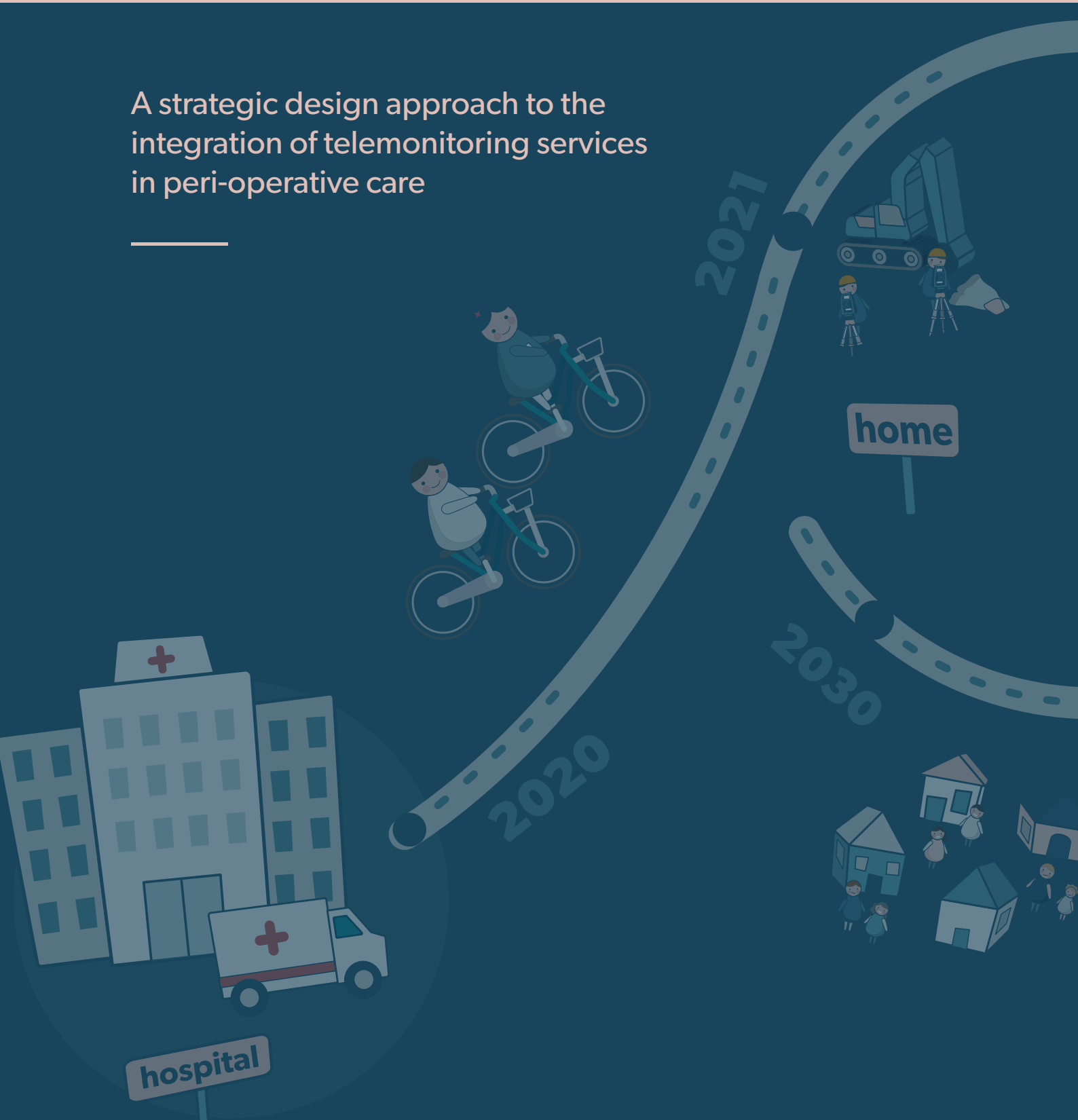
The Future of Peri-operative Care

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



Appendices

Index

Appendix I

Graduation Project Brief

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: León Aguirre
initials: M.A. given name: Maria Alejandra

Your master programme (only select the options that apply to you):

IDE master(s): ( ) IPD ( ) DfI (★) SPD
2nd non-IDE master: _____
individual programme: - - (give date of approval)
honours programme: ( ) Honours Programme Master
specialisation / annotation: (★) Medisign
( ) Tech. in Sustainable Design
( ) Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Maaike Kleinsmann — dept. / section: DOS/MOD
** mentor: Dirk Snelders — dept. / section: DOS/MOD
2nd mentor: Valeria Pannunzio
organisation: CardioLab
city: Delft — country: The Netherlands

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

comments (optional): Chair and mentor have deep knowledge on the contextual setting and despite shared affiliation to DOS, they have different backgrounds allowing for a heterogeneous team. Further explanation found at the end

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Maaike Kleinsmann date 05 - 03 - 2021 signature Maaike Kleinsmann - IO Digitally signed by Maaike Kleinsmann - IO Date: 2021.03.05 08:45:44 +01'00'

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: _____ EC
Of which, taking the conditional requirements into account, can be part of the exam programme _____ EC
List of electives obtained before the third semester without approval of the BoE

( ) YES all 1st year master courses passed
( ) NO missing 1st year master courses are:

name _____ date - - signature _____

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ( ) APPROVED ( ) NOT APPROVED
Procedure: ( ) APPROVED ( ) NOT APPROVED

comments

name _____ date - - signature _____

Improving peri-operative care workflow through telemonitoring strategy — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 08 - 03 - 2021 — 30 - 07 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Given the continuous technological developments, new opportunities for the healthcare industry appear, offering innovative solutions to medical problems. Telemonitoring or remote monitoring is the implementation of technology to monitor patients at a distance (Meystre, 2005). This has been used for different chronic illnesses, such as heart failure (Seto, 2008) as it offers the possibility of real-time adjustment on treatment, reducing the possibility of complications (Berenson et al., 2009). Also, it presents new ways of addressing the needs of home care in elderly by better follow-up (Meystre, 2005).

In general, remote monitoring has reduced emergency or urgent in-office visits, hospitalizations, re-admissions, time and total healthcare use (Aamodt et al., 2019). By collecting data remotely, events can be detected and treated earlier, reducing subsequent risks and may encourage patients to be more aware and in control of their health status (Saxon et al., 2010). However, the effect on healthcare specialist's workflow is still unclear as it eliminates some existing tasks but introduces new ones (Berenson et al., 2009). This also influences cost-effectiveness analysis because of the high complexity of the factors involved and the lack of information on means to quantify the impact and to assess the implementation of these services (Granja et al., 2018).

This research studies the specific case of the peri-operative box service delivered by the Leiden University Medical Center (LUMC), where patients undergoing major gastrointestinal surgery receive a kit to monitor their health status before and after the surgery, to reduce readmissions. This box includes the Healthdot device, by Philips, which measures different variables to keep track of patients. This project aims to provide a strategy for the peri-operative box service to optimize the workflow of the healthcare specialists in the hospital and supports this with a cost-effectiveness analysis, including administrative and medical variables. Some of the limitations are the COVID-19 measures that might hinder the access to healthcare specialists and setting. Additionally, due to the complexity of the healthcare domain some of the factors might be simplified or omitted to present a realistic plan within the time constraints.

References:

Aamodt, I. T., Lycholip, E., Celutkiene, J., Strömberg, A., Atar, D., Falk, R. S., ... & Lie, I. (2019). Health care professionals' perceptions of home telemonitoring in heart failure care: cross-sectional survey. Journal of medical Internet research, 21(2), e10362.

Berenson, R. A., Grossman, J. M., & November, E. A. (2009). Does Telemonitoring Of Patients—The eICU—Improve Intensive Care? A lack of hard data to answer the question argues for doing comparative effectiveness research on care delivery. Health Affairs, 28(Suppl1), w937-w947.

Granja, C., Janssen, W., & Johansen, M. A. (2018). Factors determining the success and failure of eHealth interventions: systematic review of the literature. Journal of medical Internet research, 20(5), e10235.

Meystre, S. (2005). The current state of telemonitoring: a comment on the literature. Telemedicine Journal & e-Health, 11(1), 63-69.

Saxon, L. A., Hayes, D. L., Gilliam, F. R., Heidenreich, P. A., Day, J., Seth, M., ... & Boehmer, J. P. (2010). Long-term outcome after ICD and CRT implantation and influence of remote device follow-up: the ALTITUDE survival study. Circulation, 122 (23), 2359-2367.

Seto, E. (2008). Cost comparison between telemonitoring and usual care of heart failure: a systematic review. Telemedicine and e-Health, 14(7), 679-686.

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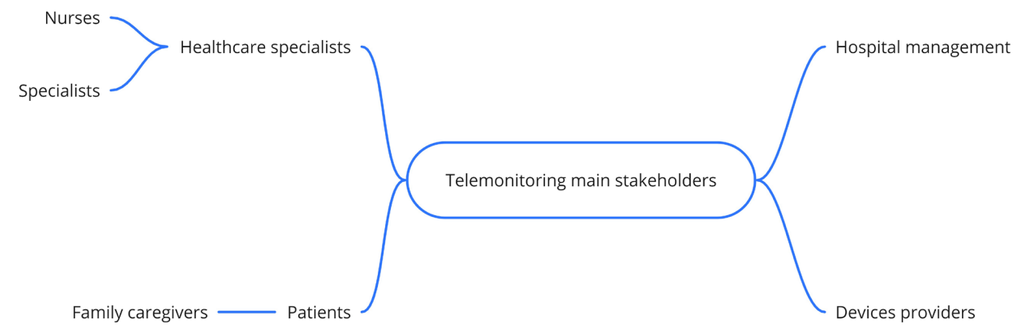
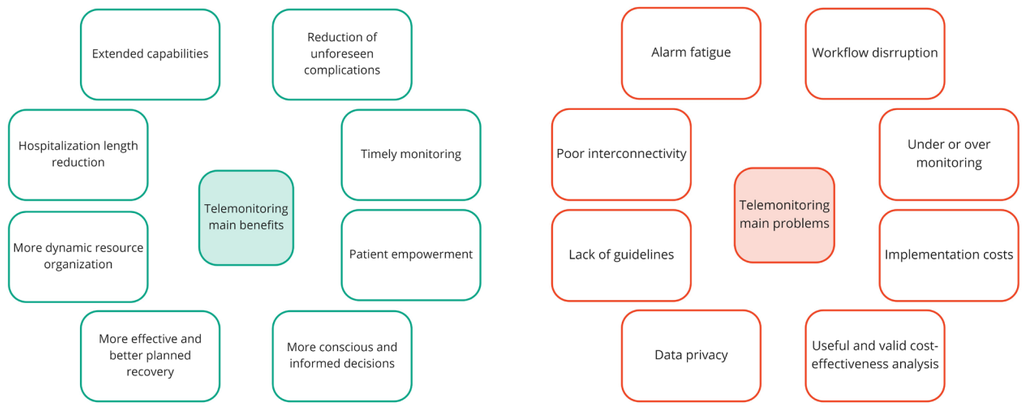


image / figure 1: Main stakeholders in telemonitoring services



*Based on previous research project findings

image / figure 2: Main benefits and problems from telemonitoring services.

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Even though telemonitoring has brought many benefits for healthcare in hospitals, there is still uncertainties regarding the overall effects on the healthcare specialists' workflow and the hospital finances. It has been difficult to quantify how these interventions help healthcare specialists with their workload, as it reduces tasks by decreasing the number and length of hospitalization and in-hospital patient care, but it also creates new responsibilities like keeping track of the patient's data and attending alerts that might interrupt their current workflow. Moreover, efforts to perform cost-effectiveness analysis have been unconclusive due to the high complexities of the healthcare environments (Fairbrother et al., 2014; Flodgren et al., 2015). In addition, telemonitoring can reduce healthcare costs due to readmission, but these might be offset by the costs of operating such services (Fairbrother et al., 2014).
This project first aims to propose an adequate workflow for healthcare specialists that reduces their current workload in perioperative box cases. Specifically, it will target the alarm system, considering what, when and how to alert caregivers for prompt action while avoiding workflow disruption. Second, it will present a cost-effectiveness analysis to evaluate this service, including both finance (resource management) and medical (health conditions) outcomes, as healthcare staff's satisfaction and performance influences service outcomes (Bodenheimer & Sinsky, 2014) . Finally, this project will reflect on the adequate business model that enables a profitable and effective use of telemonitoring.
References:
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.
Fairbrother, P., Ure, J., Hanley, J., McCloughan, L., Denvir, M., Sheikh, A., ... & Telescot Programme Team. (2014). Telemonitoring for chronic heart failure: the views of patients and healthcare professionals–a qualitative study. Journal of clinical nursing, 23(1-2), 132-144.
Flodgren, G., Rachas, A., Farmer, A. J., Inzitari, M., & Shepperd, S. (2015). Interactive telemedicine: effects on professional practice and health care outcomes. Cochrane Database of Systematic Reviews, (9).

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

The aim of this project is to present a strategy to implement a new service for telemonitoring patients of the peri-operative box by the Healthdot and other tele-health devices. This strategy consists in the definition of healthcare specialists' workflow, focused on alerts, that reduces their workload and helps them act promptly. It includes a cost-effectiveness analysis to support the implementation of this service by the Leiden University Medical Center (LUMC).

For the healthcare specialists' workflow, a service blueprint will be presented, where the activities and needed resources will be stated to present as a viable strategy for the adoption of the Heath dot within the peri-operative box context.

Moreover, a cost-effectiveness analysis will be performed to clarify the benefits of bringing this new service in the hospital. This will include the expenses of all the resources (both human and material) needed to make the service work, the savings generated from its use and the benefits it brings to patient's and caregivers' wellbeing.

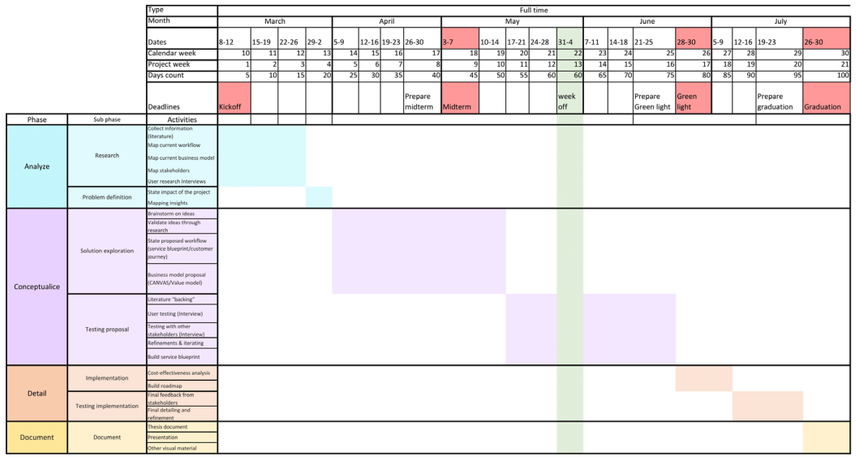
Finally, a roadmap will portray the steps to include this service in the real-life context giving an overview of how will this strategy be implemented.

This is a healthcare related topic where I combine my biomedical engineering background and my SPD knowledge to produce a strategy that is viable and feasible, fulfilling the financial and medical expected outcomes. This will make my project suitable for my medisign specialization.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 8 - 3 - 2021 30 - 7 - 2021 end date



The project has been planned for 20 weeks according to the faculty guidelines. This project consists of four phases:

Analyze phase where research on the current workflow state is defined and literature research on how to approach it for telemonitoring services. If possible interviews with healthcare specialists will be held to further clarify the context.

Conceptualize phase where a workflow proposal will be planned and validated by literature review and if possible, user testing.

Detail phase where the implementation will be specified and some more iterations of testing will be done.

Finally, the documentation phase, where all the information will be collected in the final report, presentation and other needed resources.

As it is shown in the image, the meeting days are:
1. WEEK 1 Kick off: 08/03/2021
2. WEEK 9 Midterm: 28/04/2021
3. WEEK 17 Green light: 30/06/2021
4. WEEK 21 Graduation: 30/07/2021

There is also a week-off planned with the intention of having some time away from the project to "recharge" and have a fruitful and effective work. Overall, it will be a full-time work

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

This graduation project allows the application of both biomedical engineering and strategic design as it aims to provide a plan to solve current logistic issues in hospitals by the introduction of innovatory services, such as remote monitoring devices for patients in the peri-operative period of major abdominal surgery. The biomedical knowledge will help the project to communicate with healthcare specialists and understand the different needs of the healthcare sector from a medical perspective. On the other hand, the strategic design side will provide tools to keep the broad picture in mind and propose strategies that will bring benefits for all the stakeholders involve. With this project, business abilities will be broadened, to identify appropriate decisions that bring benefits to organizations in complex contexts such us the ones of the healthcare industry, where different norms and interests meet.

This project includes the possible collaboration of Philips and the Hospital (LUMC), which will bring opportunities of extension of the project or even future collaboration with them with different projects. This is very interesting for a last year master student, as a start for the working career. Moreover, it is a real-life project, that is currently taking place and will produce a direct impact on the quality of life of people, by providing new tools that help with their well-being. Furthermore, understanding specialists' workflow and the dynamics within a hospital for the implementation of new services will be very useful in a future when trying to bring new products and services to those institutions or to look for innovative ways of working that are coherent with current protocols and politics.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Is convenient to be supervised by CardioLab members, who do research in eHealth and telemonitoring. Stakeholders' management is key and enabled by Dirk's experience in eco-system design and Maaike's appointment at entities linked to the project (NeLL). While Dirk has a psychology background and knowledge in design for human relations, Maaike has an innovation management background and a long-term affiliation with DOS. These two profiles are complementary to guarantee general academic proficiency and specific SPD and healthcare service design expertise.

Appendix II

Challenges in telemonitoring

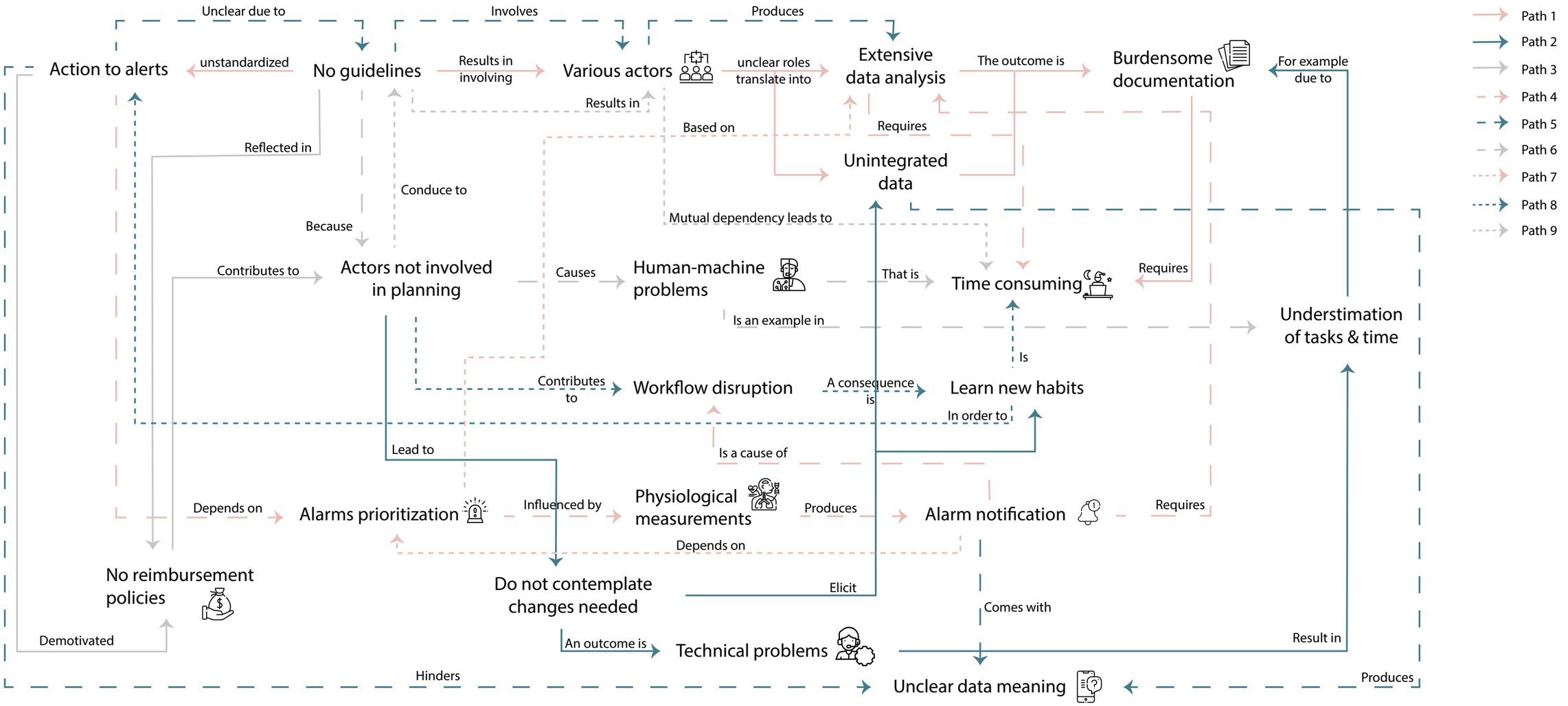


Figure 1. Mind map regarding telemonitoring challenges and the relations among them.

Appendix III

Sensitizing booklet for nurses

Hello!

Dear viewer.

I am a master student at TU Delft who is developing a project to improve the work-flow among healthcare professionals in surgical environments. I am working on a new system for remote monitoring patients from gastrointestinal surgeries and I am interested in knowing how is monitoring done. This monitoring is focused on automatic (by devices, sensor-based) or manual (by medical staff) measurements that are related to alerts and indications of the patient's condition after the procedure.

It is great to see that you want to collaborate on this project! Your knowledge and input is very valuable as I want to understand what is like to work on a clinical setting and try to improve the work environment. For this, I have designed a 5-days booklet with some activities for each day (number at the beginning of the page), which can take around 15 minutes. You can fill in this document or use the other tools explained on the email. Is okay if you don't fill all at once, feel free to go back to the activities you have done if you remember some things or come up with new information. Pace it to your own Schedule!

During these sessions I am interested in your personal experiences as a healthcare specialists in a surgical context. Remember there are no right or wrong answers, you are of course the expert of your stories and I just want to get to know you and your job a Little bit more, so feel free to write what you feel is the most suitable answer!

This booklet will be used internally for the remainder of the study. Once you finish it, please follow the instructions on the email regarding the reply with results. Feel free to contact me at any moment if you have any questions at malele.on4@gmail.com

Thank you very much for supporting this initiative and good luck!

Introducing myself

My role/profession: _____

I work in (City-Country): _____

I've been working for (number of years): _____

My current job description is: _____

_____

_____

_____

_____

1 The importance of my profession

I would like to know you a little better. In a few words tell me ...

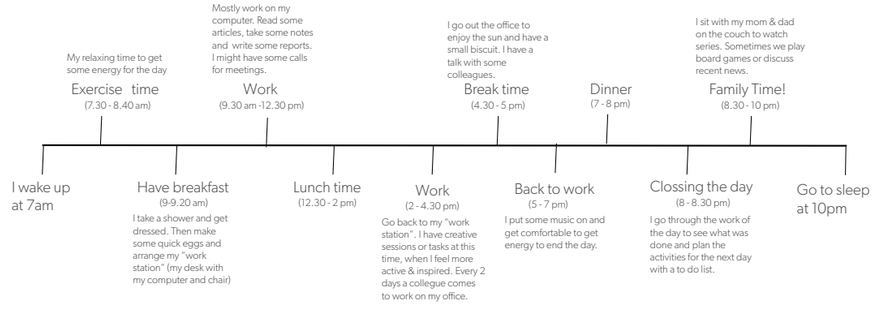
The 3 best parts of your job

The 3 best parts of monitoring patients

3 main challenges you face when monitoring patients

The most recent challenge had regarding alarms for monitoring patients?

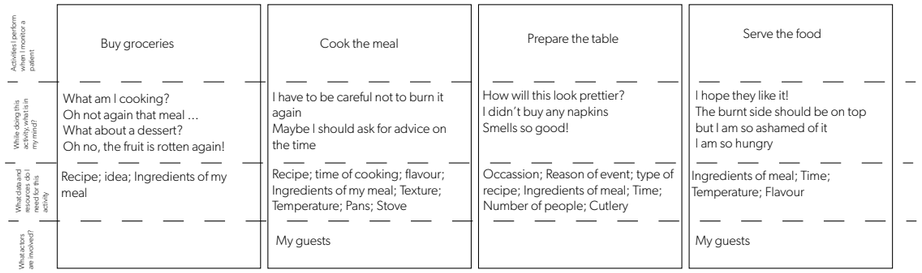
2 What does my day look like



How does a daily shift looks like: What happens during a day at work from the moment you arrive to the hospital until you leave? What do you do? Please draw or write the most relevant events on the blank timeline underneath and briefly describe them (see the small example describing my standard day). If possible, please include the starting and ending time for each activity. If you find it easier, describe your most recent working day …

Normally, I monitor _____ (number) patients in a day.

3 How do I monitor my patients?



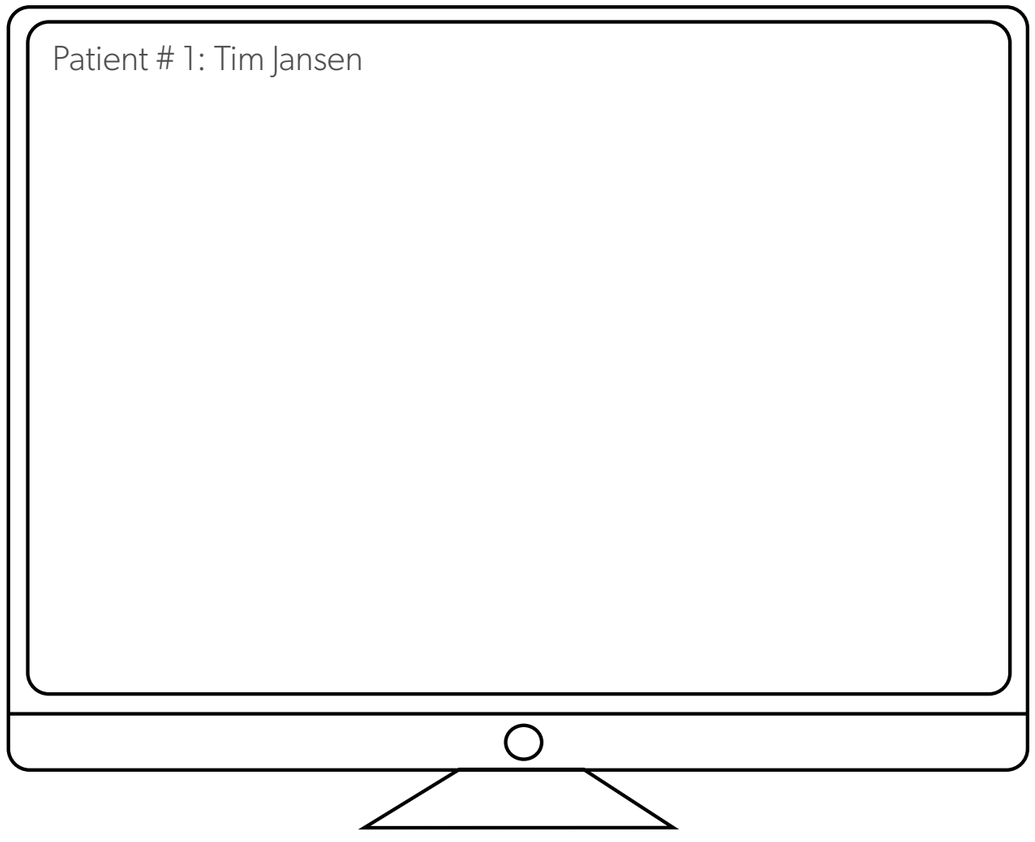
Tell me how you monitor patients after surgery. First write on the 1st row the actions you perform when monitoring (here monitor involves automatic or maual measurements related to alerts or assessing and forecasting a patient's condition). Then fill in the rest based on the questions. Feel free to think about a specific situation or very frequent type of patient or circumstance. If needed, there is more space on the next page. You can see a small example for when I cook with friends.

Activities I perform when I monitor a patient				
While doing this activity, what is in my mind?				
What data and resources do I need for this activity?				
What actors are involved?				

What actors are involved?	What data and resources do I need for this activity	While doing this activity, what is in my mind?	Activities I perform when I monitor a patient

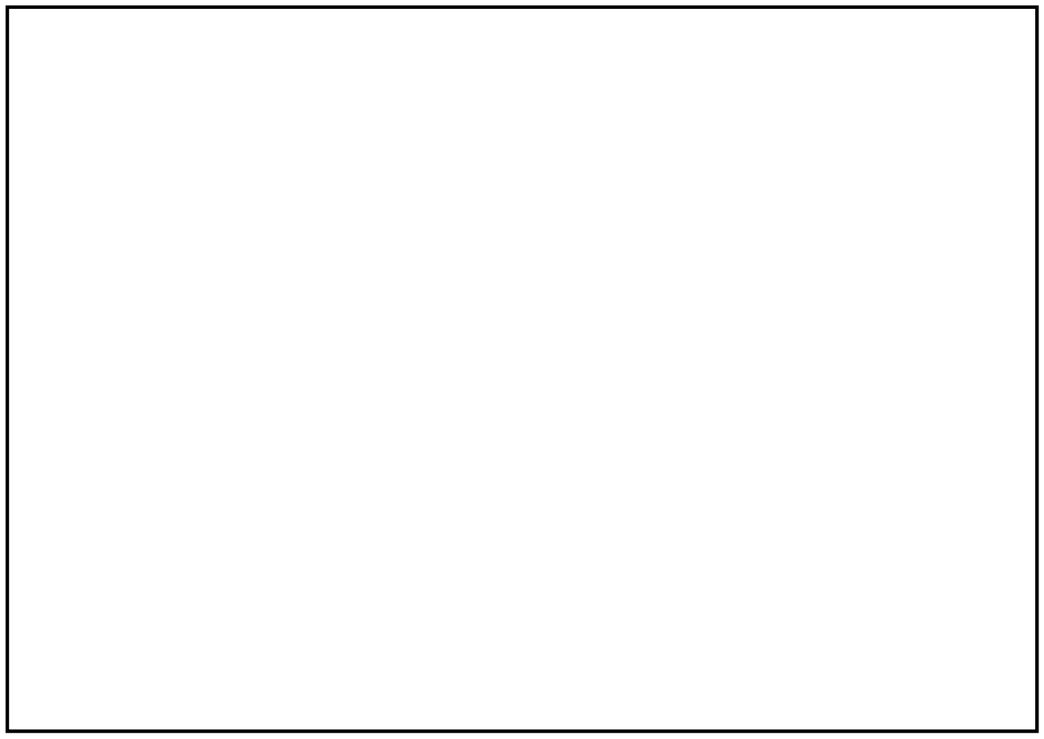
4 What do I document & collect?

When monitoring patients, you need to keep track of all the procedures and decisions made. Write down on the computer all the data that you need to document when monitoring a patient after surgery.



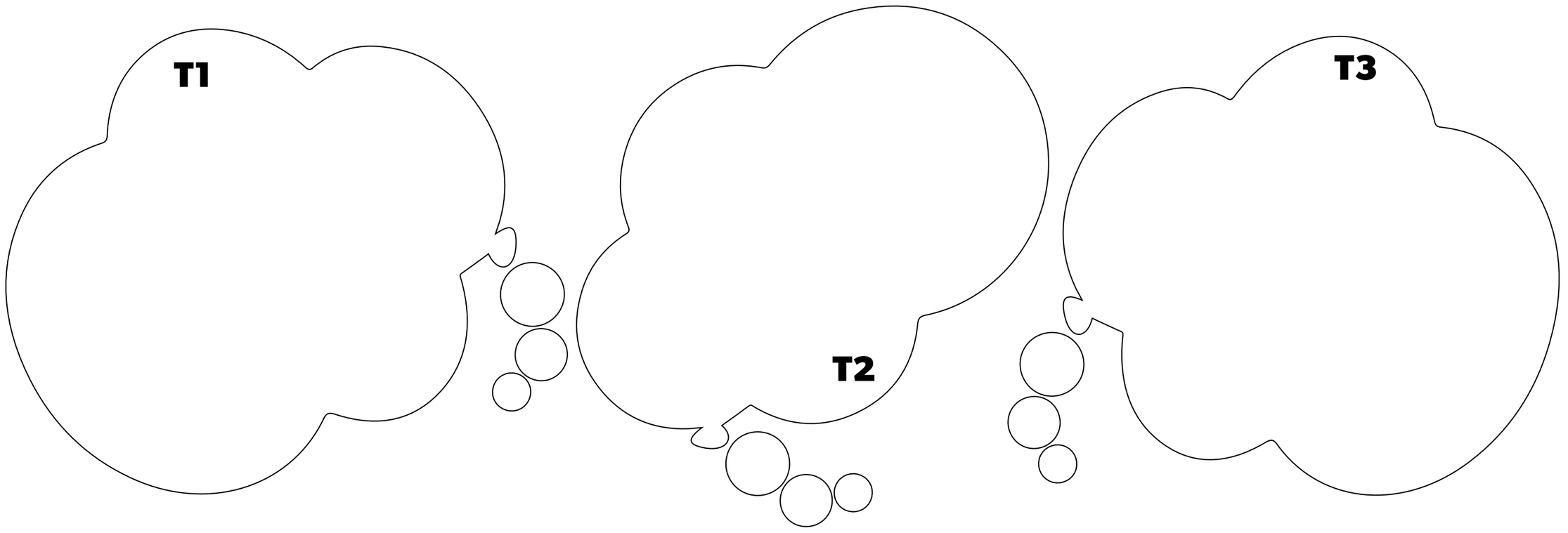
On the previous page you wrote down the information you report. Which of this information you use for assessing state of patient? Please circle the information you wrote down on the computer that you use.

Now think … Is there some data that you don't report? like your sixth sense or other data you collect or measure but is not documented? or other information kept "out of record"? or the patient's or their companion's opinion or stories? … Write down on the box below all this data that you don't document but you still gather and helps you determine the condition of the patient and forecast complications.



5 What do I think?

Reflect about alarms for monitoring patients… Read the questions underneath. After considering these questions, please write all your thoughts on the thought cloud with the number for each theme. Feel free to fill as many thought clouds as you wish! Don't forget to number the cloud with the corresponding theme.
T1: What are your thoughts regarding the role of alarms on your job? What do you find useful from alarms? What do you find problematic?
T2: Now think about the moment when you hear or see an alert. What are your immediate thoughts? What is the impact on your current task?
T3: finally, reflect on your actions to alarms … How do you know the level of urgency? How do you know which actions to take and what to do? What influences how fast you react to this and how quickly and easily you can solve it?



T?

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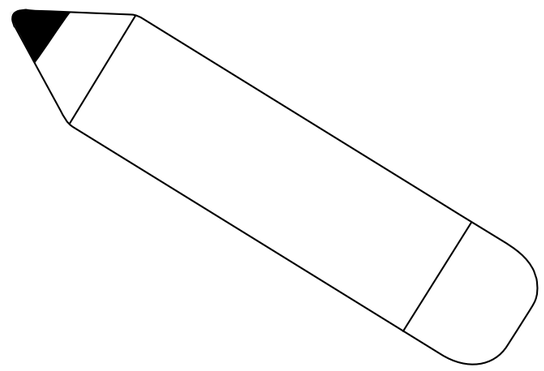
Any final remarks...

Please feel free to use the following gap for any additional remark, suggestion, experience, or even a story you would like to share!



Thank you!

Thank you very much for being part of this project, I really appreciate your contribution and I hope you enjoyed filling in this booklet, I will for sure enjoy hearing what you have to share!

Feel free to contact me if you want to know more about the project or if you would like to share some more information or contacts or even if you are willing or would like to be interviewed about this topic.

Appendix IV

Interview guides for expert talks

Interview guide 1: Designer

Theme 1: How alarms in the healthdot work

1. The healthdot is a device that facilitates remote monitoring. What are the goals of healthdot for Philips?

2. During its development, how did you decide on which data to measure and collect?
a. What is the importance of these factors into predicting patients' status?

3. This device seeks for timely detection and prevention of complications. On the webpage it says, and I quote "If sth is wrong, the healthcare provider responds." How do you define that "sth is wrong"?
   a. How are alerts and alarms defined?

4. It is also mentioned that alarms are based on the Early warning Score … How are the parameters and thresholds for alarms defined?
   a. What do you consider when defining these changes? What factors are analyzed?

5. You have "Alarm advisor", a tool that provides feedback on how staff is responding to each patient's alarm and help improve thresholds for patients … How is this included in the current healthdot for perioperative box project?

6. You also have a ProtocolWatch which is for timely diagnosis and treatment of sepsis … How is this included in the current healthdot for perioperative box projects?

Theme 2: How is the healthdot integrated in the hospital

1. As mentioned at the beginning I am very interested in the staff's workflow. How are the alarms presented by the healthdot integrated into healthcare staff's activities?
   a. How does the healthdot manage disruptions in the staff's workflow?

2. What information do specialists get?
   a. How is it communicated & presented?

3. The healthdot uses "Intellibridge" which brings together information from different sources. How is the information from the healthdot integrated into the hospital's platform?
   a. How does it integrate information from other devices or even data from the hospital's platform like electronic health records?
   b. Once all the information is collected and, let's say, integrated, how is it analyzed to ensure to get the overall view and not just "fragments of data"?

4. What changes are needed within a hospital's infrastructure to incorporate the healthdot and its platform?

Theme 3: How is the healthdot integrated in the hospital

1. What is the ongoing relation with the LUMC?
   a. What are the goals for this relation?
   b. What are future plans?

2. How is the collaboration with healthcare staff?
   a. How do they contribute to this kind of projects? (like what are they "needed for")
   b. Do you do any workshops or co-creation with them?
   c. What are their perspectives on the healthdot?

Interview guide 2: Data designer

Theme 1: Technical perspective in decision-making systems

1. Can you walk me through the current decision-making system that you are proposing, can you tell me how it works?

2. When designing these systems … How do you know what data and information to include for analysis?
   a. What do you look for in this data?

3. For making informed decisions, you need to have data from different sources … How do you integrate this data? How do you make sense of "fragments of data" to have a holistic view of the state of the patient?
   a. How do these systems incorporate that "sixth sense" that nurses mention when assessing patients? How to have that sense in "automatized decisions"?

4. The data gathered should help assess a patient's state, foresee complications and guide actions. How can these systems assess the patient's state and probability of getting worse to foresee complications?
   a. How do you define when to flag data, when should further analysis be done?
   b. What do you base these decisions on?
   c. How to early spot complications and not false indications of them?

5. There is a lot of information about monitoring vital signs. How do you define which parameters or thresholds to implement?
   a. What about customization of these parameters… How do you approach it?
   b. How do you reduce the existence of false positives without compromising sensitivity and increasing false negatives?

Theme 2: Nurse perspective in systems definition

1. Now, let's go more in depth on nurses' perspective. How do you see the role of these system within the workflow?
   a. How are these systems integrated into healthcare staff's activities?

2. And how about the role of these systems within the current nurse's role … How do nurses rely on the information collected and presented by these systems?
   a. How far should the analysis of this data should go? For example, when should the decisions of the system be corroborated by the specialists or even, should they?
   b. There are some worries about "overreliability" that nurses no longer develop that "6th sense" but rely only on technology. How do you manage this?

3. As mentioned before, these systems can come with a lot of information and it can be overwhelming to process and analyze … What data should be presented to avoid high workload on nurses?
   a. How should it be presented?

Theme 3: Integration of this system in hospital environment

1. Now let's talk more about the logistics and implementations within hospital environments. When designing decision-making system …

what is the main goal?
a. How is this different from the healthcare staff's goals? What do they expect?
b. How about other stakeholders, for example the hospital?
c. How do you integrate all these different goals?

2. Can you tell me a little more about your experience of integrating these AI based solution into nurses' routines? How do you manage to get their approval or motivate them to be "on board"?
a. Sometimes nurses don't trust technology as they feel its missing that 6th sense we mentioned before. How to deal with this mindset?

3. Nurses really enjoy caring for the patients and having contact with them. However, nurses have the perceptions that these systems can increase time behind a screen, reducing time with patients. How to deal with this?

Interview guide 3: Alarm experts

Theme 1: alarm systems role in healthcare specialists' workflow

1. What is the goal of these alarm systems within the healthcare staff's roles?
a. How is this goal integrated with the needs of the specialists?

2. How should these alarm systems support healthcare staff's functions?
a. Who is being supported?
b. How to define the level of support or even of intrusion of these systems within the specialists' workflow?
c. How do nurses currently rely on the information collected and presented by these systems?

3. How can these systems be integrated within the specialist' workflow?
a. What do these systems need to fulfill to be "supportive" and not "burdensome" systems?

4. Nurses tend to prioritize their attention and if they are busy with a task, they do not always attend alerts … How do you deal with this when designing the systems?
a. How do you define when to flag data and have alerts or when to have an alarm?
b. What do you base these decisions on?

Theme 2: Nurse perspective in alarm definition

1. These alarm systems can come with a lot of information and it can be overwhelming to process and analyze … What data should be presented to avoid workload on nurses when attending alerts?
a. How should it be presented?

2. What is the role of these alarm systems in forecasting complications?
a. How far should the analysis of this data should go? For example, when should the decisions of the system be corroborated by the specialists or even, should they?
b. How to early spot complications and not false indications of them?

3. A very big issue around alarms is alarm fatigue. A large number of alarms is produced due to false positives as for example, many of the thresholds used for the data measured is not well defined for each patient. How do you reduce the existence of false positives without compromising sensitivity and increasing false negatives?

Theme 3: Integration of this system in hospital environment

1. Now let's talk more about the logistics and implementations within hospital environments. When designing these systems, what is the role of healthcare staff?
a. How can trust in these systems be promoted?
b. Sometimes nurses don't trust technology as they feel its missing that 6th sense we mentioned before. How to deal with this mindset?
c. How do these systems incorporate that "sixth sense" that nurses mention when assessing patients? How to have that sense in "automatized decisions"?
d. On the other hand, there are some worries about "overreliability" that nurses no longer develop that "6th sense" but rely only on technology. How do you manage this?

2. Sometimes these systems can bring extra tasks and disruption that can cause stress within the specialists. How can you measure the burden caused by alarms on staff?

3. Nurses really enjoy caring for the patients and having contact with them. However, these alert systems sometimes take away this or this is a perception they have. How can these systems be a support to still increase time with patients?

Interview guide 4: Data scientist

Theme 1: Designing AI systems

1. What is the goal of using AI within hospital?

2. How is AI implemented within the hospital setting?

3. Are you familiar with AI tools for at home settings … How about AI at home setting?
a. What are requirements for this new setting?
b. How can these systems help the staff given the lack of direct contact with patient? How can they be their "eyes" and "ears"?

4. What are requirements when developing AI tools?
a. What type of data do you look for when developing these systems?
b. What is important when developing these systems?
c. How do you define guidelines or standardization for these models?

5. What are the main challenges when implementing these systems?

Theme 2: Nurse perspective in systems definition

1. Now, let's go more in depth on nurses' perspective. How do you see the role of these system within their current job?
a. How does it impact the current role of healthcare staff? (new tasks? New roles? New experts?)
b. How are these systems integrated into healthcare staff's activities?
c. How do these systems help with staff's workload?

2. How do nurses rely on these systems?
a. How far should the analysis of this data should go? For example, when should the decisions of the system be corroborated by the specialists or even, should they?
b. What about trust in these systems?

3. What are the main challenges for staff?
a. What are limitations of these systems for staff?
b. Sometimes nurses don't trust technology as they feel its missing that 6th sense we mentioned before. How to deal with this mindset?
c. Nurses really enjoy caring for the patients and having contact with them. However, nurses have the perceptions that these systems can increase time behind a screen, reducing time with patients. How to deal with this?

Theme 3: Integration of this system in hospital environment

1. How does cairelab works within the hospital?
a. How do you manage to integrate the goals of different stakeholders?

2. What is the future of cairelab?

3. How to translate knowledge from astronomy context into healthcare? (for esmee)

Interview guide 5: Project manager

Theme 1: Telemonitoring service workflow

1. Can you walk me through the current telemonitoring service?
a. How many patients is a nurse normally in charge of?
b. How do you combine this with in-hospital patients?

2. How is this monitoring at home different from in-hospital monitoring?
   a. What information is useful when monitoring patients at a distance?
   b. What do nurses look for in data?
   c. How Is data presented?

3. What are the main challenges of this data?
   a. How do you integrate the information from the different devices?
   b. You hear that nurses have this "6th sense" when assessing patients, how can you have that 6th in monitoring services?

Theme 2: Telemonitoring data

1. Now, let's go more in depth on nurses' perspective. How do you see the role of these system within the workflow?
   a. What is the role of nurses within these services?
   b. How are these systems integrated into healthcare staff's activities?
   c. Patients are grouped based on need/condition, so monitoring frequency changes, how do you define how often? who decides?
   d. What are the main challenges for nurses when incorporating these systems into their routines?

2. How do nurses rely on the information collected and presented by these systems?
   a. How far should the analysis of this data should go? For example, when should the decisions of the system be corroborated by the specialists or even, should they?

Theme 3: Integration of telemonitoring service in hospital

1. What changes were needed to incorporate these telemonitoring services?
   a. What were the perceptions of healthcare staff around these services and changes?

2. What were the most common challenges when first implementing telemonitoring?
   a. What about now?

3. These services incorporate different actors, how are roles defined?
   a. How is the integration among all the actors achieved?

4. How do you see this services in the future?

5. What are the motivations for this project?

Interview guide 6: Nurse/ Project leader

Theme 1: Data in telemonitoring systems

1. In the article "Feasibility of continuous monitoring of vital signs in surgical patients on a general ward: an observational cohort study" it is mentioned that "nurses on general wards are not used to working with and interpreting trend data of monitoring devices " … What type of data are nurses used to working with when monitoring patients?

2. How should this data be presented?

3. What are the requirements for this data?

4. How is data used in early detection of the clinical deterioration?
   a. What is the role of nurses in early detection?
   b. What about patients?

Theme 2: Nurse perspective in systems definition

1. In the article "Current Evidence for Continuous Vital Signs Monitoring by Wearable Wireless Devices in Hospitalized Adults: Systematic Review" you mentioned that EWS system should be supported by a decision support algorithm, what should this support?
   a. How should nurses rely on these systems?
   b. What are nurses looking for in these systems?

2. What is the role of nurses in telemonitoring services?
   a. What is the role of these systems within the specialists' roles?
   b. How does it impact their current workflow?

3. What are the actors involved for the development of these systems?
   a. What are the actors involved during its implementation?
   b. How do you define responsibilities within these systems and services?

Theme 3: Integration of this system in hospital environment

1. What were the reactions and adoption of nurses regarding these systems?
   a. What changes are needed within the hospital infrastructure to implement these services?
   b. What about changes within roles of the actors involved?
c. How do you define protocols around these monitoring services, for example, for responding to the different clinical outcomes from the variables measured?
2. What are the main challenges for implementation of these services?
3. How to deal with constant number of healthcare staff but increasing number of patients (as now the ones discharged will also still be monitored)? (article Feasibility of continuous monitoring of vital signs in surgical patients on a general ward: an observational cohort study)

Interview guide 7: Clinician

Theme 1: Gastrointestinal surgeries context

1. Gastrointestinal surgeries involves different actors as patients can come for different reasons. Can you walk me through the process and the actors involved for the selection of patient for gastrointestinal surgery?
   a. What about from the moment the patient comes out of surgery until the patient is discharged who is in charge?
   b. And after discharge, what happens then, who is in charge of the patient at this stage?

2. How are all these stakeholders integrated within the patient's care?
   a. Is there any creation of teams?
   b. How are the roles assigned?
   c. How do you know who lets say, "takes responsibility for the patient"?
   d. How do you manage to get to timely decisions given the busy schedules and differences in agendas between these actors?

Theme 2: Complications in gastrointestinal surgeries

1. For defining on a surgery, you evaluate the patients' state. How do you assess the risk profile prior to surgery?
   a. What about after the surgery?

2. What data do you collect before the surgery?
   a. How does this data help you evaluate the outcomes of the surgery?
   b. How is it actually used?

3. What are the most common complications?
   a. How can they be predicted or forecasted at early stage?
   b. What data is useful for assessing these complications? Why?

4. When analyzing the data, how do you know that the patient might be deteriorating and need further examination and when is just a "normal state" or "transient" or "temporary"?
   a. What are common sources or causes of "missing" the diagnosis of these complications?
   b. What are the most common mistakes when monitoring complications?
   c. Sometimes, specialists affirm that lack of diagnosis can be due to lack of information. However, how to avoid "false positives" without creating "false negatives"?

Theme 3: general data analysis

1. As you measure a lot of data, that can come from different sources like devices, or the electronic records. How do you make a lets say "global picture" of the patient and not "fragments of data"?

2. When you analyze patient's data. What do you look for in it? (patters? Deviations?)
   a. How do you analyze this data? What are variables or relations you keep on mind? (mean? Out of thresholds?)
   b. How about your "gut feeling" or 6th sense?

3. What are your thoughts on telemonitoring services?
   a. What do you think about support decision making system?

b. How in depth should the analysis provided by AI be? When should the clinician "step into" and decide and let's say check the AI outcome and when can it be fully trusted?

4. As a clinician, what are the main challenges that you think technology, AI face when being incorporated to healthcare or hospital contexts?

Appendix V

User Research outcomes data

Table 1 presents an overview of the main information gathered from the experts talks. Data was classified based on the main themes of the literature research (Data, tasks, actors and mindset). In case new information did not fulfill any of these categories a new one was created (like the "Implementation in healthcare contexts" theme presented in the user research section). Here the information of some of the categories is included as the initial focus of the project was on the telemonitoring system itself.

Here information is classified based on the research questions used for the interviews. These questions are answered in terms of the variables it involves and the factors that influence those variables. Finally, it includes some of the strategies or opportunities that were mentioned by the experts and are being (or could be) explored, to tackle the research question.

Table 1. Summary of information regarding data, tasks and mindset collected from the user research.

Theme	Mindset			Data								Tasks				
Category	Goal			Data Collection		Data Analysis	Data Overview					Action				Feedback
Question(s) addressed	Why are these systems designed? What should these systems support? For whom are these systems?			What needs to be monitored and assessed?		How do information need to be analyzed?	What information should be presented? How? When? To whom?					What is the response? What are the steps to take? Who is involved? Who is responsible for what?				How to evaluate and adapt these systems?
Variables	Stakeholders' needs	Service offerings	Fit at large	Clinical events		Criticality	What data		How data		When		Follow-up		Responsible		Supervise system
				Parameters	Devices		Automation level	Trust	User's information needs	Trust	Criticality	User's needs	Criticality	Protocol	Actors involved	Roles	
Factors			Internal organization and coordination	• Procedure • Patient comorbidities Initial conditions	• Limitations • Benefits	• Threshold • Time • Trends • Mean • Mode • Connection among variables • "The" variable	• User needs • Ease • Valuable information • User personality	• Impact on patient's life • Valiity • Limitations • Accuracy needed • Benefits • User Personality		• Impact on patient's life • Validity • Limitations • Accuracy needed • Benefits • User Personality	Hospital monitoring protocols	Workflow	Hospital monitoring protocols	• Resources needed • Clinical outcome			
Current strategies	Patients's clinical outcomes is # 1 Less time for nurses More efficient for hospital No negative effects for any stakeholder	Information is power AI as a support system	Multiple tasks/uses (planning, reimbursement system and others)	Detect Infections Monitor hear rate and respiratory rate	Healthdot Masimo Mighty-SatRx Withings Move ECG Withings Thermo Withings Blood Pressure Monitor Connect	Hospital monitoring protocols EWS Multivariable analysis (contextual)	Persona definition • Experienced • non experienced		Contextual information • Variables together • Explanation of decision • Accuracy • Validity		Stablished and fixed virtual round List of patients Prioritize patients based on criticality level		Questionnaire for patients when critical level to assess patient's state Call to evaluate patient's state				Variable system that adjust to the user's needs Experiment with users on clinical trials

Appendix VI

Trend Research

The DESTEP method was used to identify the current trends in the Demographic, Economical, Society, Technology, ecological and Political fields. Once the different trends were found, they were analyze and clustered based on the topics they address (Table 2). This produced 11 main trends.

1. Decision support systems

Given the increase in sensor technology for the healthcare field there are now more possibilities to gather data from people's health conditions. In addition, people is becoming more aware of this data and the possibilities they have to improve their lifestyles with it. All this led to an increased demand in the use of this data by all the stakeholders involved (patients, specialists, device developers) to improve care pathways, solutions and strategies. (Özcan et al., 2019; Sutton et al., 2020; Chen et al., 2020; Al-Turjman et al., 2020).

2. Security

People are becoming more conscious and aware of the data that they share throughout the different devices and tools they use and the availability of this information to different entities. This grows consumer's skepticism regarding the use and sharing of this information and open space for the discussion about data privacy and security. Among them is who should have access to patient's profiles, the use that would be given to this data and its storage or even the level of certainty when basing decisions on smart systems. Align with this is the development of solutions like block chain to protect information (Stanford Medicine, 2017; Deloitte, 2017).

3. Connectivity

Every day the world is more connected given the possibilities that technology, telecommunications and online environments provide. Sharing economies and business models that are based on connecting different stakeholders are being more common everyday. In the healthcare industry there is an increasing interest in improving the relationship between the patient and the specialists by extending it outside the hospital context though extension of care services.

4. Healthy society

COVI-19 has brough awareness of personal care and the importance of having a healthy lifestyle. Moreover, given the increase of the availability of tools and information on the internet, people have more resources to fulfill their goals.

5. Silver society

In different places around the world the population pyramid is getting a tendency towards an inverted triangle, where elder population is increasing and outnumbering younger population. This leads to an increment in the need for healthcare services, as aging process comes with the appearance of different health issues that demand for care (Eggink et al., 2017).

6. Online services

COVID-19 has forced the adoption of virtual models for service delivery. In healthcare industry this transfer into care delivery, where is vital to provide care outside of the hospital. In addition, there is a tendency towards digital and integrated HealthTech solutions where the different sources of information can be combined in one place thanks to online environments, like cloud solutions and cloudbased platforms (Hakkennes et al., 2020; Philips, 2021; Landers et al., 2016; Grabowski, 2021).

7. Ecosystem overview

Nowadays companies are shifting to service design that involves the creation of strategies for new businesses and technologies. Considering only the product is not enough (Hakkennes S et al., 2020; Philips, 2021).

8. Agility

Nowadays companies are shifting to service deln the past years agile methodologies have been increasingly adopted by several industries given their success in project development and benefits it brings in rapid implementation without compromising resource allocation. This has been boosted by the COVID-19 which has forced organizations and society into rapid innovation and quick changes to adapt to the new necessary behaviors. This type of innovation involves organizations to become more agile and cohesive for better user experiences (Hakkennes S et al., 2020; Philips, 2021).

9. Intuitive design

Given the fast lifestyle people is currently submerged in and the tendency to be constantly active and busy have led to simplicity and minimalistic behaviors, where the least time is needed to fulfill tasks. Things should be intuitive and results should be clear. Regarding technology, people don't want overly complicated devices, but some they can just easily figure out how to use and can rely on.

10. Customization

The desire and possibilities for personalization has growth in the last years. When developing services, the user is getting a more important role, to know their specific needs, personality and plan accordingly. In healthcare this translates into the inclusion of

of different patients' and specialists' profiles when developing solutions and when preparing care plans. This is enabled by the availability of information on the internet. In general, healthcare companies need to adopt novel ways to address their customers' needs effectively and efficiently (CGI, 2014; Health Catalyst, 2015).

The increasing awareness of the limited resources available has stressed the importance of sustainability. This tendency does not only relate to environmental context and "green" solutions, but also to solutions that are maintainable and justifiable even over time.

11. Sustainable design

Table 12. Trend analysis and clustering using DESTEP method.

Overall trend / Category	Decision support systems	Security	Connectivity	Healthy society	Silver society	Online services	Ecosystem overview	Agility	Intuitive design	Customization	Sustainable design
Demographic	Publicly available data Universal basic education		High immigration Transnational identities	Chronic diseases	Aging population Longevity	Digita connectedness	Situational awareness Context-based decisions			Personalized care Profiling Persona definition	Population greater than resources
Economic	Agent-based systems	New insurance needs	Sharing economy On-demand companionship services	Growth in self-car products Growth in cleaning market	Increase in healthcare demand Long-term care	e-commerce Resecion, economic "halt" Working from home Operational flexibilities Home Care Models	Stakeholders' integration Large scale economy Partnerships/joint ventures The quadruple aim	Service optimization Business model innovation Economic decline Recesion		Heterogeneity across markets Niche & on-demand markets Portfolio broadening	Scalability Hybrid business models
Socio-cultural	Continuous monitoring Multicriteria analysis	Data privacy Data confidentiality Data ownership	Seamlessly connected Information sharing Trust among stakeholders Sense of community Networking	Fit & Active lifestyle Conscious eating Self-management Patient empowerment	Senior wellness	Digital life/digital-first mindset "At-home life" Home care	Human centered design Steady state analysis High-dimensional space Ecosystem design Interdisciplinarity	Fast-pace lifestyle Resilience Practice flexibility Interdisciplinarity Uncertainty	Intuitive technology Simplicity	Do-it-Yourself Tailored services	Local ownership
Technological	Deep learning Machine learning Virtual assistants Automatization Computer-aided design Computer-assisted manufacture Big data Data centric	Blockchain Cybersecurity Fraud detection	Electronic Health Record IoT Wireless technology Smartphones Cloud services Interoperability Open source Data sharing Data integration	Fitness Trackers Biosensors Patient-generated health data		Trust in technology e-health telehealth Remote monitoring	Neural networks	Agile methods Online filters Democratization of technology	Fear of technology Confidence on technology "Master" device/platform	Nanotechnology	Long-lasting devices
Ecological				Scarce resource Decreased water, air, and food quality					Minimalistic design	Loss of biodiversity	Repurposing Multipurpose Multiuse Green environment Climate change
Political	Development of quality measures Murkier information environment	Legal policies Security best practices Quality certifications Data protection	Centralized systems Cross border collaboration	Public health Preventive measures Healthcare research budget		Policies around health information technology (HIT)	Healthcare staff performance Healthcare as a system Extension of care	Dynamic environment Scenario planning	Outcome oriented	Precision medicine	Regulatory oversight

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Master thesis

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