health professionals voiced a concern for having a more efficient way to deal with the questions posed by patients, often via phone calls. Thus, nurses asked for support that could relieve them from some of the repetitive work and at the same time assist the patient in becoming better at self-care. In addition, they needed better data from patients. During phone calls or face-to-face visits, the patients struggled to remember exact information (e.g. number of toilets visit per day, stool consistency, pain intensity). As patients suffer from serious side effects, they are not always in the status to remember or to report data.

In addition to focusing on the needs of the patients enrolled at the clinic, nurses also felt the need to reach out with their know-how beyond their clinic. This was motivated by several reasons. First, since the clinic is offering a unique service in Swedish healthcare, the clinic received an increasing number of referrals from other parts of Sweden. However, considering its limited resources, they could not attend to all requests. Still, the nurses wanted to make their expert knowledge available and accessible. In addition, cancer survivor patients may have health issues that make travelling difficult, thus the nurses recognize that it was critical to create online resources for patients. Second, every week the nurses received phone calls from primary care doctors in other parts of the country who heard about the clinic and needed support. These are usually primary care doctors treating patients with radiation induced conditions, and in need of advice for how to treat them. Third, patients themselves also expressed the need to talk to other patients who had similar experiences and conditions. They wished a peer – not only a nurse - to ask questions, share personal experiences and feel heard.

To address these different needs - i.e. to reach out to patients and practitioners in need of specialised information, to enrol patients, to support patients, and to gather quality data - various components were combined. The new digital components, such as the Facebook page and a native app in both App Store and Google Play, were chosen because a majority of Swedish people are users of these platforms. When the Facebook page and app was released, 75% of Swedish internet users were on Facebook and 85% had a smartphone (Davidsson and Thoresson, 2017). Thus, these two components were considered an efficient way of reaching out to actors outside of the clinic. Many users of the information portal, forum and Facebook page are anonymous to the nurses. During the design process, the designers combined and formed a set of resources based on three common patient archetypes and in this way supported a range of different users based on a *generic logic*. Then users can choose which components to use (e.g. the facebook page or the information portal) and how to use them (e.g. reading only, or posting). Overall, this can be described as *generic use recombinability*. In this logic, the design and recombination is *episodic*. This means that recombination takes place in specific instances, when there is a need for additional resources.

4.2 Tailored Recombinability

In case 1, the company has designed a system for remote care which supports different conditions and activities. The system receives data from the measuring devices in real time, and it visualizes this data for the nurses in different ways (e.g. as graphs or lists). Patients have access to their own data via the app on the tablet. The system supports both structured (via questions and answers) and unstructured (via text messages) communication between nurses and patients. The company seeks to offer a tool for patient-nurse collaboration which can be adjusted according to the different needs of patients as these needs change and evolve. Thus, the system supports personalization in relation to which data should be recorded, the set up of the communication and how and when the nurse and patient interact.

The need for recombinability emerged both for patients and for nurses attending to the telecare service. Patients in the pilot were selected based on three main diagnoses (diabetes, COPD and heart failures). For each of these three conditions, a combination of digital tracking devices was selected and a set of questions to answer, agreed upon by the nurse and the patient. For instance, patients with COPD were given a digital scale to track body weight, a spirometer to track their pulmonary capacity, a digital blood pressure device and a digital thermometer to track body temperature. Thus, the nurse and patients as users of the service collaboratively design a setup tailored for that specific interaction. This approach is thus *user-driven*. Prior to this, the devices are selected, certified, tested by the company, and loosely coupled to the tablet and the system. The telecare system allows for receiving data from a set of different devices. In this case, digital resources are recombined in two stages, once by the designers of the system when new resources are introduced, and once when users such as the nurse and the patient recombine in order to fit the patient's particular needs.

In addition, each patient has different symptoms that they experience in a specific way. The nurses need a tool which allows them not only to provide patients with the digital tracking devices they need, but also a combination of other resources. One example of this is the use of the questionnaire for the patient. The system supports two main modalities for interaction, text messages and questionnaire. The questionnaire is a structured set of questions with specific multiple-choice answers. Patients are asked to reply to the questions on a daily basis. For instance, a patient with diabetes is usually asked questions about nutrition, type of meals, frequency, quantity etc. The answers offer additional information to the nurses and support their sensemaking practices when interpreting the data from the devices. For instance, if a value shows low blood sugar level, the nurse would triangulate this value with details about the meals of the day that the patient has provided. The questionnaire is not predefined, and nurses can *tailor* questions in a personalised way for each patient. Answers can also be personalised according to different scales (e.g. 1 to 5, or yes/no). Thus, nurses adapt and recombine the functionality of the system to facilitate the patients' reporting and sensemaking of data.

In case 1, recombinability is used to address mainly issues of personalization. Thus, shifting care towards patient-centredness in this case is an effort towards addressing the specific needs of patients. The system supports a very tailorable way for patient-nurse communication. Nurses and patients write text messages in free text, which can be modified and adapted. For instance, nurses know which patients can read long messages, and which one would prefer to have short and concise messages. Additionally, the data show that the use of the personal devices for taking measurements in combination with the messages and the questions/answers allows for *continuous* recombination, as an ongoing accomplishment between nurses and patients. This can be described as *tailored use recombinability* where the nurse and patient continuously tailor the system to the current needs of the patient.

5 Discussion

This article focuses on lightweight technologies and how they support innovation in the context of patient-centred care. Specifically, in our study we examine the recombinability of lightweight technologies. The notion of recombinability refers to how digital resources such as code, user-oriented technologies, services or products are 'building blocks' that can be combined and recombined in various ways (Henfridsson et al., 2018). Our findings show that recombinability is important in innovation in the context of patient-centred care, and that there are different strategies for use recombination. We identify two strategies of use recombinability: generic and tailored. We discuss our findings in relation to two research topics: digital technologies and lightweight IT, and digitalization of healthcare for patient-centeredness.

5.1 Lightweight IT and use recombination in digital innovation

We identify recombinability as a core quality of lightweight technology. The recombinatorial capability of lightweight technology enables strategies of flexibility and adaptability in digital infrastructures (Aanestad et al., 2017; Greenhalgh et al., 2017; Magnusson et al., 2019). These strategies rely on use recombinability. As mentioned, Henfridsson et al., (2018) distinguish between two types of recombination, which they call design recombination and use recombination. We contribute to further developing the understanding of use recombination in two ways.

First, we point attention to the role of the ‘recombinators’ - meaning those users who combine a set of pre-defined modular digital resources. These modular blocks are selected or designed and developed in close collaboration with the prospective recombinators into a recombinatorial offer. In our findings, a recombinator selects, recombines and alters a set of digital resources with the aim to create a digital infrastructure which supports specific use contexts. For instance, in case 1 the nurses act as recombinator by selecting the proper digital devices per patient, and by tailoring the questions in a personalised way for each patient in the remote care software.

Second, we specify use recombination into two strategies, generic and tailored. These two strategies differ in relation to how use recombinability is performed at the point of use. A user engages in *generic* use recombination when they select a set of generic digital resources offered by the digital infrastructure. For example in case 2 patients choose which resources to use, for instance the forum and/or the app. The app and the forum are generic components, which offer patients the same capabilities. Differently, a user engages in *tailored* use recombination when selecting a set of generic digital resources and then integrating and tailoring these resources to specific needs. Thus, tailored use recombination relies on digital resources which allow the user to combine, add, take away or update them. In case 1 this is exemplified by how the practitioners select a set of digital resources (the spirometer, the questionnaire) and together with the patient tailors the threshold values and questions towards that particular patient's specific needs.

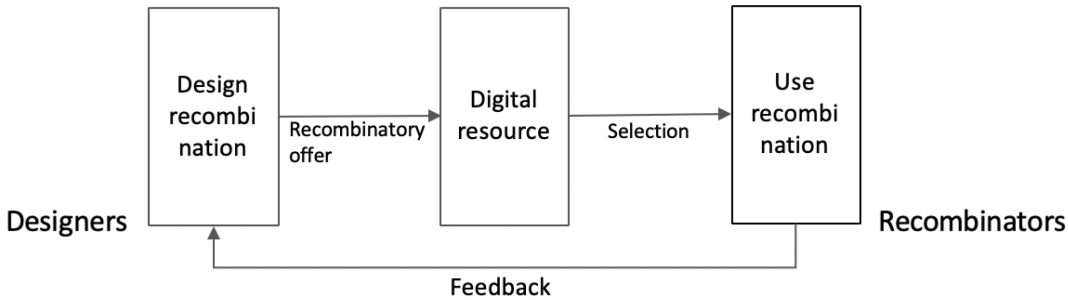

Figure 4. The lightweight recombinability process.

In the two types of recombinability, control is distributed (Yoo et al., 2010). This means that the recombinators (e.g. users) have control over which components to select and to tailor to a certain extent. The distribution of control is important in lightweight technologies. While the heavyweight regime implied a centralised form of control, mainly in the hands of IT experts (e.g. software engineers) (Bygstad 2016), lightweight technologies distribute control to users. Specifically, the recombinatorial capability of lightweight technologies as use recombinaton implies a shift of design capability from the designer of digital resources to the recombinators. Still, the design capacity is not transferred in its entirety, instead, the design capacity is shared. Thus, an iterative feedback process between designers and recombinators is needed so that the digital resources are continuously adapted and improved as the practice develops. In both case 1 and case 2, this feedback consisted of qualitative, in-person meetings at a regular interval. See Figure 4 for a basic overview of the lightweight recombinability process.

5.2 Use recombination of digital technologies for patient-centred care

The shift towards patient-centric healthcare requires flexible and adaptable digital technologies and infrastructures (Lindroth et al, 2018; Von Korff et al 2002: von Thiele Schwarz, 2016). Our findings show how flexibility and adaptability can be supported by the recombinability of digital technologies. Specifically, we show that recombination should not be regarded as an activity taking place once, but rather should be understood as a continuous process. As patients’ disease progresses their needs change and evolve and digital technologies need to be combined and recombined over time, to address these evolving needs. Additionally, it is important that patients and nurses can act as recombinators as they have up-to-date knowledge of the care situation and the changing needs of patients (Malone 2003; Oudshoorn 2009). This finding has important implications as patients and nurses need to be offered the appropriate knowledge and tools to be able to act as recombinators. From the discussion in 5.1 it follows that nurses and patients are required to act as designers of the lightweight technologies they are using.

6 Conclusion

This study has addressed the challenge of technology innovation in healthcare. As mobile apps, personal devices, web interfaces – so-called lightweight technology – become more widespread, a novel innovation logic emerges. We have focused on recombinability as one core aspect in this logic, and showed how it is a core capability for enabling innovation. Specifically, our findings show that recombinability is crucial to enable personalization of care. In addition, we contribute to IS research on lightweight IT by identifying two different logics of recombinability that enable digital innovation for patient-centered health practice. Additionally, we point to the central role of the recombinators and their continuous work of tailoring the digital resources towards the patients changing needs.

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