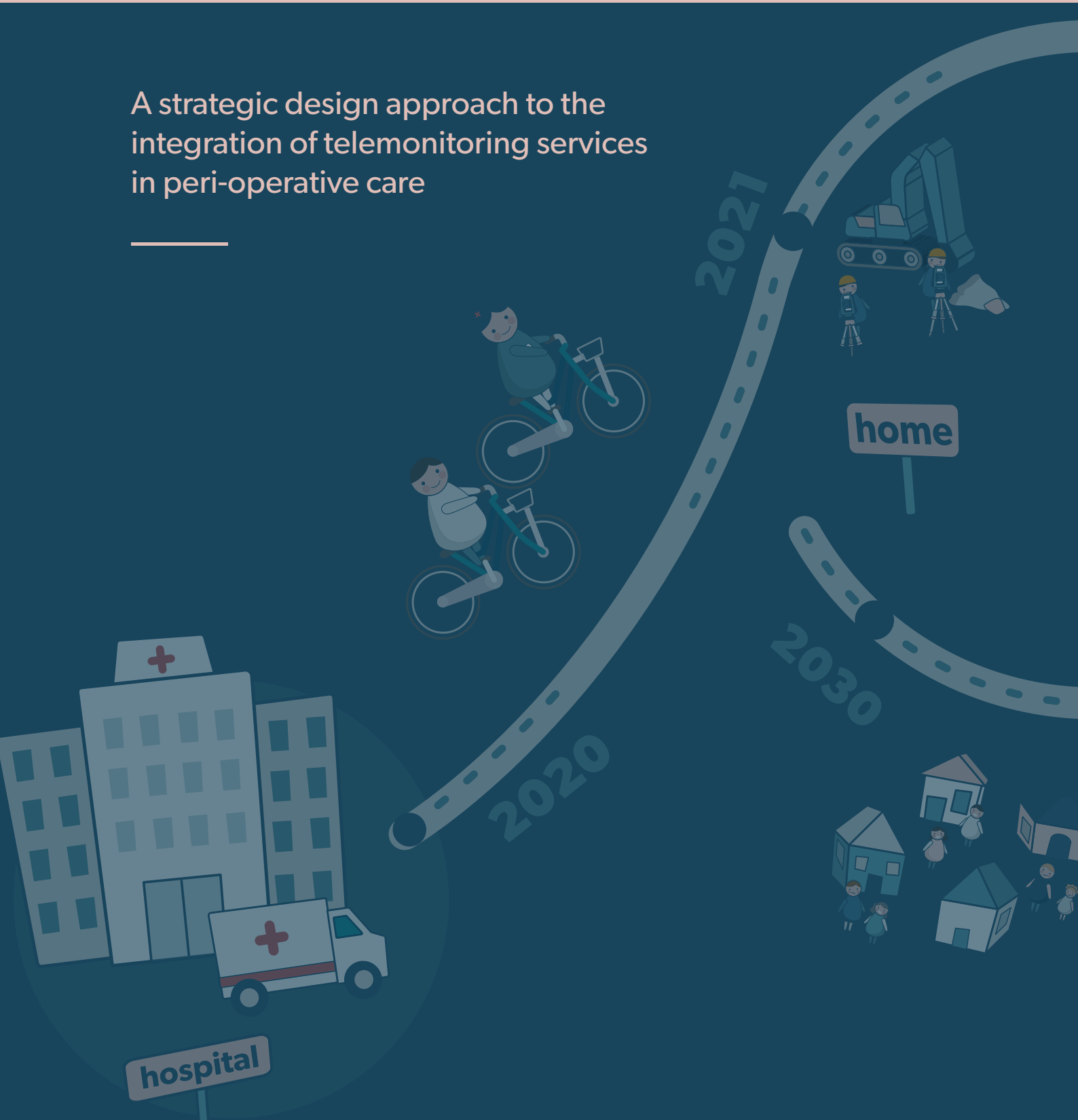
The Future of Peri-operative Care

A strategic design approach to the integration of telemonitoring services in peri-operative care



Peri-operative care of major gastrointestinal surgeries through telemonitoring

A strategic design approach to the integration of telemonitoring services in peri-operative care

Master Thesis

Author

Maria Alejandra León Aguirre

Delft University of technology
MSc. Strategic Product Design (MVE, Medisign Specialization)
Faculty of Industrial Design Engineering, TU Delft

Supervisory team

Chair: Prof. Dr. Ir. M.S. Kleinsmann (Maaike)
Mentor: Prof. Dr. H.M.J.J. Snelders (Dirk)
Company mentor: MSc. V. Pannunzio (Valeria)
External supervisor (Philips): IR. J.H.M. Raijmakers (Jeroen)

Company

Philips International B.V.

July, 2021

TU Delft PHILIPS

Acknowledgements

There are no words that can express all my gratefulness to the people who supported me during this incredible journey of my graduation.

First, to my supervisory team, thank you for believing in me and always pushing me to do better. Maaike, I cannot express more gratitude for your guidance as my chair, with your critical designer eye you always provided me with new ways of looking at things that sharpened my thinking and brought my work to a higher level. Valeria, I am grateful for your endless support as a mentor, you always knew how to overcome the "mental blocks" and kept an eye for my wellness with your outstanding inspirational talks and striking enthusiasm to get the best opportunities.

To Philips and LUMC stakeholders, thank you for sharing your knowledge, expertise, resources, and experiences, they facilitated gathering essential information to achieve the project goal.

To my friends who saw me at my worst but still chose to support me and kept believing in me, even at times when I doubted myself. Thank you for always cheering up for me and pushed me to always keep fighting. To *"my church community"*, who made unbearable weeks seemed brighter with our Sundays and who were always there for a laugh. To "*The three musketeers"* who always knew how to get me out of my mental breakdowns and for accompanying me through this emotional roller coaster. Finally, to the family I made in Delft, my "*Five guys"*, who helped me get the most out of this journey and showed me that is not blood that makes us a family but is love and support.

Finally, to my family, who believed in that little girl and her crazy dreams to reach for the stars and always gave me the help I needed.

Executive Summary

This project envisions the future of telemonitoring for peri-operative care. Through an extensive literature research and further expert and context exploration, a design strategy is created, as a starting point for the development of new services and technologies in healthcare around surgical environments. The design process, with a strong focus on analysis, guided the development of the project. This allowed the creation of a future vision that considers the findings from the literature, user and trend research and gives a direction to the current state. Within the creation of a future vision, different scenarios are detailed, to give a more detailed idea of how peri-operative care would be. In addition, some recommendations and future steps are presented, to facilitate the achievement of these future scenarios by providing the stakeholders involved with some tools to assess the viability of implementation and inclusion in planning. Finally, the project includes a call to action to develop technologies and services that enables the extension of care to the home context, the empowerment of patients to have a conscious and active role in maintaining and seeking their wellbeing, the reduction in the burdensome tasks of healthcare staff and an improvement in the nurse-patient relationship.

About the team

This project is performed for the graduation of a master student of the program Strategic Product Design from the Industrial Design Engineering faculty at the Delft University of Technology. It was supervised by Maaike Kleinsmann, professor at the Faculty of Industrial Design at TU Delft, who is part of the Design, Organization and Strategy department, focusing on methodology and organization of design. She is involved in active research in the eHealth and telemonitoring domain and is one of the founders of the Fieldlab Cardiolab. The mentor of this project was Dirk Snelders, professor at the Faculty of Industrial Design at TU Delft. Some of his areas of expertise are in eco-system collaboration in healthcare, service design and prototyping, and designing human relations within services. Valeria Pannunzio, a PhD candidate, was involved as a company mentor, given her background in design for interaction and expertise in health-related service design. Finally, Jeroen Raijmakers, who is a design Innovation manager at Philips, and would bring his expertise on healthcare Design Innovation and his insights from the company's perspective (Philips).

General Structure

This document walks the reader through the design process of a future vision for telemonitoring services around peri-operative care. Its structure is based on the stages of the design process. We start with part A, which includes an overview of the context of the project, the stakeholders involved, the initial assignment and the design method, which guided the objective and process of the project. This part also contains the literature research performed to get a better understanding of the background. Part B presents the user and expert research, with the corresponding conclusions, which provided the insights necessary to guide the design process in a later stage. It also comprehends the trend research that serves as inspiration for the design outcomes, such as the future vision. Part C is the conceptualization stage, starting with the future vision. Then this vision is detailed and some examples of situations around the concept implementation, are presented, to explain more in-depth how would telemonitoring services for peri-operative care be in the future. Afterwards, part D includes some final recommendations and reflections around the implementation of the design outcomes and overall advice regarding the implementation of technology within surgical contexts in the future. This is followed by a conclusion and reflection of the project and the design process in part E. The final part (part F) includes the references.

Index

Discover & Analyze

The first part of this master thesis presents the reasoning behind this assignment and the exploration of the context. It introduces the framework and gives an overview of the current situation around telemonitoring services for major gastrointestinal surgeries. This part also includes the stakeholders involved and their motivation for the graduation project. It presents the design approach and process followed for this project. Finally, it goes in-depth with the exploration of the context starting with literature research on the context of gastrointestinal surgeries, possible complications and its prediction and monitoring. And second, presenting a scoping review using two databases and other impactful resources regarding telemonitoring strategies in surgical contexts. The aim of this review was to know more about telemonitoring around surgeries, mainly about challenges, opportunities, strategies and learnings from already existing (or proposed) services.

1. Introduction

1.1 Major gastrointestinal surgeries

Major gastrointestinal surgeries are complex interventions that comprise the digestive systems, for example, the intestinal tract (Hall, 2019; Straatman et al. 2016). These procedures are performed for different reasons, being classified mainly into two. First for oncology-related patients for diagnosis or treatment; and second due to diverse gastrointestinal pathologies, for example, severe bowel inflammation. For clarification to the reader, the term "gastrointestinal surgeries" will be used to refer to major gastrointestinal surgeries in this document.

Every year over 20,000 gastrointestinal surgeries are performed in the Netherlands (CBS, 2014). This can be a very complex process (the patient jouney is seen in Figure 1) that comprises patients with delicate health status (Balentine et al., 2016; Hughes et al., 2015; Orcutt et al., 2012). Consequently, it requires the involvement of different healthcare specialists, such as physicians; typically, gastroenterologists (MDL-arts) and or oncologists, depending on the reasons for the intervention and the type of patient; a surgeon (maagdarmchirurgen), physicians' assistant and nurses whose roles range from endoscopy to recovery (Catharina, n.d; St. Antonius Ziekenhuis, 2021; LUMC, 2016).

In addition, this intervention starts some days before the surgery. During this time the patient and the team prepare for the procedure to ensure it is performed under the most adequate conditions. This is the peri-operative period (pre-, post-, and during surgery) and it is a critical one, as most of the clinical events take place at this stage (Balentine et al., 2016). Around 20% of the patients who undergo this surgery have complications after the procedure, which might lead to death if not treated accordingly (Straatman et al., 2014; Straatman et al., 2016). As a result, healthcare specialists dedicate a considerable amount of time for adequate monitoring of patients during this phase, to prevent risks and ensure patients' recovery. However, the effort for efficiency among hospital dynamics and the implementation of rapid-recovery have promoted faster discharge of patients, which in turn reduces the time between healthcare professionals and patients and the opportunity for detection of early complications at the hospital (Van Der Meij et al, 2018).

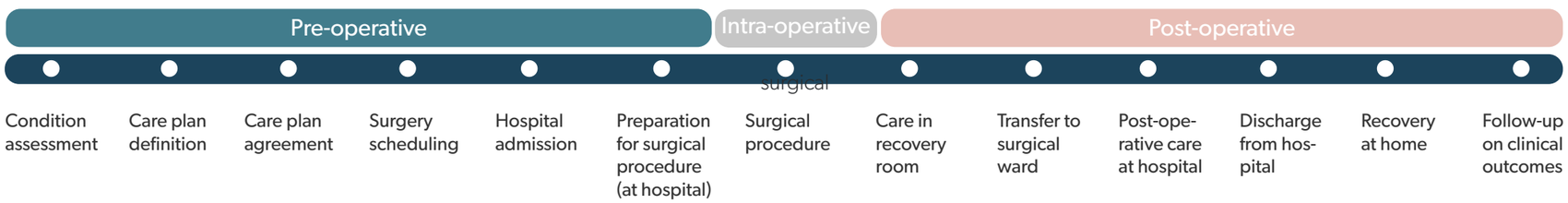


Figure 1. Patient jouney for gastrointestinal surgeries.

1.2 The Peri-operative box project

To improve peri-operative care different telemonitoring strategies have been proposed, which allow tracking patients' health conditions even when they are not in the healthcare facilities. This ensures that the patent's physiological variables can be obtained prior to the surgery to assess if they are in the optimal values and use them as a basis for overseeing patients in the post-operative period. Moreover, patients can be discharged earlier as their monitoring service can be extended to their homes. These services have been proven to provide positive outcomes not only for patients (Baniasadi et al., 2020; Mehta, 2020; Shah et al., 2021), but also for healthcare institutions, given an improvement in resource allocation (Viers et al., 2017; Forbes, 2018).

These strategies are supported by the current growth in the eHealth field. With the creation of the National eHealth Living Lab (NeLL) a collaborative community was established, where researchers interested in these topics can have further conversations and support technological developments. This institute has boosted different projects by providing means where experts can interact to design scientifically based eHealth applications and study the possibility of upscaling these innovations in the Netherlands and international environments.

The peri-operative box project appears around this context. This is a service in which a box, with self-monitoring devices, is provided to the patients so that they can track their physiological variables before and after the surgery. The data is collected and analyzed so that timely responses and actions can be performed to avoid complications and improve patient's recovery. In this case, different actors are also involved, as now, care for the patient does not stop when they are discharged, but the specialists check the data and in case of an emergency or signs of secondary effects from the surgery the patient would be called back to the hospital.

This project is part of a broader concept already implemented in the Leiden University Medical Center (LUMC). “The box project” started as an opportunity for extended care of patients with heart-related problems (Hart Long Centrum Leiden, 2019) This way, the patients could be monitored outside the clinical setting, and more informed decisions could be taken regarding the treatment. This project was then translated to a very diverse set of clinical settings. For example, the “Kidney Transplant box”, the “Pregnancy box” for patients diagnosed with high blood pressure; the “ImmunoBox” for cancer patients who receive immunotherapy infusion; the “DiabetesBox”; recently the “CovidBox”; among others. Each of these services seek to provide telemonitoring for patients, but they need to be individually evaluated, as they are under different contexts.

Even though this service brings many benefits for all the stakeholders involved, there are still some considerations that make certain healthcare givers unwilling to adopt it. This is mainly due to the changes that this technology brings to their current work logistics (Das et al., 2015; Harsha et al., 2019; Sanger et al., 2016), the increment on their current workload, due to the lack of planning or the underestimation of tasks and their time (Das et al., 2015; Makhni et al., 2020; Parkes et al., 2019); the lack of technological knowledge or skills necessary for their implementation (Brophy, 2017; Das et al., 2015; Davoody & Hägglund, 2016; Parkes et al., 2019; Sousa et al., 2016; Timmerman et al., 2017), the uncertainties related to the reimbursement policies (Brophy, 2017; Ke et al., 2019; Semple et al., 2019), among others.

1.3 The stakeholders involved

This project involves three main stakeholders: the healthcare institution where the telemonitoring service is offered (LUMC), the provider of the medical devices that will support telemonitoring (Philips), and the facilitator between them (TU Delft University).

First, the Leiden University Medical Center (LUMC), where the surgical procedures are performed. This institution is where patients from different pathologies are diagnosed and treated. Moreover, it is committed to research and seeks to be a pioneer in developing solutions to health issues. Their aim is to improve the use of their resources and the conditions for their healthcare staff by evaluating the current work dynamics. Given their interest in research and innovation, they are partners of the National eHealth Living Lab (NeLL), a collaborative community around e-health developments, that brings together users, public organizations, private institutions and experts in these topics and offer a space for co-creation and discussion about new healthcare applications.

Leiden University Medical Center

Second, the company Philips, which provides monitoring devices for the patients. This company is a leader in health technology, who seeks to improve people’s health and well-being through meaningful innovation. The organization has developed the Healthdot, a wearable sensor that enables clinicians to look after and monitor patients during peri-operative period at home. Their main interest in the project is to find a suitable business case for the Healthdot, that benefits them and their clients.

PHILIPS

Finally, TU Delft university is part of the project as it is an initiative and on-going research from the CardioLab from the faculty of industrial design. This is one of the existing design labs which seeks to explore how technology can support the treatment, diagnosis, and daily life of patients with cardiovascular diseases. Moreover, the researcher is affiliated to this institution and will provide a service that allows the connection and collaboration between the previous two actors. The main goal of this actor is to establish and build a relationship with the other stakeholder involved, for future collaboration.

TU Delft

2. The Assignment

2.1 Initial brief

Nowadays online services and at home care have been increasing given the developments in technology and the recent pandemic that has created the need for remote services and reduced “in-person” interaction among people. With these come the use of telemonitoring services, where patients can be monitored without the need of a physically present healthcare specialist. These changes can bring improvements in the lives of people given the extension and tailoring of care they offer. However, they bring disruptions to current paradigms and behaviors of people and organizations and raise questions about ongoing dynamics in roles, activities, privacy and even safety.

The impact of telemonitoring tools on patients has been long studied as healthcare developments need to prove their safety, outcomes and bring benefits to them to be approved. Nevertheless, these studies don’t normally consider specialists or the organizational changes or implementation plans around these strategies. This results in failed implementations, where the staff do not benefit from them, but may even be burdensome and thus stop using them. As a result, there is a need for studying these services from the perspectives of healthcare specialists so that they not only bring benefits to the patient and clinical outcomes, but also presents an opportunity to the healthcare specialists.

The aim of this project is to present a strategy for the implementation of a new service for patient telemonitoring around surgical contexts. This strategy consists in the definition of a future

vision on telemonitoring systems in peri-operative care and the way it impacts the different actors involved, focusing on the healthcare staff perspective, especially the nurse.

This exploration will hopefully bring new opportunities and strategies that can help understand and improve the telemonitoring services on their first steps as common and viable solutions for the extension of personalized care, starting by their application in major gastrointestinal surgeries and the support of healthcare companies like Philips and providers as the LUMC. The full project brief can be found in Appendix I.

2.2 Design approach

The methodology for this project is based on the Basic design cycle (Van Boeijen et al., 2014) and the double diamond (Design Council, 2015). It consists of 5 main stages: Discover & Analyze, Define & Synthesize, Develop & validate and Feasibility & viability (Figure 2).

Discover & Analyze
This stage focused on the user and context research. The starting point for this project was the analysis of the results from a literature review regarding impact on healthcare staff of telemonitoring strategies for surgical procedures. This guided the interests of the author into possible opportunities for improving these services and some questions were obtained to be solved employing user research. In this case, interviews with experts on the topics were considered the most suitable mean of understanding the challenges. In addition, a sensitizing booklet was used to empathize and understand the context from the healthcare staff's perspective. This is part A of this document.

Define & Synthesize
After gathering information on the context for peri-operative care in telemonitoring services and monitoring it was time to analyze and propose a goal to the project. Insights were synthetized and prioritized by means of a context mapping analysis, using the "analysis on the wall" strategy (Sanders et al., 2012). In addition, a trend analysis was performed to get a full overview of the current context, its tendencies and developments. The results from these two activities were used as the basis for the problem statement, the creation of the future vision and the desired outcome. This stage is presented as part B.

Develop & validate
With the problem brief, it was time to ideate on how to approach it. Part D explains in detail this conceptualization phase. Ideation sessions, led by brainstorming, supported this stage by pro viding possible solutions that help improve the current challenges of telemonitoring services, keeping the focus mainly on dynamics around healthcare staff. To visualize the proposal, a future vision was created. This was detailed with the use of scenarios, that would help explain the design outcome. Different iterations were done to ensure that the result could contain the complexity of the context without compromising its understanding and have a balance between the overall picture of telemonitoring and the details around specific implementation aspects.

Feasibility & viability
The last stage aimed to present some recommendations to successfully implement telemonitoring services around surgical contexts that might concern the stakeholders or researchers interested in this field. This is also accompanied by some reflection on the design outcome, regarding its feasibility and viability for implementation. This is presented as part E within this document.

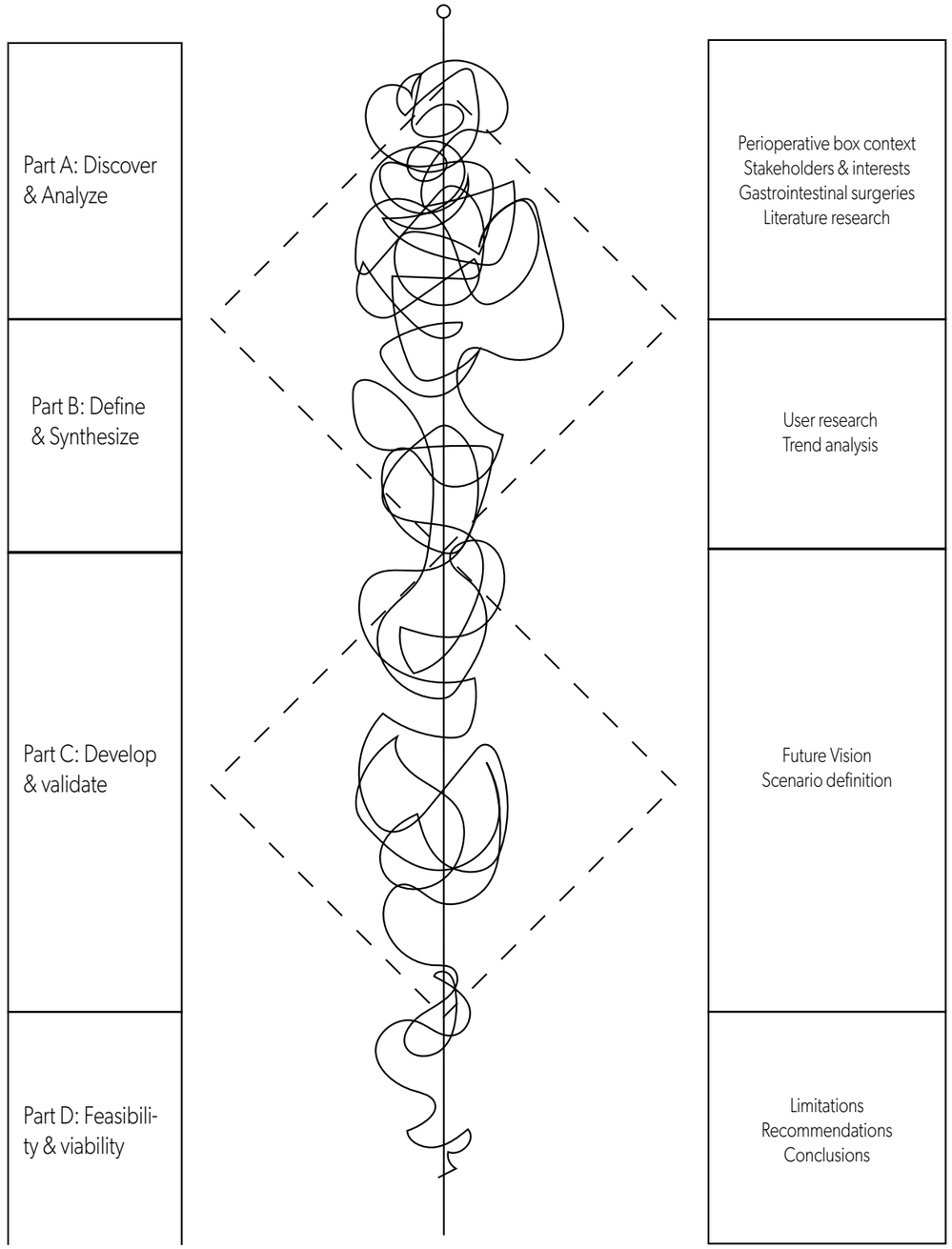


Figure 2. Design approach for the project.

3. Literature research

3.1 Complications around gastrointestinal surgeries

Surgical procedures can have side effects or complications as they involve changes in the current state of the body. Regarding gastrointestinal surgeries, there are minor and major complications. Major complications can involve different systems, for example, the respiratory (pneumonia, reintubation, or dependency on ventilator), cardiovascular (cardiac arrest requiring CPR, myocardial infarction, venous thromboembolic event, stroke) or urinary (renal failure) (Kelly et al., 2014). Also, deep wound infections, sepsis or septic shock, intraabdominal abscess, anastomotic leakage, or other events that involve stay in Intensive Care Unit for more than 15 days (Sørensen et al., 2007). For minor complications, there is urinary tract infection, postoperative hypotension, superficial wound infection, among others. These last ones can transform into major complications if the appropriate care is not given (Sørensen et al., 2007).

Currently, up to 30% of the patients that are discharged need readmission due to complications (Hicks et al., 2015; LUMC, 2021; Martin et al., 2011). The most common adverse events are related to infection, such as pulmonary infection (pneumonia), septic shock, wound infection, anastomotic leakage among others (Jakobson et al., 2014). For example, according to Al-Mazrou et al., 2020 surgical site infections (SSIs) is one of the most common complications and reasons for readmissions, after major gastrointestinal surgeries. This can represent a clinical and economic burden due to an increased length of hospital stay and additional costs (Daneman et al., 2010).

As a result, there is a need for reducing the appearance of complications that lead to hospital readmission and increase in the length of stay of patients and thus, in the use of physical and human resources. Constant monitoring of patients allows to keep a closer look at the patient's recovery and provide prompt action and feedback to avoid further decline in the health condition. However, once patients are discharged from the hospital, healthcare staff loses contact, and they cannot keep track of the state.

Telemonitoring appears as a possible answer to continuous monitoring by providing continuous care outside healthcare institutions, however, the dynamics around it still need to be explored and defined.

3.2 Measurements for patient monitoring

To understand telemonitoring, more in-depth information was analyzed regarding the type of information and data that is normally used for monitoring patients. According to the literature, the main source for surveillance are vital signs, which include, blood pressure, respiratory rate, temperature, among others (Figure 3) (Elliott & Coventry, 2012). More physiological variables can be measured depending on the condition of the patient and its context (the type of intervention or treatment, the disease or comorbidities, among others) (Shah & Hamilton, 2013). In general, the most common variables measured for monitoring patients after surgical procedures are:

1. Heart rate:
Refers to the heart rhythm (given by its contraction and relaxation) and provides information on its performance. It can be measured on any surface where an artery is present by the palpable rhythmic expansion on the skin.

2. Blood pressure:
Determines the pressure exerted by the blood against the arterial wall and informs on the blood flow and thus on cardiovascular activity. This is normally measured by special devices that apply pressure to the skin.

3. Respiratory rate:
Informs about the number of breaths on a determined period of time. This serves for assessing malfunctioning in the respiratory system. It can be measured by different methods, for example, by the movement of the chest or directly from the heart rate.

4. Oxygen saturation:
This variable shows the quantity of oxygen in the blood, which is normally obtained by a pulse oximeter or light sensors. It indicates possible impairments of circulatory or respiratory functions.

5. Temperature:
There are different types of temperature (the patient's core body temperature, the surface body temperature and how the patient feels) (Elliott & Coventry, 2012). All of them gives information of the patient's state, as during infection or triggers to the immunology system can produce temperature changes. It is normally measured by a thermometer.

These variables are analyzed to determine the condition of the patient and prevent possible complications or certain clinical outcomes. Some studies indicate that almost 70% of the patients present respiratory deterioration eight hours prior to a cardiac arrest (Schein et al., 1990) and more than 50% show abnormalities on their vital signs within six hours (Franklin & Mathew, 1994).

There are different risk predictions models that help assess the measurements collected (Shah & Hamilton, 2013). For example, the EuroSCORE risk scoring system and the American Society of Anesthetists (ASA) classification both of which focus on assessing the patient's conditions before surgery, to foresee the level of risk and take the pertaining precautions and have a care plan accordingly. This report presents two strategies the Enhanced Recovery After Surgery (ERAS) and the Early warning Score (EWS) given its importance on the healthcare context.

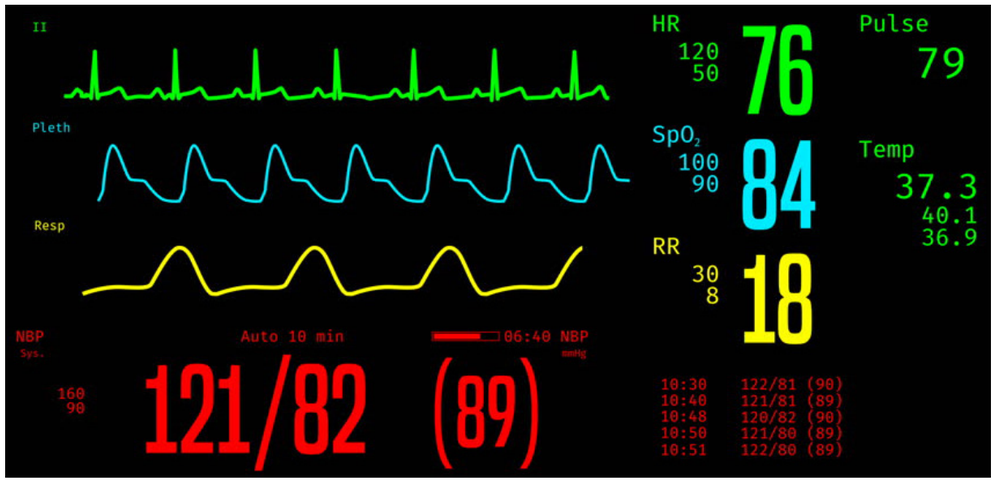


Figure 3. Example of a device's interface used for monitoring patients.

3.2.1 Enhanced Recovery After Surgery (ERAS)

ERAS is a patient-centered pathway that comprises the peri-operative period. It considers different factors from the moment the surgery is decided for the patient until the patient is discharge from the hospital and a new therapy or follow-up is done (Figure 4). For the preoperative stage, it establishes different criteria that help assess if a patient is ready for surgery and what could be some complications and the level of risk, based on existing comorbidities, the type of surgery and the physical condition and values of physiological variables of the patient. During the postoperative phase, it also helps to keep track of the patient state to prevent possible complications and improve care. This is a method that does not only considers the values of physiological variables, but also other factors for better planning of the care pathway, that result in the reduction of possible adverse events during and after surgery (Visioni et al., 2018).

3.2.2 Early Warning Score (EWS)

EWS is an evaluation of a patient's condition, that indicates possible clinical decline and the need for intervention. This should accurately capture the vital signs information, which comprises multiple organ systems in a timely manner, to have an overview of the patient state and be able to act promptly if needed (Kramer et al., 2019). This is part of a rapid response system (RRS) that seeks the early recognition of at-risk patients and prompt response of clinicians. Over time, there have been modifications to this method, as a response to false alarms and false negatives (fails to indicate the presence of a condition). Most of them are based on the same variables (heart rate, blood pressure, respiratory rate, oxygen saturation and temperature) (Table 1).

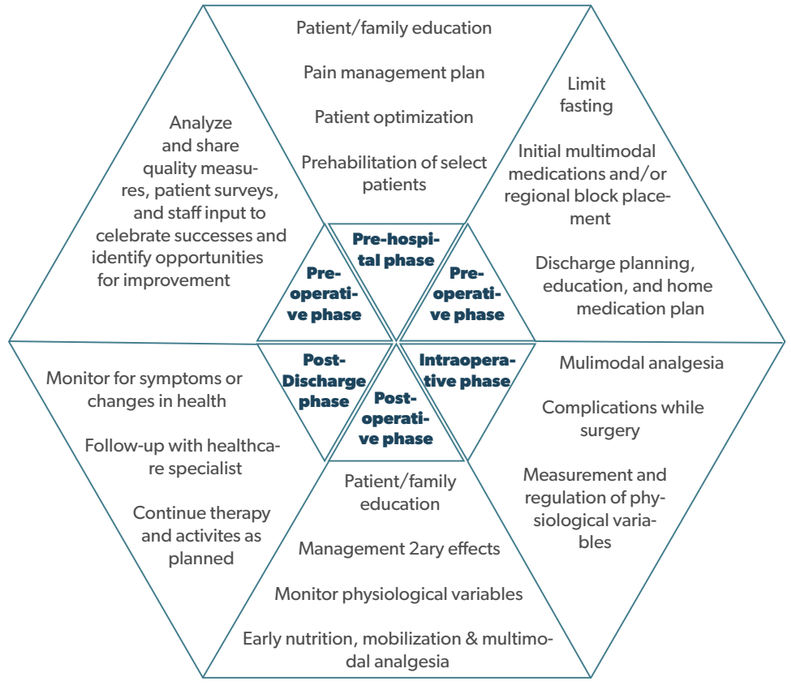


Figure 4. ERAS guidelines.

Table 1. EWS protocol values (Doyle, 2018; NEWS, 2012).

Physiological parameters	3	2	1	0	1	2	3
Respiration rate (breaths/min)	⩽ 8		9 - 11	12 - 20		21 - 24	⩾ 25
Oxygen saturation (%)	⩽ 91	92 - 93	94 - 95	⩾ 96		⩾ 96	
Suplemental oxygen		Yes		No			
Temperature (°C)	⩽ 35.0		35.1 - 36.0	36.1 - 38.0	38.1 - 39.0	⩾ 39.1	
Systolic BP (mmHG)	⩽ 90	91 - 100	101 - 110	111 - 219			⩾ 220
Heart Rate (beats/min)	⩽ 40		41 - 50	51 - 90	91 - 110	111 - 130	⩾ 131
Level of consciousness				Alert			CV/PU

With the continuous advances in technology and machine learning new algorithms have been developed that incorporate multiple risk scores (as the ones presented in a previous section) for more accurate monitoring (Heller et al, 2020; Ghosh et al., 2018). Moreover, customization is now available where, based on the patient's own condition, new parameters can be set as thresholds to increase precision and prediction.

There is still room for improvement on these tools by incorporating already existing data from patient's electronic records or qualitative information reported by the patient, including pain measurement, level of activity, among others.

3.3 Risk factors in gastrointestinal patients

For gastrointestinal surgeries, there are already some factors that help assess the state of each patient and prepare the care plan accordingly to possible risks that the healthcare staff should "keep an eye on". The preoperative state is very important, as poor conditions (abnormal respiratory or heart rates) can precede postoperative complications due to their effect on immunity response or wound healing processes. Before the surgical procedure patients undergo an examination to find comorbidities or aspects that have an impact on post-discharge infection. For gastrointestinal surgeries common aspects are:

1. Alcoholism
2. Diabetes
3. Obesity
4. Age

High values of these factors might represent high-risk patients. Moreover, the characteristics of the disease and of the procedure also influence the results. For example, longer and more complex procedures have higher possibilities of blood loss, re-operations or other complications. On the other hand, shorter procedures can result in shorter lengths of stay and consequently, there is less time available for symptoms of complications manifest prior to leaving the hospital (Daneman et al., 2010).

After the surgery, there are other elements that should be considered. For example, the place of residency might influence as the access to care might be scarce in rural settings, which can compromise the treatment. In addition, regarding the vital signs previously mentioned, there are certain values that are considered "standard" and act as thresholds for assessing the patient' state (Table 2).

These last values are often a topic of discussion as they vary depending on the person and even on the procedures. For example, some patients might experience a postoperative hypermetabolic state, that might lead to a tachycardic condition (Hamilton et al., 2003). This increases the difficulty in keeping track of patients as not all the values outside the established parameters represent an actual emergency. Moreover, signs can be on the established values, but patients might be already presenting some complications, for example, the lack of fever in patients with a gastrointestinal leak (Hamilton et al., 2003).

This presents an opportunity for improving the parameter and variables for prompt detection and prediction of adverse effects.

Table 2. Usual vital signs values for patients after gastrointestinal surgeries (Kelly et al., 2014).

Risk Factors	Lower threshold	Upper threshold
Systolic BP (mmHG)	< 110	>130
Heart Rate (beats/min)	<50	>90
Respiratory Rate (breaths/min)		> 20
Temperature (°C)	< 350	> 38.0
Electrocardiogram	Not sinus rythm	
White blood cell count	< 4000	> 12000
Hemoglobin (mmol/l)	< 6.8	> 10.2

3.4 About telemonitoring challenges

To understand more about the context, a scoping review was performed regarding the impact of telemonitoring strategies for surgical procedures on healthcare staff's workflow. This review was done using two databases (PubMed and EMBASE) and three concepts were defined for the search. These concepts were: Telemedicine, Workflow and Surgery. Medical terms that were considered as synonyms or related to the concepts or commonly used within these categories were included as keywords. Articles were selected based on two inclusion criteria. First, if they presented telemonitoring strategies for surgical contexts and second if they included the healthcare staff perspective or mention measures of impact on their workflow. Additional to this search, some external sources were used, if they included relevant authors and research regarding the context of this project (telemonitoring,peri-operative care, healthcare staff's workflow) or if they presented examples or trials around telemonitoring implementations and designs.

The findings from the research were clustered into existing challenges that telemonitoring presents to healthcare staff and strategies that have been or are being used in existing services or that have been proposed as a solution to the problems that arose during the development and implementation of these tools. The conclusions on the main telemonitoring challenges and strategies were developed by means of a mind map. Overall, 7 main categories were identified for challenges (Figure 5), however, not all of them had a corresponding strategy. This presented some unsolved problems to further explore. For example, most of the issues regarding time invested on tasks or the workload they might bring to staff have not been addressed and should be considered during the design of telemonitoring tools.

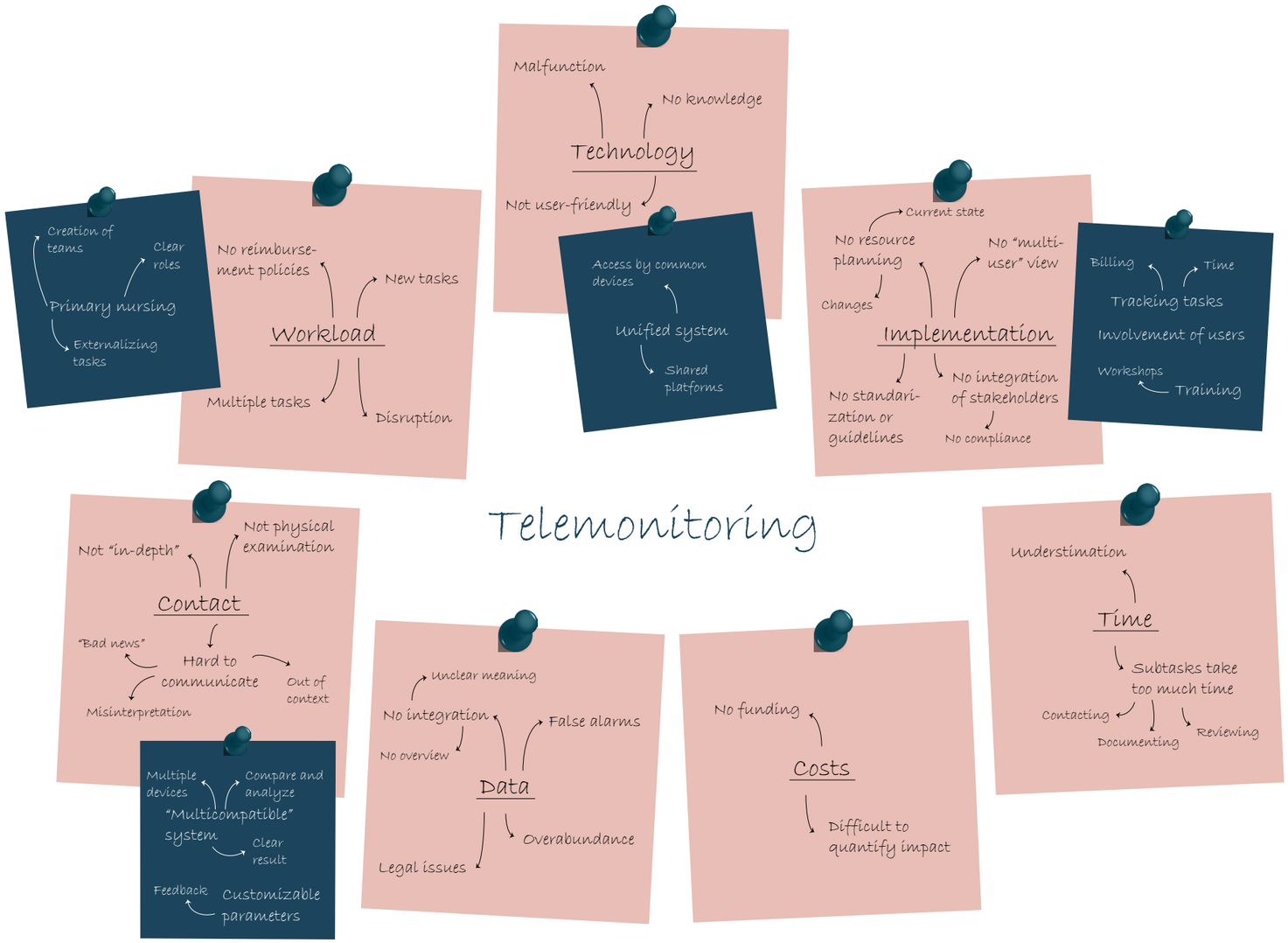


Figure 5 . Overview of the main telemonitoring challenges and strategies.

Having the main issues in mind, a more in-depth analysis was performed with a similar strategy as the one used in laddering for contextmapping (Sanders & Stappers, 2012). By constantly asking the questions "why" and "how", relations among the challenges were established (the complete analysis can be found in Appendix 2) This gave an initial overview of the framework for the projectand pointed out some key problems that could be further explored later in the user research.

Challenges

Strategies

For example, the activities and processes that brought the most burden and convenience for staff were:

1 Response to alerts

This sometimes requires learning new habits, or other stakeholders that might result in a disruption of their current workflow, delays on other tasks and spending more time than planned on these activities. These responses need to be supported by the expertise of the person in charge and need to be clearly communicated to the patients and among healthcare staff (Nijland et al., 2008). Figure 6 presents an overview of this first challenge.

2 Data analysis

Data gathered by telemonitoring might not be integrated with current systems, which results in burdensome documentation. The involvement of various actors, contributes to underestimating the time spent on tasks due to delays. Telemonitoring tools might offer only a glimpse of the patient's healthcare state, however given the high amount of data, and its lacks of integration, healthcare especialists can't always perform exhaustively or in detailed analysis (Nijland et al., 2008), and when they do, these might require more time. This situation is presented in Figure 7.

3 Alarm notification

This can be seen in Figure 8 and it is one of the main issues from telemonitoring as it leads to alarm fatigue (Sanz-Segura et al., 2019). Specialists are alerted of the state of patients while they are performing other activities, disrupting their workflow. The level of disruption depends on factors as its prioritization (the urgency of the alarm), or the clarification of the alarm (how clear is the clinical event and the actions required).

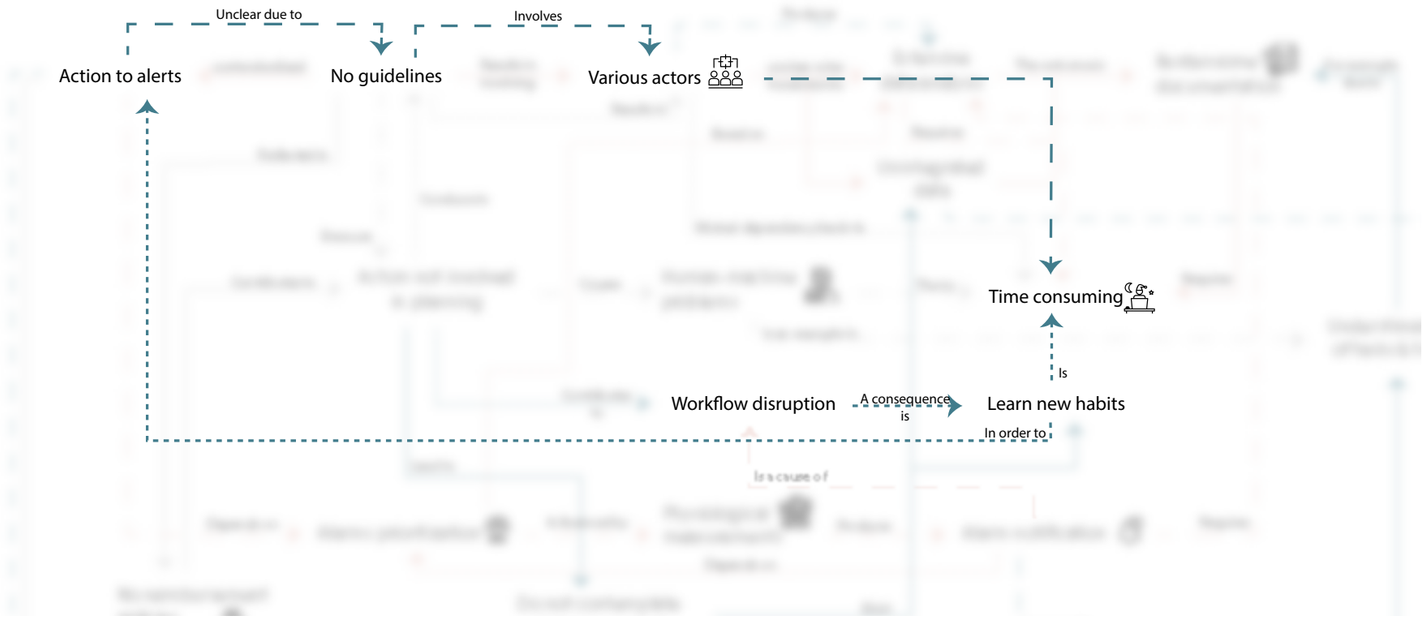


Figure 6. Outline of the challenges around the response to alerts.

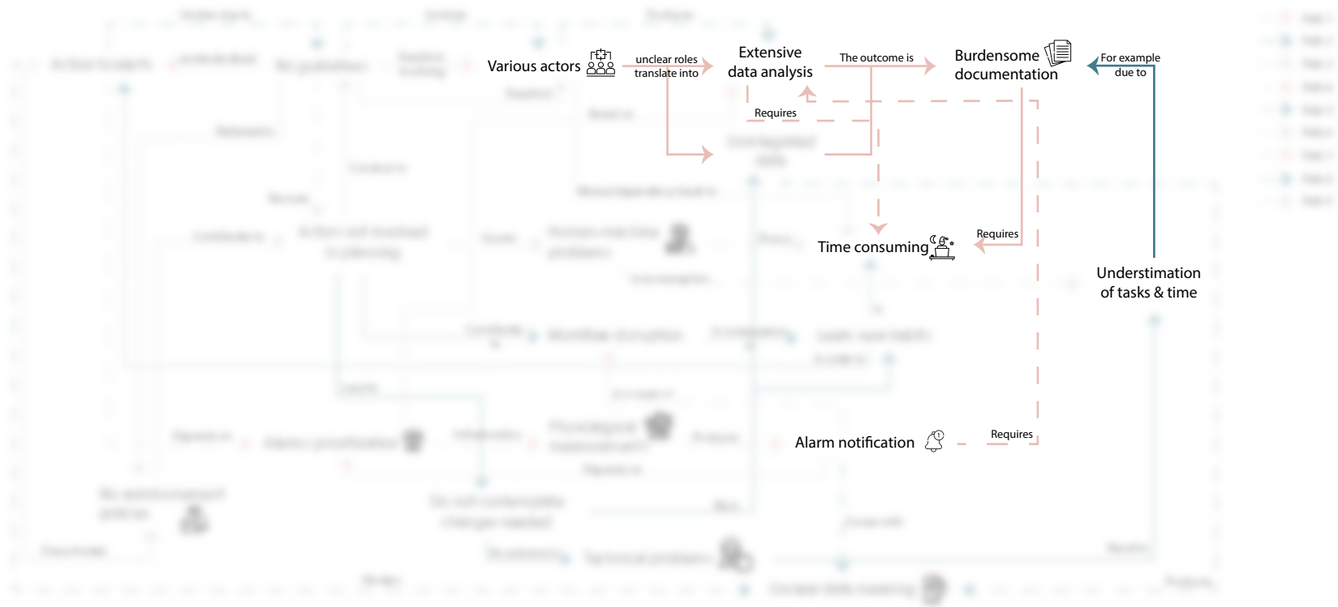


Figure 7. Main problems regarding data analysis in telemonitoring services.

This analysis also presented two overarching issues that have a considerable impact on these previous problems.

1 Lack of inclusion of some stakeholders during planning

Planning can be a task performed only by the managers at hospitals or external companies developing services or devices to implement in clinical settings. Without the input of nurses and other specialists, crucial points can be omitted. For example, current telemonitoring tools do not always consider existing platforms or software at hospitals and they introduce new ones. Consequently, specialists need to manually incorporate and analyze data from different sources, which might lead to omitting data or confusion and requires time for extra documentation.

Another example is the omission of on-going collaboration and dynamics among staff. These telemonitoring systems might propose interaction of actors who do not have communication channels among them, increasing the time expend on tasks.

2 Lack of guidelines

This is closely related to the previous point, as not involving stakeholders makes it difficult to define standard procedures. Not having protocols or clarity on them prevents some stakeholders from acting, which increases their lack of motivation in being part of this process and adopting the new measurements, which contributes to the first point mentioned, providing a “negative feedback” closing the loop (Figure 9). As sometimes there are no clear procedures, reimbur-

Figure 8. Issues around alarm notifications and its relation to other telemonitoring challenges.

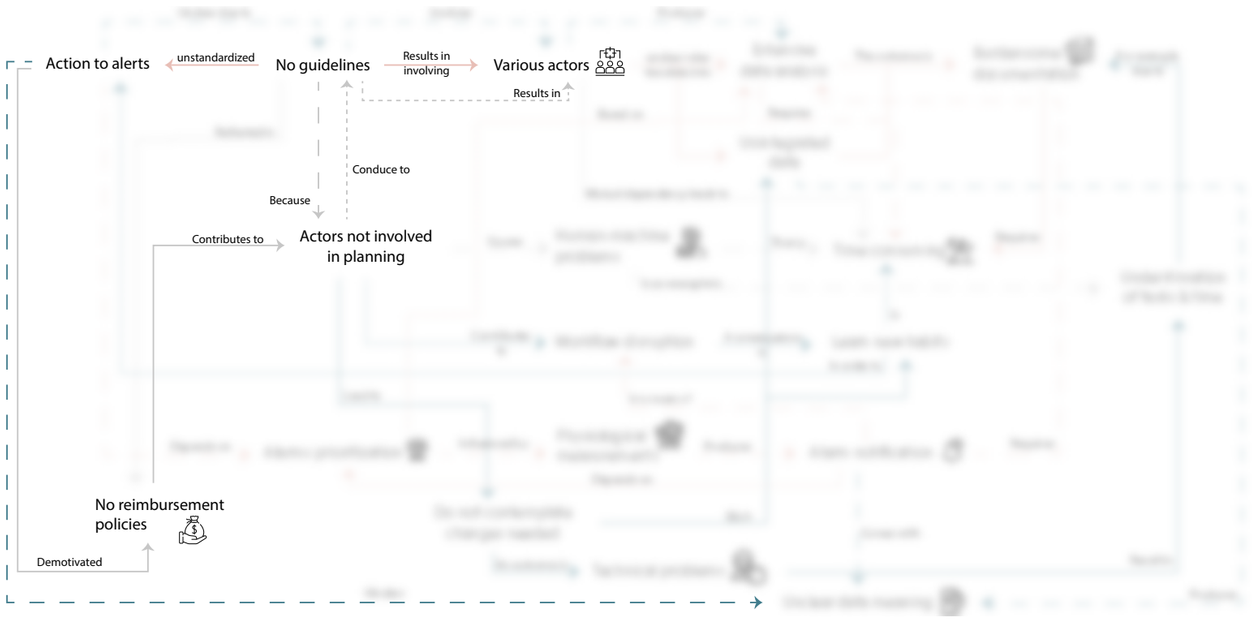


Figure 9. The lack of guidelines and involvement of stakeholders are interrelated.

sement policies can't be defined, which makes implementation of telemonitoring a challenge. Moreover, the roles for staff are not clarified, and two actors can be performing the same tasks, without being aware of it. This can lead to confusion on treatments and the state of patients. This is also seen in activities, as specialists don't necessarily are aware of the adequate procedures to follow when a certain task arise, as responding to an alarm.

3.5 About alarms

The analysis showed how logistics around alarms have a considerable impact on staff's workflow during telemonitoring services. With this in mind, specific focus was reserved on alarms to understand the causes and effects around these challenges. In healthcare, alerts are used to keep track of the patient's condition and the status of the equipment used for the measurements (includes malfunction, changes needed, among others). According to Imhoff et al. (2009) there are five main types of alerts, which respond to a predefined hierarchy, given by the clinical events:

1. ***Detection of life-threatening situations:*** represent patients' conditions that can lead to severe patient harm or death. For example, asystole or apnea.

2. ***Detection of life-threatening device malfunction:*** detect devices' malfunctions or conditions that can lead to severe patient harm or death. Some can be when sensors or devices disconnect from the patient or from power supply.

3. ***Detection of imminent danger:*** related to patient's conditions, which gradual change might be indicative of imminent danger. Here we find sudden and abrupt increments in blood pressure.

4. ***Detection of imminent device malfunction:*** these alarms are device-related problems that could result in malfunction We can find low-battery or misposition of sensors.

5. ***Diagnostic alarms:*** characterized by alarms that directly indicate a pathophysiological condition and not an "out-of-range" variable. Here we find when there is a septic shock.

One of the main issues regarding alarms is the large amount, which produces negative impacts on staff and might lead to desensitization (Kristensen et al., 2016). As mentioned before, large quantities of alarms can hinder healthcare staff's work as it increases stress levels due to the constant sound (Harsha et al., 2019; Richards et al.,2020). This can end in alarm fatigue. Consequently, some nurses do not always support or are willing to accept new devices or telemonitoring strategies as they can bring inconvenient changes to their routine. Some of these are disruptions in their current tasks with one patient due to an emergent alarm on another patient (Das et al., 2015; Downey et al., 2018; Harsha et al., 2019; Sanger et al., 2016). Also, the response to these alerts might add more tasks for the staff to analyze the patient's information and decide on how to improve their condition, which can be time-consuming (Das et al., 2015; Leppla et al., 2020; Sharif et al., 2020).

In addition, not all alerts represent real emergencies in patients. They might have been triggered by external factors or are not associated with a major change in clinical outcome, but with certain comorbidities of patients. Moreover, they are pressured by patients and their companions for timely responses to these alarms, which also increases their stress and can worsen their condition (AAMI, 2011; Özcan et al., 2019). These contribute to nurses being more reluctant to implementing these tools and even end up turning the sound off or not using the devices at all (Harsha et al., 2019).

In general, false alarms are one of the most common alerts and they can represent more than 50% of them (Konkani et al., 2012; Imhoff et al., 2009). These can be caused by either inappropriate clinical values or relevance, or problems on the device or algorithm. According to Imhoff et al. (2009), we can identify:

1. ***Technically false alarms:*** a specific variable is within the accepted values, but the device identifies as it is not. For example, detecting hypothermia because of a wet sensor but the patient's values are in the standard range.

2. ***Clinically false alarms:*** presented if a certain variable is beyond the thresholds but has no clinical relevance for the patient. In a patient that suffers from arrythmias the device can alarm with an increased heart rate, but this has no clinical implication.

3. ***False alarms through interventions:*** which are caused by medical or nursing interventions. During or after respiratory therapies, is normal to have an increase in respiratory rate, detected by the alarm.

These false alarms respond to the variability seen in risk score assessments (section 3.2.1 and 3.2.2). Establishing more accurate parameters that respond to the needs and conditions of each patient will help with more precise forecasting of risks, reducing false positives and avoiding false negatives.

But not only healthcare staff is overburden by these false alarms, as mentioned before, there are not always guidelines regarding the actions to respond to these alerts, which add workload to know the correct steps to effectively respond to an alarm. Also, it is not always evident whether the notification requires immediate attention or if the staff can first attend other tasks. For some situations like alarms that represent life-threatening situations, for example, a cardiac arrest, the procedures are very clear among staff and they know this require immediate actions. On the other hand, the detection of imminent danger or other conditions, that are not "life or death", might not be very clear, as they might involve different expertise and knowledge to address them. These kinds of alarms are the ones that the staff tend to omit due to the high incidence of false positives. With this in mind, it was decided to narrow the scope of this project to a specific set of alarms, those that do not re- present a "life-or-death" situation for the patient and that can wait for action.

This information is synthesized in a mindmap to have an overview of the main challenges regarding alarms in healthcare environments (Figure 10). This included the lack of integration with current devices and software in the healthcare institutions, which lead to large amounts of data being processed by staff. This data can be presented at different moments, for example when the patient is only starting to have values outside the standard ones, but with no clinical meaning, or when the patient is in a critical condition.

Moreover, it can come in different modalities (raw data, filtered information, average value of variables, or data processed to a certain degree) that might produce extensive and time-consuming analysis. All this data conduces to different actions to correct the alerted event, which can need large amounts of time and work and affect more than one actor and task. Finally, there are gaps between the reasons why an alarm system is implemented and how it responds to healthcare staff's needs, as the hospital seeks for the early diagnosis of complications, while this might bring increments in the workload and alarm fatigue of nurses. In the end, these systems do not satisfy the staff's expectations and result in more inconveniences.

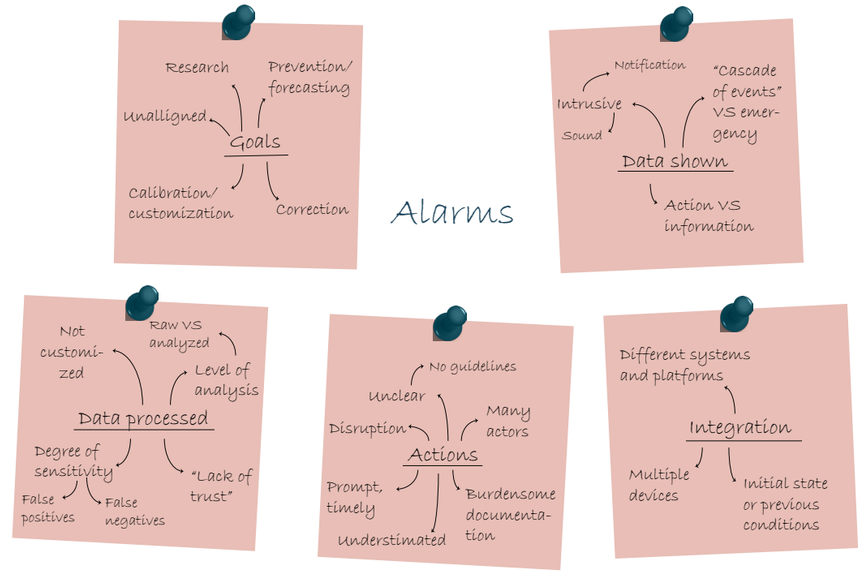


Figure 10. Overview of the alarm context.

3.6 Overall challenges

The data gathered was analyzed to determine the main issues and the "roots" of the barriers for incorporating telemonitoring strategies.

This would present possible directions on the projects. In general, there are four main pillars regarding the challenges that we can highlight.

1 Data

Figure 11 presents an overview of the main issues that telemonitoring brings regarding data. Telemonitoring systems need a broad variety of information to have an accurate overview of the patient's status. To make more informed decisions, more data is needed. This data can come from multiple sources like medical devices, electronic health records, among others. In general, it produces overabundance of data that sometimes represents "fragments" of the situation and not the "whole picture". This is also produced by a lack of compatibility among these resources. In the end, it can bring a high workload for healthcare specialists due to the extensive analysis and documentation it requires to understand the condition of the patient and forecast possible events. For example, the systems can present a value of a certain variable, like Heart rate is 150bpm, but no clinical outcomes come with this and the healthcare specialists need to explore all the context as there can be multiple explanations for this value being outside the "standard" thresholds defined. Moreover, this data presents some challenges as when programing for early alerts to have timely interventions, can produce false alerts given too sensitive thresholds.

Finally, healthcare staff need to respond to emergent notifications, and this can bring disruptions to their current activities, leading to a high mental workload. This is seen when they have to decide which patient to attend first based on their condition.

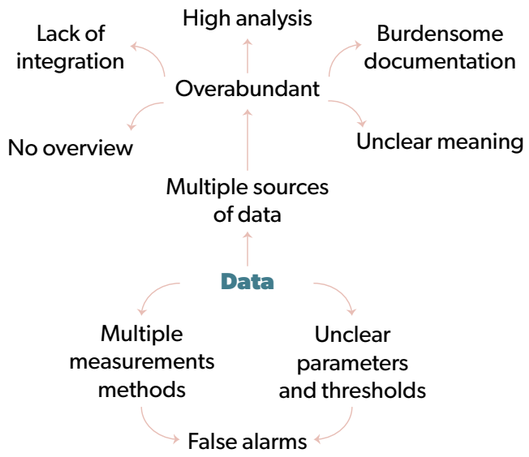


Figure 11. Main problems regarding data analysis in telemonitoring services.

2 Tasks

Given the high amount of data, the healthcare staff is overburden with increasing workload. Telemonitoring comes with a wide range of tasks and activities that specialists need to fulfill. It can also bring new responsibilities that are not always included in the current state. This is due to the lack of planning and inclusion of staff in the definition of these strategies (as presented in section 3.4 by the issue of ***"lack of inclusion of some stakeholders during planning"***). In addition, dynamics around care at home are new and there are no guidelines on how to monitor patients, which lead to new tasks and need for training and changing the current habits of specialists. In the end, this can result in inefficiency, as roles, actions and resources are not always clear or they do not align with the needs and abilities of specialists.

Finally, in section 3.4 it was found from the literature research that there is a ***"lack of guide lines" .*** But not only are the protocols regarding the activities that come with telemonitoring not defined but also the time needed is not spe cified or determined adequately. Even on some occasions the time is underestimated as the experience level of staff with these technologies is not considered and they might take longer while learning. There can be emergent tasks, part of their current workflow, that interrupt the activities. When continuing this previous task they might need more time to remember where they left and avoid making mistakes.

Figure 12 presents the summary of the main challenges that telemonitoring services bring to healthcare staff's tasks and workflow.

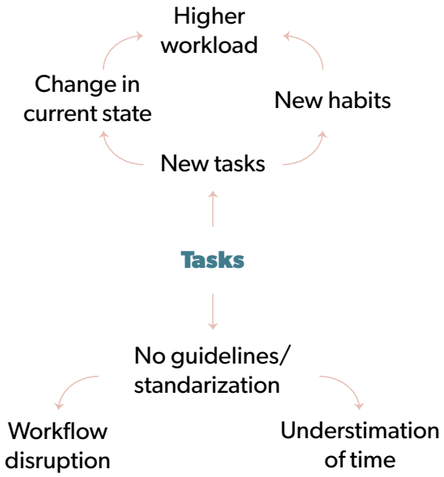


Figure 12. Overview of the main challenges for healthcare staff's tasks and workflow

3 Actors

Multiple actors are involved when monitoring patients from gastrointestinal surgeries, given the broad knowledge that is needed to analyze the data and checking over the patients. As previously mentioned, patients from these surgeries can come from a diverse set of causes, for example, surgery being part of cancer treatment or for a digestive disorder, as bowel syndrome. This translates into the involvement of actors with different knowledge and backgrounds, that might involve various departments within the hospital. This can complicate communication, make it difficult to coordinate patients' care and produce delays while waiting for the response of actors. And, as mentioned in section 3.4 by the issue of ***"lack of inclusion of some stakehol-***

ders during planning" communication is not efficient as the current interaction and relation among actors and their perspective about them is not considered.

Moreover, given the complexity of these procedures, multiple roles are needed to respond to the activities. In some cases, is not clear the tasks and roles of the actors involved in certain procedures, to the point that they might not be aware of who is responsible on each stage. This results in multiple actors doing the same task. These issues are presented in Figure 13.

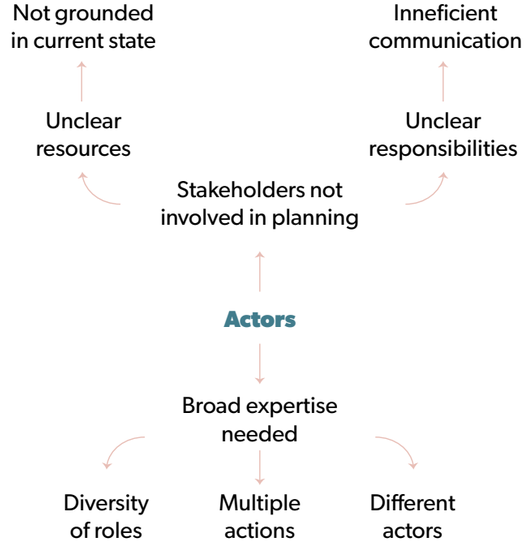


Figure 13. The diversity of activities and actors involved presents challenges to telemonitoring services.

4 Mindset

As previously seen telemonitoring context involves many actors and users (the patients, the clinicians, the developers, and data scientists). Each of them have different needs and goals regarding these services. Currently, there is a lack of integration which is associated to the lack of involvement of all the actors during its development. This is one of the factors for the inappropriate definition of alarms, as they don't always respond to the reasons why healthcare staff want them, but why the device developers need them, as to comply with quality or regulatory standards.

The goal for these systems is also associated with the way data is presented and the level of analysis that is performed by these systems, whether they should present the raw data, the variable itself, or the clinical outcome that relates to these values, including a more in depth analysis.

The differences in mindset is also dependent of the context for the use of these systems, if a patient's life depends on the outcome or if the decision is taken by only relying on this data. Additionally it changes with each user and their experience on their roles (some specialists might be more risk-taking than others) and with technology itself (tech-savvy people are more prone to adopt new technologies). The overview is shown in Figure 14.

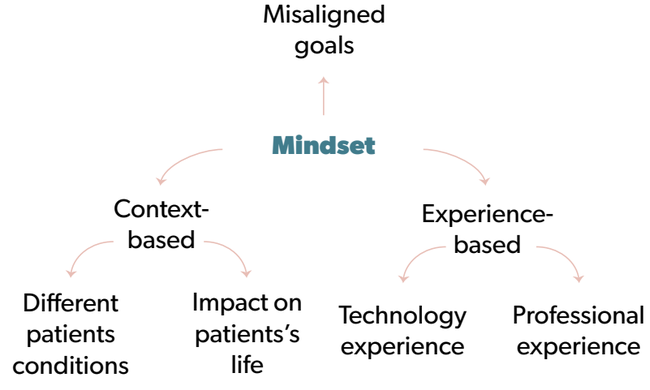
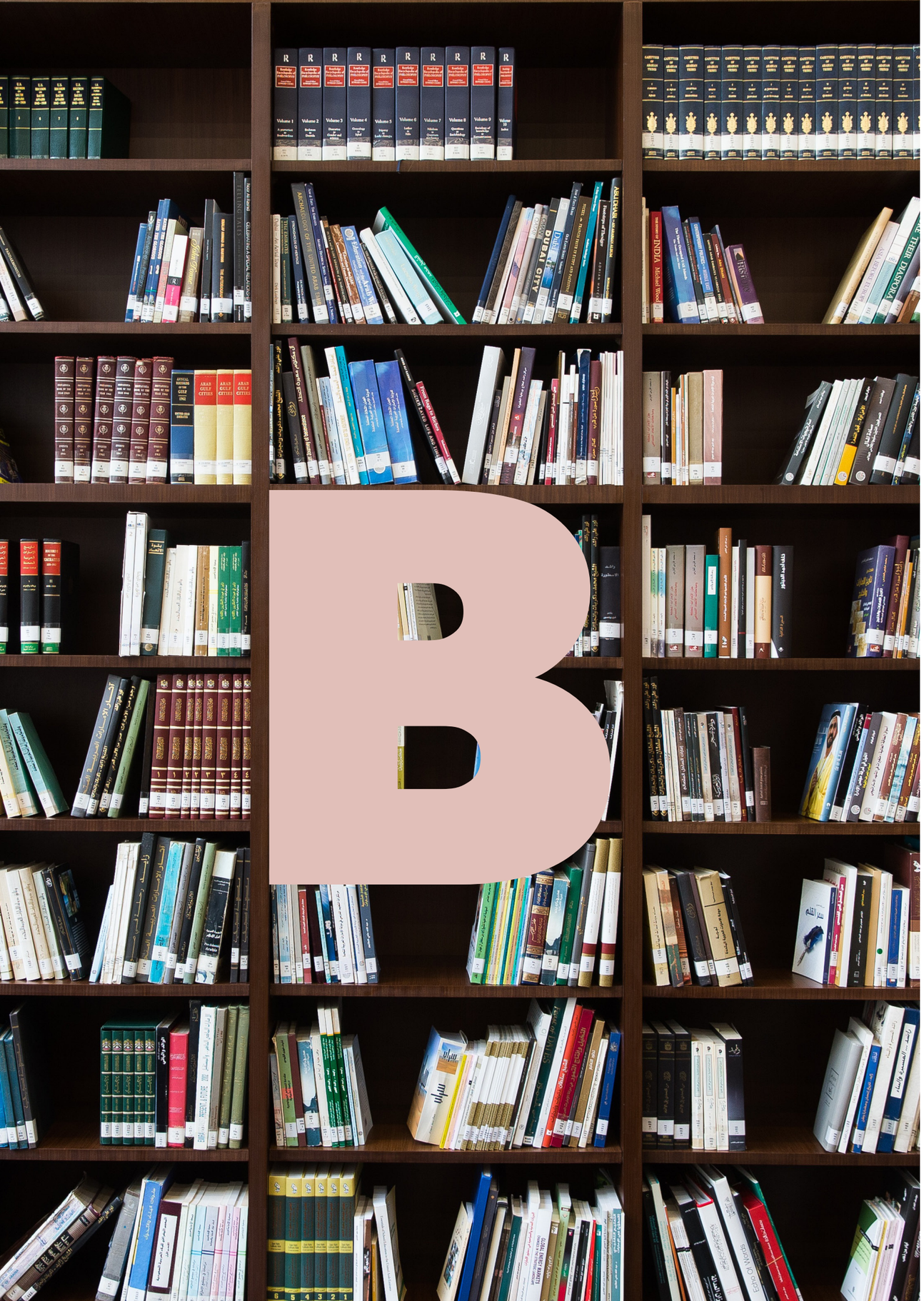


Figure 14. Mindset as a challenge for telemonitoring services.

Telemonitoring is a useful tool for extending care for major gastrointestinal surgeries. However, current services are not yet prepared for its adoption. The main barriers are the overabundance and lack of integration of data, that don't present an overview of patient's state. The lack of integration is also seen in the actors involved, given the need for a diverse range of specialties and knowledge. Overall, there is a lack of standardization and guidelines regarding procedures and a lack of involvement of stakeholders, whose goals are not always the driving forces for these services.



Define & Synthesize

This part consists of two stages. The first one consists of the user research, guided by the results from the literature. This included expert talks with data scientists, healthcare staff, data and smart system designers and professionals around alarms and implementation in healthcare. These talks corroborated the findings from the literature research and presented new information and perspectives about telemonitoring challenges. The second stage is the trend research, performed to conclude the research phase and guide the design process from the current state to the future outlook. This analysis is a base of inspiration for the later steps of conceptualization as it brings the possibility to foresee the future based on existing facts and directions in the different fields.

4. User research

4.1 Methods

To understand the current state and possibilities it was time to approach users and experts on telemonitoring services. As seen from the literature review many problems arise due to misalignments between new and existing dynamics. This results in ineffective strategies that increase work and prevents healthcare staff from using them. Consequently, specialists were approached to know more about how smart systems are implemented, their performance in hospital settings and general perspectives around them. Other experts regarding smart devices, alarms, and telemonitoring services were consulted as their input can provide viewpoints for unexplored directions and limitations or challenges to be aware of in this context (Evans, 2011).

Overall, the main research question to address was ***How to design a smart system for telemonitoring patients from gastrointestinal surgeries that fit healthcare specialists' needs and dynamics?***

A set of subquestions were identified based on the current problems and unknowns of monitoring systems (Table 3, Table 4) in the pre- and post-operative period. The pre-operative phase considered the proposal of the peri-operative box project, while the post-operative stage focuses on the current process for monitoring and responding to notifications and alarms from systems. These questions guided the creation of a sensitizing booklet for nurses, to understand more about their job, the tasks they need to fulfill and the hospital context. Also, they guided the creation of interview guides for the consultations with experts so that these could provide insights on reasons for the challenges seen in the literature review and possible solutions or strategies already implemented.

As mentioned before, a sensitizing booklet was designed for nurses involved in surgical environments, as an exercise of reflection on their routines and behavior. This booklet was designed to provide information about their current routine, patient monitoring (data gathering and analysis for forecasting complications) and their thoughts on alarm systems. The full Sensitizing Booklet can be seen in Appendix 3. Snowballing and opportunistic sampling approaches were used to contact staff given the difficulty to get in touch with nurses due to the control measures taken for the sanitary emergency caused by the pandemic. These restrict the contact and access to healthcare staff, who are already overloaded with Covid-related tasks.

Moreover, interviews were planned to clarify with experts on relevant topics for the research question. In this case, experts on smart systems, AI, telemonitoring tools, alarms and clinicians were contacted via e-mail for an interview session. As with the booklet, a snowballing and opportunistic sampling approaches were used. A semi-structured interview was used based on the guides developed. These guides were constantly updated to consider the feedback and preliminary findings from each conversation with the experts. The different interview guides used are presented in Appendix 4.

Once the information was collected from the booklet and the interviews, a qualitative analysis was done by means of a context mapping strategy, using "analysis on the wall" (Sanders et al., 2012). Interviews were transcribed and processed by selecting meaningful quotes and information. This was done by listening to the recorded files of the interviews and writing down the highlighted data. A full transcription of the interviews was not done, as partly transcribing them was sufficient to obtain interesting insights and meaningful quotes. By doing this, raw data from conversations can be transformed into meaningful insights that can guide the design process and be discussed by the different stakeholders. The quotes were separated from personal interpretations to facilitate the analysis, avoid biases and imposing the interviewer's viewpoint. Later these quotes and data were interpreted and sorted into themes. Within each theme different categories were defined that help synthesize and prioritize the information into insights.

4.2 The Participants

To contact healthcare specialists first the personal networks were explored. Later, external sources were used like blogs, websites and magazines for nurses and nursing themes to contact specialists via e-mail. Some of the personnel contacted seemed reluctant to participate due to their lack of interest in these topics or the importance for gastrointestinal surgical contexts.

"Complication rates are too low at gastrointestinal department, so we are not the right population to approach to gain knowledge on these issues"

However, others were very interested in participating in this study as they consider the results from this project very relevant and that could help improve their working dynamics.

"You chose a very interesting subject"

"Of course I want to help you"

"The work you have done looked very nice and helpful for future studies and implementation of E-health in peri-operative care"

Among them, some expressed their lack of time for participation. This already gives an indication of the high workload that healthcare staff have and how time is very important for them.

" ... it became impossible to see or speak everyone"

"Although your research topic likely matches with my experiences, I don't have any opportunities over the next few months ..."

In the end, four nurses filled the sensitizing booklet, two of them through the online version, and two of them had the booklet sent to their houses. Their overall characteristics are included in Table 5. The experts consulted in the interviews are summarized in Table 6.

Table 3. User research questions based on the current problems and unknowns of monitoring systems in post-operative stage.

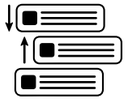
Stage	Pre-alert	During alert							Post-alert	
Post-operative period	 Doing other tasks	 Hear alarm	 Check notification	 Decide emergency level	 Analyze all data	 Decide actions	 Consult on actions	 Implement actions	 Document	 Return to previous task
Problems	Postpone tasks Too complex algorithm Incomplete data Disrupting	Sound does not indicate event Disruptive Alarming state/stress	Technical issues Inadequate measurements Fragments of data	Too early VS too late Ignore alarm No overview when based on 1 variable Underconfidence VS overconfidence on alarms	Contradicting data Too general parameters No clinical relevance Multiple devices/ platforms Too complex algorithms Feel trapped behind desk Understimation of tasks and time	Not enough or adequate knowledge Need for more data "Trial-error" based decision	Wait for response/ approval Tasks on "pause"	Uncorrectly done by patients Not available actors Unclarity on roles "Overtasking"	Burdensome Prefer to be with patients Fail to update information Multiple platforms Unfamiliar with technology	Forget previous task Errors on previous task
Questions	How is the current routine? Tasks? Likeliness? How long? Track time? How to monitor patients? How long? How many?	How, what, when, how often? Goal? Perceptions? (Disruptive? Helpful? ..?) Integration with current routine?	Common complications? Information received? How to recall patient's information? False positives?	Prioritization? Risk profile/ scores? Knowledge needed?	Data recorded? analyzed? Input from other sources? How is data integrated? Skills/knowledge needed? False negatives?	How? Guidelines? Who? Information needed?	Actors involved? How are roles defined?	Guidelines? Who in charge?	Data reported? VS data gathered? Workload? Automatic?	How to keep track?

Table 4. User research questions based on the current problems and unknowns of monitoring systems in pre-operative stage.

Stage	Pre-alert	During alert			Post-alert	
Pre-operative period	Doing tasks	Check status	Check data	Consult on data	Decide on surgery	Adapt parameters
 Problems	Postpone tasks Too complex algorithm Incomplete data Disrupting	False negatives Overconfidence on data	Unnecessary delay Feel "trapped" behind desk Understimation of time spend on tasks	Very complex algorithm		Data only right before surgery
 Questions	How is the current routine? Tasks? Likeliness? How long? Track time? How to monitor patients? How long? How many?	How, what, when, how often? Prioritization? Disruption?	Data recorded? analyzed? documented? How is data integrated? Skills needed	Actors involved? How are roles defined?	Parameters? Who decides?	How? Guidelines?

Table 5. Characteristics of the participants for the sensitizing booklet.

	Role/Job	Location
Participant 1	Nurse in ICU	Colombia
Participant 2	Nurse assistant	Colombia
Participant 3	Nurse assistant	Colombia
Participant 4	Senior nurse in acute care	Colombia

4.3 The Results

The information obtained from the expert talks were sorted into themes based on the similarity of the issues addressed. The themes previously presented as the outcome of the literature research (section 3.5) were considered as the initial point for this categorization, and further sub-categories were defined to distinguish among specific aspects of each main topic. The results from this analysis (analysis on the wall) are presented in the following sections. Appendix 5 includes a summary of the information gathered from the expert talks based on some of the themes from the literature review.

Table 6. Experts consulted and research question addresed

Michael Hesemaans Venture Lead Healthdot Philips	**Saskia Bakker** Senior Data Designer Philips	**Elif Özcan** Alarm expert & sound design TU Delft	**Rosana Sanz Segura** Alarm expert TU Delft,Universidad Zaragoza	**Anne de Hond** Data scientist LUMC	**Kim Brons** Project manager (The Box) LUMC	**Job Leenen** Project leader Isala clinc	**Robert van Kooten** Surgeon LUMC	**Leonardo Angulo** ICU Physician Int. Hospital of Colombia (HIC)
Expertise Part of the development team of the Healthdot.	**Expertise** Development of decision support systems in healthcare contexts.	**Expertise** Director of the Critical Alarms Lab (CAL), which aims to shape the future of product-user interactions in complex environments through audible, visual and haptic information design.	**Expertise** PhD candidate part of the Critical Alarms Lab (CAL). Her work presents a new perspective on alarm systems and nurses's workflow around them.	**Expertise** Development of smart systems by the implementation of AI in healthcare contexts.	**Expertise** Leading projects regarding telemonitoring strategies in the LUMC. Especifically coordinates box related initiatives in the LUMC for extending care to the "at-home" context.	**Expertise** Research on remote monitoring around surgical contexts and experience in surgical nursing.	**Expertise** Part of the peri-operative box project and experience in surgical contexts.	**Expertise** Experience in patient care, monitoring and logistics in Intensive care Units.
Research questions How does healthdot project supports alerts for patient monitoring in hospital settings? • Logistics/dynamics around healthdot project • Incorporation into hospital setting	**Research questions** How to design a clinical decision making system that forecast complications and fit nurses' needs within hospital environments? • What data is needed for early forecasting? • How to incorporate them within the existing staff and hospital dynamics?	**Research questions** How to design an alert system that forecast complications and fit nurses' needs within hospital environments? • What data is needed for early forecasting? • How to incorporate them within the existing staff and hospital dynamics?	**Research questions** How to design an alert system that forecast complications and fit nurses' needs within hospital environments? • What data is needed for early forecasting? • How to incorporate them within the existing staff and hospital dynamics?	**Research questions** How to design a clinical decision making system that forecast complications and fit nurses' needs within hospital environments? • What data is needed for early forecasting? • How to incorporate them within the existing staff and hospital dynamics?	**Research questions** How is telemonitoring implemented in current box projects? • How is current workflow? • How is data managed? • How was it integrated into hospital?	**Research questions** How to design monitoring systems for early detection of clinical deterioration that fit nurses' needs within hospital environments? • What data is needed for early forecasting? • How to incorporate them within the existing staff and hospital dynamics?	**Research questions** How is the current healthcare pathway for gastrointestinal surgeries? • What actors are involved? • What are the steps? • What are common complications and how can they be forecasted?	**Research questions** How is the current pathway for monioring patients? • What are common complications and how can they be forecasted? • What information is gathered? • How is data analyzed? • What actors involved? What are their roles?

Data

Throughout the different expert talks, one common topic was the importance of data for clinical decision making. This was also seen in the answers from the sensitizing booklets where nurses expressed the importance of knowing the patients' conditions (like vital signs, mental activity, physical ability) for assessing the state and recovery. Around data, some things can be highlighted. Figure 15 presents an overview of the main findings with quotes.

1. The entire picture

For monitoring patients, vital signs seem to be the main source of information used by specialists.

However, they should not be presented or analyzed as individual pieces of data as underlying relations can be ignored. For example, an increase in the heart rate might indicate tachycardia, but if there is also a rise in the respiratory rate it, could mean that the patient is doing an activity, but no sign of complication.

Moreover, they should be complemented with other variables, for example, questionnaires for the patient about their perceptions of their conditions or just to corroborate if the measurements are accurate and are due to a physiological state or if they are because of technical problems.

This last issue lead us to the second point.

2. Actionable events

Telemonitoring services come with an overabundance of data, given the extended possibilities of automatizing measurements and the desire to make more informed decisions.

This data is also accompanied by alarms to keep the staff informed on possible emergencies. However, they are usually based on standard cases and "in-hospital" care and not necessarily for the "at-home" situation and it is not always clear what changes are needed, which parameters and values indicate complications.

When hearing an alarm nurses immediately worry about the patient's state, as an alarm should present a critical condition of the patient and lead to an action or response. However, as mentioned by alarm experts, ***"nurses surpass that function often"*** by having preventive alarms. These preventive alarms indicate that healthcare staff have an idea of how things should behave or what to expect. Which relates to the third aspect.

3. Context

3.1 Know how it goes

Telemonitoring services come with an overabundance of data, given the extended possibilities

Figure 15. Main findings from expert talks regarding data topics.

of automatizing measurements and the desire to make more informed decisions.

Healthcare staff already have an idea and expectations of the clinical outcomes and progress of the patients, so they are constantly looking at data to see if they are at any point different from these expectations or outside the "safe values" or thresholds defined. These predictions are based on the patient's initial conditions or baselines and the surgical procedure.

3.2 Explanation

The patient's conditions and context are very important, as is the reasoning behind certain decisions from smart systems. For example, in clinical decision support systems, the clinician needs to know why the algorithm is indicating that a certain patient might be having a complication. What was this decision based on? Which parameters were outside the thresholds?

Nevertheless, is not always clear why the algorithm makes a decision. It can be too complex to narrow it down to 1 or 2 parameters. Also, when giving these explanations, the specialists might not have time to go through endless measure ments or to corroborate every time the process or reasoning behind decisions, so they need to be very clear and relevant, which connects to the last point.

4. Prioritize

With continuous measurements comes a lot of information and it can be overwhelming, especially to know what to look for, which are the main variables that are causing distress in a patient. In addition, more patients are monitored and therefore, it is necessary to know which patients need urgent attention and which ones can wait.

Not only information needs to be prioritized, but also the actions that the healthcare staff needs to perform to respond to certain situations (like possible emergencies). Protocols about what to measure, how to act, when should a patient be contacted, when should further examination or "in-hospital" consultation be done, are not clear. These questions lead us to the actions that healthcare staff need to make.

Tasks

The booklet gave an overview of the nurse's tasks and their schedule. It showed the diversity in the nature of the different activities they need to perform. These can range from checking on the patient, the monitored variables and devices, to administering different medications and even discussing with specialists about the care plan of patients. Experts also mentioned the importance of the tasks and routines in the implementation of new services, as changes (in habits, behaviors, logistics) imply training and thus effort and time that healthcare staff don't really have or are not willing to sacrifice. New developments are accepted when staff is benefited from them, by reducing burdensome tasks, like documentation, and increasing time on tasks they prefer, like sharing time with patients. Figure 16 presents an overview of the main findings regarding tasks with its corresponding quotes from the expert talks.

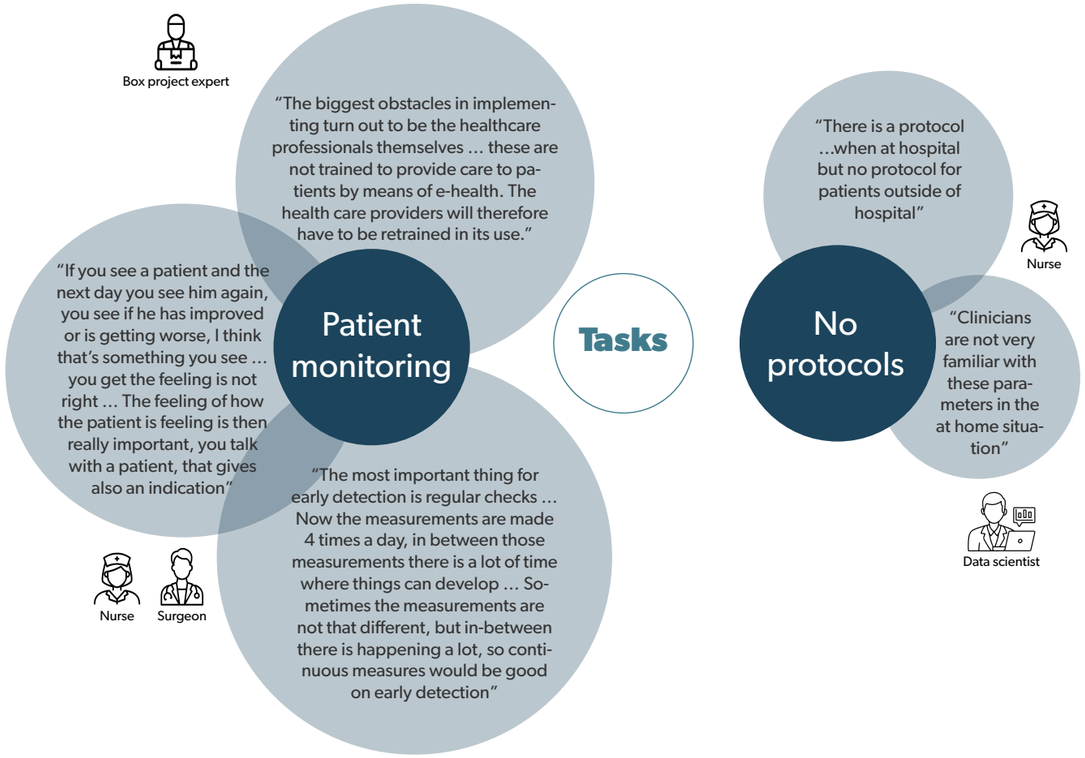


Figure 16. Main findings from expert talks about task theme.

1. Patient monitoring

In general, the main tasks for healthcare specialists are around patient monitoring. To correctly assess patient's recovery, regular checks are vital. Having continuous data can give information that would not have been gathered with measurements taken at certain times. As seen in Figure 17 if the patient was only monitored on the timeslots indicated by the arrows, the clinicians will not obtain information about the values outside the thresholds that might be a sign for early detection of complications.

This continuous monitoring brings new tasks and changes in workflow, which translates into adopting new habits that might be a challenge for healthcare staff.

One of these challenges is the reduction in the interaction with patients once they are discharged from hospital. Nowadays, there is no connection with patients, however, telemonitoring strategies bring the possibility to keep in contact with patients by means of data collection. It is still a challenge for specialists when assessing patients' condition, when they are not at the hospital but at home, as the "impression" that they have when looking at a patient is key.

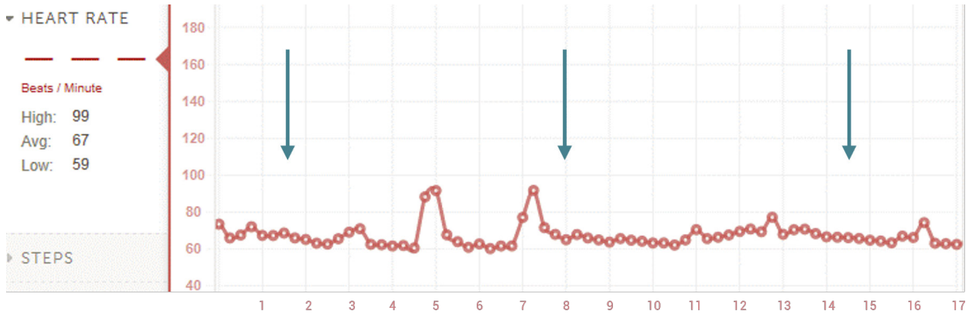


Figure 17. Example of continuous monitoring of vital signs that allow. Arrows indicate abnormal values and possible of adverse events.

2. No protocols

For data, there are no clear protocols around what to gather or how to analyze it for the "at-home" situation. This is also valid for the actions of healthcare staff, when should a nurse intervene, when the doctor needs to provide support. Consequently, assessing the patient's state demands time and effort to closely look at the information provided by the system. This can be the patient's measurements, so that staff can have a clear diagnosis and make an informed decision on the treatment.

Additionally, the analysis of this data is not standardized, especially regarding the accepted thresholds for the measured variables at home context. Given the newness and lack of information on how a patient and its recovery process should be like (the physiological and physical changes), the parameters that can give an adequate overview of the patient's condition are not clear and need to be further studied. Consequently, there are no protocols on risk assessment or data analysis, leaving it to the personal experience and knowledge of the healthcare. This is time-consuming and also burdensome due to the sense of responsibility they have on providing the most adequate care to patients and ensuring their safety, that without proper guidelines, can be compromised. For example, the nurse might miss the diagnosis of an adverse effect because, in her experience and knowledge, the patient presented the vital signs among the standard values, thus representing a healthy state.

Actors

The experts presented a broad list of stakeholders involved within this context, ranging from technical roles for the development of systems to more clinical ones, specific to deliver patient's care. From the booklet, it was clear the relationship between the nurse and the specialists, which is seen as a hierarchical one, in which the nurse get the knowledge and advice from the specia

lists in order to act. On the other hand, patients are seen more as someone they need to help and interact with not only by providing and ensuring care (medications, procedures, measurements), but also by talking with them and having a more personal connection when possible.

1. Multidisciplinar context

"Together with ... small project group for defining a new box, that's essential if you want to work for home monitoring on a new department or patient group and then we are making the care path with all the people who are involved and then you decide who will decide which patient gets a box, who will hand over a box to the patient, who will explain the box to the patient, who will look at the data"

- Project manager (The Box)

"we have to involve clinicians and they have to involve us, it's their problem, their project, they are the owner of the product that we are developing"

When developing tools to assist patient care, there is also a creation of teams that involve multiple stakeholders (Figure 18). These come from a diverse range of disciplines given the need for multiple areas of expertise as it requires medical and technical knowledge for the creation of tools that support specialist's tasks. In addition, the involvement of the users of these tools, like patients and healthcare staff, is important to understand their needs and the goals for these interventions.

2. Roles and responsibilities

"The treatment decision are usually make by an entire team of multiple specialists"

- Surgeon

"Over the world, the multidisciplinary meeting are becoming more implemented and studied"

- Surgeon

Regarding gastrointestinal surgeries, they involve different specialists that comply with a broad range of tasks (Figure 19).

"The question always arises where the responsibility of the patient lies and where the responsibility of the LUMC lies"

- Box project expert

In addition, the responsibilities of the different actors change over time as each stage of the process requires different expertise (Figure 20). For example, at the beginning when the patient is being diagnosed the specialist in charge is the "leading specialist", which could be the oncologist for patients with cancer or the gastroenterologist for gastrointestinal disorders, like bowel syndrome. Later, during the surgery and the first days after it, the surgeon takes the leading role, and the nurse is now closer to the patient. Finally, once the patient is discharged, the leading specialist is again the main actor and the nurse keep close contact with the patient in case of readmissions.

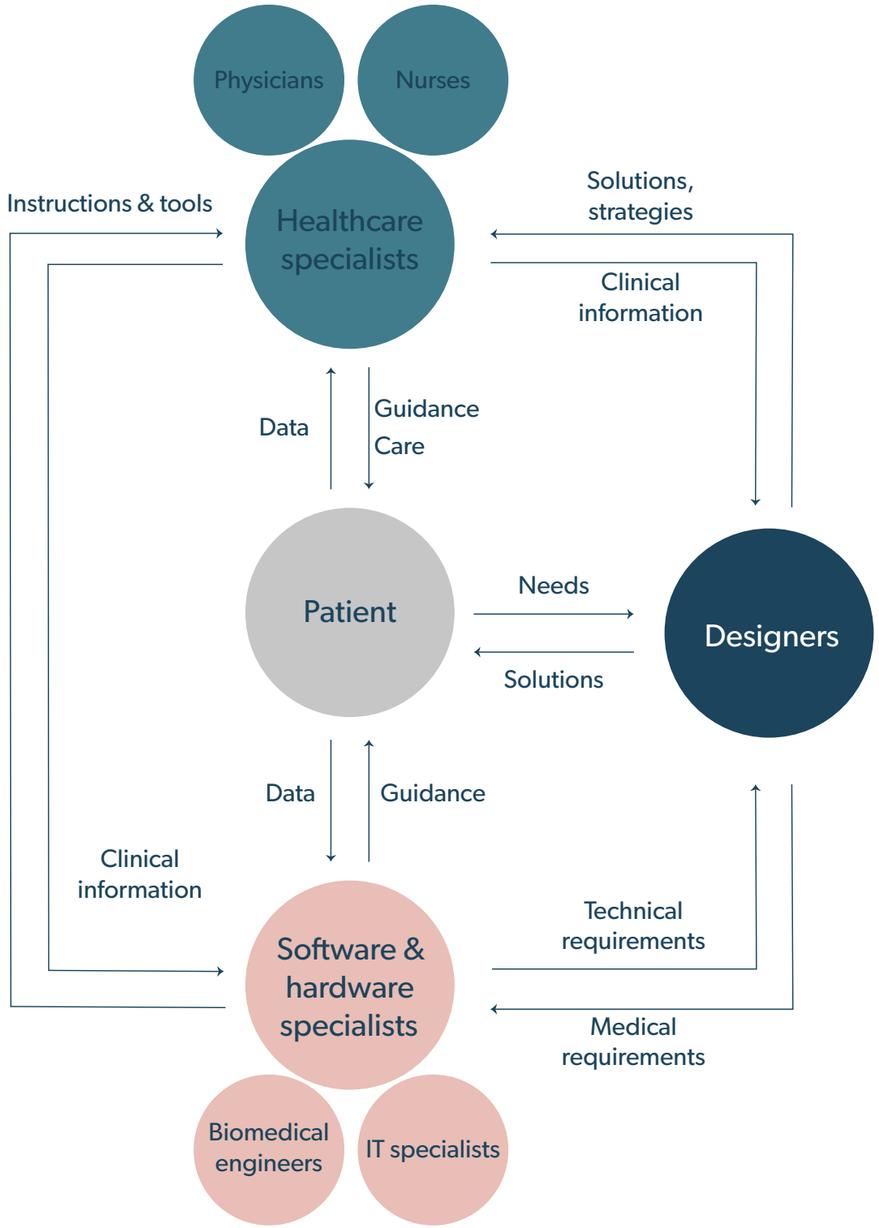


Figure 18. Overview of the actors involved for development of systems and tools in healthcare contexts.

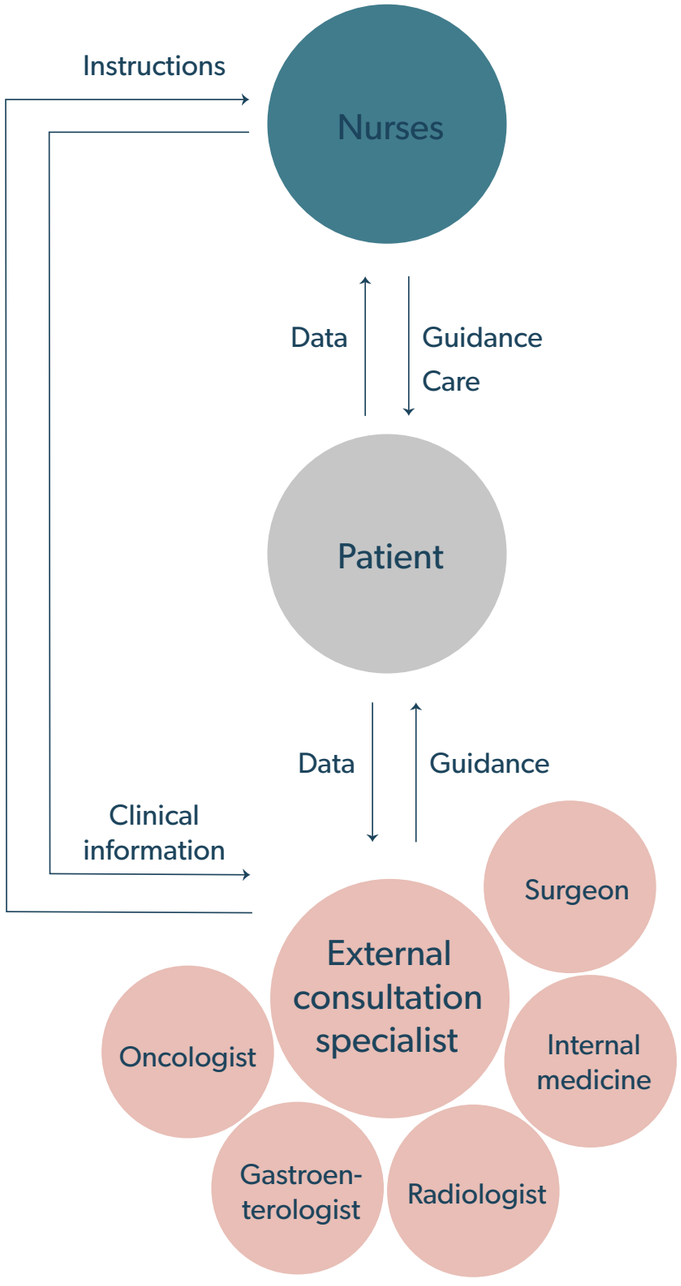


Figure 19. Actors involved in gastrointestinal surgeries.

Mindset

Some of the experts expressed that when developing systems, the individual characteristics, and ways of thinking, influence the perception of them. Even with the limited number of responses from the sensitizing booklet, it was clear how the mindset and way of answering from the different participants was influenced by their personality and behavior, like their experience and role. Nurses with less experience and a more "assistive" role, were more opened to innovations, research, and learning.

1. Persona

"There are differences among the goals of stakeholders. You have the designers who are more into sounds, visuals ... you have the engineers that are more into sensors ... you also have the ones more focused on humans and cognitive-factors.."

-Alarm expert

The plurality of stakeholders involved produces a broad set of goals based on their own needs, which are not always aligned.

"if see more on why something is happening, I would trust it a little bit more but may depend among persons"

- Surgeon

This is also influenced by the personality and the experience of the different stakeholders. For example, some specialists do not seem very opened to implementing telemonitoring strategies as they consider the benefits will not outweigh the costs and efforts for its development. This can bring difficulties during implementation as not all the staff will be motivated and compliant with the new protocols and dynamics, affecting the overall system performance. As seen in Table 7, we can identify two types of nurses.

The experienced nurse trust in her/his own skills and knowledge, as she/he has developed an extensive and clear tacit knowledge and has dealt with a set of different situations that have helped build a strong critical thinking process. On the other hand, the apprentice nurse is less secure when taking decisions given the limited experience and the ongoing learning process.

"How well it works is such a subjective question. It depends completely on the needs & definition of your clinician"

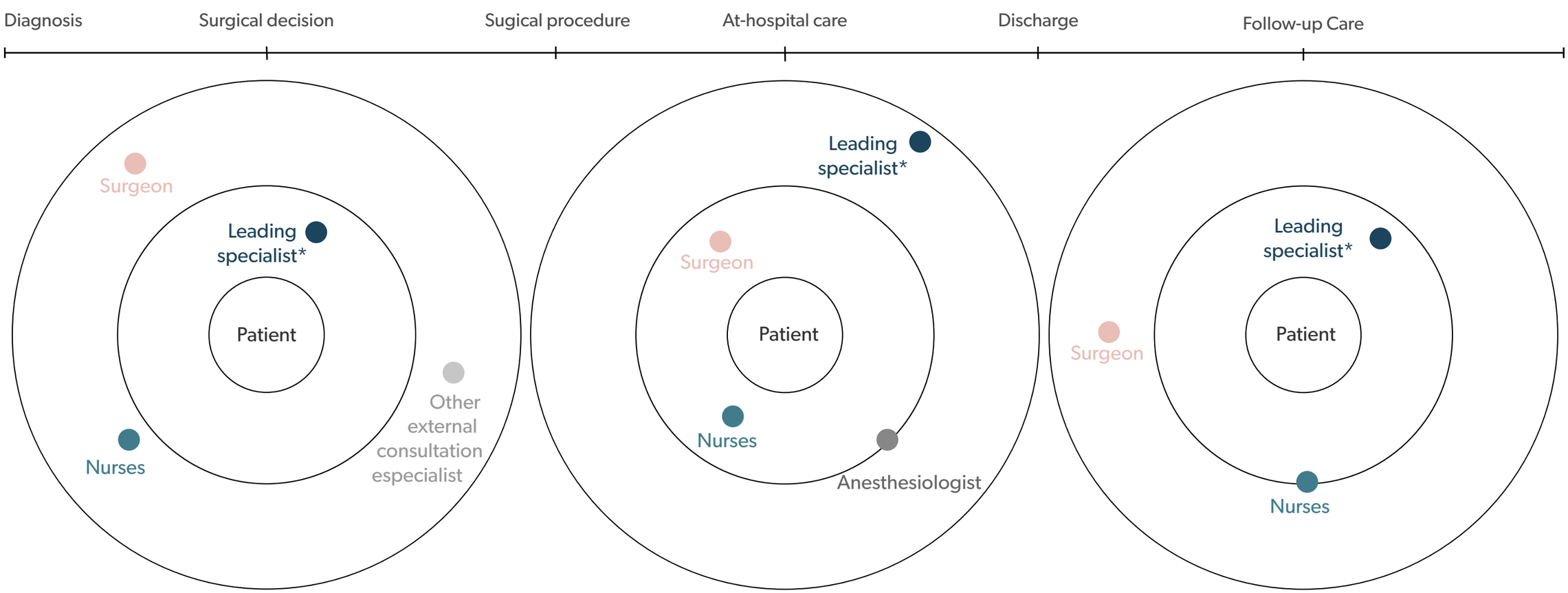
-Data scientist

This presents also a challenge for the implementation of smart systems as the more experienced nurse tend to trust more on her/his own decisions, while the apprentice nurse appreciates the support of the information given. It was mentioned by experts how nurses in general value the importance of these systems when they help reduce the burden without compromising their current tasks or reducing time with the patient. This leads to the second topic.

2. Trust in smart systems

"In the future they can rely in the model ... so now it's like they do the same, but they need to trust the model first before thy rely on the model"

- Project manager



*Leading specialist can be:
Gastroenterologist
Internal medicine especialist
Oncologist

**Other external consultation specialist can be:
General practitioner
Radiologist

Figure 20. Overview of actors' involvement throughout the patient care journey.

Table 7. Persona definition for nurses.

	The experienced nurse	The apprentice nurse
		
Quotes	*"Seeing how Mr. Jansen looked makes me think he might have an infection."* *"The human should be making the decisions but the AI can be supporting"* "AI should not make decisions, especially clinical decisions"	*"The monitor suggests that with the values from Mr. Jansen measurements he might have an infection."* *"When you are gathering more and more data the decisions tools are getting more important"*
Characteristics	Don't need many alarms Rely more on their "gut feeling" More narrow thresholds More easy with alarms and thresholds Need less data Corroborate their own concerns More self-confident with decisions	Don't want to miss out anything Need more alarms More streched thresholds Need a lot of contextual knowledge Rely on different sources and measurements More doubtful decisions
Behaviors	"Experience" based	"Theoretical evidence" based
Pains	Question systems' results if they don't match their thoughts "We (system designers) don't want that they will be second guessing everything because then they (systems) don't have much added value" - Data designer	Lack of tacit knowledge "We (system designers) don't want them to blindly accept what the AI tells them, they have to be able to verify if that's not the correct conclusion." - Data designer
Gains	Systems as support System results matches their suspicions	Systems explaining results Data from different sources guiding to same direction Approval from specialists
Perspectives on AI	System as a "Safety net" Uncomfortable with "command-based" systems Staff brings "human factor" and has decision power	System as a "Foreteller" Comfortable with "command-based" systems

Trust in the systems is vital for implementation to be effective and to bring positive outcomes. Based on the expert talks, we can talk about trust based on three main aspects. An overview of these aspects is presented in the next paragraphs. The full overview is presented in Figure 21.

"we don't have any idea what the issues are, we are supportive in that sense... it's the clinician that should have the ownership of the development product and the process and should be in charge... it can be a nurse, the specialists, the physician, so anybody that's in the clinic and would like decision support anyway""

- Data scientist

First, the value that these systems bring to users, the goal and the "job to be done". In general, the different experts refer to these systems as support tools rather than autonomous actors or having a central role in the care pathways.

Second, the gains these systems bring, or if they present new opportunities or complies with some requirements. For example, specialists have a special connection to the systems when they have a good relationship with the developing team, as it makes technology more human and less distant to their current and known situation. They like to be involved and empowered in the process, which translates into responsibility and ownership, making them advocates of these tools.

"Everybody is pretty anxious to see what AI can really mean to these patients...but also they are critical because it's before you leave a decision to a model you really need to know for sure that it's the right decision"

- Project manager

Finally, the pains, the situations that lead specialists to mistrust the systems. This is provoked by

different reasons, as the lack of transparency in these systems. Clinicians need to know the context and all the variables very clearly to make decisions, so if an outcome is presented without the procedure or reasoning behind it, they might doubt it. But the explanation is not the only thing needed, also their validity and acceptance in the clinical domain. For example, whether the system is valid for an specific type of patients with certain conditions, or if it can be generalized. In the end, this is seen in the clashes the reality and expectations, as not everything that the users need can be addressedor when it can, it might not fulfill the imagined outcome.

Implementation in healthcare contexts

"We have a roadmap or a checklist that we kind of go through in all the projects. Kind of a generalizable broad sense that we use for all of our projects"

- Data scientist

"We have the development process in stages and we define go/no go criteria for each stage"

- Data scientist

For the implementation of new services or tools for healthcare institutions have defined a process that goes from the problem definition between the stakeholders, until its implementation and integration into the current state. Figure 22 presents an example of a roadmap that is being used by a hospital for the development of smart systems and was mentioned by one of the experts. Here six main stages are defined. First problem definition, where the needs of the stakeholders drive the team to change the

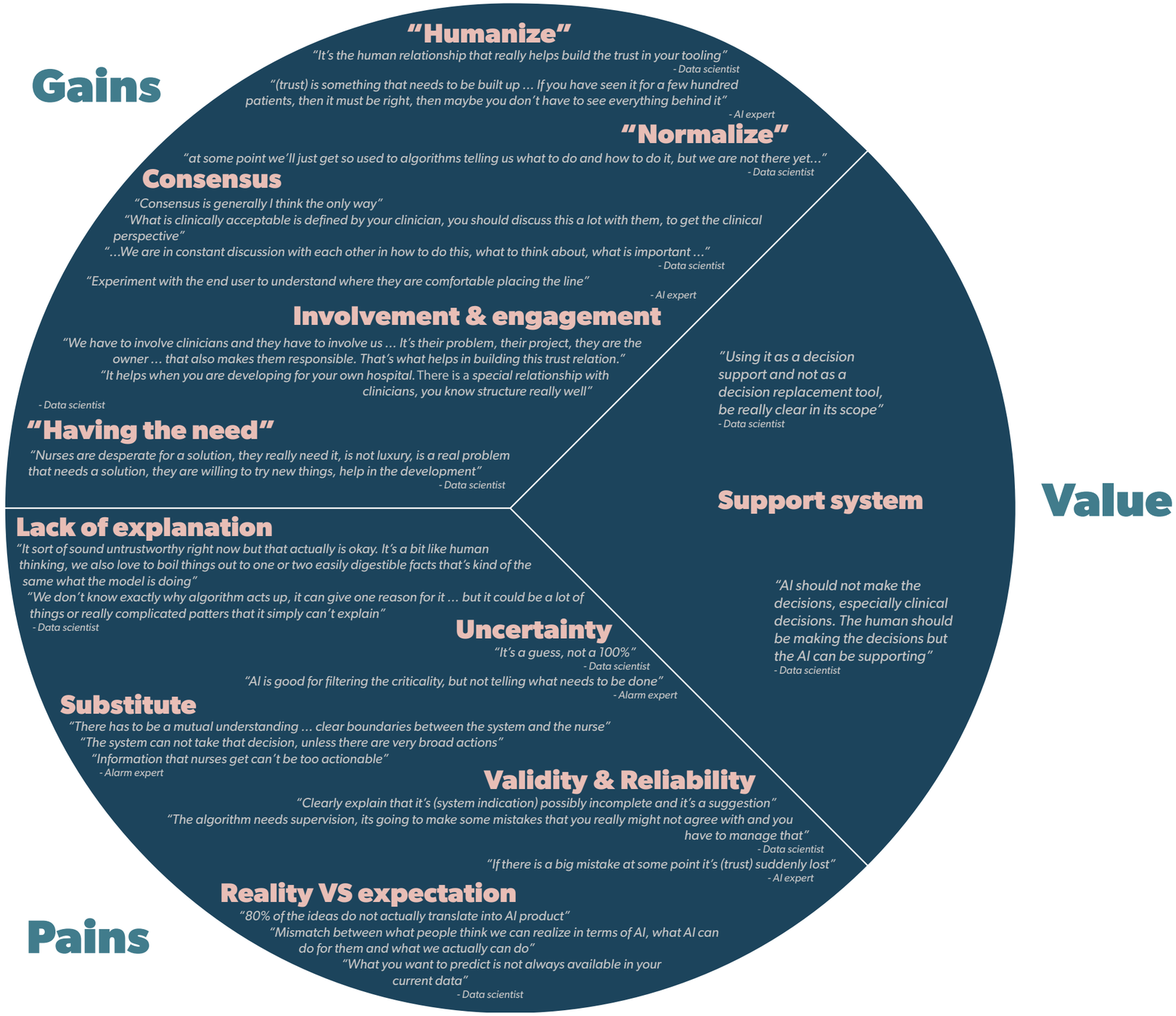


Figure 21. Overview of trust in telemonitoring systems.

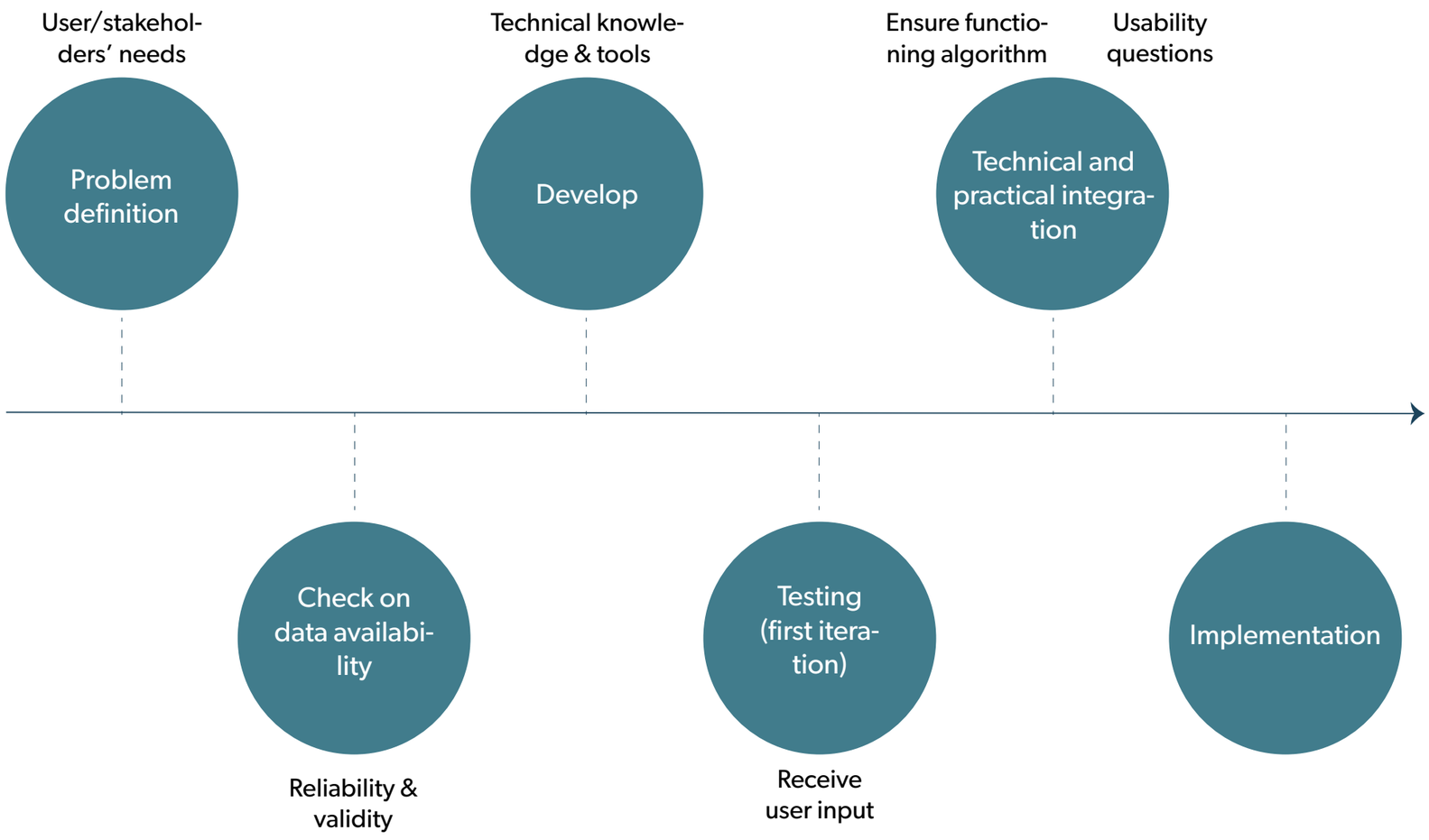


Figure 22. Example of an implementation process in hospital context mentioned during one of the experts talks.

current state to seek its improvement. Second, is to check on data availability, to know whether the challenge can be solved with the resources available or if something needs to be done or researched first, for example, if some extra information needs to be collected. Third, is to develop the smart system using the technical tools and knowledge from the team. Fourth, is to test the first iteration of the system with the users and actors involved. Here feedback will be gathered to adjust the system and iterate on it. Fifth is h technical and practical integration, where the technical is about algorithm, to make sure that it works correctly; while the practical part is about usability questions, if users agree on the way things are presented, on the system, the platform, and its functionalities. The last step is to implement the solution in the hospital context.

"Long time for development of these clinical things"

- Healthcare designer

"Legal frameworks must also be indicated for the use of eHealth, because part of the care is provided outside the hospital."

- Box project expert

Implementations around healthcare contexts need to comply with different regulations regarding patients and user safety that comprise their physical conditions, but also their data and its privacy. In general, projects can take longer than expected or than standard times, because of the need for several tests and approval form different entities.

This part presented the findings of the exploration phase, which comprised literature and user research. We could see how the main issues found in the theory were also relevant and corroborated when talking to the experts. Information around data, tasks, actors, mindset and the healthcare context was identified and it brought some of the main challenges and opportunities for telemonitoring services in peri-operative contexts. Figure 23 presents the overview of the most relevant findings and conclusions from this part. Here the insights are presented on the aforementioned five categories, and they are classified based on the type of information they bring, whether they were presented as challenges or requirements within that category.

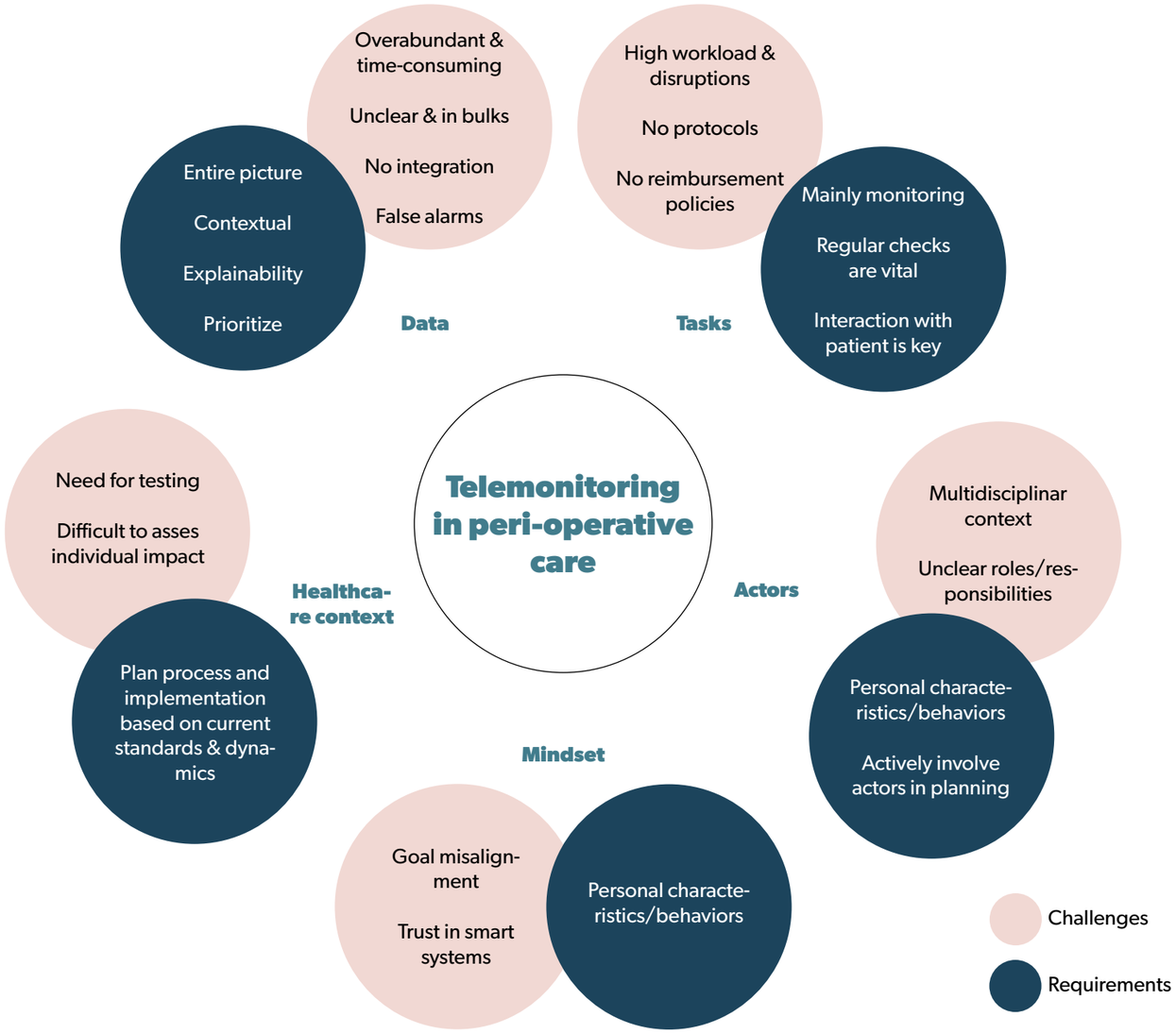


Figure 23. Overall findings from the user research based on the categories established.

Overall, from the expert talks we can see how smart systems are needed in healthcare contexts. However, their role should be to support, rather than as a decision-making actor. This "last call" should only be made by specialists.

To fulfill this task, the system needs to provide constant monitoring that considers the context and allow for informed decision making. Also, they need to be developed considering the multidisciplinary environment, and the multiple needs of the actors with different expertise and backgrounds. In general, systems need to adapt to the different types of actors (experienced vs apprentice, tech-savvy vs non-tech savvy) and not the other way around, so that these systems can be trusted.

One last challenge that needs to be addressed is the gap between the smart system's capabilities and the expectations of people.

5. Trend Analysis

Some research on current trends and the current state of technology around this context supported the exploration of directions for the future vision. This would help as a source of inspiration for the scenario definition, but also give a basis for a realistic scenario by forecasting based on the current direction of society, technology and different fields.

In this case, the DESTEP method was used, were different trends and developments in areas such as Demographics, Economics, Sociey, Technology, Environment (Ecologic) and Politics. For this, trend reports from companies such as Global trends, Deloitte and healthcare companies like Philips, CareVoyant (CareVoyat, 2021), among others, were analyzed. In addition, literature was researched to learn about recent inventions and the prediction on fields including home care, data processing, clinical decision support systems, patient monitoring, e-health.

Once general trends were gathered, they were clustered to determine the underlying main trends that would help forecast the future of healthcare around telemonitoring of patients. The results can be seen in Figure 24.

Overall, we can highlight the importance of healthcare for society. Given the recent pandemic, people are being more aware and actively seeking their wellbeing. This situation showed the fragility of life, especially when not having a healthy lifestyle, which leads to getting sick more easily or having higher probabilities of developing complications. Consequently, people started to be more aware of their way of living (the things they eat, the amount of activity they perform, the level of stress and emotions that they deal with daily) and seek behaviors that bring the best outcomes for their health.

Being more conscious of their state also makes people wanting to know more about how they are feeling and why. This is supported by the development of devices that keep track of people's vital signs and conditions, as they want to know how they are doing and what might help improve their state or what could deteriorate it. These devices provided support by keeping track of people's physiological data and providing information to determine a patient's condition or diagnosis when needed, during the quarantine period in the pandemic, where people could not leave their houses. This even helps prevent and attend possible emergencies. This is also promoted by the increase in the older population, who, given their physical conditions and physiological consequences of aging, have a higher demand for care and ensuring it from the home context became a priority.

On the other hand, we should also emphasize the value of smart systems and their increasing adoption in all types of activities. These systems have not only been actively involved in people's tasks given the need for remote and online services due to COVID-19 outbreak, but also for the benefits it brings. For example, it allows for an extension of service delivery, given the possibility of reaching out to more people throughout the online environment. Also, in decision support by providing more data (greater capacity for storing information by means like cloud solutions) and tools to analyze it. This last one presents an opportunity in the healthcare industry, where clinicians' choices have a significant impact on patients' life and accuracy and precision are crucial in care.

The inclusion of smart systems involves a broad network of stakeholders, who should be included during its development, to fulfill their different needs and motivate implementation. This is supported by the importance of the ecosystem around solutions, which has been continuously increasing. With this, a product can no longer be defined by the user, but by all the stakeholders and the variables around it. And not only a product will be offered, but the service it entails, considering the dynamics of the environment where it is introduced. In healthcare, innovations can't only focus on the patient, they need to consider the caregivers (healthcare staff and healthcare institution), the patient's context (relatives, friends), healthcare insurance companies and even public entities to ensure policies and regulations around these new strategies.

Considering the whole context requires more agile methods that can help in the creation and testing of new models and practices in shorter periods of time, with the least amount of resources, without compromising quality. For healthcare, nowadays co-creation sessions are taking an important role, where actors like physicians, work together with designers, politicians and even civilians to build together policies around healthcare and strategies to improve the clinical outcomes, the patient and medical staff's experience and environments, and efficiency in care (Bodenheimer & Sinsky, 2014).

This is also possible given the increase in the importance of connectivity among people and the development of means that support it. For example, the creation of different platforms that allow video calling, virtual meetings and education and in healthcare, the possibility of specialists still getting information about the patient's condition even though they are not in the same room.

In addition, these new systems will lead to new dynamics given the challenges that arise, like the security of the patient's data and the clinical outcomes; or the need for customization of these systems to fit into healthcare staff's roles or facilitate the transition into new logistics; or the development of new policies and guidelines around how should care be provided for the contexts introduced by the new services.

To sum up, society is striving towards more technological and online services that can bring the same or even better quality. These services should extend the coverage and functionalities to the home context and increase the offerings to provide a better fit to the user's needs. Now, people who couldn't buy things or services from a certain company will be able to order them online, which for most people is more convenient and preferred than going to the physical facility. These services should ensure a smooth and well-defined structure by considering the ecosystem around it, like the stakeholders and resources to build a strong network and offer a desirable experience.

A more in-depth explanation of each of these trends can be found in Appendix 6. The information provided by this trend analysis was used for inspiration when defining the future vision, to shape peri-operative care of the future and the services and logistics around it. With these trends, we can see what the society is looking for

(like online and intuitive services, customization, wellbeing, sustainability) and how could those things be achieved (technological developments agile methodologies, ecosystem overview).

Decision support systems

Security

Connectivity

Healthy society

Silver society

Online services

Ecosystem overview

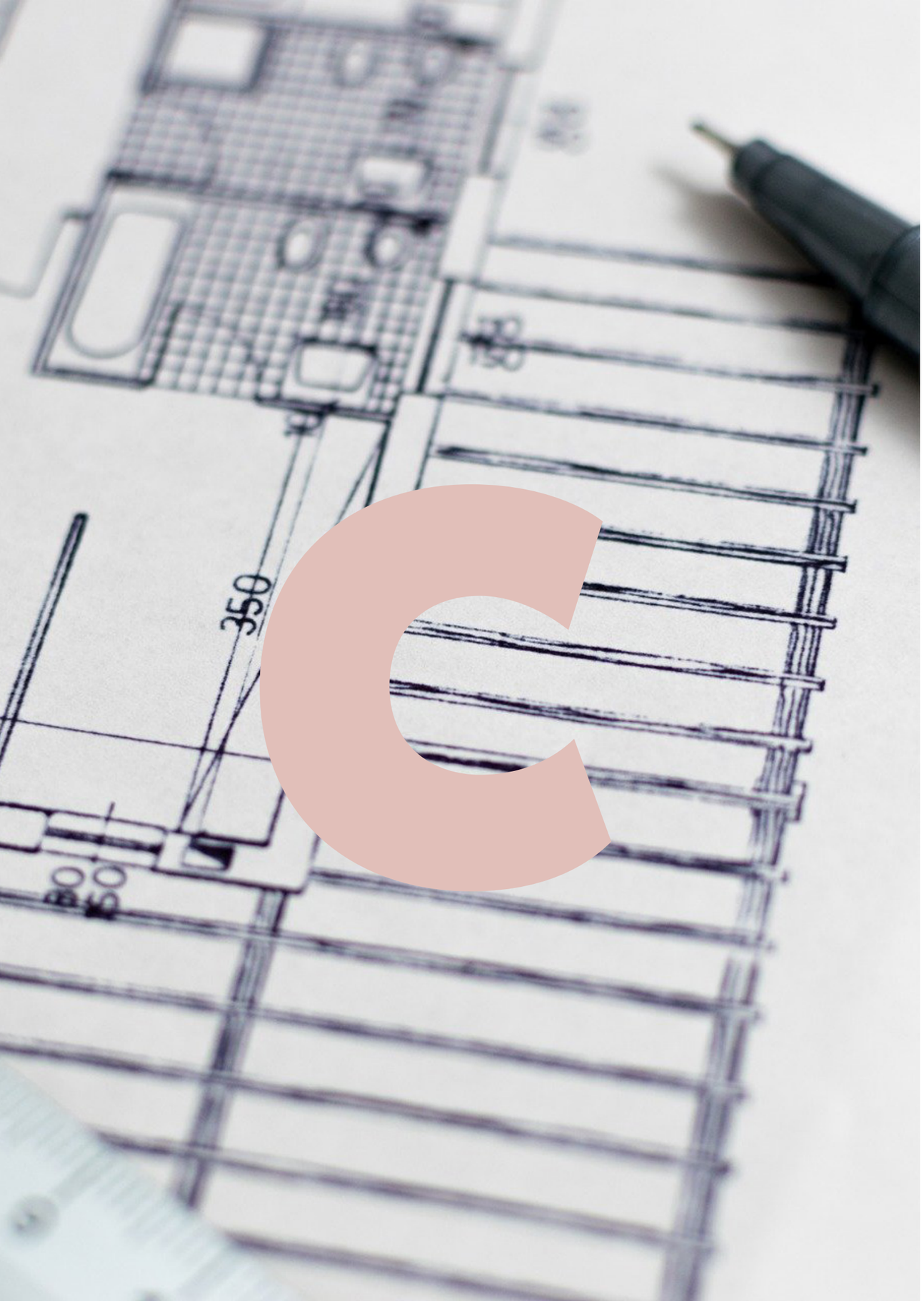
Agility

Intuitive design

Customization

Sustainable design

Figure 24. Main trends found from the trend analysis.



Develop & validate

After the information was gathered and analyzed and the different insights were stated, it was time to decide the direction for the project. This chapter includes the future vision proposed for telemonitoring services and its explanation of how it is different from the current context.

6. The future of telemonitoring: The future Vision

When designing, stating a future context is a very important part of the process to have solutions that would fit the dynamic environment. This context is influenced by

> ***"Notions or measurements of the (physical) surroundings, and any meanings users may attach to various properties, but it could also be comprised of any idea, observation, belief, or even obsession the designer holds and regards as appropriate for the project"***
>
> ***(Hekkert & Van Dijk, 2011).***

Consequently, factors around the context should be considered, like trends, cultural developments, behaviors or even human principles and needs. Having a future vision help define a framework to work on and contributes to the creative spirit needed for innovations. It is also a tool to align the needs and desires of the different stakeholders and to trigger discussion regarding the opportunities for a certain field.

In this project, a future vision was created to guide the design process. This future vision is about peri-operative care with telemonitoring services, focusing on the role of the nurse, the patient and the smart system. Its creation was based on the outcomes of the research phase that provided insights regarding beliefs, behaviors and tendencies around telemonitoring.

6.1 The Challenge

Before presenting the future vision, the current state needs to be stated to understand the problems that need to be addressed and the opportunities that arise and that will be the basis for the desired future context. As mentioned in the research stage, nurses already have a large number of tasks given the nature of their job: patient monitoring, medication administration, operate medical equipment, perform diagnostic tests, documentation, assists on surgeries or other medical procedures, among others. Here a distinction needs to be made between the type of tasks a nurse has. They can be either elective procedures or emergencies. Elective procedures comprise all practices that are scheduled in the hospital to respond to a clinical condition of a patient. On the other hand, emergencies include all the procedures that are not scheduled. Tasks are often interrupted by emergencies (e.g., sudden deterioration on patient's condition or life-threatening situations) and because of the unanticipated and unexpected nature of these situations, nurses' workflow is disrupted.

Figure 25 shows how this situation for the year 2020. Here, Emma, a surgical nurse, has a scroll with all her tasks on it. This is a representation of the number of tasks, as it can be felt as a "never-ending list". We can see how the word "Emergency" is written in capital letters several times in this list to show its intrusion and disturbing effect it has on nurses. Next to Emma is Noah, a patient from a recent surgical procedure. He feels overwhelmed, as his physical and mental condition is still impaired due to the medical procedure. He needs to take care of different things, like being aware of eating properly (having the right food at the indicated hours), having the medication on time, ensure that the wound is properly cleaned and is healing, and so on. However, the lack of medical knowledge makes him scared of possible side effects or complications he might have. This builds a barrier with nurses, who need to calm the patient and explain the situation, which takes time that given the amount of tasks, they don't have and thus, can't properly connect and interact with patients.

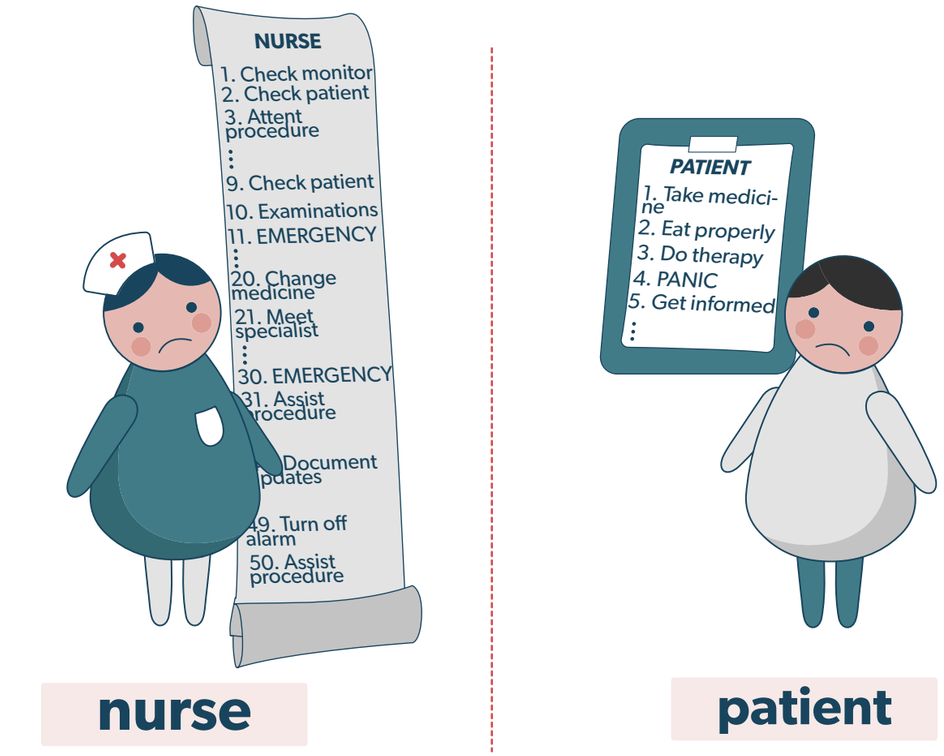


Figure 25. Overview of the nurse and patient's responsibilities in the year 2020 without telemonitoring services.

This situation is intended to change in the future, by the implementation of telemonitoring services. The inclusion of a smart system in the context of peri-operative care opens a door to the automation of some tasks and the support of others. Those burdensome activities that nurses don't feel comfortable or motivated to do, can be done by technology. For example, documenting the updates on the patient's con dition, diagnosis and treatment is an assignment that can be done by technology as it doesn't require a specialized skillset or human-related abilities. This use of smart systems can help reduce errors in the documentation that are due to staff's exhaustion and distress at work. On the other hand, smart systems can also provide support on some tasks, for instance in monitoring patients.

Technology allows the collection of patient's data (physiological variables like vital signs), its analysis and presentation of information in a way that gives a clear idea of the patient's status and that allow staff to take actionable and informed decisions. With the developments in technology, data can be collected outside the hospital environment and providing continuous care in the home context and after the discharge period. This is crucial when detecting complications to treat them on time.

As presented in Figure 26, by the year 2030, thanks to telemonitoring Emma will count with the support of a system that will take some of her tasks. In this figure, she no longer has a scroll with the tasks but a clipboard and the system is the one with a scroll. This represents how the system will now take many demanding tasks of the nurse, to reduce their workload. Emma will now be able to focus on the tasks she enjoys the most, like sharing time with patients. By the reduction of tasks, stress levels can be reduced, which will help improve care of patients, share a better and higher-quality time together, which will nourish the patient-nurse relationship. This time with patients can be used to support and instruct them on their care so that patients can actively seek for their wellbeing and know how to achieve it. As we can see, now Noah is no longer nervous for its status as he is empowered with knowledge shared by Emma and the system and now know more about his condition and how to act upon certain situations. This will in turn be seen in a reduction of the overall medical procedures, as patients will be more aware of their state and be healthier, decreasing the possibility of getting sick and thus of needing medical attention. And in case there is a deterioration in the patient's state, it can be detected by the patient on time so that an emergency can be turned into a scheduled procedure. The system will also enable this situation by support in complication forecasting and risk assessment through analysis of the "telemonitored" data, as seen in its task list.

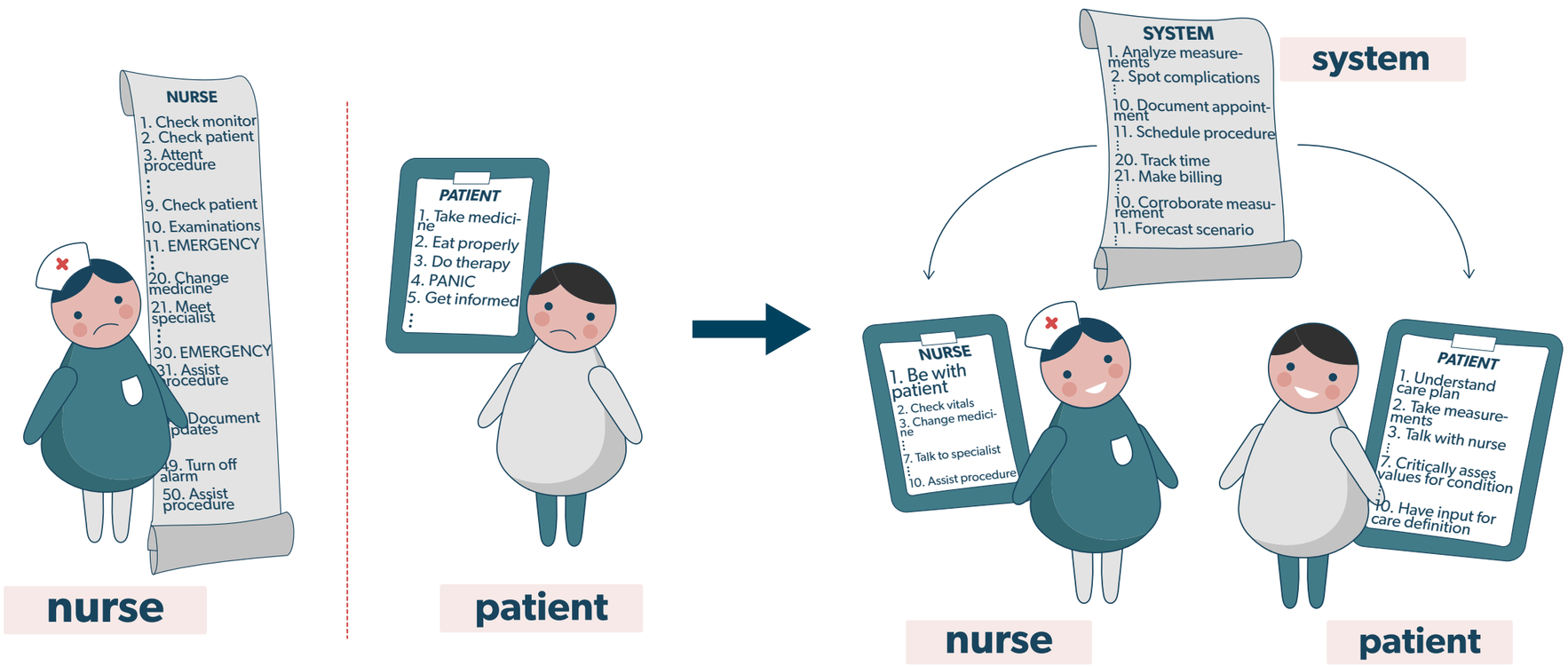


Figure 26. Change in the nurse and patient's responsibilities between the year 2020, without telemonitoring services, and 2030 after the implementation of telemonitoring services.

6.2 The Proposal

One of the main goals of the current peri-operative box project is the reduction in readmissions. Readmission can be considered as emergencies as they are not planned, and the hospital and the different actors involved in them (specialists, nurses, patients) are not adequately prepared to attend them. As mentioned before, the healthcare specialists need to perform different procedures to determine the state of the patient, spending resources and time that were initially destined for other purposes. This increases the expenses of the hospital. To cover these unforeseen expenditures, the hospital needs a reduction in other areas, reducing the budget of some departments. It can even lead to a "cut" in the overall payroll, which can negatively impact the service itself, making it slower due to the lack of resources (both human and physical), closing the loop presented in Figure 27. These dynamics are also seen for emergencies, given their "unexpected" nature. Consequently, the future vision presented in this project extends the aim of telemonitoring services in peri-operative care to:

1. Decrease the overall amount of medical procedures.

2. Reduce the number of emergencies by transformingi them into scheduled procedures.

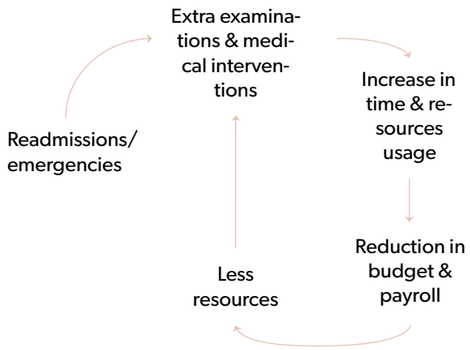


Figure 27. Impact of readmissions in hospital dynamics.

Here a proposal around **education, innovation and research** is made as the source for fulfilling these aims. But before explaining the way these goals will be achieved, let's further explore how they will be progressively accomplished in time.

Figure 28 presents an overview of the state of the goal in four different scenarios. First, is the 2020 scenario, which shows the context before telemonitoring services, in this case, the peri-operative box. Then, there is 2021, which is the current state of the service, based on the definition and first implementation and trial of the peri-operative box. Third, is the first future scenario, 2025, to see how changes in a gradual manner and short-term goals for these services. Finally, is the long-term vision, where 2030 includes the ideal scenario for telemonitoring.

2020

We start by 2020, which presents the initial state of the number of procedures and the basis to assess the efficiency of telemonitoring services. This is shown by the pie chart, where there is a high percentage of emergencies that need to be attended. Given the high number of emergencies, the work of the nurse is disrupted, and the levels of stress increase due to the unplanned activities that arise. This is seen on the rectangle on top of the pie chart, which represents the state of the nurse and the patient at this point and relates to the visuals presented in Figure 25 and Figure 26. Without the existence of a system, the nurse has a lot of tasks to perform and the patient "is on its own" after being discharged from the hospital. This also translates into a barrier between the patient and the nurse, as they can not interact once the patient leaves the hospital and, during the hospital stay, the relationship is distant (represented by the space between the two characters in the figure) given the reduce time the nurse has available to share with the patient due to all the tasks she needs to fulfill, written in the "never ending scroll".

2021

In 2021, the first iteration of the implementation

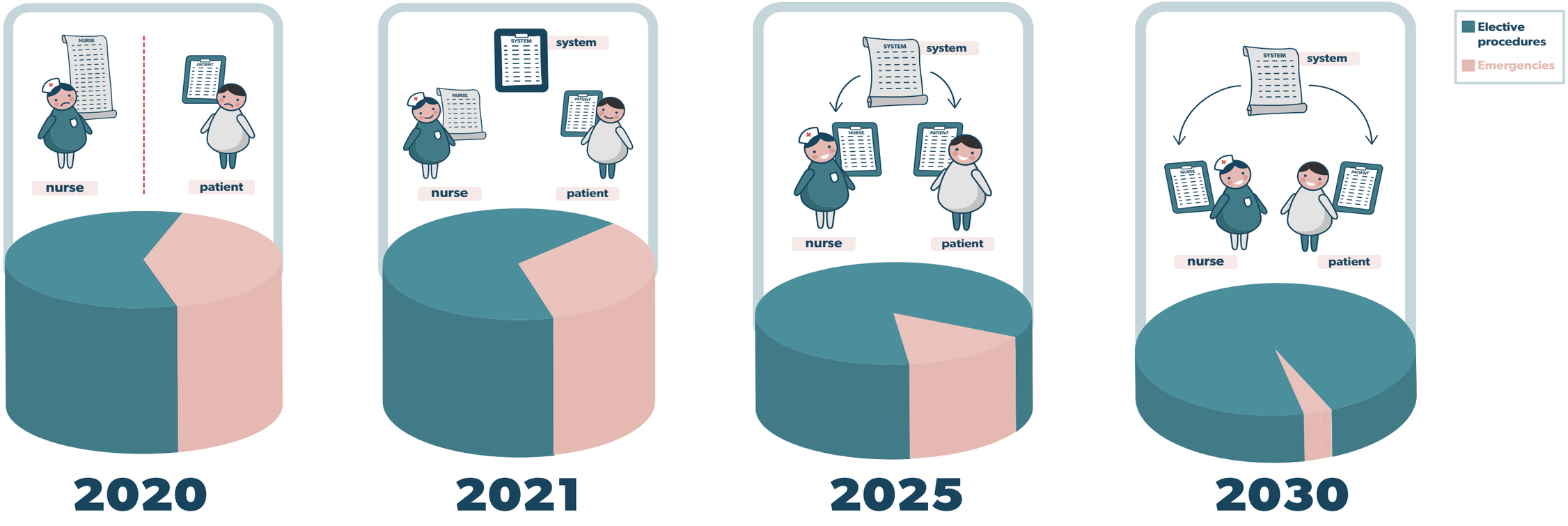


Figure 28. Changes over time on the amount of elective procedures and emergencies with the introduction of telemonitoring services and the impact on nurses and patients' tasks and relationship..

2021

of the peri-operative box takes place. Here, a smart system is introduced, that will allow for continuous monitoring of patients outside of the hospital context. This will enable an extension of care provision and of the contact between the nurse and the patient, eliminating the barrier from 2020. Throughout the data collection and its analysis, now more informed decision on the patient's condition can be made. It also brings the possibility to forecast complications by studying the patient's recovery process more closely, based on the values of the measured vital signs. This will in turn allow for the reduction of emergencies by turning them into plannable procedures as seen in the pie chart.

In the research phase, it was presented how one of the main problems of telemonitoring for staff is the high workload. Besides their current tasks, with the introduction of telemonitoring new tasks arise, like the analysis of "telemonitored" data which is consider burdensome given overabundance of information. Consequently, a system that support nurses in those tasks that only represent a burden and they are not motivated to do, will have a positive impact on their job environment and even on their performance. For example, the system will support the collection and digitalization of monitored data, which will give them more time with the patients, increasing their satisfaction at work and the relationship with the patient. The system will also offer support for patients, by giving them information on their health status from their home, which will help them be more in control of the situation, by knowing what "is going on with their bodies". The familiarity with the data will act as positive feedback on the relationship with healthcare staff, as more information (and more valuable) can be exchanged.

2025

By 2025 telemonitoring services will be further improved, allowing for the extension of the support and functionalities of the smart system. Now, as we see in the rectangle above the pie chart, the system's tasks are written on a scroll and the nurse's tasks on a clipboard. This represents the switch of the effort from the nurse to the system, where the automatable tasks, like administrative assignments, are automatized and the human resources can focus on the ones that motivate them, like human interaction.

Here we can see how the nurse and the patient are getting closer to each other, as they can share more time together, where the nurse can offer the support they need and with better quality. This support will be on educating and making patients more aware of their condition so that in turn, they will be able to critically assess their recovery state and know when they are having a complication, helping to transform it into a scheduled procedure; or even by keeping healthier lifestyles that reduce the overall need for medical interventions.

Also, the system will improve on its performance on complication forecasting and outcomes prediction. This will in turn have an impact on the number of emergencies, reducing it gives the timely intervention and the possibility to plan for them.

2030

Finally, 2030 presents the ideal scenario where emergencies are almost a negligible section of the pie charts, as with all the advancements in technology and patient education, they can be avoided and turned into elective procedures. The smart system will fully support both the nurse and the patient in their own tasks and contexts, and it will even promote and foster the relationship between them. It will provide the nurse with more time to focus on patients and offer tools to better empathize with patient and know how to considerate and empower them for clinical decision making.

For patients, the system will offer education to increase their knowledge and confidence around medical contexts that will in turn improve the interaction with the medical staff. This is seen in the rectangle above the pie chart by the closeness and "barrier-less" interaction among the staff in the nurse, where the system act as a mediator.

With this on mind, is now time to present the overview of the journey that peri-operative care needs to undertake to arrive to the scenario presented in Figure 26. Figure 29 presents the future vision. This vision represents the mindset around peri-operative care supported by telemonitoring. It takes the reader through an expedition along the four previously mentioned scenarios, to see how telemonitoring services would change over time and some of the transformations needed around the roles and tasks of main actors involved (the patient, the nurse and the system) for its successful implementation. This vision addresses different topics that range from the overall explanation of the process for implementing telemonitoring services in surgical contexts, through the changes needed for this implementation to be successful, and up to the dynamics around how is patient care transformed by these services and the benefits and outcomes it brings. The following sections will explain the future vision and its different parts in more detail.

1. Shift from hospital to home mindset

Figure 30 shows two main settings for peri-operative care services. These are contained in circles and are the Hospital and the Home contexts.

1. The hospital context represents the place where the surgical procedure is performed and where the patient would go in case of any emergency of if some extra interventions are needed. It is representation for all the activities that will take place within the hospital facilities, as they require the use of the available resources (material and human).

2. The at home context, includes the environment where the patient goes after being discharged from the hospital and where the pre-surgery phase and the recovery take place.

As mentioned before, the vision is a representation of the mindset around telemonitoring for peri-operative care. In this case, a journey from the hospital to the home context signifies how this last one will become increasingly important and, in a future, be the main setting for patient's care. Healthcare will shift its focus from the hospital context to the home context, making the patient a central user that needs to take an active role for the system to work effectively.

Both contexts will continue to exist in the year 2030, however, most of the care will now take place at home, and the hospital will only be used when specific resources, which can't be provided outside the hospital context, are needed. The increase in the importance of the home context is based on the continuous advancement in technologies that will provide services that could only be performed at hospital, to be performed at home, for example, some blood test, or image sampling. So, in a future, many elective procedures will take place at home. This increase in the

Road in time for the mindset around telemonitoring in peri-operative care

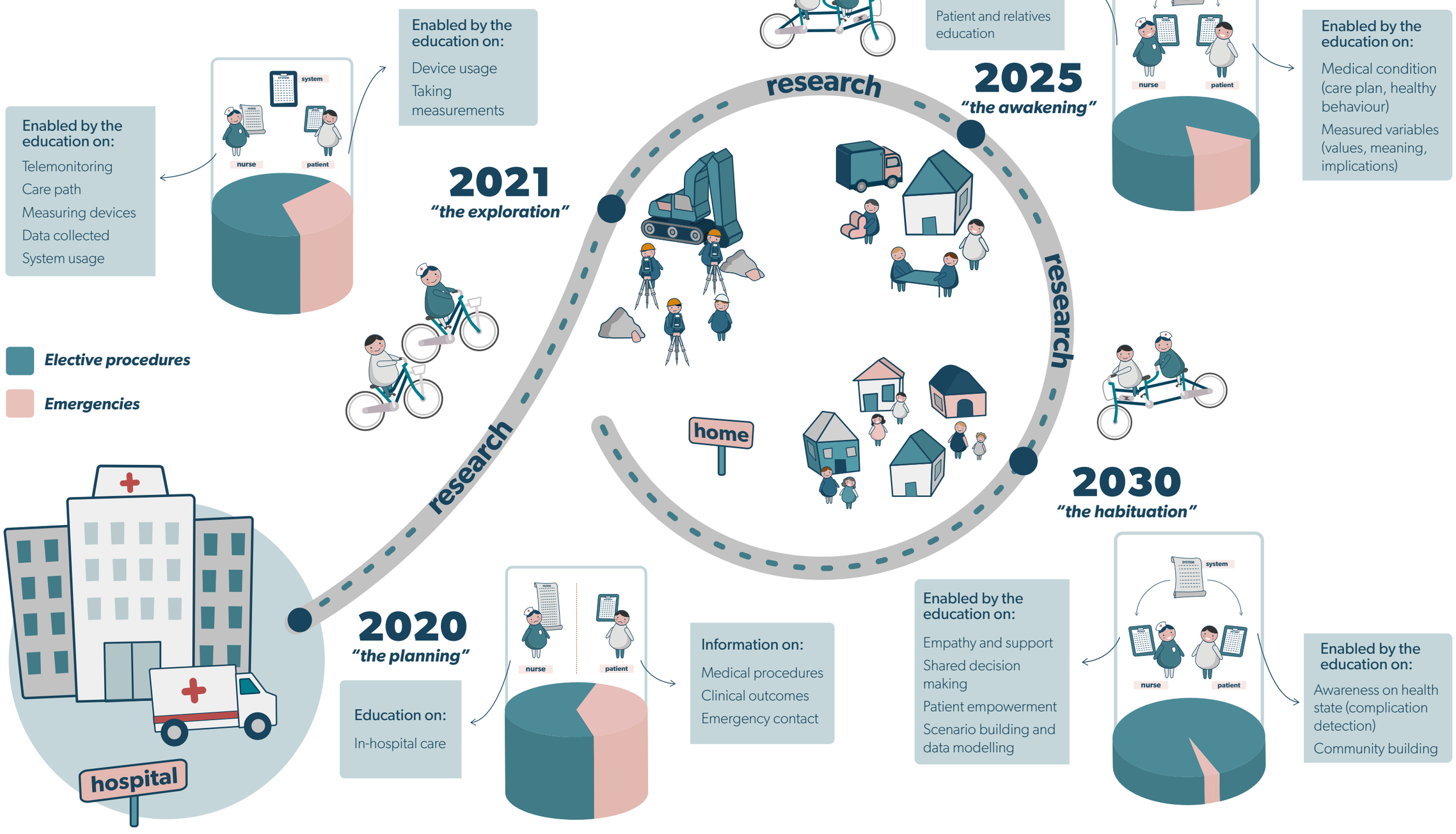


Figure 29. Future vision on telemonitoring services in peri-operative care.

in the home context will also be possible because of the system support on patient's education, allowing patients to get trained on better care and medical knowledge outside of the hospital. This turns into an increased awareness of patients on their wellbeing, which will turn them into active actors of their own care, making their own setting a key part in their empowerment. This represents one of the insights from the user research about the role and responsibility that the patients should take for telemonitoring services to effectively be implemented.

In the circle that represents the "Home context" within Figure 27, some changes are identified in its state. In 2021, we can see how there is no construction yet, as at this stage, the telemonitoring services are only starting to be used and tested. By 2025 telemonitoring services will be already properly implemented, a house is established in the land previously studied.

Here staff and patients are moving into this "new land", where they are discovering different possibilities and with this exploration, adaptations to the system are made to fit their needs. In the drawing this is represented by the moving to a new house, in which for example, people would buy new things for the house, to make it a more comfortable place, or even sell those things they no longer use and are no longer needed. At this point, the "field" can be expanded, and new houses can be built, meaning that the system can have new functionalities and different patients and staff can use this system. This is seen in 2030 with the different houses, as each user has its own needs, and the system should adapt to those (this was presented as an insight from the user research regarding trust in smart systems). By 2030, a neighborhood is created, like the patient community to provide support and empower each other on telemonitoring, care and healthy behaviors.

Road in time for the mindset around telemonitoring in peri-operative care

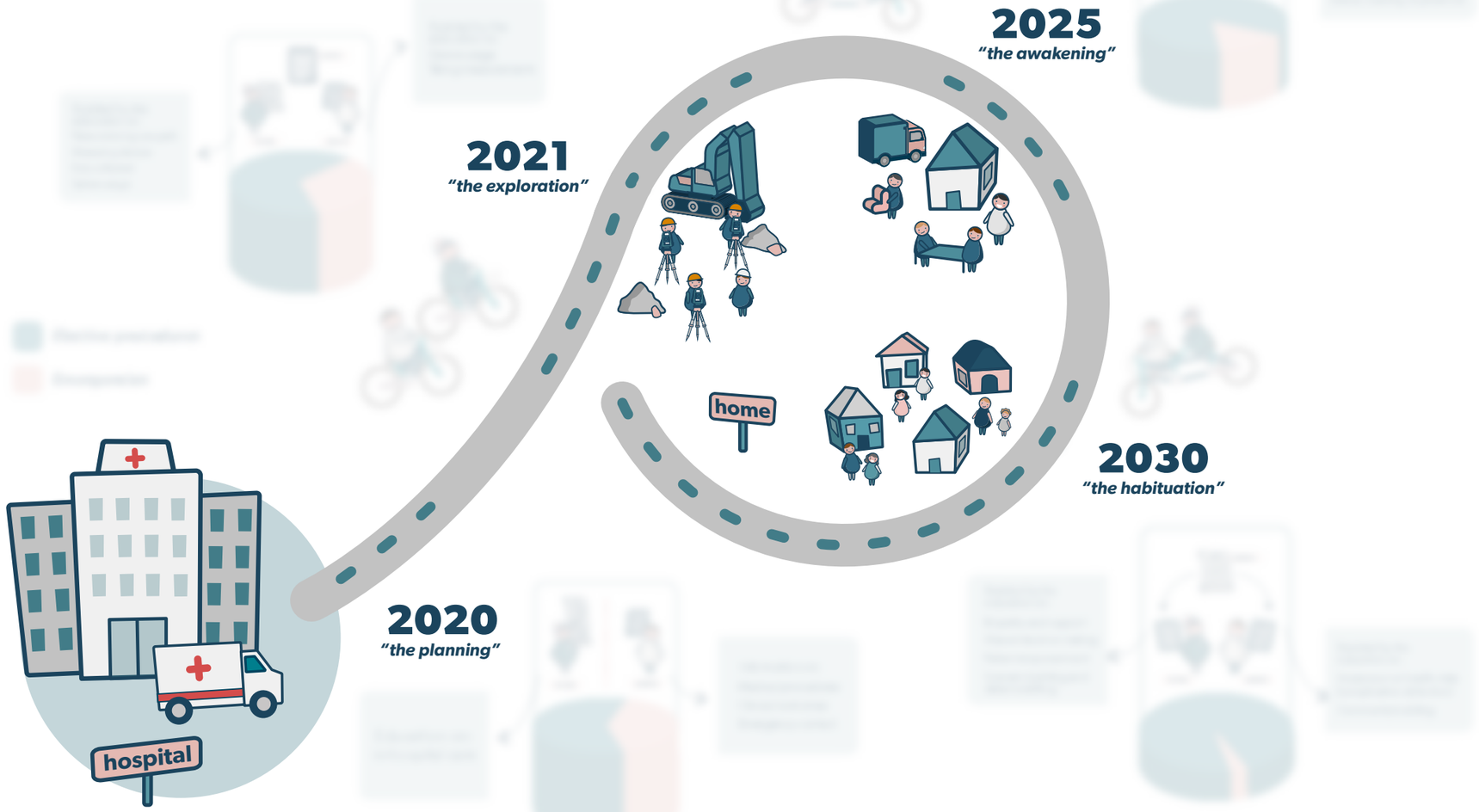


Figure 30. Change on the contexts for the future vision on telemonitoring services in peri-operative care.

2. The journey

Another part of the vision is about the journey itself for the patient and the nurse. Within the visual, there is a road that enables the connection between the hospital and the home context. This road represents the research needed for telemonitoring services to be developed and implemented.

Research can be divided into two main types.

First is academical-medical research, which is based on scientific research around clinical outcomes and patient's data. For example, the use of the data gathered as a resource for an on-going investigation on a specific patient condition, as a control or intervention group, or just the use of raw data. Or the medical research for the development of the system for telemonitoring services, to determine the adequate parameters that benefit the prediction algorithms (for early detection of adverse events and possible complications).

Second, there is academical design research, which is focused on how to design and embed remote patient monitoring systems into the healthcare context, that includes the development of methodologies suitable for this context; and on understanding its dynamics. The consideration of design research as core during the development of these services is vital for addressing trust issues in technology presented in the user research. Design provides ways of understanding the needs of healthcare staff to translate them into requirements and later designs of smart systems that enable and support clinical decisions.

The road is used by the nurse and the patient to develop the desired mindset of having the home context as the core for patient care and keeping an active attitude towards seeking wellbeing and healthy behaviors. To get to this outcome two main things will support these actors: **education and innovation.**

First is **education**. Previously, when discussing the scenarios, it was mentioned some knowledge that the patient and the nurse will need to achieve the overall goals of reducing emergencies and medical procedures and the individual goals of reducing burden and stress and improving the care experience. This is a core area as healthcare will turn into a more preventive than corrective role.

Patients will actively seek their well-being and healthcare staff will facilitate this by instructing them and providing spaces where support is given from other patients and specialists. Patient's education focus on preparing them for the surgical procedures and examinations, their medical condition, the adequate care around it and the monitoring process itself.

On the other hand, staff education is about the use of smart systems; the new dynamics and tasks required for telemonitoring; acknowledging patients as active actors, their needs, wishes and experiences; empathic interaction and a way of supporting, understanding and fulfilling patient's requirements. This will keep the focus of the healthcare staff on the interaction with the patients and not with the system, which was expressed as one of the main interests of staff during the user research. In general, the goal of healthcare staff will shift from a reactive attitude to a more proactive one, focusing on training patients to prevent diseases.

Second is **innovation**. In the previous sections, it was mentioned that a system needs to be developed to enable telemonitoring services. It was also expressed how it will support patient's care through complication forecasting and provision of information and guides to patients; nurses' activities by automation of some tasks; and education of both patients and staff. The development of this system is addressed in the vision as innovation. This area is divided into two types.

First is new product development, in which radical innovation is involved and includes the creation of new services and products around telemonitoring strategies. This will be a fundamental part of telemonitoring during the initial stages, as most of the technology and tools required for the implementation of these services, needs to be developed.

Second is continuous improvements or incremental innovation, which involves a baseline to start working on enhancements of the current options. Consequently, first, the service needs to achieve its critical mass regarding development, where no more "new" things are introduced or created, but there is a need for focusing on improving the existing ones. This also acknowledges the challenges presented during the user research section, about the healthcare context, which require time for the approval and implementation of new strategies, given the need for testing and validation.

3. Stages of telemonitoring implementation

As mentioned before, this vision presents the reader with a journey for the implementation of telemonitoring services in peri-operative care. This involves different stages for a stepwise approach, where the technology and changes it entails will be made progressively, to avoid overloading the actors with sudden and disruptive modifications that might not be welcomed. Consequently, the vision uses the construction and setting up of a new neighborhood to explain the different stages to ensure its understanding through a well-known context.

Road in time for the mindset around telemonitoring in peri-operative care

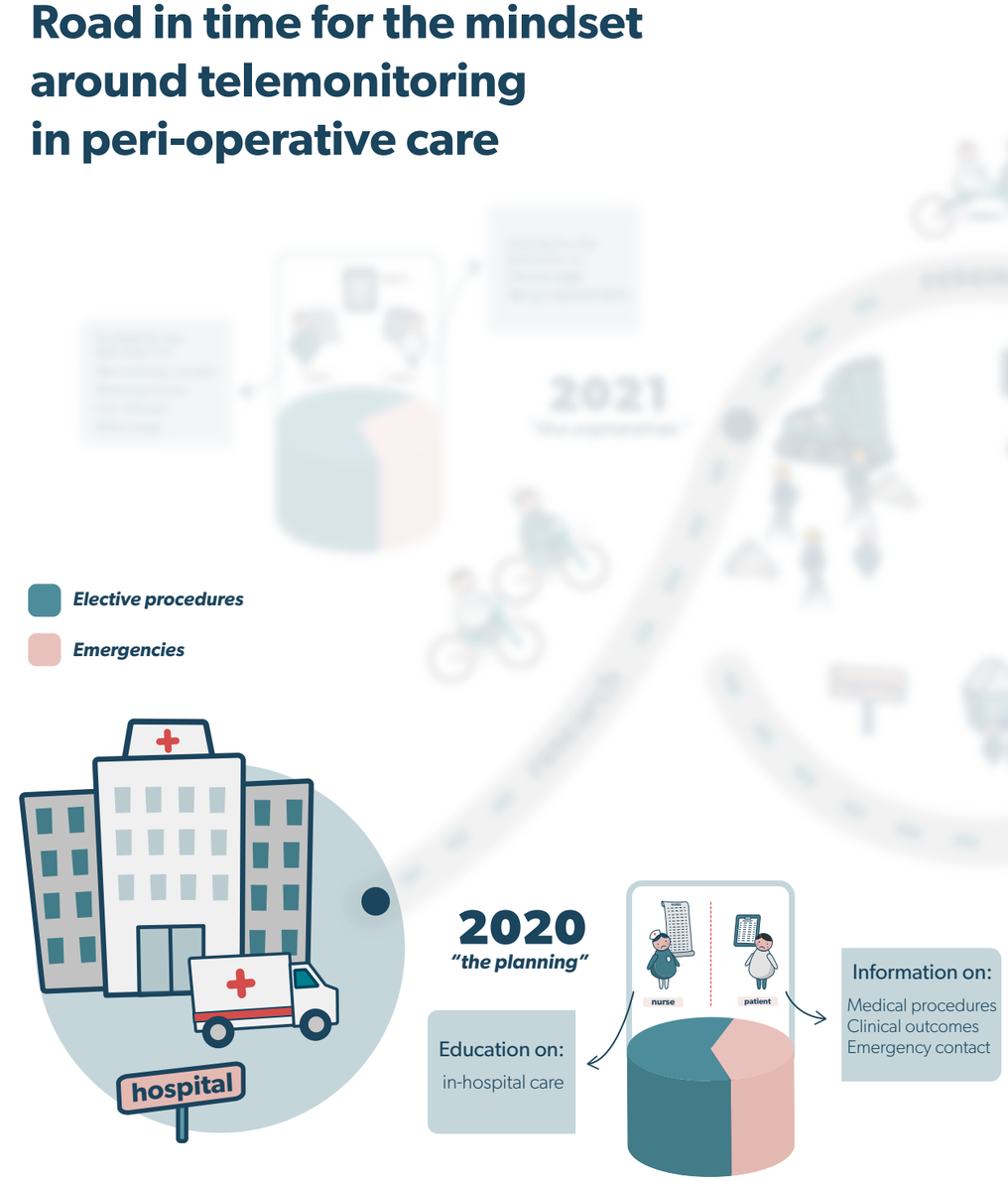


Figure 31. First stage in the journey regarding implementation of telemonitoring services in peri-operative care.

2020

As presented in Figure 31, the first stage is called **"The Planning"**, where the idea around the implementation of telemonitoring services arises and is initially studied. This emerges as an initiative from the hospital context, given the need for the reduction of readmissions, through the improvement of care provision, especially from the moment that patients are no longer in the hospital environment.

In 2020 the nurse is overwhelmed by all the tasks she must perform and her role focus on providing care to the patient at the hospital, administrative tasks (like the ones discussed in the previous section), and attending emergencies, which are very common in a nurse's routine.

On the other hand, the patient is constantly worried over the condition and outcomes from the surgery and does not receive any education but is informed about the medical procedures on the care plan and the logistics around it.

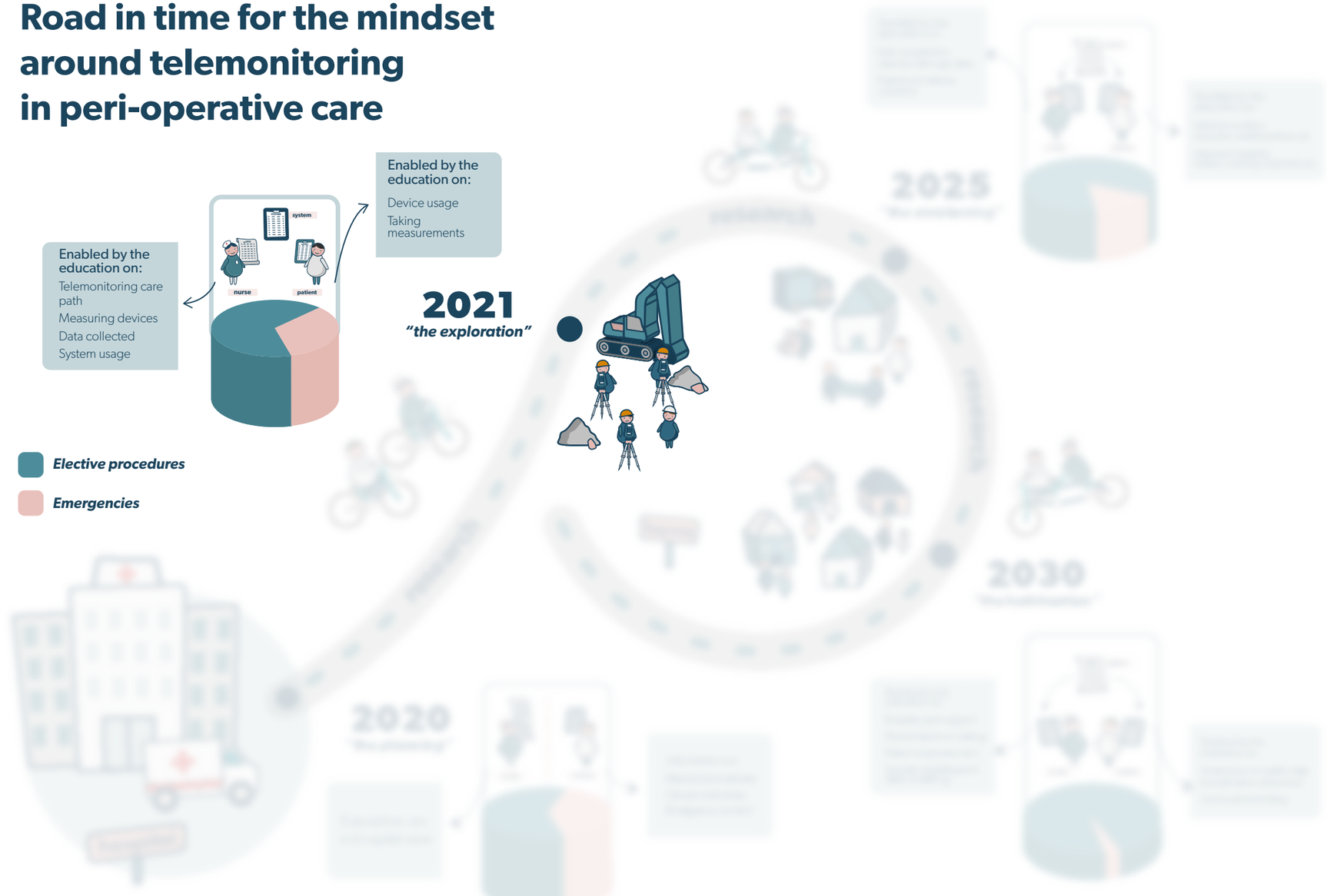


Figure 32. Second stage in the journey regarding implementation of telemonitoring services in peri-operative care.

2021

Moving to 2021, **"The Exploration"** stage starts, where the home context is now accessed through telemonitoring services. The visual in Figure 32 shows how the road moves from the hospital to the home context, as the mindset will now start to focus on providing care to the patient in their settings, outside of the clinic. This is compared to land surveying and mapping that is performed before starting any construction. In this, some actors are sent to determine if the land is suitable for construction and what is needed so that it can be prepared, and the foundations can be built. 2021 focus on data collection for the development and testing of smart systems, like algorithms for prediction of adverse events; the adequation to the ecosystem around it, for example, how patients behave in the at-home setting; variables that are introduced to care provision, as relatives (in this document the word relatives is used to refer to the people closest to the patient, her/his loved one and those he/she share their daily life with, which include friends or family), daily schedules and routines, work and social activities; among others.

At this moment, with the introduction of the system, the dynamics around the nurse and the patient change. Now nurses will also learn about the use of telemonitoring devices and systems so that they can actively look into the patient's condition (through the data collected) and determine the possibility of a complication. This will in turn help forecast and prevent it or turn it into a scheduled procedure. This task will also be supported by the system, through an algorithm that with time, will improve its accuracy. Additionally, patient education starts and with monitoring from home, by the devices and system provided in telemonitoring services. As with the nurse, making patients aware of their data will help them understand when their condition is deteriorating or improving, to adequately determine, prevent and act upon emergencies.

Road in time for the mindset around telemonitoring in peri-operative care

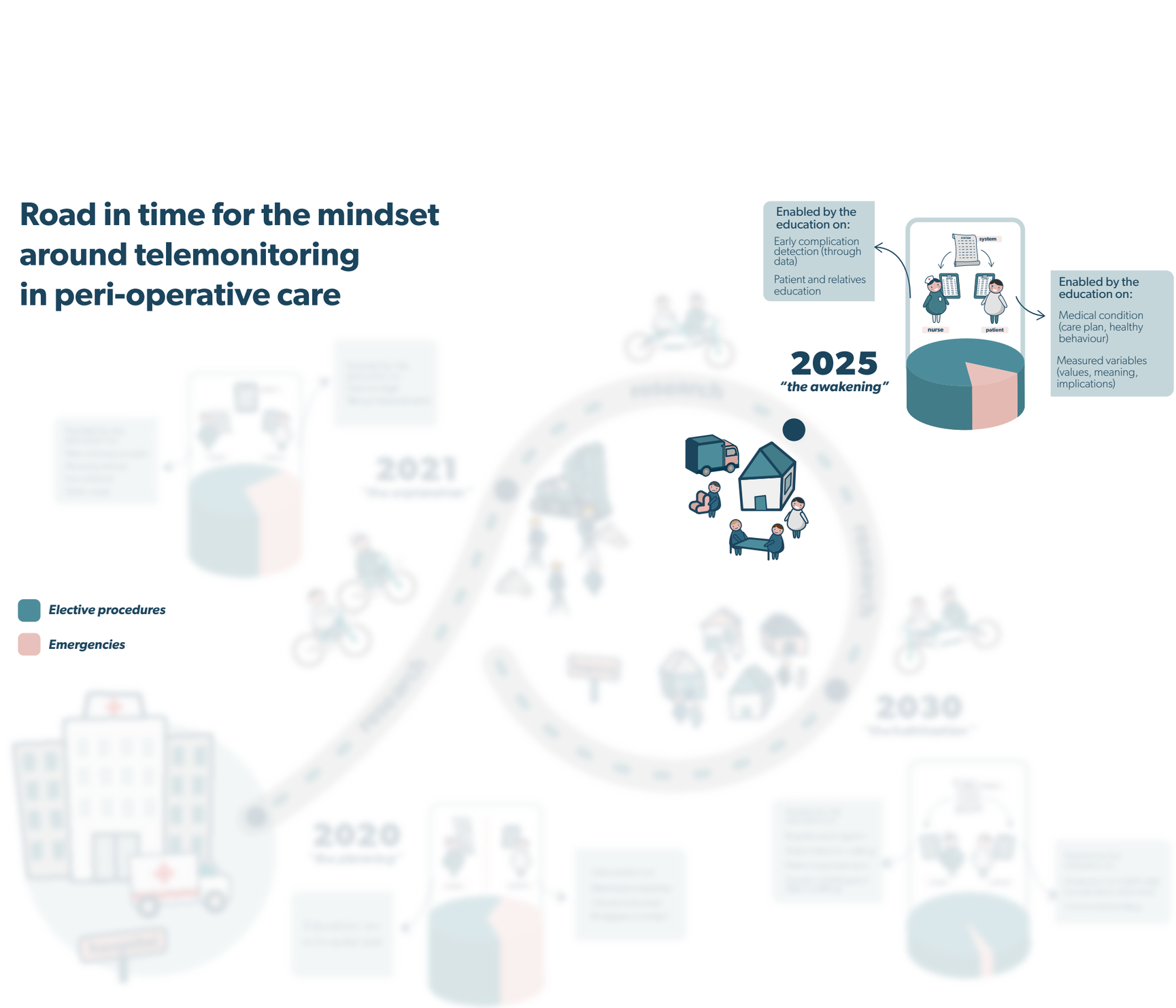


Figure 33. Third stage in the journey regarding implementation of telemonitoring services in peri-operative care.

2025

As presented in Figure 33, 2025 is called **"The awakening"** stage and this refers to the moment where the shift in the mindset of the actors involved reaches its peak by getting to a level of consciousness about care. As mentioned before, the vision makes a comparison with the process of people moving to a new house, a process that requires actors to be very active and providing continuous feedback and proposals on what is needed, what can be thrown away, and, in the end, how to organize all the things in a way that makes them feel comfortable. For telemonitoring, patients and nurses will try these services and lead them to take active roles, where they get the most out of the data and even provide input so that the system can be improved to better fit their needs.

Given all these system improvements, emergencies can be avoided and "scheduled" by forecasting complications. Additionally, as nurses will be more conscious and knowledgeable on data collected, they can achieve earlier complication detection and help train the system, having a critical role to improve its accuracy. The system will also take care of many of nurses' tasks so that they can focus on their preferred activity: to be with the patient. This time will be invested in educating patients, regarding their condition, care around it and even more medical-related knowledge on the measured variables to empower them to become active actors in the process. As before, patients will help reducing emergencies with the increasing knowledge, understanding, and awareness of their condition and now even with the overall reduction of medical procedures with the improvement of their health condition.

Road in time for the mindset around telemonitoring in peri-operative care

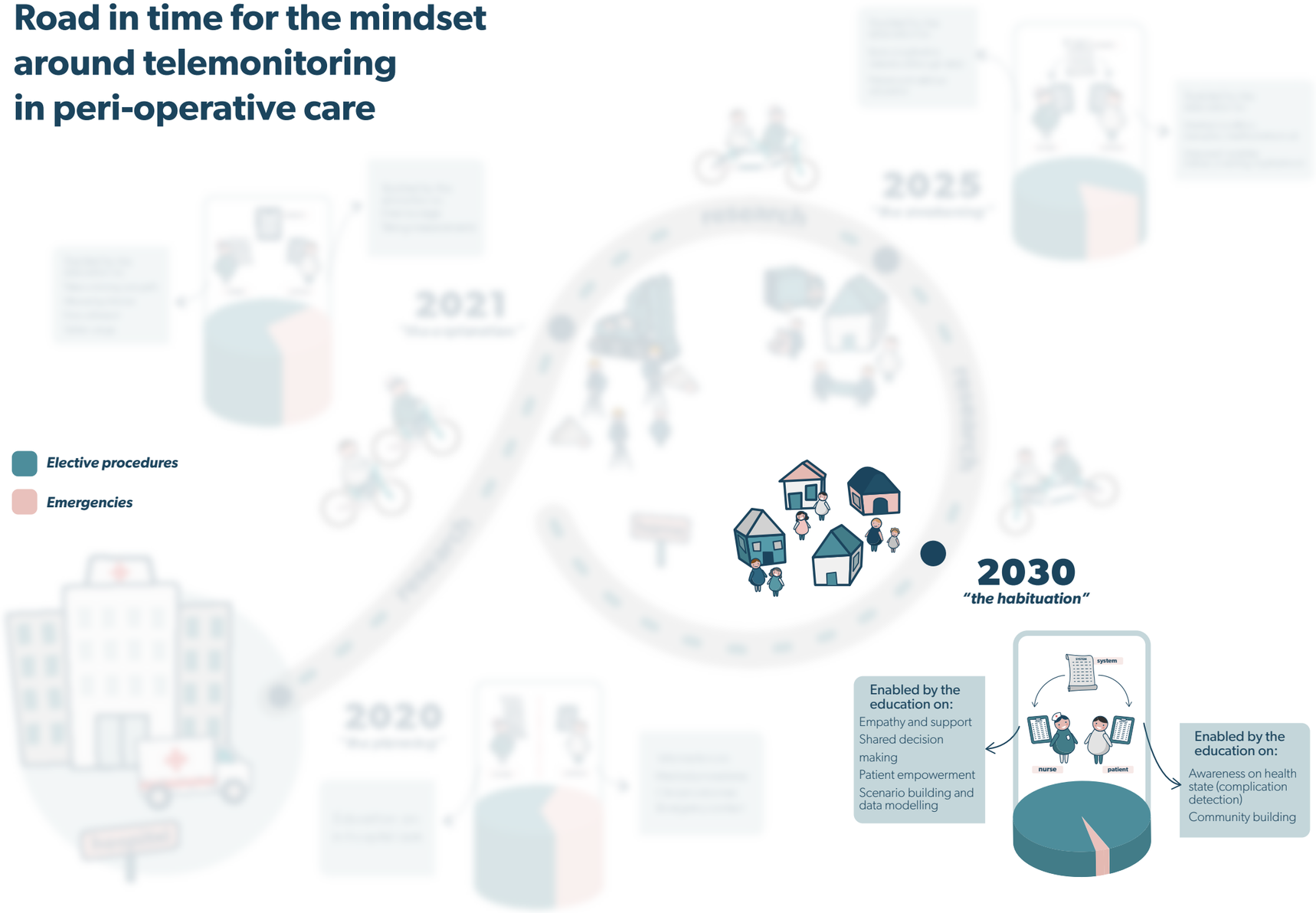


Figure 34. Fourth stage in the journey regarding implementation of telemonitoring services in peri-operative care.

2030

Finally comes **"The habituation"** stage, where telemonitoring services are now smoothly integrated into the nurse and the patient's daily routines. In Figure 34, this is represented by the establishment of a neighborhood with different houses, as the system will allow for customization and adapt to the different users' needs. In this final stage, nurses will now take a more supportive and "secondary" role in patient's care. They will mainly seek shared decision-making and let the patients be in charge by providing them with the necessary knowledge and advice. These learnings will focus on prevention, more than correction, and relate to healthy behaviors, which will, in the end, help reduce the need for medical procedures.

Moreover, monitoring in the pre-surgical phase will provide information to assess the outcomes of the surgery, to adjust the care plan and the resource allocation around it. Nurses will learn to determine and analyze the creation of scenarios, based on different patients' conditions ad characteristics to find the best fit. Furthermore, technology will bring new possibilities like the creation of online communities for patients, where they can learn from other's experiences and how to support each other.

4. Patient & nurse relationship

The last part of the vision is about the dynamics around the patient and the nurse's relationship in peri-operative care. Before, we mentioned that the nurse and the patient will use the road in the vision to get to the desired mindset. But how are they going to travel? Here, a bike ride was chosen to enable both actors to enjoy the landscape while on their journey and be aware of the surroundings and the changes throughout it. To change the mindset, the nurse and the patient need to be conscious of their actions, but they also need to have a pleasant experience so that they accept and embrace the changes needed. Throughout the vision in Figure 35 there is a picture of how the nurse and the patient are riding at the moment where they are almost entering the next stage, so right before 2021, 2025, and 2030, showing the achievement from the previous stage and what is required to continue the journey.

The nurse and the patient will go to the first stage by a normal bike, each on their own bike, however close enough so that the nurse can guide, and the patient can follow and doesn't get lost. In 2021, the nurses will have the most control of the services, as they will be the ones analyzing the data and keeping track of the patient's recovery. The patient is seen more as a passive actor, who needs to collect data but doesn't necessarily use it as they lack the required knowledge to make the most out of it.

Continuing the journey, we can see how near the third scenario (2025) the patient and the nurse are going on the same bike, and now is not a manual bike, but an electrical one (e-bike). These e-bikes are commonly used when the cyclist needs (or wants) some support, as the motor provides power and reduces the effort the rider must do to move the bike. This is a representation of the system that will be built around the services, which will do some of the tasks of nurses, to lessen their workload and allow them to focus on their preferred (and most important) activities, like patient care. Moreover, with the

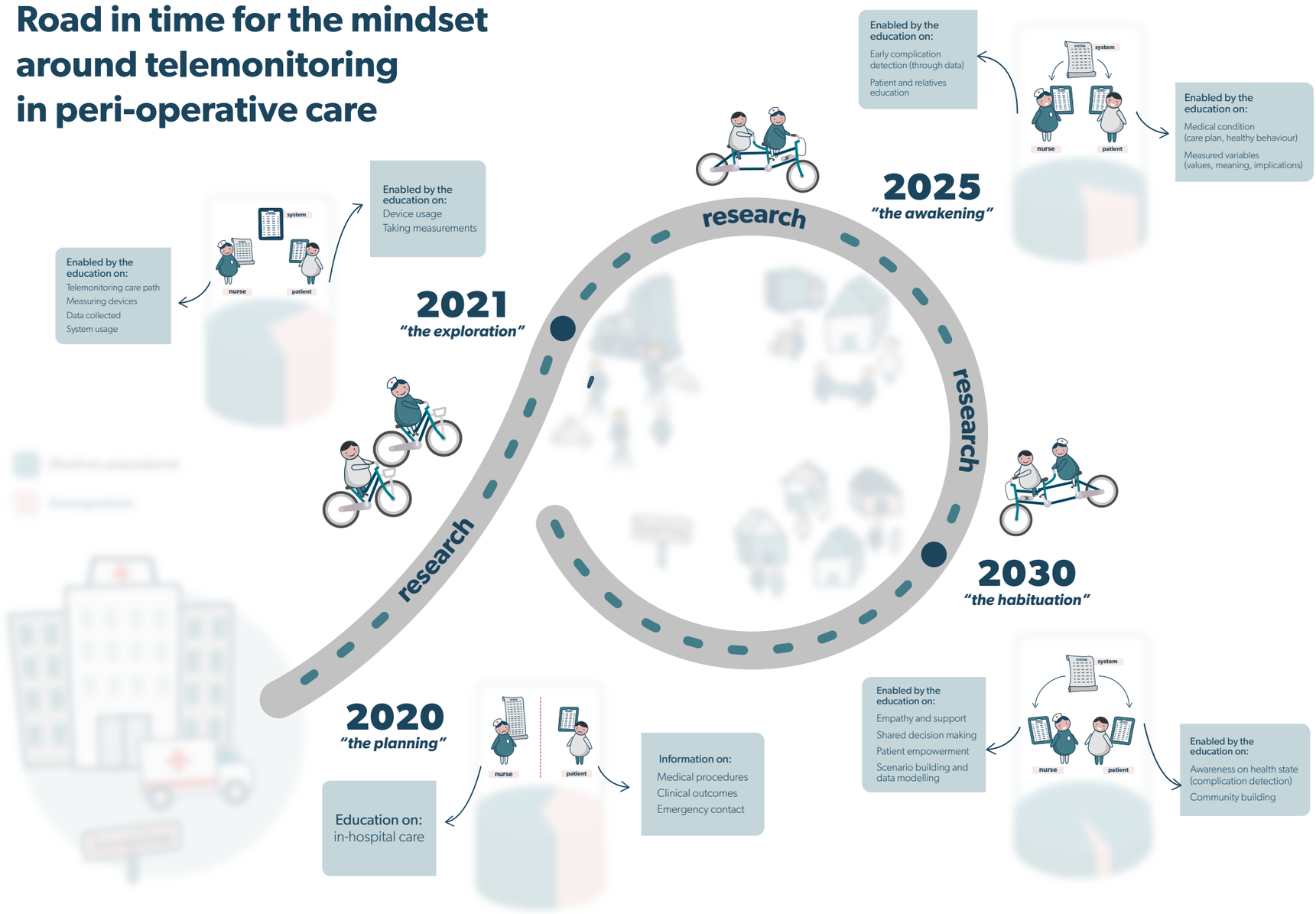


Figure 35. Overview of patient and nurse relationship and throughout the entire journey regarding implementation of telemonitoring services in peri-operative care.

continuous use and promotion of telemonitoring services, patients will be more knowledgeable of their condition, their care, and the uses and benefits and telemonitoring and the data it provides. Here the nurse is still the one guiding the patient in the process, as awareness is only being created among patients. Nevertheless, nurses are striving for empowering the patients so that they can be in control of their own health. In the visual, it is represented by the nurse being the pilot of this shared bike, and the patient the co-pilot.

In the last stage, given the developments in the system to support and extend education to patients and nurses, both actors will achieve a high level of consciousness on their own responsibilities and roles. The patient will be acknowledged as an active actor who can take part in clinical decision-making and even be in charge of it, by making informed judgments and choices. Now the nurse will be able to enjoy the surroundings and have an "eagle" look on the patient to provide guidance when they feel lost, without taking away their power or freedom as the pilots of their own care pathway and healthy lifestyle. This is seen in the vision by the patient being the pilot of the bike and the nurse takes the position of co-pilot.

6.3 Detailing the future vision

Figure 36 presents a more detailed explanation of the future vision. If the future vision is seen as the strategic roadmap, this can be the tactical roadmap. It includes how will the future vision be achieved by describing the changes needed in the areas (staff and patient education and innovation) that enable the fulfillment of the main goals of telemonitoring services (overall reduction of medical procedures and transformation of emergencies into scheduled procedures). This visual includes specific actions that healthcare staff and patients need to do, and learnings needed to fulfill them. Regarding innovation, it addresses the functionalities and features smart systems will have in order to provide adequate support to the actors in each stage. The system can be described as support in four main tasks:

1. Prediction of emergencies.
By data gathering and analysis, a better follow-up of patients can be done that allows for early detection and treatment of complications or adverse events. By continuously monitoring patients, signs of deterioration can be spotted, and actions can be taken to prevent further detriment of the patient's condition.

2. Education: For patients and staff.
The system provides courses and activities that will help these actors learn at their own pace and at the most suitable time based on their own schedules. The learning, as mentioned before, will change on each stage (stepwise), so that the actors will be better prepared without causing stress or burden due to learning new habits, adapting to new behaviors, in short periods of time (or "out of a sudden"), which is one of the main challenges found in the literature research.

3. Nurses' tasks: Given the technological developments, many of the tasks that are burdensome to nurses can be automized and done by the system, thus improving nurses' satisfaction with their job by focusing their efforts on the activities they enjoy most.

4. Source for research: the data gathered by the system can be used as input or feedback on its performance. The system will feed on new patients, clinical outcomes (data sets and values) to improve the algorithm for spotting complications and the way it is presented to the different actors. Additionally, it can be used as a tool for research clinical management using data for optimization of processes, medical procedures, among others. Moreover, this data can be used for external purposes on other research, to, for example, extend the learnings to the development of clinical decision support tools. This will allow to "close the loop" and to find new sources of value on data use as expressed by some of the experts during the user research.

These tasks are used to classify the different functionalities/features of the system in each scenario. In general, these tasks will be achieved gradually and the focus on each of them will vary throughout the years. In 2021, the system will be mainly used for training the algorithm on spotting the complication (Research), but also, some will already help prevent emergencies by the earlier detection of complications (Prediction of emergencies). By 2025, patient and staff education (Education) will become the core, due to the developments of tools to support it and the increase in awareness and motivation from the actors. Finally, in 2030, the system will bring further support to the nurse by taking care of different tasks (Nurses' tasks), so that in the end the four main objectives are fulfilled. Now let's go more into detail on each of these scenarios.

2020

First, in 2020 staff is trained to provide care to the patient and know how to act if help is needed in terms of medical procedures. In this stage, there is no real patient education, but they are mostly informed about the things they need to be aware of given their diagnosis and treatment. Finally, there is no innovation as the system has not been created yet, the telemonitoring proposal arises along with initial planning on its development.

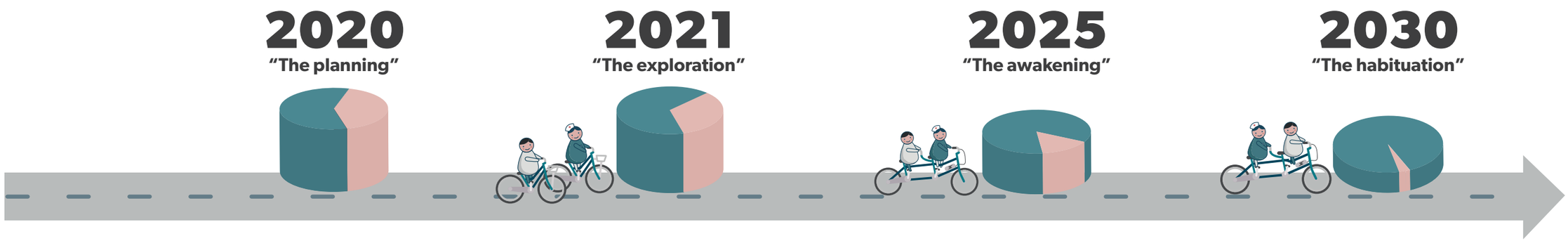
2021

By 2021, innovation focus on the development of the telemonitoring system. In this case, an algorithm that supports the detection of the detriment of the patient's condition is developed (***"Algorithm for adverse events forecasting"***), to identify complications on time. Additionally, a platform that helps nurses to analyze patient's data (***"Interface for data analysis and visualization (nurse)"***) is created to enable them to help train the algorithm and ensure no false positives (or false negatives) arise from data, like a patient being diagnosed with a possible complication due to one value that was a consequence of a mistake in measuring by the patient. Additionally, patients have a platform to check on their data (***"Interface for data collection and visualization"***). The difference in these platforms complies with one of the issues addressed in the research when defining the personas, where they have different requirements based on their experience and relationship with technology.

One of the issues from telemonitoring services found in the research stage was the lack of data integration, which produced a higher workload for nurses, who needed to check different inputs from diverse devices and variables that were used to track the patient's condition. In the end, the patient's state is the combination of all these individual measurements and not each of them separately. In the peri-operative box, a ***"Device and data integration"*** is possible. Nurses receive the data gathered from different vital signs under the same platform, which allows them to keep the overview of the patient in the same place, facilitating its analysis.

2025

Being 2025 "The awakening" stage makes education a key part of it. Consequently, the system



Staff Education

Nurses are trained on how to monitor in-hospital patients after surgical procedures, assessing their state based on patient's data as vital signs, self-reported symptoms, consciousness level, among others.

They also learn to provide care according to the medical needs and condition of patients, like administering medication or wound care.

Nurses are trained on telemonitoring services, on the new care pathway and procedures. Prior to the implementation (and at the beginning) they will meet with data scientists, designers and actors involved in the system development (engineering team) and clinical experts (medical team), all of whom are in charge of the training. The engineering team explain the way data is collected (devices used, variables and measurements) and how it is analyzed and presented by the system.

On the other hand, clinical experts will introduce the clinical meaning and implications of the data gathered so that nurses can assess the patient's condition.

For support on the system or devices, or medical related-issues (data) the corresponding team is contacted.

The system will support training through self-paced courses and videos, that can be followed "on-the-job".

Education is on:

1. Forecasting complication based on data, to assess the system's performance and patient's condition.
2. How to educate patients on their condition and care. This will be promoted in professional education itself.

Nurses' role is around supporting and empowering patients. Consequently, nurses are educated on how to empathize with patients and their relatives in a way that they are motivated to take active role in care and clinical decision making.

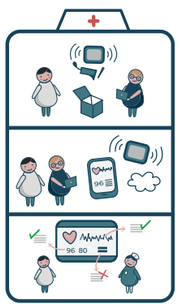
Additionally, learnings on keeping an active listening for patient's experience are important to promote a comfortable environment for patients.

Nurses use data and systems for evaluation of scenarios of patient's outcomes and conditions to optimize procedures and determine the right timing.

Patient Education

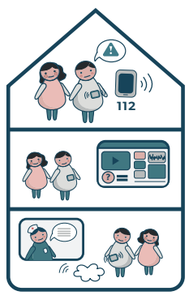
Patients receive information about their care plan, for example on expected procedures and clinical outcomes.

Before being discharged from the hospital they are informed about when to contact the hospital, based on symptomatology (emergencies).



Patients now receive education by the engineering team on how to use the devices for telemonitoring and how the interface works so that they can look at their own data.

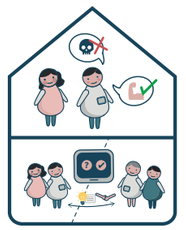
The nurses teach them how and when to take the measurements and the general meaning of data gathered for them to have a sense of their condition and possible complications.



Now that patients receive more indications on the care plan and their condition, they can learn more insightful and in-depth information about the measurements. For example, to be aware of and actively keep track of their recovery by looking at trends or specific values and its relation to possible complications.

Education will be supported by the system, so that it can be done at home. Nurses will assist in case is needed.

Relatives will be included in this education to encourage patients.



Patients are now encouraged to be more aware of their health condition. They better understand gathered data, due to the education provided by the system on their condition and care, which helps them assess their state. Based on data, they know what are things that might be harmful or beneficial for them and given the empowerment from nurses and relatives, they actively seek for those that benefit their health.

They will also learn to collaborate with other patients to build a support network.

Innovation

Complication detection
Education
Nurse's tasks

- Algorithm for adverse events forecasting
- False positives/negatives spotting algorithm
- Interface for data analysis and visualization (nurse)
- Interface for data collection and visualization (patient)
- Device and data integration

- Automatic data check with patient by notification & questionnaires
- Automatic data analysis and prioritization with tables & color-coding
- Early complication detection algorithm (improvement by self-learning & nurse's assessment)
- Complication prediction based on self-reported symptoms & state)
- Reminders & feedback for measurement taking
- Chatbot and FAQ for support
- Tips on care at home
- Self-paced virtual classes
- Level-based training
- Detailed information on complication detection
- Assessment on complication detection (fill-in form and scenarios)
- Integrated platform for online consultation (video calling)
- Automatic charting (patient's care)
- Automatic appointment scheduling

- Algorithm for modeling surgical outcomes (parameters, reports)
- Algorithm for modeling recovery process (parameters, reports)
- Customized complication forecasting based on pre-operative telemonitoring
- Customizable care plan modeling
- Patients' forums
- Emergency reporting (ISBAR)
- Automatic time & activity tracking
- Automatic documentation (incorporation of actions taken in charting)
- Smart billing
- Algorithm for process optimization based on collected data (nurses' activities & time, patients' clinical outcomes)

Research

Figure 36. Detailed explanation of the future vision (tactical roadmap).

will ensure that the actors can learn when it fits them the most and based on their own learning skills (***Self-paced virtual classes***) through online education with pre-recorded videos, tutorials, infographics and documents on the different topics for this scenario (mentioned under the categories of staff and patient education in Figure 36). For the specific case of staff, to avoid spending extra time on this training, the system will allow for a "step-wise" education (***Level-based training***), where the system will little by little introduce different functionalities and with time, reduce its support so that the nurse can have more control over it. Similar to a videogame, where the user needs to achieve certain qualifications to continue to the next level. For example, at the beginning, the system can make suggestions on different medical conditions of patients when showing the measurements and give advice on which measurements to check and when and later the user can customize these settings so that it will be less "intrusive" and fit the user's own needs. This responds to the needs of the different persona presented in the user research.

Nurses are more aware of how the system works, the measurements gathered, and patients' behaviors, which will make them be critically assessing the system's performance. This input helps to improve the system and thus make nurses more trusting in it and combined with the system's constant learning (characteristic from machine learning) will facilitate assessing the patient's condition on possible complications. (***Early complication detection algorithm (improvement by self-learning & nurse's assessment)***). Moreover, the system will help the nurse in data analysis by a smart prioritization of information based on the patient's status (***Automatic data analysis and prioritization with tables and color-coding***). Patients whose state is more critical will be presented first so that nurses can adequately allocate resources and their effort to attend tasks based on the real urgency and criticality.

Other tasks will be also supported by the system, as documentation (***Automatic charting (patient's care)***), which includes the information on the patient status and clinical outcomes and decisions. It will thus reduce the burdensome documentation work of healthcare staff, which was one of the main issues presented in the research phase. With the development of their own platform for online consultations (***Integrated online platform for online consultation (video calling)***), the system can keep track of them (by voice recognition) and fill in predetermined report layouts that include the conclusions of the patient and can be checked by the specialists to ensure they include the correct key information. Another burdensome activity presented during the research phase was scheduling appointments, as sometimes the patients are not available, or their contact number is not correct. The system will ensure to get the correct contact and directly schedule appointments with the patient via notification when required (***Automatic appointment scheduling***). Also, by having access to the specialists and nurse calendar it can automatically look for a timeslot that is convenient for all the actors. This automatic schedule is also based on the system's predictions on complications. If it shows a high probability, the system creates a task for the nurse to check on this data. Once the nurse checks it and agrees on it being a possible adverse event, the nurse has the option to send this to the specialists for further check. The system then creates the task for the specialist to determine and if considered necessary, can ask for scheduling an appointment with the patient.

Here we mention that patients will also be more aware of the information and their condition, which in turn can help them know when their state might be deteriorating. The system even provides patients with detailed information on complications, making it very clear to distinguish when there is one and when it is a normal part of the process (***Detailed information on complication detection***). For example, a section indicating "how much" bleeding is considered as "normal" after surgery and when should it be alerting and worth contacting the hospital; or how should the injury or the scar look like after certain days and how it should not look like. This increase in instructions and guidance will help patients be more assertive when determining if they have or not signs of deterioration and reduce the stress or worries in case something is not as expected.

Furthermore, now with patient's increased knowledge, they can spot certain symptoms that can help assess the presence of a medical condition. Consequently, the system will keep a constant update on how the patient is feeling and the possibility for them to report these symptoms (***Complication prediction based on self-reported symptoms & state***), which are considered when calculating the possibility of having an adverse event.

Additionally, if patients still are doubting their state, they can answer these questions by some tests that the system offer (***Assessment on complication detection (fill-in form and scenarios)***), where based on the symptoms and measurements the system can tell the patient if it could be a possible complication. of the patient with questions on how they are feeling and in case they do not feel very well, this is included in the calculation of the probability of an adverse event. For example, the patient informs the system that is not feeling well and even include external signs (that are not registered within the measurements of the telemonitoring devices) like dizziness, headaches, or others. With this information, the healthcare staff can corroborate whether they are "normal" in the recovery process or if there is indeed a possible complication and decide how to act.

This increased knowledge can also be stressful for patients, which is why the system provide support & help (***Tips on care at home, Chatbot, and FAQ for support***) by advising the patient what can be done in certain situations to improve the condition and feel better (for example, tips to keep rest or avoid certain foods). By means of an FAQ section and explanatory videos, patients can address topics about a certain device (how they work, what they measure), measurements (how to measure a physiological variable, when to do it), a specific condition or situation (what possible complications are, how to determine whether a condition is a possible deterioration sign), among others. Moreover, a chatbot is included so that patients can have support 24/7. When a question can't be automatically answered or is not included in the FAQ, the system will share the question with the e-health consultant (technical) or the nurse (medical) for them to answer it. If the question is applicable to all patients, the system will include it, responding to the need of constantly adapting to the user needs, mentioned in the user research.

In case patients have a measurement that immediately indicates risk, the system will ensure that it is not a mistake (***Automatic data check with patient by notification and questionnaires***), by asking the patient to repeat the measurement and some questions to know the current surrounding conditions (like if the patient was running and thus has a high heart rate). With these notifications, the system will present helpful information to the patient, regarding how measurements should be taken (steps to follow), at what moment (conditions around the patient and environment), common mistakes, among other aspects to ensure adequate measurements and discard the possibility of an emergency or a false positive. For example, if a very high value of blood pressure is received, the system will ask the patient to repeat the measurement and indicate to be careful with the body posture, not doing it while standing or keeping the arm still or after prolonged and demanding activity. As mentioned, the system also asks some questions on the state (how they feel, the current and recent activity, position, sensors, among others), to check if certain conditions are met and thus if the patient is in an emergency. The relatives will play a key role by helping the system determine the existence of an emergency and its criticality level and acting in case the patient is not able to do it on its own. In case the patient does not respond to these notifications in a certain period of time and the variable still presents alarming values, the system contacts the nurse to raise awareness of the patient's condition and assess if the situation requires immediate action depending on the level of criticality of the patient's condition. Then the emergency services and/or specialists can be contacted or even schedule an appointment (automatically by the system) (***Automatic appointment scheduling***).

Additionally, due to the clinical procedure patients might not be on their full cognitive capacity and they might forget to take some measurements. Here the system will present reminders (***Reminders & feedback for measurement taking***) so that a continuous measurement can be ensured, and thus informed decisions are taken.

2030

In this last stage, given the achievement of awareness of staff and patients on the importance of having an active role in care and s, the education for both focus more on achieving shared clinical decision making and overall, not only seeking for good care after medical procedures but seeking for an overall healthy behavior that can reduce the need for clinical attention.

As mentioned in Figure 36 nurses can use the data and the functionalities of the system to not only spotting adverse events and thus early complication detection, but also to perform an evaluation of the outcomes of the surgery and the recovery process. Now telemonitoring services are used prior to the surgery. This monitoring is used to assess the adequate moment for the surgical procedure (***Algorithm for modeling surgical outcomes (parameters, reports)***). To know when the patient's vitals and the condition is stable and thus more likely to have favorable outcomes. For example, if a patient who has a special cardiac condition has been stable and can have the surgery or if there is some therapy or treatment needed. To achieve this, the system provides reports that include the results on the clinical outcomes and resource usage based on the patient's data. These reports can be generated by applying different parameters (patient's comorbidities, the vital signs, the time of the surgery, among others) to determine the set of optimal patient conditions and thus the adequate moment for surgery.

These reports can also be used to model the recovery process (***Algorithm for modeling recovery process (parameters, reports)***). As before, the staff can change different parameters regarding the patient's condition, and given the information of other patient that the system already has, it is possible to determine possible scenarios and outcomes. This helps in determining the resource usage and allocation, by forecasting the outcomes for a patient and thus their criticality level after surgery and probability of needing certain care facilities. For example, if the system shows a high probability of a patient developing a complication, given the criticality of the status prior to the surgery, then the care pathway can include these possible scenarios and plan for additional resources.

Additionally, the system considers the pre-operative data as a baseline on the patient's condition. This baseline can be used for setting the thresholds on each of the monitored variables, which will help determine when a parameter is out of the "standard" values, and to evaluate the progress (***Customized complication forecasting based on pre-operative telemonitoring***). For example, if the patient has very high values on the blood pressure on the period prior to the surgery, it will be very likely to still have those values high after the surgery. However, this will not create an alert on the criticality of the patient's status as there is no relevant or critical clinical event associated with the high values.

The patient's care plan is first defined in a multidisciplinary meeting among specialists and later shared and discussed with the patient and their relatives to make adjustments based on their input and decisions. In the end, a shared decision is made. Patients are in control of the clinical decisions and specialists help them understand the medical context. The system supports informed decisions by providing data and the possibility to do an analysis of different conditions, scenarios, and goals, by modeling and algorithms (***Customizable care plan modeling***). For example, if a patient's main concern is for its mobility, what is the most adequate medical intervention that will benefit this aspect. Furthermore, decisions can be on different steps of the care pathway, it no longer needs to be evaluated as a whole, but small variations can be considered, when possible, from specific aspects of the whole process. For example, if a patient does not agree on a specific type of medication or therapy proposed in the healthcare plan, together with the specialists they can find another option that fits the patient's needs and provides the desires clinical outcomes.

As explained before, the system will help the nurse with different tasks. One of the most burdensome activities, as stated in the user research, is handling emergencies. By 2030 the system will support them by reporting the patient's conditions in a way that is easy and efficient to communicate and determine the diagnosis and treatment (***Emergency reporting (ISBAR)***). These reports comply with the ISBAR communication (Introduction, Situation, Background Assessment, Recommendation) (Burgess et al., 2020; Kitney et al., 2018; Kitney et al., 2016) in which is clear what are the physiological phenomena that produced the emergency so that the medical team can act upon it (Table 8). For example, it tells the staff the physiological variables that are out of the threshold, the frequency and duration of these conditions, and relevant medical background of the patient (like diabetes, hypertension). It also presents an idea on the prognosis and suggests an action for the nurse to take (like examinations or medical procedures to perform). Table 9 presents an example of some information that should be shared within reports based on each part of the ISBAR framework.

Furthermore, with the integration of the system in the nurses' tasks and working environment, it can keep track of the time and of the different activities performed by the healthcare staff on the platforms (***Automatic time and activity tracking***). This can be done by calculating the screen-time and the pages/sections that are visited within the platform. The possibility of keeping track of tasks by the system enables the automation of documentation on the tasks and actions of the nurses (***Automatic documentation (incorporation of actions taken in charting)***) to know the status of a patient or the overall hospital logistics.

Table 8. ISBAR framework used for handovers in medical contexts.

Identification	Introduce/identify the patient, own self and the team
Situation	Provide current diagnosis, problems, concerns and results from examinations
Background	Relevant medical and support information
Assessment & actions	Determine plan for assessment, treatment and discharge
Responsibility & referal	Confirm plan for assessment (clarify tasks, timing and responsibilities)

Also, with the integration of a platform for online integration from the previous scenario, it will be possible to include the time spent on consultation. In the end, it will be possible to know the time and effort spent by the healthcare staff which is used in smart billing (***Smart billing***) by considering the time and cost of these activities and facilitate reimbursement with third parties. All this data is further used to improve planning and resource allocation (***Algorithm for process optimization based on data collected (nurses' activities and time, patients' clinical outcomes)***) for hospital and the definition of healthcare plans and alliances with insurance companies, by modeling and scenario definition, again with parameter variation. For example, ***what happens if more nurses are hired, would the process be faster?*** Or ***when and where do they receive more patients?*** to know what the busiest times are to hire more personnel or schedule their agendas based on this.

On the other hand, for supporting patients, a forum will be available for them to share their experiences, tips, and questions with other patients (***Patients' forums***), which will also have a positive impact on their interest in learning. Patients can contact and support each other, building a community around peri-operative care and the promotion of healthy behaviors.

Table 9. Proposal for ISBAR framework in peri-operative contexts (based on Kitney et al., 2018; Kitney et al., 2016).

Identification	Patient/ Staff members (name, age, team,...)
Situation	Symptoms Level of concern Procedure Anaesthetic type
Background	Patient's medical history (Allergies, Comorbidities, ...) Relevant recent medical information (diagnosis, vital signs/other measured variables) Communication difficulties
Assessment & actions	Current diagnosis Actions so far Intra-operative issues (Surgery and anaesthesia) Current issues: • Cardiovascular, or respiratory: observations, acceptable limits, therapy • Analgaesia: interventions to date, ongoing therapy • Additional needs: medicines, examinations (x-ray, biochemistry/haematology/...)
Responsibility & referal	Plan on tasks/actions to be done Actors involved Name and contact details Patient's (administrative) status (ICU/HDU/ward/discharge home)

7. The future of telemonitoring: Scenario description

With the future vision detailed it was time to see more in-depth how would it impact the nurse, the workflow, and logistics on a daily basis to assess the viability and benefits of telemonitoring services. This provides a first approach for the creation of a harmonized service where the patient and the improvements on clinical outcomes are not the only concern, but also the nurse and the way the service impacts on its role and working dynamics. Here some situations (scenarios) are explained that will help understand the proposed future and clarify its effects.

1. Prediction of complications

In the literature research, it was stated that up to 30% of the patients who undergo gastrointestinal surgeries can suffer from a complication and need to be readmitted to the hospital. These readmissions are not planned and represent extra work for healthcare specialists and unforeseen costs for the hospital. When a patient arrives at the hospital, he/she needs attention from a very costly department, the emergency department. These high expenses are due to the need to perform many examinations that are unforeseen, making it more expensive than if a specific number of resources was previously determined and was constant. For example, deals with the laboratory regarding a certain number of tests per week for a lesser price can't be made, as each day different patients arrive with a diverse set of medical requirements. Also, due to the need for these examinations to be done under the least amount of time possible given the criticality of the patients, which require immediate attention. In this case, if the laboratory needs to have some test results faster, more resources (or more expensive and of better quality) need to be used.

Telemonitoring offers a solution to unforeseen readmissions, by extending monitoring of patients to the at-home context. Healthcare staff can keep track of the patient's recovery process and determine whether they might be developing a complication. With this, they can act on time and prevent further aggravation and the need for

clinical intervention, and if case it is needed, it can be planned. In the future proposed, as shown in Figure 37, by 2030 the smart system is able to analyze the collected data from patients and determine the presence or absence of adverse events. Some of the advantages this causes are:

1. A **decrease** in the **unplanned and emergent tasks** of nurses by the reduction of unforeseen readmissions.

2. **Reduction** in the **expenses** of the **emergency departmen**t as fewer patients will need this type of care and more will have planned interventions within the surgical department.

3. The **reduction** of **expenses** in the **overall hospital** as many adverse events can be treated early so that patients don't need special care.

4. **Increase** the possibility of **planning** for resources and better resource allocation given the extension of knowledge on the patient's status and the possibility of predicting and thus preparing for attending complications, medical procedures, or other "non-standard" situations in the recovery phase.

5. **Healthcare staff** can **better prepare** to attend patients and spend more time with them, which can benefit the relationship.

6. Similarly, **patients** can be **better prepared** to interact with healthcare staff and be part of clinical decision making

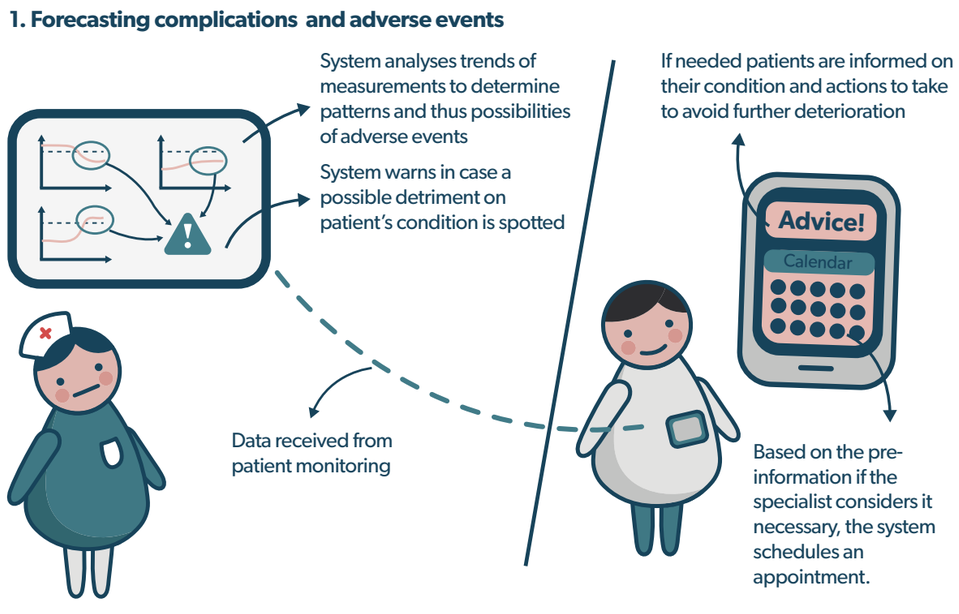


Figure 37. Prediction of complications in the future of peri-operative care with telemonitoring services.

2. Examinations during emergency

Before, we mentioned that many of the issues about the current state of nurses' workflow in peri-operative care were around emergencies. Most of these emergencies relate to the readmission of patients to the hospital. In these situations, the patient arrives at the hospital scared and confused by the medical condition and the staff needs to do a lot of examinations to determine the cause and diagnosis of the patient, as they lack information on the patient's condition outside of the hospital. With this data, they can make informed decisions to prescribe a treatment and help the patient recover. All these extra examinations require a lot of time from the nurse, who needs to take samples from the patient, take them to the laboratory or even prepare patients for certain procedures. On the other hand, the patient needs to stay within the emergency department for some time, even if the situation is not critical, to provide an adequate care plan to patients. This also causes unnecessary use of resources, like bed and monitor occupancy, which could be used for patients who have a more severe condition and require close monitoring.

Thanks to telemonitoring, all these issues can be addressed. As we can see in Figure 38, by 2030, when patients go to the hospital due to an emergency, the staff will already be informed of their state, so the need for extra examinations is reduced, only those procedures that could not take place at home will be performed in case they are needed for the diagnosis and treatment definition. Also, thanks to patient education and empowerment they will already have some knowledge of their condition, which will benefit the interaction with the nurse and help them be in control of the medical decisions. All this creates:

1. A **reduction** in the **time spent on** procedural and administrative **tasks of** the **nurse** and will in turn increase the time with the patient.

2. A **decrease** in the **time** patients spend **in** the **emergency** department, improving resource allocation and reducing the costs for these activities.

3. An **increase** in **nurses' satisfaction** with their tasks and the working environment.

3. Information during emergency

As mentioned in the research phase, nowadays patient monitoring implies gathering a lot of data to get the most adequate picture of the patient's condition and make informed decision. As mentioned before, when attending emergencies, a lot of data needs to be collected. Patients can't be assessed on solely one variable or symptom, but on the combination of multiple of them.

This data is normally collected separately, which gives a fragmented overview of the patient. For example, a nurse measures the heart rate of the patient and sees that it is elevated, then measures the respiratory rate, which is also elevated, if she doesn't consider that the patient had recently been in a rehabilitation activity, she might think the patient's condition might be deteriorating.

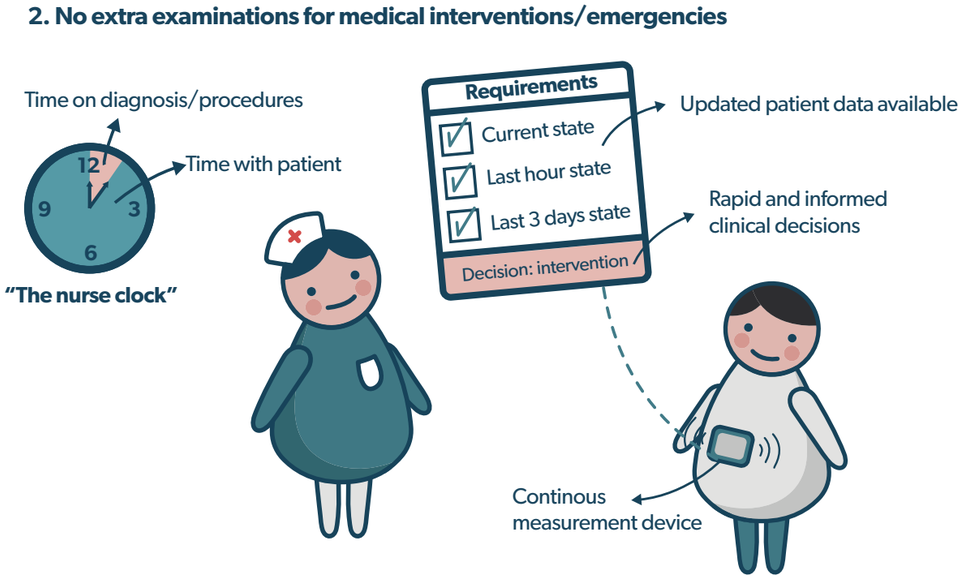


Figure 38. Examinations needed for emergency care in the future of peri-operative care with telemonitoring services.

Alternatively, if a nurse only looks at the heart activity, as it presents normal values, she might miss the possibility of detecting pulmonary problems and consequently, overlook a possible complication.

In the proposed future of 2030, as Figure 39 presents, these issues are solved with the integration of data through ISBAR-based reports. Once at the hospital, the healthcare staff is already aware of the condition and the trends or behaviors that led to the emergency given the information collected and reported by the system. Then, the patient can be easily and seamlessly transferred from the emergency to the surgical department and already start with the treatment, or medical interventions needed. Once again, the is reduced and thus its costs.

Finally, as this information is also available to the patient, it can help them understand their condition and have more informed and clear conversations with the healthcare staff (Figure 40). This last point does not only cover emergencies but the overall understanding of patients regarding their condition, for example, for assessing the care plan and actions taken by healthcare specialists, making patients active actors in shared clinical decision making. With the information on their medical condition, on the complications, the measurements themselves, and reports generated, the patients have extensive knowledge to effectively communicate with healthcare staff. In the end, this scenario leads to:

1. **Reduction** in the **time spent in emergencies** by the emergency reports that speed the process given its effectiveness in information transfer.

2. **Decrease** in the need for the **use of resources in** the **emergency** department and thus on its costs.

3. **Increase** in **patients' confidence** and ease of mind when in an emergency given the availability of data about their condition and their understanding of it.

4. **Increase** in **mutual understanding** between the healthcare staff and the patient, given the shared knowledge on the patient's condition.

5. This last point in turn **improves the relationship** between these actors.

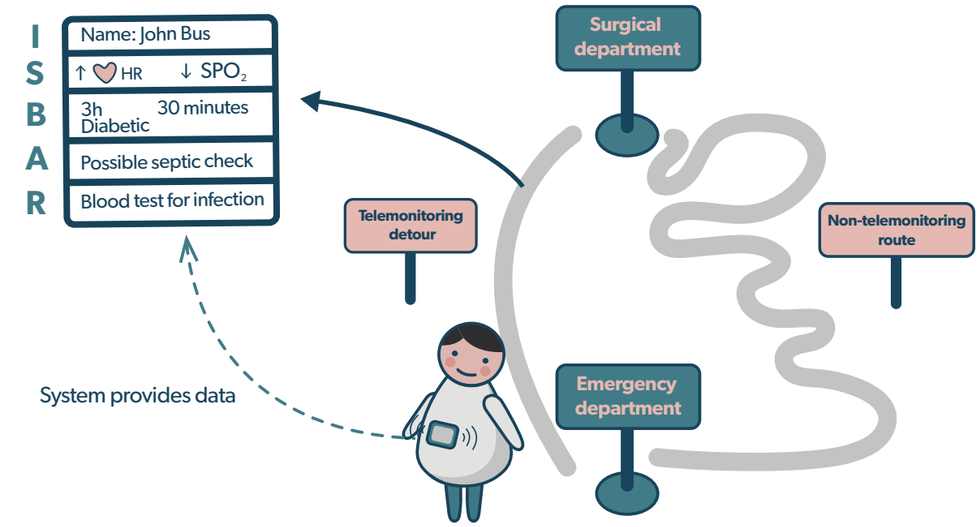


Figure 39. Information sharing for and during emergencies in the future of peri-operative care with telemonitoring services.

4. Corroborate measurements

False positives (or negatives) and non-actionable alarms were part of the challenges found from the research phase. Given the large amount of data and the differences among patients, it can be very difficult to establish standard values for thresholds on the measurements gathered during monitoring. For example, determining if a patient is hypertense depends on the normal value of their blood pressure, which also differs with age and other conditions. For instance, a patient older than 70 years old will have significantly higher blood pressure values than a patient who is 30 years old and if the system has a standard threshold, then if it is too low (to detect

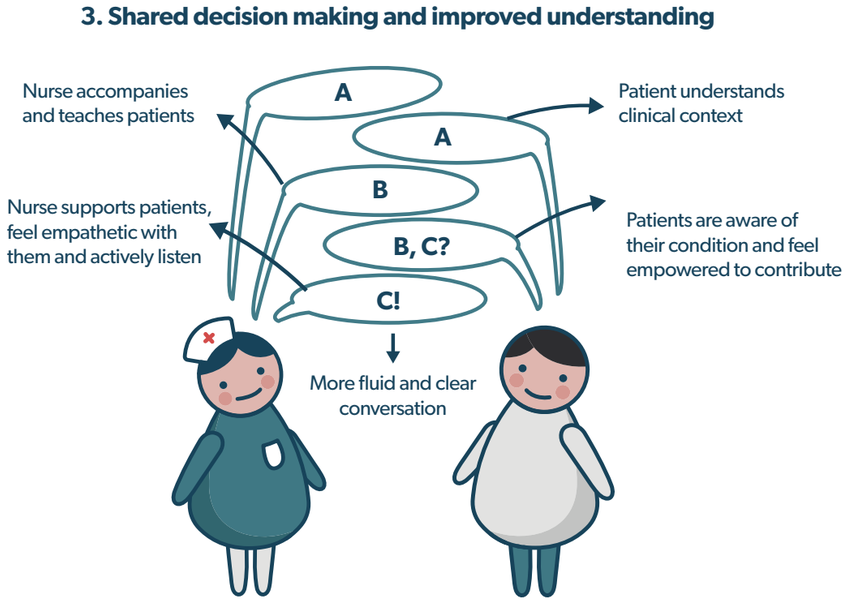


Figure 40. Communication among nurse and patient in the future of peri-operative care with telemonitoring services.

when the pressure of the younger patient is high) might indicate that the older patient is hypertense, when the reality is that it is his normal state. On the other hand, if the threshold is too high (to detect when the pressure of the older patient is high), then the system might not detect that the younger patients are hypertense. As we can see, these false alarms result in extra work for healthcare staff. For the case of a false positive (a complication was detected when there was none), they needed to do extra examinations that were not necessarily or even interrupt certain activities to attend the emergency. Moreover, when there is a false negative (a complication was not detected when there was one), it might lead to a life-threatening situation and the need for more urgent care for patients, which turns into more workload, stress, and costs.

In 2030 (Figure 41) the smart system will reduce these situations by ensuring that a value collected from the measurement represents a real clinical condition and thus, need to be attended. By checking with the patient, asking to corroborate the measurement and further background on their current state, the system can easily spot false positives. Furthermore, with constant check-ups on the patient's self-reported symptoms and their state, the system can have more informed decisions on the possibility of developing a complication and keep an eye for "difficult to spot" cases that tend to end up as false negatives. This can even help the nurse understand the patient's mental state, whether they might be feeling depressed or anxious so that they can provide emotional support. This translates into:

1. **Reduction** in the **workload of nurses** by the decrease of sudden tasks that are caused by false alarms.

2. **Decrease** in the **unnecessary use of resources** for responding to non-actionable alarms, like false positives and thus reducing the expenses (resource and time consumption

3. **Increase** of **patient's awareness** of their condition with the regular input of their self-reported symptoms and their state/how they feel, asked by the system.

4. **Improvement** on **patient's measuring** procedures by the feedback given from the system when asking to corroborate measurements.

5. **Increase** in the n**urse's knowledge on the patient's condition** and self with the provision of information regarding patient's own perception of their condition.

6. **Better relationship** between the nurse and the patient by the emotional support provided and the improvement in their connection by the increased of knowledge on the patient's mental and emotional state.

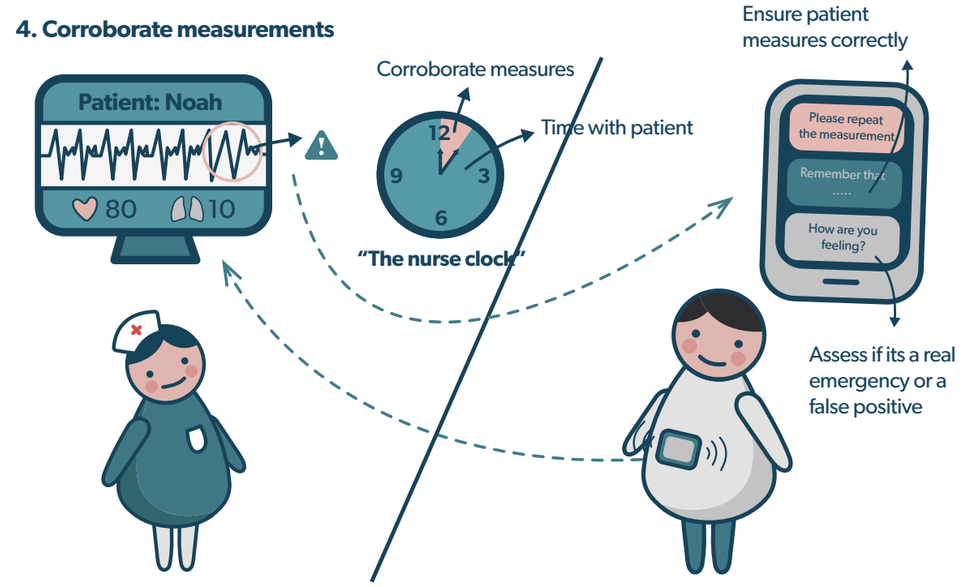


Figure 41. Validation of patient's measurements in the future of peri-operative care with telemonitoring services.

5. Modelling of surgical scenarios

Not only there is a lack of information on the patient's condition outside of the hospital context, but also, on the possible risks and outcomes of surgerical procedures based on different factors.

These can be very complex analyses, as many variables play a role in these decisions. For example, how is the patient before surgery (medical conditions), the performance of healthcare staff on the surgery, the availability of certain resources, among others. Technology offers a solution by prediction algorithms where multiple situations can be created and the system determines the outcomes for each of them and can reveal which one brings the most benefits or risks.

With the improvements of the algorithm for the smart system, it will be possible to not only forecast complications but also to explores possible scenarios on the outcomes of the surgery based on different factors like the patient's condition (pre-operative monitoring data, right before surgery, comorbidities), the performance of the surgery, among others. With this, as seen in Figure 42, healthcare staff can "play around" with these factors and see possible outcomes and risks they need to be aware of. If a patient is for example diabetic or is hypertense right before surgery or if the surgery had certain complications and thus be aware of possible problems or risks. This modeling will provide:

1. **Improvement** in **risk mitigation** by an analysis of possible scenarios.

2. **Better resource allocation** with the information on the probabilities of its use.

3. **Better preparation of healthcare staff** regarding the procedures given the knowledge of complications or events that are more likely to happen.

5. Prediction, prevention and preparation for surgery and clinical outcomes

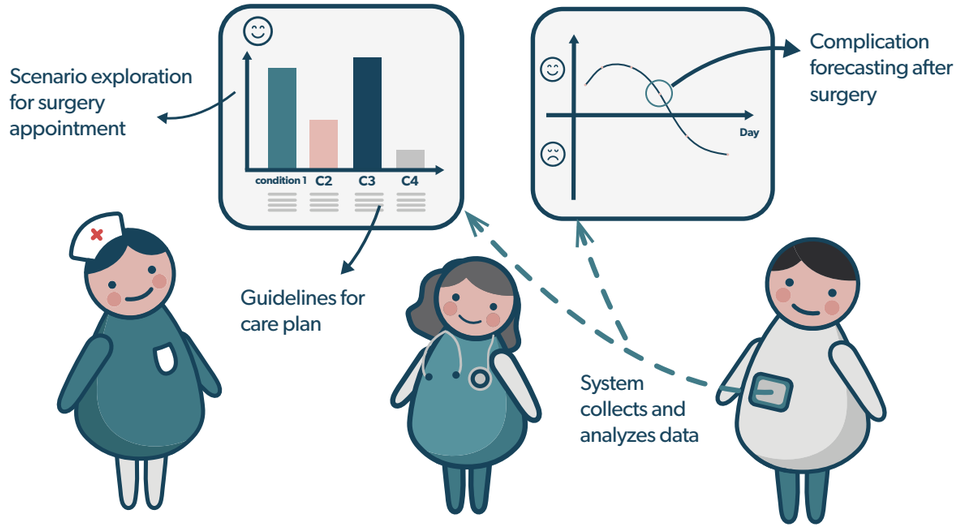


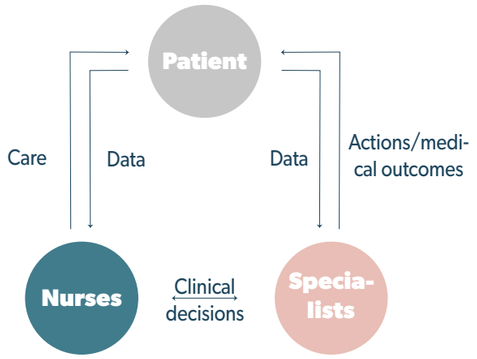
Figure 42. Use of smart system for the prediction of surgical outcomes in the future of peri-operative care with telemonitoring services.

8. Roles and Responsibilities

In previous sections, actors were mentioned to explain how the future vision will look like in the hospital context with ongoing surgical procedures. New actors appear given the changes in the services and the appearance of novel activities and tools. Also, current actors will have modifications on their existing actions to perform new ones and avoid those that were a burden. All these situations bring questions around the roles and responsibilities of the stakeholders. Some of them are:

> *Who will be in charge of a certain decision or activity? Who is responsible for a specific action? Who is involved during certain procedures and who is not? How will actors interact with each other?*

With telemonitoring services come with inexistent tasks that need the definition of strategies and guidelines so that their implementation is feasible and free of inconveniences. For this, an analysis of the interaction among the main actors involved in care provision to the patient is presented for the different scenarios present in the future vision. Figure 43 gives an overview of how the relationship among actors would be on each scenario, the main actions and responsibilities of each of them, and their interdependencies.

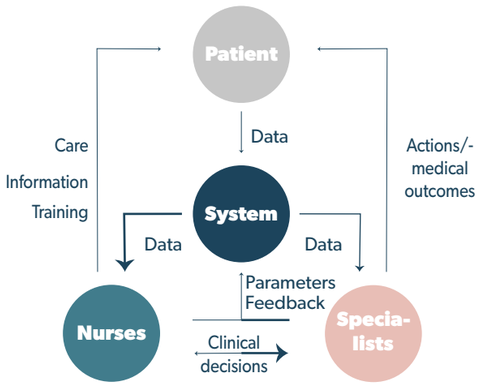


2020

Before the implementation of the box (telemonitoring services), there are three main actors involved in patient care: the nurse, the specialist, and the patient. The interaction among them is only possible when the patient is at the hospital, as care is only provided there, limiting the time and place where information can be collected and the patient can be monitored.

The patient has a very passive role. The healthcare staff provides them with indications and information about their condition and the medical procedures that they are advised to take. Decisions on the clinical interventions are mainly taken by the specialists, who is the most knowledgeable actor and the one who has "the final word". These decisions are based on the information of the patient's health status. This information is provided by the patient from the examinations prescribed by specialists to understand and determine the diagnosis and most adequate treatment for the physiological phenomena.

The nurse on the other hand focuses more on providing care to the patient when they are at the hospital and monitoring their recovery process by checking on their vital signs every certain time and acting when needed.



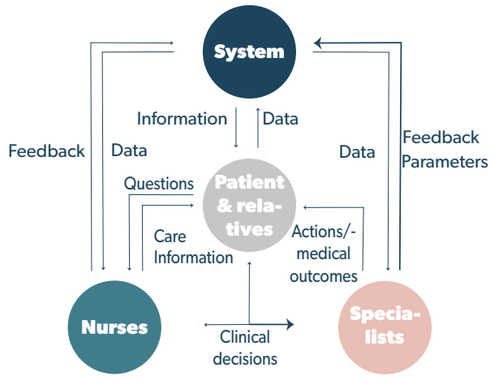
2021

In 2021, thanks to the implementation of telemonitoring services, now a new actor is introduced: the system. This is seen as an enabler and connector among the different actors, through the data that it gathers from the patient's monitoring.

The patient still has a passive role in the definition of care, as the clinical decisions are mainly taken by the specialists. However, now the patient has an active role by taking measurements to help with their recovery process.

The system supports specialists with decision-making. Specialists need to adjust the system to the patient's personal needs to ensure that adequate care is provided. They also evaluate the system's performance by a critical analysis of the results.

Finally, the nurse are now responsible for training patients on monitoring from home and their condition so that patients can have an understanding of their status throughout the recovery process.

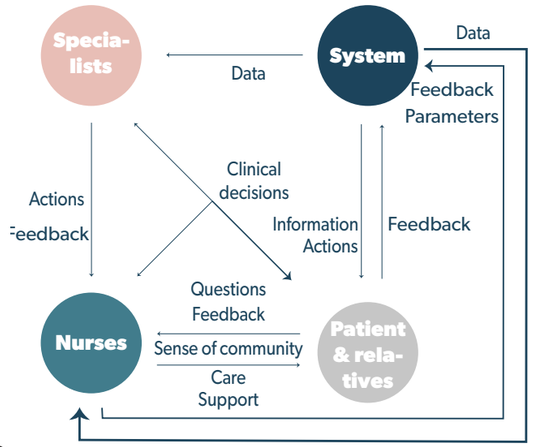


2025

As mentioned before, by 2025 automatization of telemonitoring services is reaching its peak, thus, many tasks can now be done by the system. For example, the nurse no longer needs to be fully dedicated to educating patients, but this task is supported by the system. Only if required by the patient or in specific cases (questions, clarifications) the nurse will help them. This ensures that the nurse focuses on providing care to the patient and support. Feedback to the system can be also given by the nurse, who now has more knowledge and abilities on telemonitoring patients and can be critically assessing the system's behavior.

Now patients are empowered to be part of the clinical decisions. With the training and awareness on their medical condition, care itself, and monitoring, their input is valuable and there is a shared decision-making process between the patient, the nurse, and the specialist, who is still in the lead.

This scenario starts to include the patients' relatives, where they also have an active role and support and motivate patients on their tasks.



2030

In 2030 the focus of peri-operative care is on the shared clinical decision-making process between the specialist, the nurse, and the patient. Patients now have the control and are very active actors, who can contribute to their treatment by providing insights on their condition. They are also more conscious about their health and the recovery process and even be aware of patterns that might be harmful or healthy for them so that they can start implementing the ones that benefit them by their own initiative.

Now the nurse focuses more on providing support to patients emotionally, by creating communities and training on emphatic communications and a better understanding of patients. Nurses now have more time with patients as many administrative tasks are done by the system.

Finally, the specialist is part of telemonitoring activities when a specific action or decision requires high-level knowledge or abilities. This allows specialists to focus on other more urgent, critical, and complex tasks.

Figure 43. Interaction among the different actors involved in patient's care throughout the journey regarding implementation of telemonitoring services in peri-operative care.

9. The challenges and the design intervention

With the design proposed, it is now time to see how the different challenges presented in the research are addressed. Table 10 presents the challenges that have been addressed by the design intervention and the outcomes or the benefits that it brings to the different stakeholders involved in these services (like the nurse, the patient, the hospital) and to the overall logistics around the patient's peri-operative care.

Table 10. Overview of the challenges addressed by the design interventions.

Category	Challenge	Design intervention	Outcomes/Benefits
Data	False alarms	Automatic data check with patient by notification & questionnaires Assessment on complication detection (fill-in form and scenarios) Regular questions on patient's status and self-reported symptoms Detailed information on complication detection	• Reduce workflow disruption of healthcare staff • Reduce false negatives • Increase heathcare staff's understanding of patients's physicial, emotional and mental condition • Increase patient's empowerment & inclussion
	Unclear & lack of integration	ISBAR-based reports or emergencies	• Reduce workload on healthcare staff • Reduce time & resource usage for diagnosis & treatment of emergencies
Tasks	High workload	"On-the-Job" training Automation of burdensome tasks (charting, documentation, scheduling appointments, task creation, patient's information sharing among specialists, billing) Chatbot and FAQ for support Reminders & feedback for measurement taking	• Reduce workload on healthcare staff • Increase time with patients
	Lack of/unclarity in reimbursement policies	Smart billing, automatic activity and time tracking	• Increase healthcare staff's motivation for smart systems • Improve definition of policies and logistics with insurance companies and healthcare entities
	No protocols	Algorithm for scenario/activities/performance evaluation (data modelling) Integrated platform for online consultation	• Service and process optimization • Better resource allocation
Actors	Various actors involved (different schedules)	Automatic task creation & appointment scheduling	• Reduce staff's workload • More efficient time allocation
	Differences in goals and interests among actors	Customized options for degree of support of the system	• "Persona-based" education • Improve healthcare staff's staisfaction with the system
Mindset	Trust in smart systems	Level-based education Nurses's active assessment and input on the algorithm's performance Automation of burdensome tasks (charting, documentation, scheduling appointments, task creation, patient's information sharing among specialists, billing) Modelling of surgical outcomes and recovery process (Algorithm for modelling surgical outcomes & recovery process, Customized complication forecasting based on pre-surgical telemonitoring)	• Increase time with patients • Better resource allocation • More accurate care planning • Improve healthcare staff preparation for care plan implementation • Support/facilitate clinical decision making • Informed clinical decision making

By the creation of a future vision, it is possible to have a guide for the implementation of telemonitoring services.

Here, it is proposed that through education of staff and patients and innovation, it is possible to provide a telemonitoring service that reduces the number of medical procedures and transforms emergencies into elective procedures. Additionally, research is seen as the "meta-enabler", an engine or a fuel, as it is a means for both innovation and education to be developed and implemented.

In this scenario, patients are empowered to actively seek for their wellbeing and are given the tools to be more knowledgeable and aware of their condition. Staff on the other hand becomes more conscious of the need of being a support for patients and recognizing them as part of the clinical decision making. They also see the potential of technology and promote its use in studying surgical outcomes based on different conditions and the prediction of adverse events to prevent complications.

In the end, this brings benefits as better resource allocation, reduction in unforeseen situations and emergencies and thus in hospital's expenses, increased nurse-patient time, with an improved quality, given the extension in their mutual understanding and consequently, an enhance in their relationship and personal satisfaction with the service.

Feasibility & viability

With the design interventions detailed, it was now time to reflect on the outcomes. This chapter includes the conclusions of this reflection on the possibility of implementing these services in a real-life context. Here, the reader can find some recommendations on next steps and things to consider for the future of telemonitoring in healthcare, especially in peri-operative care, based on the research performed; and limitations of the design with some considerations around them.

10. Recommendations

This project presents some recommendations regarding the implementation and development of telemonitoring strategies in healthcare contexts, based on the research and design work done for peri-operative care, specifically, the peri-operative box project.

Validation

To ensure the adequate implementation of telemonitoring services within peri-operative care, the design interventions need to be validated with experts and users to ensure that the proposals are an adequate fit to the environment and the needs. As mentioned by Nijland et al. (2008): "The use of scenario-based tests combined with in-depth interviews proved to be a powerful method for describing and identifying user problems and for supporting the re-design processes of the Internet-based applications for self-care". In this case, for testing the future vision, this is a very suitable approach where the input from healthcare staff and stakeholders from this context can be considered. This allows to further iterate on the proposal and improve it, so that the future presented is a desired, feasible and a viable one. The different scenarios presented in this document can be used during a session with the stakeholders, where they can give feedback on the proposals, how helpful and impactful are they, or how intrusive and unnecessary. Also, this can help determine the key aspects for the different stakeholders and differentiate them from the ones that are not as crucial, to set the adequate list of requirements for the design proposal.

Co-creation in healthcare contexts

As mentioned before, validation with the stakeholders is crucial for ensuring the adoption and adequate implementation of a service. However, involving actors only at the last stage of the design process is not the most efficient strategy, as the final design presented might not be the adequate for them, but no "core" changes can be made at this point. Co-creation appears as a solution to this situation, where actors are actively engaged in activities to collaborate on the design process. By including different stakeholders, their diverse set of needs can be addressed and can even promote the creation of "bonds", interaction and collaborations among these actors, making a more cohesive ecosystem. Frow et al. (2016) states some of the benefits of co-creation in healthcare contexts like:

- Harnessing the active involvement of participants and strengthening the relationship with them.
- Empowering participants by providing shared responsibility and a feeling of ownership.
- Sharing resources and knowledge that enhances new product development.
- Providing and building a network for solutions.
- Contributing to the well-being of a service system by promoting cohesion.

Development of telemonitoring services, especially of smart systems, benefit from co-creation. One of the outcomes of the user research was the persona definition, where based on the experience and characteristic behavior of nurses, they interact and have different perspectives on technology. If both personas are included when creating the systems, then the project team ensures that it fits the needs of all the actors and not only a part of them. In general, when co-creating, the team in charge needs to keep in mind the needs of the actors involved and not only the technological possibilities or proposals, as users should not be the ones adapting to these solutions, but the solutions should be the ones that adjust to the user context and provide a support to the challenges.

As mentioned before, co-creation also allows for keeping all the stakeholders under the same goal, which results in cohesion in the ecosystem. By bringing all the actors together, they can interact and learn what are each other's pains, gains and objectives, so that together, they can get to a "common ground" where the proposals benefit all of them. Many times, innovations only consider one party, for example, in healthcare, focus on the patient's outcomes and experiences, leaving aside the healthcare staff. If co-creation is part of the design process, then staff can be heard, and their needs would be integrated with the ones of the patient. This can be extended to as many stakeholders as the ecosystem includes, which takes us to the next point.

The quadruple aim

It was mentioned the importance of addressing the goals and needs of the ecosystem's stakeholders and of having all of them under one common goal that drives the innovation. In healthcare this can be described as he quadruple aim, an approach in which innovations should (Bodenheimer & Sinsky, 2014):

1. Improve the health of populations
2. Enhance the patient experience of care
3. Reduce the per capita cost of health care
4. Improve the work life of health care providers, including clinicians and staff

Telemonitoring services many times don't comply with the quadruple aim, as seen from the user research, where their implementation does reduce costs and improve clinical outcomes, but at the expense of overburden staff. Consequently, when developing these systems the different actors involved should be considered when assessing the impact of these solutions on their daily lives and routines. Also, the changes that the adoption of these technologies bring to the dynamics of the activities of the actors and the relations among them. One of the challenges found from the literature review was the lack of protocols or standardization of practices. This was corroborated by experts who expressed their concerns on unclarity of the roles and the responsibilities of the actors in these systems, which are not always considered prior to their implementation. This project presented a first approach on the changes of the roles and

responsibilities of the main actors involved in peri-operative care. However, these dynamics need to be validated and updated once the system is implemented, as with practice logistics might change so that actors feel more comfortable and develop habits around the new practices.

Development of smart systems in healthcare contexts

The development of Smart systems should involve different specialists. In healthcare contexts, there is a need for technical knowledge for the creation of algorithms that ensure that the system complies its function, but also, there is a need for medical knowledge to determine the clinical relevance and impact. This is especially true for systems that serve as a support in decision making, where the data gathered is analyzed and processed by a system, by using logic, mathematics and other abstract processes. However, this data needs to be based on certain medical parameters. For example, as mentioned in the design phase, a complication on the patient's status can be spotted when one or more vital signs are outside of their thresholds. Moreover, the data presented needs to have clinical relevance and needs to be understood by professionals so that they can act upon it. If a number of the probability of the patient developing a complication is presented, this has no impact on the staff's decision, unless the system explains how this probability was calculated, whether this is because certain values are not on their standard level, or because the patient presents some symptoms that might indicate an adverse event.

A third role is also important to allow the cohesion between these two previous parts mentioned (technical and medical) and is the designer's role. By design it is possible to integrate these two perspectives and understand the requirements from each side to create common guidelines that address both of them. Furthermore, designers can help determine the data needed to create the systems' interfaces so that users can get the most out of the system. For example, what information should the system present to the healthcare specialists so that they can trust the decision made by the system, but in a way that does not take much time or effort for them to understand it and analyze if it makes sense and fits their "intuition" (presented in the research as a main resource when assessing patients' state). In other words, what, how, when to present data that leads to a clear and effective outcome, with the minimum viable effort from the users but without compromising their independence and criticality.

Trust in smart systems

Smart systems can't simply be developed and immediately be operating. The implementation of technological innovation comes with some barriers as people are not used to the way they work, for example, that now some tasks are not needed as they are automated. Consequently, trust needs to be developed among the actors involved. To ensure this trust, the expectations and goals of the users should be considered. In the specific context of healthcare and of this project, the systems developed for supporting healthcare staff on their job need to automate those tasks that are burdensome to them, and not those that they enjoy. For instance, the system should perform tasks that are more administrative or procedural and do not require the abilities of a nurse, but the system should not be the one in charge of providing emotional support to the patient or taking care of their wounds of their condition, as this is something that nurses appreciate from their profession, as stated in the user research with the booklets and interviews. Clarification on the burdensome VS pleasant tasks should be made to prioritize on the system's functionalities.

Data collection

As mentioned in the research phase, the healthcare context is very complex, and innovations need to comply with many requirements, standards and certifications. This implies a long process of validation to demonstrate that the claims are fulfilled, and that safety is ensured. For innovations to be accepted, first testing in laboratory and controlled environments is needed, to be able to test it in the real context, as a clinical trial. These trials require gathering a lot of data to guarantee that the medical innovation was tested under different conditions and for different types of patients, to reduce risks of possible negative or side effects. This is not always an easy task as many actors are not willing to perform extra activities or consider them burdensome. Telemonitoring services bring a solution by providing automatic data collection and analysis.

Furthermore, this data gathered by telemonitoring opens a door for medical research in which, by studying patient's cases, better and more extensive understandings can be developed about certain conditions. For example, by examining whether patients who suffered from diabetes are more or less prone to developing an specific adverse events; or what are the effects of particular medications or therapies on the likeliness of having a faster recovery. Not only is research for peri-operative care, but it can also contribute to the creation of a big data set that can be used in academical clinical research for studying a disease or a treatment; or patient's or staff's behavior in regard to certain procedures; or even hospital's logistics around implementation of technology on care plans. Smart systems can be improved to support data classification for research purposes, so that depending on the need of the researcher, a data set can be used. For instance, for research on patients with cardiovascular problems who undergo surgery, the system can filter those whose medical file included this comorbidity.

However, these services need to be careful with data privacy, as it is sensitive information. This data should be anonymized from the patient's identity once it is part of a research data set, so that the person itself is not known, but the data can still be used and benefit research. This will also avoid legal issues, and lack of collaboration of actors, who are not always willing to share their personal information, specially, as seen in the trend analysis, with the increasing consciousness on data availability and uses from companies.

Home Centeredness

In this project, the home context is presented as the core of care in the future. The transformation of healthcare from a corrective to a more preventive role, where by education of patients and innovations that allows this education, they can be empowered to actively seek for their wellbeing. Additionally, by innovating on new ways and methods for medical interventions, it is possible to expand the hospital to the home, providing care to more people and reducing the costs of the hospitals, which can be fully dedicated to attending emergencies and complex procedures that require higher levels of expertise and more sophisticated technology and resources.

This process should start by making patients aware of the need of having a proactive role, instead of a reactive attitude. Once this need and desire is "awakened" in patients, thanks to the tools provided (by education and innovation) they can and will actively seek for their own care. This is also true for staff, where they will get more conscious about the importance of including the patients and empowering them so that better care plans and outcomes can be obtained.

Further use

As presented at the beginning, this project is part of a large initiative of the implementation of telemonitoring services in different contexts. The learning from these previous projects have been used in its variations for having a better understanding of how things work and ensuring its success. However, these learnings need to be translated as the needs and conditions between projects change and thus, not all the proposals are valid. In general, the learning of this project can serve as a basis when developing smart systems that have a supporting role in clinical decision. It is important to document and keep track of the feedback and process of these projects to have information on the iterations and reasons behind changes. This will help in new projects where the team can study the experience of previous projects with similar contexts or situations, and check whether something is valid or not and up to what point or stage it can be applied.

11. Limitations

Strategies in healthcare domain need to consider a very broad system that comprises different stakeholder with different needs and goals. In the specific case of telemonitoring, it brings the possibility of including the home as a new context and expanding care but this comes with additional complexity given the extension of the stakeholders, the settings, and the resources. This all might lead to ambiguity among project if the changes are not planned adequately or if not all the stakeholders are considered (Kallinikos et al., 2013). Here is where design play an important role by providing tools to ensure collaboration and interaction among the actors (Sanders & Stappers, 2008) and the creation of an ecosystem where a "greater goal" is aligned with the goals of each stakeholder. The creation of this common vision also ensures, that the overall service is delimited and helps determine the roles, responsibilities and gains of all the actors.

Some of the changes that telemonitoring brings is that now the patient needs to be considered as a more active actor, who plays a crucial role in decision making. And not only the patient, but also his/her relatives and close circle he/she lives with. By introducing care into the home environment, patient's habits and behavior outside of the hospital will be unraveled and need to be contemplated for the service definition. For example, if patients need to go back to work as soon as they are discharged from the hospital, will they get time for taking the measurements? Will this be a burden in their (or their relatives) daily schedule? Will their relatives be able to help them? Among other issues that might appear on the way.

Extending the care to the home context allows for getting more information on the patient, which turns into having more informed decisions and control over the care plan. However, there are still many variables that are out of the control of the staff, the system and even from the scope of telemonitoring services. This is due to the lack of information around the home dynamics and its changing nature. One patient might be comfortable staying at home and have the possibility to have someone who can help with care; another patient might want to keep with his normal itinerary and go out; all these things need to be considered when defining the monitoring activities and possible guidelines around them. Additionally, taking these services to a context where the nurses or the specialists are not all the time with the patient ensuring that they take the medicines or do certain activities, will require a commitment from the patient to fulfill their responsibilities.

The peri-operative box is an initiative from the LUMC, given the success of other "Box projects". However, its context differs, as it is a service for a shorter period of time, where the monitoring of patients is limited to the peri-operative period and not for a daily basis to supervise a specific health condition. The strategies used in the existing boxes can not be implemented as they are, but they need to be adapted to the specific conditions of the peri-operative period. For example, for the cardio box, patients get monitored for months and the measurements are checked by the nurse once every week or even two weeks however, for the peri-operative box, these checkups need to be regular, if necessary more than once per day, so the logistics around them need to be adapted so that the nurse doesn't feel burden with the extra tasks.

The system plays a vital role in telemonitoring as it will support the healthcare staff in many of the tasks. For this assistance to be effective, there should be a well-established and accepted relationship between the staff and the system, where trust is the basis. Developing trust in these systems requires time and iterations for the nurse to feel comfortable using the input from the system on their daily tasks and allow it to take control of some of their tasks, especially those that are burdensome for the staff (documentation, appointment scheduling, among other administrative tasks). Even though trust takes time to develop, intermediate results need to be achieved so that the benefits of telemonitoring services are perceived and this initiative continue to be supported by providing resources for continuous improvement and development.

In addition, not only trust is a challenge for acceptance among staff, but also the need for changes and adapting to the new situation, that bring novel roles, activities and the need for other skills. Staff might not feel entirely comfortable with this and even be reluctant with the new proposed roles. This makes co-creation a crucial part when developing telemonitoring strategies, to understand and address staff's needs and make systems fit them and not the other way around. Additionally, having enthusiasts of technology or defenders of these services (or so called, champions) promoting their implementation will help with its approval among the personnel.

Time and resources are not only needed for the development of a system that staff can trust, but also for the development of a service that complies with the need of the at home context. As mentioned above, this new environment has many unknowns and new variables, which is why the current protocols and activities done at the hospital can't always be directly implemented. Further research and various phases of testing and validation should be done on the mechanisms that will work for the at home care. For example, after discharge, the recovery process is not entirely evident to patients. Defining clear guidelines on issues like complications (what type of bleeding is severe, standard values of vital signs, expected symptoms after surgery, what is normal to see on a scar) is needed to support the patients at home and even to forecast complications.

This provides room for new opportunities, which is where the second stakeholder, Philips, appears. The company provides a tool, the Healthdot, which can be more suitable for this type of service. The Healthdot enables continuous data gathering from the vital signs and thus, regular checkups on the patient's condition, which are the main source when assessing complications after surgical procedures. Nevertheless, its impact has not been assessed and the benefits have not yet been proven. This makes its adoption challenging for the hospital, as it requires certain changes within the organization, that might result in conflict of interest.

Furthermore, these new telemonitoring services offer the possibility of getting more data about the patient's status, through the measurement of different physiological variables with the devices in the box. Having continuous measurements

of data gives more information to specialists on the patient's condition. This enables clinicians to get more insights and discover possible medical conditions that were not aware of before, as they only saw the patient for specific and short periods of time. For example, by using the box, the healthcare staff can see periods of abnormal heart rate that could be a sign for a cardiovascular disease. One possible consequence of this is the increase in medical procedures, as more diseases or conditions can be spotted. Nevertheless, this also leads to more awareness and prevention towards these conditions, and boost research on the causes to prevent and diagnose them, their consequences, and treatments.

Reflection

A final part is the reflection on the overall design process. This chapter presents some of the challenges faced during the completion of this project and some of the strategies used to address those challenges, along with some recommendations for improvements and future assignments. Finally, it presents a conclusion regarding the design outcome and the main findings from this project.

12. Reflections

The last part of the design process should include a reflection on the outcomes and overall performance so that they can serve as an input for improving future work. Here, reflections are made around certain topics such as how are innovations in healthcare contexts, the design process and methodologies used for these innovations and a more personal statement on the professional development of designers.

Innovations in healthcare contexts

This project shows the complexity of innovation around healthcare. On its initial phase, there were many delays due to organizational issues, as there were conflicting interests between the stakeholders involved. Even though both the LUMC and Philips seek to provide solutions to medical challenges, they need to comply to different requirements. **Problems that contribute to society** (for example, improve of health conditions) **can't be isolated from the economic or political circumstances,** thus business model and financial interests are part of the equation of solving healthcare challenges.

Although there was already a proposal ready to be implemented, there were other indirect factors that hindered its execution. For example, the approval from the management department or the resistance for changes in the internal logistics; the individual interests of the stakeholders, which sometimes can't be reconciled; among others. Furthermore, the **versatile environment** where at different stages **new actors need to be incorporated to fulfill requirements** specific to the medical field, such as clinical trials or quality standards. This is also seen when projects do not include the end-users, as it might fail to include some dynamics or agents, translating into inefficiencies and initiatives not being implemented. For example, in current telemonitoring solutions, when nurses are not considered, there is a misalignment in needs, leading to not focusing on the right problems.

The design process

The design process followed in this project stimulated its completion as it provided steps and guides that ensure a direction. The **division** of the project **in phases** was an aid when feeling lost or being "stuck" in the process because it **provided a goal** of what should be achieved, and thus different **strategies to accomplish it could be investigated.** For example, during the user research, the amount of data gathered was very overwhelming and it was not clear how to analyze it. However, it was known that this research should lead to insights about telemonitoring challenges and strategies, and possible directions for the design proposal. Consequently, techniques that could help were explored. Some of them were the analysis on the wall, the persona definition, the creation of mind maps around the clusters from the analysis, among others. In the end, these helped structure the process and be able to reach to valuable conclusions more easily.

Moreover, the **planning** defined at the beginning of the project was very **useful to keep an overview of time and avoid getting lost** in the process and in spending too much time in activities that might not lead to fruitful actions. However, this planning **changed along the process** given the different challenges that arise from the inclusion of stakeholders and other factors of this complex ecosystem of healthcare and research itself. Waiting for stakeholders to be involved and actively collaborating can be a big challenge and time consuming. For instance, for some companies, they need to have the approval from different committees or have a lot of documentation and explanation prior to their full commitment. In this project, the active participation of the LUMC was not possible given the logistics within the organization that required extra time, that the graduation did not have.

When developing plans, people focus on scheduling time for activities that help finalize a project and achieve milestones, like doing a literature research, interviews, sessions of brainstorming, among others. Given the goal-oriented and practical mindset that people tend to have nowadays, **breaks or moments for relaxing** and switching the mind from the project are not always considered. In design, these moments **can be crucial,** as they help in reflecting on the findings and processing ideas. Incubation or breaks in problem solving **allow to surpass the initial fixations** that one can have and **start making connections that are not "straightforward"** (Davidson, 2003). Also, getting the input from the environment around us can even promote these connections and bring us with new ideas to "think outside the box".

Furthermore, **support from peers** can be very valuable as they can **provide tools** for addressing certain challenges or experiences on how they have tackled them in the past or **strategies** that have helped. This **support** can come **from people from a different area of study or expertise** as this can bring new and unexplored perspectives and directions in problem solving. This is seen in techniques as biomimicry, where nature is used as a source of inspiration when **the situation or context can be extrapolated.** For example, in this project, talking with an civil engineer helped in giving a new spin to the future vision by the use of a metaphor of the construction of a neighborhood to explain the process of the change in mindset around telemonitoring services for peri-operative care. In general, **interaction and talking ideas out help to organize thoughts, validate it with others and get their input for improvements or even new ideas.**

Iterations and constant testing are very important in design, as having the input from the users and stakeholders helps in developing solutions that adequately fit and address their needs. When presenting a solution or proposal to stakeholders to get feedback, one should be careful of **not showing a too finalized version** as this might prevent the participants on commenting about it, as there might not be room for their input. **Neither should a too initial and "drafty" version** be presented, as they might not understand it or might judge its appearance and not the reasoning behind it. Designers should find a balance to be able to get the feedback from the actors and on the core aspects of their design. This project included many iterations of the future vision, where different styles, tools and perspectives were explored to find the most suitable one that would help tell the desired story and get the message through

to the audience.

Given this last point and the fact that **the design process is very dynamic,** one should **be aware and open to changes** as sometimes they lead to more interesting and better directions. In this case, the initial aim of the project was regarding alarm systems for nurses in telemonitoring services. However, in the process, it was clear that alarm systems might not be the answer for telemonitoring as they can be burdensome and even create more challenges. This created a **reframing of the problem** that led to focusing on the "root of the problem" (to provide a telemonitoring service where not only the patients, but also the nurses feel comfortable and motivated, and at the same time, it improves clinical outcomes and benefits the other stakeholders around the healthcare system, like the hospital) and not on redesigning an existing proposal to it (alarm systems).

The strategic design input

Design plays an important role in these types of projects. **Strategic designers provide an overview of the general context, which helps discover the existing stakeholders and their needs.** By keeping a "gestalt view" and constant discussions with stakeholders, it is possible to **provide strategies that help align the interests of all the actors.** This leads to fruitful collaborations and establishment of systems where all the parties involved can benefit. For this project, keeping an eye on the overall context helps when creating the future vision, where the telemonitoring services were proposed around the whole ecosystem and not just one actor or a specific activity. Additionally, this helps in focusing on the nurse as the main target for the design interventions but considering the patient as an active actor and not just as a source of data, which was the reason behind educating and empowering them.

The research methodology

For this project, user research was conducted. This presented a big challenge especially given the conditions of a pandemic, where most of the work was done online and life was mostly happening at home throughout the whole world. Consequently, it was not possible to go to the hospitals or different healthcare institutions to observe or get in touch with healthcare specialists or experts around these topics. Contacting experts needed to be done through emailing and personal network. Therefore, different strategies were used to get participants, as:

- **Contacting authors from relevant papers** read in the literature review **or relevant researchers** in the concerning areas of study.
- Looking at one's **own personal network** to see who might be a suitable participant or who might know or provide useful contacts.
- When contacting one possible participant, **asking for possible contacts** who might be suitable for the research.
- Researching for **nursing websites, online communities** and contacting people who were active or seemed like a fit for the research given their background and expertise.
- **Using social media such as LinkedIn** to contact experts on certain fields or people who work at a specific company (or hospital) that might provide valuable information.

When planning for participant selection, one should be aware that many of the **initial participants might not continue or finish the process,** as they might get tired, busy or demotivated in the process. It is important to **ensure that a large number of participants are congregated** to compensate for these actors that might not be until the very end. Additionally, **not all the information gathered will be useful or as expected**, so the researcher needs to be aware of this and again, plan for a bigger sample to get more results and gather a broad range of viewpoints to reach the point where information starts to be repetitive and no novel elements are introduced. Finally, **clear selection criteria should be defined** prior to the selection to avoid having participants who do not fit the research and might be outliers that lead to the wrong conclusions; or that might not have the knowledge or expertise required and thus might make them feel uncomfortable which can harm the "atmosphere" of the research in case they are part of a group activity.

For the literature review the definition for selection criteria is a key aspect, as one might get lost in the process by selecting certain papers that leads to completely different directions that do not contribute in the process. These **criteria should relate to the research question**, which is crucial in research to have a clear aim and a direction. As mentioned before, it is important as designers to still keep an open mind as new opportunities and roads for tackling the problems might surge while doing the research. This is especially true once user research is included as their experience and the interaction with the real context is a validation of the theory. It helps assess whether the challenges presented exist or not, how they are perceived and addressed by users, and the outcomes or consequences they bring. Consequently, **user research phase can be entangled within literature research** to make the results stronger and increase their validity and impact.

The learning process

Coming from a biomedical background the design process appeared as a strategy to address many of the challenges in healthcare. This project allowed to corroborate the importance of design and its role when creating solutions for healthcare context. Thanks to some of the design methods and strategies, it was possible to create a common goal for telemonitoring services that would fit the needs of the different stakeholders and present a desirable scenario for all of them. This was enabled by user research and interviews, keeping a "gestalt view" and integrating information, abilities that are crucial for designers. Moreover, it was possible to put into practice many of the concepts learnt during the master, for example, how to perform context mapping through sensitizing booklets, the use of trend analysis to provide directions to the design, the creation of strategies and concepts based on a future vision, among others. In the end, this helped me assess my learning process in the master and the abilities acquired that would help in design, such as knowing how to interact and empathize with users, how to get to the core information and problems of users or insights (explicit, implicit or tacit), or how to effectively communicate ideas through visuals and metaphors.

13. Conclusions

This project brings a new perspective on the inclusion of telemonitoring services within peri-operative care. For this, a future vision is presented as a means of a roadmap regarding the change in the mindset around these services and its impact in healthcare. Additionally, details on the implementation of these strategies in healthcare contexts were presented, that can be used as a strategic roadmap to guide the process and ensure a smooth and logical transition from the current situation (that includes telemonitoring and peri-operative care challenges) to the desired one.

With telemonitoring comes a broad set of possibilities regarding patient care. This allows the extension of care in:

- Time by providing monitoring of patients after discharge
- Location as now patients can receive treatment and guidance from their home
- The amount of people because more people can be attended as more in-hospital resource will be available for care once the unnecessary procedures can be supported and performed at home; and patients who could not easily have access to a hospital or the time for it, will be facilitated introducing remote and automatic (continuous measurement) options.

Now the hospital can have a better resource allocation that will benefit its logistics and improve care provision and the experience of patients with clinical procedures. Furthermore, these resources include human forces such as nurses and specialists. Improved planning and allocation lead to a reduction in their workload and burden and promote an increased satisfaction with their job and working environment.

This project answers the problem brief by stages of research and conceptualization regarding the design of smart systems for telemonitoring services around peri-operative care that fit healthcare specialists' needs and dynamics. In the end, telemonitoring is presented as a core part in the future of peri-operative care by enabling the solution to some of the current problems that the healthcare staff, especially the nurse, the patient and the healthcare institutions are facing. The main goal of telemonitoring in this future vision is to reduce the overall amount of medical procedures and transform emergencies into elective procedures. This implies an improvement in care provision and in the health conditions of the population.

Here education and innovation are seen as the means to this end. By educating patients on their condition and the importance of their wellbeing and providing them with the tools to have a better understanding of their state and act upon it, they can become active actors in the provision of care and in clinical decision making. This is reinforced by educating nurses on promoting this empowerment of patients and the awareness of the importance of seeing them as informed and qualified actors whose input is needed when defining the care plan. Moreover, nurses will be aware of the advantages of implementing smart systems in their daily routines and activities and will even become supporters and encourage these initiatives. All this education will be possible thanks to innovation, as systems will be created to provide online tools for learning; support staff on burdensome tasks; and help actors make more informed decisions by data collection and analysis. Finally, research is presented as a "meta-mean" where by constantly studying the contexts, the users and being critical on the iterations and implementations of the proposals, provide knowledge on the best way to address these challenges.

With the future vision, the whole context of telemonitoring is included. Later with the scenarios it is possible to see what are the changes and benefits that the design interventions bring to the healthcare staff, specifically to the nurses. This ensures keeping the focus on medical personnel, that as stated in the initial brief, are often left aside when developing innovations in healthcare and thus, striving for the quadruple aim. In the end, telemonitoring services improve conditions for the different actors involved. First, for the patient, by the clinical outcomes, their experience in peri-operative care and the overall health conditions in the population. Second, the healthcare providers as hospitals, given the reduction in the expenses in care and the improvement in resource allocation. Third, in healthcare staff with a decrease in their burden, the enhancement of the relationship with the patients and their overall satisfaction with their jobs.


$800
$700
$600
$500
$400
$300
$1000
$900
$800
$700
$600
$500
$400
$300
Jul.
Aug
Sep.
15%
15%

References

14. References

AAMI: Association for the Advancement of Medical Instrumentation (2011). Clinical Alarms Summit. Arlington, VA.

Al-Mazrou, A. M., Cruz, M. V., Dakin, G., Bellorin, O., Pomp, A., & Afaneh, C. (2020). Stratification of Readmission after Bariatric Surgery by Day of Post-Discharge Presentation. Obesity surgery, 1-9.

Balentine, C. J., Naik, A. D., Berger, D. H., Chen, H., Anaya, D. A., & Kennedy, G. D. (2016). Postacute care after major abdominal surgery in elderly patients: intersection of age, functional status, and postoperative complications. JAMA surgery, 151(8), 759-766.

Baniasadi, T., Ghazisaeedi, M., Hassaniazad, M., Kalhori, S. R. N., Shahi, M., & Esmaeili, M. (2020, June). Surgical Patients Follow-Up by Smartphone-Based Applications: A Systematic Literature Review. In dHealth 2020–Biomedical Informatics for Health and Care: Proceedings of the 14th Health Informatics Meets Digital Health Conference (Vol. 271, p. 85). IOS Press.

Bodenheimer, T., & Sinsky, C. (2014). From triple to quadruple aim: care of the patient requires care of the provider. The Annals of Family Medicine, 12(6), 573-576.

Brophy, P. D. (2017). Overview on the challenges and benefits of using telehealth tools in a pediatric population. Advances in chronic kidney disease, 24(1), 17-21.

Burgess, A., van Diggele, C., Roberts, C., & Mellis, C. (2020). Teaching clinical handover with ISBAR. BMC Medical Education, 20(2), 1-8.

CareVoyant (2021). Top Home Healthcare Trends for 2021. Retrieved on April 19th 2021, from https://www.carevoyant.com/home-health-blog/top-home-healthcare-trends-for-2021

Catharina ziekenhuis. Over maag-, DARM- en Leverziekten. (n.d.). Retrieved March 17, 2021, from https://www.catharinaziekenhuis.nl/patient/specialismen/25-maag-darm-en-leverziekten.html#:~:text=Klachten%20en%20ziekten%20aan%20de%20spijsverteringsorganen%20kunnen%20heel%20divers%20zijn,ulcerosa%20en%20coeliakie%20(glutenintolerantie).

Centraal Bureau voor de Statistiek (CBS) (2014). Operaties in het ziekenhuis; soort opname, leeftijd en geslacht, 1995–2010. Retrieved from: http://statline.cbs.nl/StatWeb/publication/?VW=T&

Chen, Y. W., Stanley, K., & Att, W. (2020). Artificial intelligence in dentistry: Current applications and future perspectives. Quintessence Int, 51(3), 248-57.

Daneman, N., Lu, H., & Redelmeier, D. A. (2010). Discharge after discharge: predicting surgical site infections after patients leave hospital. Journal of Hospital Infection, 75(3), 188-194.

Das, A., Faxvaag, A., & Svanæs, D. (2015). The impact of an eHealth portal on health care professionals' interaction with patients: qualitative study. Journal of medical Internet research, 17(11), e267.

Davidson, J. E. (2003). Insights about insightful problem solving. The psychology of problem solving, 149-175.

Davoody, N., & Hägglund, M. (2016). Care Professionals' Perceived Usefulness of eHealth for Post-Discharge Stroke Patients. Studies in health technology and informatics, 228, 589-593.

Deloitte (2017). Global health care outlook. Making progress against persistent challenges. Retrieved on April 8, 2018, from: https://www2.deloitte.com/insights/us/en/industry/dcom/2017-global-health-care-sectoroutlook.html

Design Council (2015). Design methods for developing services. Keeping Connected Business Challenge.

Downey, C. L., Croft, J., Buckley, H., Randell, R., Brown, J. M., & Jayne, D. G. (2018). Trial of Remote Continuous versus Intermittent NEWS monitoring after major surgery (TRaCINg): protocol for a feasibility randomised controlled trial. Pilot and feasibility studies, 4(1), 1-8.

Eggink, E., Ras, M., & Woittiez, I. (2017). Dutch long-term care use in an ageing population. The Journal of the Economics of Ageing, 9, 63-70.

Elliott, M., & Coventry, A. (2012). Critical care: the eight vital signs of patient monitoring. British Journal of Nursing, 21(10), 621-625.

Evans, M. (2011). Empathizing with the future: Creating next-next generation products and services. The Design Journal, 14(2), 231-251.

Forbes, R. C., Rybacki, D. B., Johnson, T. B., Hannah-Gillis, A., Shaffer, D., & Hale, D. A. (2018). A cost comparison for telehealth utilization in the kidney transplant waitlist evaluation process. Transplantation, 102(2), 279-283.

Franklin, C., & Mathew, J. (1994). Developing strategies to prevent inhospital cardiac arrest: analyzing responses of physicians and nurses in the hours before the event. Critical care medicine, 22(2), 244-247.

Frow, P., McColl-Kennedy, J. R., & Payne, A. (2016). Co-creation practices: Their role in shaping a health care ecosystem. Industrial Marketing Management, 56, 24-39.

Ghosh, E., Eshelman, L., Yang, L., Carlson, E., & Lord, B. (2018). Early Deterioration Indicator: Data-driven approach to detecting deterioration in general ward. Resuscitation, 122, 99-105.

Grabowski, D. C. (2021). The future of long-term care requires investment in both facility-and home-based services. Nature Aging, 1(1), 10-11.

Hakkennes S., Runyon B., Jones M. & Gilbert M. (2020). Gartner, Predicts 2021: Healthcare Providers Must Accelerate Digital Transformation to Address Disruption.

Hall R. (2019). Recovering from Major Abdominal Surgery Physiotherapy and exercise guide for patients, relatives and carers. NHS York Teachin Hospital. Retrieved from: https://www.yorkhospitals.nhs.uk/seecmsfile/?id=1906#:~:text=Major%20abdominal%20surgery%20is%20when,have%20about%20physiotherapy%20and%20exercises.

Hamilton, E. C., Sims, T. L., Hamilton, T. T., Mullican, M. A., Jones, D. B., & Provost, D. A. (2003). Clinical predictors of leak after laparoscopic Roux-en-Y gastric bypass for morbid obesity. Surgical Endoscopy and Other Interventional Techniques, 17(5), 679-684

Harsha, P., Paul, J. E., Chong, M. A., Buckley, N., Tidy, A., Clarke, A., ... & Thabane, L. (2019). Challenges with continuous pulse oximetry monitoring and wireless clinician notification systems after surgery: reactive analysis of a randomized controlled trial. JMIR medical informatics, 7(4), e14603.

Hart Long Centrum Leiden (2019). The Box. Retrieved March 25, 2021, from https://hartlongcentrum.nl/informatie-voor-patienten/the-box/.

Heller, A. R., Mees, S. T., Lauterwald, B., Reeps, C., Koch, T., & Weitz, J. (2020). Detection of deteriorating patients on surgical wards outside the ICU by an automated MEWS-based early warning system with paging functionality. Annals of surgery, 271(1), 100-105.

Hicks, C. W., Tosoian, J. J., Craig-Schapiro, R., Valero III, V., Cameron, J. L., Eckhauser, F. E., ... & Wolfgang, C. L. (2015). Early hospital readmission for gastrointestinal-related complications predicts long-term mortality after pancreatectomy. The American Journal of Surgery, 210(4), 636-642.

Hughes, M., Coolsen, M. M., Aahlin, E. K., Harrison, E. M., McNally, S. J., Dejong, C. H. C., ... &

& Wigmore, S. J. (2015). Attitudes of patients and care providers to enhanced recovery after surgery programs after major abdominal surgery. journal of surgical research, 193(1), 102-110.

Imhoff, M., Kuhls, S., Gather, U., & Fried, R. (2009). Smart alarms from medical devices in the OR and ICU. Best Practice & Research Clinical Anaesthesiology, 23(1), 39-50.

Jakobson, T., Karjagin, J., Vipp, L., Padar, M., Parik, A. H., Starkopf, L., ... & Starkopf, J. (2014). Postoperative complications and mortality after major gastrointestinal surgery. Medicina, 50(2), 111-117.

Ke, J. X. C., George, R. B., Wozney, L., & Chorney, J. L. (2019). Patient-centred peri-operative mobile application in cesarean delivery: Needs assessment and development. Canadian Journal of Anesthesia/Journal canadien d'anesthésie, 66(10), 1194-1201.

Kelly, K. N., Iannuzzi, J. C., Rickles, A. S., Monson, J. R., & Fleming, F. J. (2014). Risk factors associated with 30-day postoperative readmissions in major gastrointestinal resections. Journal of gastrointestinal surgery, 18(1), 35-44.

Kitney, P., Bramley, D., Tam, R., & Simons, K. (2018). Perioperative handover using ISBAR at two sites: A quality improvement project. Journal of Perioperative Nursing, 31(4), 17-25.

Kitney, P., Tam, R., Bennett, P., Buttigieg, D., Bramley, D., & Wang, W. (2016). Handover between anaesthetists and post-anaesthetic care unit nursing staff using ISBAR principles: A quality improvement study. ACORN: The Journal of Perioperative Nursing in Australia, 29(1), 30-35.

Konkani, A., Oakley, B., & Bauld, T. J. (2012). Reducing hospital noise: a review of medical device alarm management. Biomedical Instrumentation & Technology, 46(6), 478-487.

Kramer, A. A., Sebat, F., & Lissauer, M. (2019). A review of early warning systems for prompt detection of patients at risk for clinical decline. Journal of Trauma and Acute Care Surgery, 87(1S), S67-S73.

Kristensen, M. S., Edworthy, J., & Özcan, E. (2016). Alarm fatigue in the ward: An acoustical problem?. SoundEffects-An Interdisciplinary Journal of Sound and Sound Experience, 6(1), 88-104. Leids Universitair Medisch Centrum (LUMC) (2016). Maag-, darm- en leverziekten | LUMC. Retrieved March 11, 2021, from https://www.lumc.nl/org/mdl/

Leids Universitair Medisch Centrum (LUMC). (2021). Infectie voorspellen na operaties | LUMC. Retrieved May 5, 2021, from https://www.lumc.nl/over-het-lumc/nieuws/2021/april/infectie-voorspellen-na-operatie/?setlanguage=Dutch&setcountry=nl

Leppla, L., Mielke, J., Kunze, M., Mauthner, O., Teynor, A., Valenta, S., ... & SMILe study team. (2020). Clinicians and patients perspectives on follow-up care and eHealth support after allogeneic hematopoietic stem cell transplantation: a mixed-methods contextual analysis as part of the SMILe study. European Journal of Oncology Nursing, 45, 101723.

Martin, R. C., Brown, R., Puffer, L., Block, S., Callender, G., Quillo, A., ... & McMasters, K. M. (2011). Readmission rates after abdominal surgery: the role of surgeon, primary caregiver, home health, and subacute rehab. Annals of surgery, 254(4), 591-597.

Mehta, S. J., Hume, E., Troxel, A. B., Reitz, C., Norton, L., Lacko, H., ... & Asch, D. A. (2020). Effect of Remote Monitoring on Discharge to Home, Return to Activity, and Rehospitalization After Hip and Knee Arthroplasty: A Randomized Clinical Trial. JAMA network open, 3(12), e2028328-e2028328.

Nijland, N., van Gemert-Pijnen, J., Boer, H., Steehouder, M., & Seydel, E. (2008). Evaluation of internet-based technology for supporting self-care: problems encountered by patients and caregivers when using self-care applications. Journal of medical Internet research, 10(2), e13.

On Designing a Context. In: Hekkert, P., & Van Dijk, M. (2011). ViP-Vision in
design: A guidebook for innovators. BIS publishers, 230-237

Orcutt, S. T., Artinyan, A., Li, L. T., Silberfein, E. J., Berger, D. H., Albo, D., & Anaya, D. A. (2012). Postoperative mortality and need for transitional care following liver resection for metastatic disease in elderly patients: a population-level analysis of 4026 patients. HPB, 14(12), 863-870.

Özcan, E., Birdja, D., Simonse, L., & Struijs, A. (2019). Alarm in the ICU! Envisioning patient monitoring and alarm management in future intensive care units. In Service Design and Service Thinking in Healthcare and Hospital Management (pp. 421-446). Springer, Cham.

Parkes, R. J., Palmer, J., Wingham, J., & Williams, D. H. (2019). Is virtual clinic follow-up of hip and knee joint replacement acceptable to patients and clinicians? A sequential mixed methods evaluation. BMJ open quality, 8(1).

Richards, H. S., Blazeby, J. M., Portal, A., Harding, R., Reed, T., Lander, T., ... & Avery, K. N. L. (2020). A real-time electronic symptom monitoring system for patients after discharge following surgery: a pilot study in cancer-related surgery. BMC cancer, 20(1), 1-17.

Sanders, E. B. N., & Stappers, P. J. (2012). Convivial toolbox: Generative research for the front end of design. Amsterdam: BIS.

Sanger, P. C., Hartzler, A., Lordon, R. J., Armstrong, C. A., Lober, W. B., Evans, H. L., & Pratt, W. (2016). A patient-centered system in a provider-centered world: challenges of incorporating post-discharge wound data into practice. Journal of the American Medical Informatics Association, 23(3), 514-525.

Sanz-Segura, R., Pérez, E. M., & Özcan, E. (2019, July). Alarm compliance in healthcare: Design considerations for actionable alarms (in intensive care units). In Proceedings of the Design Society: International Conference on Engineering Design (Vol. 1, No. 1, pp. 839-846). Cambridge University Press.

Scales, K. (2019). Envisioning the future of home care: Trends and opportunities in workforce policy and practice.

Schein, R. M., Hazday, N., Pena, M., Ruben, B. H., & Sprung, C. L. (1990). Clinical antecedents to in-hospital cardiopulmonary arrest. Chest, 98(6), 1388-1392.

Semple, J. L., Evans, H. L., Lober, W. B., & Lavallee, D. C. (2019). Implementing mobile health interventions to capture post-operative patient-generated health data. Surgical infections, 20(7), 566-570.

Shah, M., Douglas, J., Carey, R., Daftari, M., Smink, T., Paisley, A., ... & Rajasekaran, K. (2021). Reducing ER Visits and Readmissions after Head and Neck Surgery Through a Phone-based Quality Improvement Program. Annals of Otology, Rhinology & Laryngology, 130(1), 24-31.

Shah, N., & Hamilton, M. (2013). Clinical review: Can we predict which patients are at risk of complications following surgery?. Critical Care, 17(3), 1-8.

Sharif, F., Rahman, A., Tonner, E., Ahmed, H., Haq, I., Abbass, R., ... & Sbai, M. (2020). Can technology optimise the pre-operative pathway for elective hip and knee replacement surgery: a qualitative study. Peri-operative Medicine, 9(1), 1-15.

Sørensen, L. T., Malaki, A., Wille-Jørgensen, P., Kallehave, F., Kjærgaard, J., Hemmingsen, U., ... & Jørgensen, T. (2007). Risk factors for mortality and postoperative complications after gastrointestinal surgery. Journal of Gastrointestinal Surgery, 11(7), 903-910.

St. Antonius Ziekenhuis. (2021). Maag-Darm-Lever (MDL). Retrieved March 17, 2021, frotm https://www.antoniusziekenhuis.nl/specialismen/maag-darm-lever-mdl

Stanford Medicine (2017). Harnessing the Power of Data in Health. Standford Medicine (Ed.), Retrieved on April 1, 2018, from https://med.stanford.edu/content/dam/sm/smnews/documents/StanfordMedicineHealthTrendsWhitePaper2017.pdf

Straatman J, Cuesta MA, Gisbertz SS, van der Peet DL (2014). Value of a step-up diagnosis plan: CRP and CT-scan to diagnose and manage postoperative complications after major abdominal surgery. Rev Esp Enferm Dig. 106:515–21.

Straatman, J., Cuesta, M.A., de Lange – de Klerk, E.S.M. & van der Peet, D.L. (2016). Long-Term Survival After Complications Following Major Abdominal Surgery. Journal of Gastrointestinal Surgery. 20, pp. 1034-1041.

Timmerman, J. G., Dekker-van Weering, M. G. H., Stuiver, M. M., Groen, W. G., Wouters, M. W. J. M., Tönis, T. M., ... & Vollenbroek-Hutten, M. M. R. (2017). Ambulant monitoring and web-accessible home-based exercise program during outpatient follow-up for resected lung cancer survivors: actual use and feasibility in clinical practice. Journal of cancer survivorship, 11(6), 720-731.

Van Boeijen, A., Daalhuizen, J., van der Schoor, R., & Zijlstra, J. (2014). Delft design guide: Design strategies and methods.

Van Der Meij, E., Anema, J. R., Leclercq, W. K., Bongers, M. Y., Consten, E. C., Koops, S. E. S., ... & Huirne, J. A. (2018). Personalised peri-operative care by e-health after intermediate-grade abdominal surgery: a multicentre, single-blind, randomised, placebo-controlled trial. The Lancet, 392(10141), 51-59.

Viers, B. R., Lightner, D. J., Rivera, M. E., Tollefson, M. K., Boorjian, S. A., Karnes, R. J., ... & Gettman,M. T. (2015). Efficiency, satisfaction, and costs for remote video visits following radical prostatectomy: a randomized controlled trial. European urology, 68(4), 729-735.

Visioni, A., Shah, R., Gabriel, E., Attwood, K., Kukar, M., & Nurkin, S. (2018). Enhanced recovery after surgery for noncolorectal surgery?: a systematic review and meta-analysis of major abdominal surgery. Annals of surgery, 267(1), 57-65.

TU Delft

Master thesis

Maria A. León