Monitoring Patient Safety in Real-Time

An Application of Design and Systems Thinking

Master's thesis in Master Program Quality and Operations Management

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Abstract

The thought of being hospitalized always strikes a fear in the mind of an individual. According to the Swedish Board of Health and Welfare, nearly 10 percent of the patients administered into healthcare fall victim to adverse events that emerge from patient safety risks. Patient safety within the healthcare context has been gaining increased attention and providing quality care to the patients has become a top priority. Therefore, monitoring patient safety in real-time is the need of the hour.

The purpose of the thesis is to develop customer-focused solutions for online monitoring of patient safety in real-time using design and systems thinking approach. The design thinking approach benefits in developing customer-centric solutions; it offers a framework entailing empathy building, radical collaboration and prototyping to manage healthcare and innovation.

The healthcare is a complex system consisting of various components that interact with each other across different system levels and interfaces, hence a systems safety approach is beneficial in this context. It is especially useful to monitor patient safety as healthcare systems are often subject to change and are highly unpredictable.

The findings on existing ways of monitoring and managing patient safety uncovers several pain points and user needs to which a solution is proposed. A multi-tab dashboard that displays key metrics and data associated with managing patient safety is developed. A medium-fidelity prototype was generated through multiple rapid iterations and recommendations for full scale dashboard have been provided. This solution will help in establishing a systems perspective on safety in managing and monitoring patient safety at the healthcare facility.

Keywords: Patient Safety, Systems Thinking, Design Thinking, Visual Management

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I would especially like to thank Kristina Lifvergren for being my guide at the Skaraborg Hospital. She has been equally important in guiding and shaping this thesis. Her contributions have helped me in executing this thesis at the ward with ease. She has given her best to make me feel welcome at the ward, sending you my warmest gratitude.

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Finally, I would like to send love to my family and friends who have supported me throughout my Master's studies.

Vishwal Moogi, Gothenburg, June 2021

Definitions and Abbreviations

Adverse Events: An adverse event is defined as any unintended or unanticipated incident irrespective of harm caused to a patient.

SkaS: Skaraborg Hospital Group

Vårdtyngdsmätning: Care Burden Measurement

NEWS 2: National Early Warning Score

SAMSA: It is an IT-system used by Skaraborg Hospital Group to administer a safe and secure patient discharge process and to support communication between hospitals, primary care and municipalities in Västra Götaland Region.

Melior: It is a medical record system/journal that provides support for both outpatient and inpatient care. Melior contains functions for documenting medicines, referrals, certificates and much more.

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1
Introduction

In this chapter, the background for the thesis will be presented. In addition to this, the purpose for this thesis will be defined following which, the research questions and delimitation will be stated.

1.1 Background

The thought of getting hospitalized is always terrifying and it gets even worse to learn that nearly half a million people in the US die due to avoidable hospital errors (How to Ensure Patient Safety in a Healthcare Setting, 2021). Karlsson and Hagberg (2015) report that according to the Swedish National Board of Health and Welfare, around 10 percent of the patients administered into healthcare fall victim to adverse events that originate at the hospital. A study carried out by Nilsson et al., (2018) indicated an average of 12 in 100 patients suffered adverse events throughout 2013-2016. It also revealed that out of those 12 adverse events, 8 of them could be prevented. According to a Harvard Medical Practice study, the occurrence of adverse events in general surgery was twice as likely as in general medical care, in a Swedish study between 2003-2004, 62 percent of the adverse events emanated from surgeries (Nilsson et al., 2016). Patient safety within healthcare has been gaining increased attention and providing quality care to the patients has been a priority (Nicklin and McVeety, 2002). However, Karlsson and Hagberg (2015) have reported that the work on patient safety has not shown acceptable progress. Nygren et al., (2013) also highlight in their study that patient safety officers believe there is a huge scope of improvement in patient safety work. Whereas, healthcare leaders and practitioners still strive towards developing strategies that address patient safety issues (Nicklin and McVeety, 2002).

The term patient safety can be attributed to the presence of evidence-based principles and methods to avoid the occurrence of adverse events to a patient during the process of receiving care, thereby possibly reducing the risk of care damages to a bare minimum. However, there are many instances where patients suffering from physical or psychological illness can fall victim to these care-related damages which can be avoided if the right actions are taken at the right time. Although a lot of theories have been emerging concerning patient safety, none of them have proven effective to the mark. Recent studies show a new approach towards patient safety focusing on a systems perspective on safety (Karlsson and Hagberg, 2015). The concept focuses on establishing safety at a systems level by mainly improving

and balancing two dimensions: 1) working behavior and 2) managing the internal and external environmental and operational conditions. A system built on these dimensions will pave the way towards how safety is perceived and will be pivotal in avoiding care-related adverse events which occur due to an underdeveloped system understanding and strained resources.

A healthcare setting fosters an environment that involves complex interactions between components with high variance and low predictability. All these functioning components within the healthcare system are responsible for keeping the patient safe and hence need to be monitored. Brooks (2018) describes five factors that can aid in improving patient safety at the hospital out of which the use of monitoring technology is one. Healthcare workers dedicate their entire shift towards taking care of multiple patients with varying needs and medications. The use of real-time monitoring technology can help healthcare workers especially nurses keep track of procedures and updated care needs of the patient during their shifts.

Patient safety in real-time encompasses a system view that would consider the historic and current data on the varied needs of patients to produce hourly predictions on the resources that will be required for the coming hours (Svante Lifvergren, Personal Communication, February 9, 2021). This can help the healthcare setting carefully manage its internal and external operational conditions to balance the resources to match the combined care needs of various groups of patients on a micro-system level, i.e., at the ward. Similarly, it aids in shaping the working behavior by making the interactions more predictable.

The point of focus for this research will be the surgical ward at Lidköping, a unit under the Skaraborg Hospital Group (SkaS). This unit deals with patients receiving care before and after surgery. The SkaS has in total of four healthcare centers located across different towns in the Skaraborg region and the surgical ward is one unit under one of the four healthcare centers.

The Skaraborg Hospital Group (SkaS) has been following the traditional way of managing risks where the system depends on independent individual components. Further, the current approaches are based on an offline approach, where risks are analyzed before an adverse event to minimize them, or where adverse events are analyzed after they have happened, a so-called root-cause analysis approach (Svante Lifvergren, Personal Communication, February 9, 2021). These approaches have hitherto had minor effects on the safety level of the care system. Another drawback of these approaches is that the improvements made will be short-lived and their effects will fade over time, post which, the usual approach will follow. The current approaches need to be complemented with an online approach, where the interactions between various actors and the accessibility of critical resources in the complex micro-system are continuously managed to match the care needs of the current patients in the system.

1.2 Purpose

The purpose of this thesis is to develop customer-focused solutions for online monitoring of patient safety in real-time using design and system thinking approach.

1.3 Research Questions

RQ1: What are the challenges faced by the healthcare workers in managing patient safety at the ward?

The aim is to identify the pain points associated with patient safety work and their impact on a patient in terms of harm caused while receiving care. A micro-level analysis of the adverse events will lead the way towards identifying the commonly occurring incidents. A meso-level analysis of the processes and the interaction between its components will help understand the factors influencing the occurrence of adverse events

RQ2: What are the needs of the healthcare workers when monitoring patient safety in real-time?

This question aims at uncovering the needs of different user groups working in the process of providing care at the ward. Simultaneously, looks for opportunities provided by online monitoring and how it can offer different ways of working with patient safety.

1.4 Delimitation

The research work will be limited to the surgical unit at SkaS, Lidköping, and will focus on processes carried out within this system. Additionally, only design prototypes for the online monitoring of patient safety in real-time will be developed. Its adaptation to national standards, its implementation, and its feedback will not be captured in this report due to time and resource constraints.

1.5 Overview of Report

The structure of the report is outlined as follows:

Chapter 1: The chapter begins with a background study where the thesis is introduced and its relevant fields of research are discussed. Followed by clear and concise statements describing the purpose of the thesis. Following which a list of research questions is presented whose answers aim at fulfilling the purpose. In the end, the delimitation for the thesis is discussed followed by a brief outline of the report.

Chapter 2: The chapter presents the methodology followed to guide the thesis. Things like research design, data collection, and analysis methods have been discussed in detail. In the end, few points on ethical considerations can be found.

Chapter 3: The chapter focuses on providing theoretical knowledge which is fundamental in understanding the thesis. The relevant research fields are presented in detail with the help of available existing theories.

Chapter 4: The chapter illustrates the empirical data focusing on SkaS and its current ways of working with patient safety at the ward. It presents the data on the existing processes and practices at the surgical ward. The chapter also focuses on proposed solution for improving patient safety by adopting online monitoring methods. The process of obtaining solutions is demonstrated involving a combined analysis of the data collected, along with the literature review and empirical findings.

Chapter 5: The chapter discusses the results and gathers the author's insights on the findings. The results are compared with the literature and some comparison points are presented. It also offer further recommendations for the proposed solution.

Chapter 6: The chapter conveys the concluding statements along with answers to the research questions. It also discusses the limitations of this research and scope for future work.

2
Methods

The methods chapter will focus on describing the methods used to carry out this thesis. Starting with the choice of research design, type of design and motivation behind the choice will be provided. It also describes data collection and analysis methods that will be used in this thesis, along with the process of performing literature review. In the end, ethical aspects regarding the thesis will be discussed.

2.1 Research Strategy and Design

At the Skaraborg Hospital Group, an effort to monitor patient safety in real-time by adopting a systems perspective on safety demands the use of mixed methods research strategy, i.e. combining both qualitative and quantitative research methods. The qualitative approach in a mixed methods strategy is relevant when the researcher aims to study the social phenomenon and understand the perspective of different user groups (Karlsson and Hagberg, 2015). In a healthcare setting, the starting point of this approach would be to study the symbolic processes involved in providing and receiving care (Bryman and Bell, 2011). The quantitative approach in a mixed methods strategy is suitable when numerical data is to be analyzed using statistics (Bryman and Bell, 2011). This approach houses numerical, statistical, and mathematical analysis of data collected either from primary or secondary sources. It helps identify what, when, where, and how often a particular phenomenon occurs helping researchers identify variables that contribute to desired outcomes.
On the side of research design, an abductive approach, i.e. a combination of both deductive and inductive approaches will be followed. Instead of developing new theories or confirming them, this type of research design focuses on developing new concepts and theoretical models with the help of existing theories (Karlsson and Hagberg, 2015). The inductive approach will be used to make sense of the observations at the ward and build a theoretical model around it while the deductive approach will be used to collect relevant qualitative and quantitative data around the theoretical model.

2.2 Literature Review

As important as laying a solid foundation is to a building, in the same way, a literature review is important while carrying out research. The main purpose of carrying out a literature review is to map and assess the research area and build a theoretical framework around it to gain an overall understanding of the subject

with the help of existing relevant literature (Snyder, 2019). Snyder (2019) also states that literature review might be the best method to answer several research questions. Table 2.1 shows the approach followed to carry out the literature review.

Phase	Process
Selecting Keywords	The keywords represents the research topics for this thesis and they are patient safety, systems thinking approach design thinking and visual management.
Searching for Literature	The literature search was done by looking up keywords in various search engines like google scholar, science direct, research gate, and web of science. Filters were used during the search to display the newest and most cited research to arrive at credible literature. The use of Chalmers Library was done for several articles which were not accessible to students and were acquired through the professor. Few additional articles were identified and acquired from reference lists published by highly cited authors.
Reading and Analyzing the Literature	All the relevant literature from the search operation was gathered at first. The process of skimming down to the articles to be considered consists of several steps. First, the abstract and conclusion of the research article were read. Based on its applicability, a decision was made whether it was relevant to the research or not. If it was relevant, then the next step was to read the background and introduction to further funnel down on relevancy. If the literature still made sense, then it was read completely and adopted to be presented in the theory chapter.
Discussing the Literature	The literature has been used in most of the chapters either to explain concepts and research areas or to support a claim or an argument. The literature has been discussed in detail under the theory chapter to help the reader obtain a fundamental understanding of the research area. The literature is also compared with the empirical findings of this study and has been written in the discussion chapter of this report.
References	All the literature used in this thesis have been cited and listed in the end under the bibliography. The referencing style used is the Harvard system of referencing. All the Harvard-styled references have been cited with the help of Google Scholar.

Table 2.1: Literature Review Process, adapted from Karlsson and Hagberg (2015)

The process of literature review aids in developing research design and sheds light on preferred data collection methods to be used, while the theoretical framework guides in the analysis of data (Bryman and Bell, 2011). A conceptual framework was developed with the help of studied literature. This framework emphasized specific information about the scope of the project, purpose, and methods involved in carrying out the research. The conceptual framework along with the theoretical framework combined forms an analytical framework to this thesis.

2.3 Data Collection

The process comprised of both qualitative and quantitative data collection methods. All the qualitative data collection methods used has been listed in Table 2.2.

Serial Number	***Type***	***Participant***	***Date***
1	Online Interview 1	Nurse A Assistant Nurse A Assistant Nurse C Unit Manager	February 16, 2021
2	Online Interview 2	Nurse B Assistant Nurse B Assistant Nurse D Unit Manager	February 18, 2021
3	Face-to-Face Interview 1	Unit Manager Operations Coordinator	March 16, 2021
4	Face-to-Face Interview 2	Nurse B	March 30, 2021
5	Face-to-Face Interview 3	Assistnat Nurse A	March 30, 2021
6	Face-to-Face Interview 4	Unit Manager	March 30, 2021
7	Face-to-Face Interview 5	Nurse A	April 15, 2021
8	Face-to-Face Interview 6	Unit Manager	April 15, 2021
9	Participant Shadowing 1	Nurse B	March 30, 2021
10	Participant Shadowing 2	Assistant Nurse A	March 30, 2021
11	Participant Shadowing 3	Unit Manager	March 16, 2021
12	Focus Group Discussion 1	Nurse A Nurse B Nurse C Assistant Nurse A Assistant Nurse B Assistant Nurse D Unit Manager	March 16, 2021
13	Focus Group Discussion 2	Nurse A Nurse C Nurse D Assistant Nurse A Assistant Nurse B Assistant Nurse C Unit Manager Operations Coordinator	April 15, 2021

Table 2.2: List of qualitative data collection methods

The collection of primary data used qualitative methods like semi-structured interviews, shadowing techniques, focus groups, data sampling, and extraction. A quantitative method like open-ended questions was used to collect feedback data during prototype iterations (see Chapter 4). The secondary data were collected by reviewing the retrospective data extracted from electronic health records. These methodologies have been discussed in detail below.

2.3.1 Semi-Structured Interviews

Qualitative interviews are a great source of producing rich and detailed data (Bryman and Bell, 2011). Interviews are the most widely used method in qualitative research by researchers (Bryman and Bell, 2011). The approach in these kinds of interviews tends to be less structured hence giving the interviewer the flexibility to change the direction of the interview based on the responses of the interviewee. Although the process of interviewing, preparing transcripts of interviews, and the analysis of these transcripts are time-consuming, the content and information it generates are valuable and hard to replicate with any other methods.

The method of semi-structured interviews was used in this research to gain a comprehensive understanding of the ongoing processes while at the same time trying to capture the perspectives of different user groups. The interviews were partially carried out online through Skype and mostly face-to-face at the hospital ward. Carrying out online interviews were not by choice but rather by the limitations set by the Covid-19 pandemic which made visiting the hospital hard.

2.3.1.1 Online Interviews

The online interviews were focused on getting to know the people working at the ward and their daily routines. A list of general questions was prepared to gather specific information and at the same time ask questions related to pain points experienced by user groups to empathize with them. The list of general questions included introducing, probing, follow-up, interpreting, some direct and indirect type of questions. A total of 2 online interviews were carried out where each interview spanned between 60-90 minutes; however, the number and duration of interviews were not predetermined. The participants for the interview were selected based on their availability and at random. Each interview consisted of 4 participants, refer to Table 2.2 for details. Unfortunately, these interviews were not recorded due to technological limitations.

2.3.1.2 Face-to-Face Interviews

As the Covid-19 situation eased, it was possible to visit the hospital to carry out further interviews face-to-face. The interviews were aimed at gathering an in-depth understanding of the present ways of working with patient safety and risks associated with it at the ward. The areas of focus while questioning were 1) the current state at the ward, 2) participants' perspective of patient safety, 3) current efforts to deal with patient safety, 4) technology and tools used in daily lives to manage operations

and patient safety. A framework of questions was generated to uncover the needs of the user groups, i.e. the nurses, assistant nurses, and the unit manager while keeping it adaptive to modify questions based on the responses, competence, and knowledge level of the user groups. Apart from questions aimed at understanding the current operations, additional questions were targeted at various pain points and existing risks in the system; both at an individual and systems level, while also following up with questions on the potential risks likely to cause adverse events. Few specifying questions were aimed at letting participants narrate scenarios which helped in obtaining a clear understanding of pain points in an operational context. A total of 6 in-depth interviews were carried out, see Table 2.2 for details about the participants. The duration of the interviews ranged from 90-120 minutes. The duration and number of interviews were not predetermined but depended on the depth of interviews, quality, and quantity of the content acquired. Participants in a few of the interviews consented to have the meeting recorded, and these recordings have been transcribed systematically.

2.3.2 Participant Shadowing

To gain a deeper understanding of the interactions between different components within the system, the process of participant shadowing was carried out. In shadowing, the researcher closely follows a participant, in this case, a healthcare worker, throughout their shift or over a couple of days (McDonald, 2005). The researcher follows the participant on all occasions from the start of their working day. This includes shadowing the participant while carrying out their routine tasks, attending meetings, and also during their coffee breaks when they meet their colleagues (McDonald, 2005). The researcher can ask questions while shadowing to gain clarity on certain matters. Also, the researcher can ask direct questions which are intended to reveal the purposes of various activities or dialogues (McDonald, 2005). The shadowing technique was chosen as it offers a higher level of analysis. The qualitative data acquired by this approach is more detailed when compared with other data collection methods (McDonald, 2005). Besides, shadowing also offers the chance to personally witness the process and gather reliable first-hand data (McDonald, 2005) rather than relying on responses given by an individual, which may not be true all the time.

The main aim of shadowing was to observe how the healthcare staff work with patient safety and identify the risks in the system. A secondary goal was to observe the needs of the workers for monitoring patient safety in real-time. A total of 3 participant shadowing were carried out during the research, refer to Table 2.2 for details about the participants. The shadowing was carried out by the researcher at the ward and the choice of participants was dictated by voluntary participation. The shadowing lasted from 2-3 hours during the working shift of the participants. During the process, a lot of follow-up questions were asked to gain clarity and to determine the purpose of several activities performed by the participants. The researcher simultaneously made notes of all the activities performed and relevant interactions with other workers at the ward. However, to maintain the confidentiality of the

patients, only certain parts of the shadowing process were recorded and transcribed.

2.3.3 Focus Group Discussion

In addition to the semi-structured interviews and shadowing, participants were requested to attend focus group discussions. Focus group discussions are widely used in qualitative research to get a deeper understanding of the social causes (Nyumba et al., 2018). The dynamics of a focus group produce good quality and quantity of information needed as participants tend to open more in a group setting.

The focus group discussions were aimed at uncovering the participants' perception of patient safety and their ways of working with it. A total of two focus group discussions were carried out in a comfortable setting where the participants felt at ease. The groups were well informed about the study and all the necessary information required for them to know was provided beforehand.

The first focus group discussion had around 7 participants, see Table 2.2 for more details. The topic for discussion was patient safety issues and causes of adverse events. The participants were asked to share their experience about this topic and how they perceive it was recorded. On the other hand, the second focus group discussion consisted of 8 participants. The topic of discussion was about the current ways of working with patient safety and Green Cross. Green Cross is an incident reporting system based on a procedure designed to identify risks and potential adverse events (see Section 3.1 and Figure 3.2). The participants were asked to discuss the last occurred adverse events and how have they been dealing or dealt with them, also to share their understanding of the Green Cross. In both focus groups, the participants were free to discuss and talk with the other group members.

2.4 Data Analysis

Qualitative research produces a large amount of data in quick successions in the form of field notes, transcripts, and documents (Bryman and Bell, 2011). The richness of the data gathered makes it difficult to define an analytical path or in other words channelize the data to make sense of it. Bryman and Bell (2011) suggest several approaches to perform qualitative data analysis, from which the general approach is being used in this research. This approach is based on the fact that data analysis is an iterative process. There is repetition to and from between the data collection and analysis (Bryman and Bell, 2011). A general approach of analysis begins after a certain amount of data is collected and the results obtained by its analysis shapes the next and future steps of the data collection process. By following this approach, the qualitative data collected throughout the research through interviews, participant shadowing, and focus group discussions were analyzed at regular intervals or mostly right after collecting the data. The insights generated from regular analysis of data shaped the next steps in the research process. The results of the analysis were constantly discussed with the different user groups at the hospital to cross

verify the researcher's interpretations.

In this research, almost all of the quantitative data were extracted from electronic health records and incident reporting systems. This data had been collected by the hospital over the years and is referred to as secondary data. Due to time and resource constraints, the researcher had to resort to the use of secondary data. A secondary analysis approach was used in the research to obtain relevant information from the historic quantitative data (Bryman and Bell, 2011). This type of approach towards analysis saved a lot of time and costs and provided more time for the analysis of the data. Although Bryman and Bell (2011) state that secondary data tend to have very high quality but a lot of inconsistencies like missing fields were observed in the secondary data collected by the researcher. In the process of fetching quality data and meaningful insights, quantitative data analysis was performed. The first step in this analysis was to identify the missing data and categorize them as 'others'. The next step was to sort the data according to specific conditions and build frequency tables. Diagrams are claimed to be the most frequently used method of representing quantitative data (Bryman and Bell, 2011). The next and final step was to construct various graphs and charts to visualize the quantitative data from the frequency tables. This marked the end of both the qualitative and quantitative data analysis process.

2.5 Ethical Considerations

Bell et al. (2018) proposed a set of important principles related to ethical considerations in research projects. Out of those, the following four areas were used to evaluate the ethical level of the report.

Harm to Patients - This principle preaches that no participant in the form of respondents or interviewees should be harmed or left harmed in any way including psychological, financial, and social harm. To comply with this principle, all the participants involved in any sort have been made anonymous. The data collected from different individuals are aggregated and presented, hence the chance of identifying an individual based on particular data remains difficult. Although, there are instances where only a small group was involved and making it possible to identify individuals based on the response data. Additionally, all the participants involved have been notified about their anonymity in turn preserving their psychological comfort.

Informed Consent - This principle expects the researcher to obtain informed consent from all the prospective participants. Information related to the study, in specific, the purpose and resulting expectations of the project were provided to all participants. All questions and concerns of the prospective participants were answered to help them make an informed decision about their participation in the study. The interviews and observations began only when the participants were ready. The participants were informed about the progress of the project to make them feel included.

Invasion of Privacy - This principle deals with maintaining the right to privacy of participants. The participants were asked for their consent before performing shadowing techniques. They were given full privacy and also the chance to back out if and when the questions or the study made them uncomfortable. The participants were also respected if they were not willing to disclose certain information and were not forced to do so. Lastly, the participants were informed about their right to stop or remove any piece of information provided by them from being published.

Deception - This principle narrates that the participants should not be deceived by portraying the research to be something else. The interactions with the participants were transparent and honest, also no foul play was used to trick them into giving certain information. All questions asked during the project were intended in good faith and did not cause any deceit to the participant.

Finally, another important ethical consideration apart from the ones listed above is data protection and confidentiality. The data acquired by different sources will be used for research purposes and will not be used for any other purpose. Confidentiality will be maintained on the requested aspects and attributes.

3

Theory

The theory chapter is aimed at offering an analytical framework to the readers. Several theoretical concepts and research fields will be presented for the readers to get an understanding of the underlying concepts affecting the research questions. In order to get a comprehensive understanding of the concepts, every concept will be presented in terms of its history, meaning, associated concepts, currents trends, and challenges.

3.1 Patient Safety

According to WHO, patient safety is one of the disciplines in healthcare that emerged because of increased complexity in healthcare systems with the consequential rise of patient harm at health care facilities. Patient safety focuses on preventing and reducing the risks, errors, and harm to patients while receiving care. Facilitated learning from past errors and adverse events is fundamental in improving patient safety. The WHO also states that patient safety can simply be defined as the prevention of errors and adverse events to patients in a healthcare system and is fundamental in delivering quality healthcare. Although Emanuel et al. (2009) argue that distinguishing safety from quality is a challenge that some find important to address, while others dismiss it as an exercise in semantics. They propose a definition for patient safety in a way that considers patient safety as both an emergent discipline and a way of doing things. Emanuel et al. (2009) define patient safety as a discipline in healthcare that follows safety science methods towards achieving the goal of establishing a trustworthy system of healthcare delivery. It is also considered as an attribute of the healthcare systems as it reduces the incidence and impact of adverse events.

Patient safety contributes to delivering safe care to patients by preventing the occurrence of adverse events in a healthcare setting. Patient safety exists exactly in the micro-system, the same environment where care-related activities occur; the operation theatre, the emergency department, and the care units are few places. The discipline of patient safety is relatively new in healthcare and is believed to have its roots in disciplines outside medicine (Emanuel et al., 2009). Healthcare quality, human factors engineering, cognitive psychology, organizational management science, and few paths of engineering can be thought of as the seeds from which the discipline of patient safety grew. Patient safety in a system strives to achieve high reliability under risky situations (Karlsson and Hagberg, 2015). Falling ill can be attributed

to being the first situation of risk. Patient safety can be the second situation where there is a therapeutic intervention. Surgeries can be one situation that demands no errors. Hence patient safety demands the design of safety systems to make risky interventions reliable (Emanuel et al., 2009). Patient safety also features an inherent learning tool that acts as a learning facilitator. The data on the occurrence of errors and adverse events can be primarily used to get a better understanding of the system. It provides continuous cycles of learning and offers different perspectives on the adverse events to understand how risks like these can be avoided and mitigated.

The Agency for Healthcare Research and Quality (AHRQ) has determined a list of the best safety practices on the recommendation of the IOM (Institute of Medicine, now referred to as The National Academy of Medicine) (Leape et al., 2002). Based on a consensus process carried out by the experts from the National Quality Forum under the AHRQ, generated a list of effective practices and disseminated it to all the clinicians. A 600-page long report was released which is way too complex to concisely summarize. The emphasis was given by the practitioners on the practices that showed strong evidence. However, many contradicting reports surfaced. One of the many arguments was based on the currently unpreventable adverse events which made more than a third in the list of best practices. Although Emanuel et al. (2009) propose their model of patient safety that practitioners can adopt. They promote their model as a simple overarching model that is compatible with the existing models. Figure 3.1 portrays the model having four domains that interact with each other internally and with the environment externally.

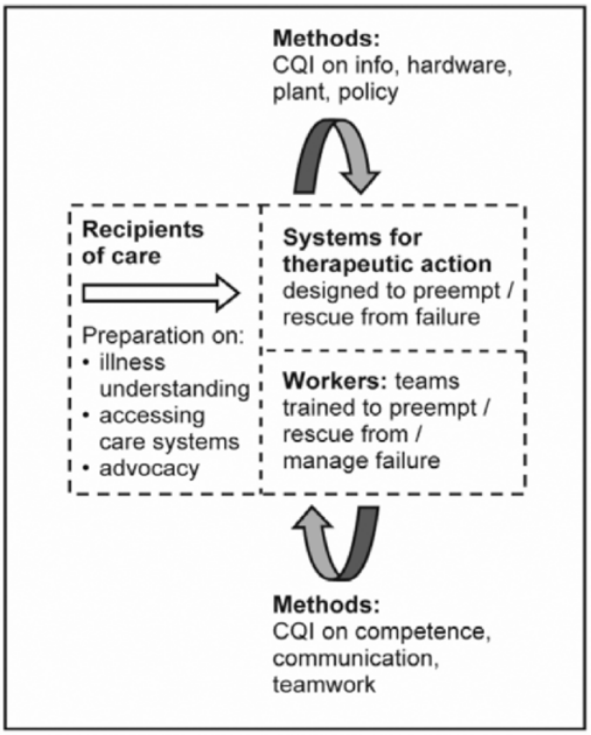

Figure 3.1: Overarching model for patient safety. (Emanuel et al., 2009)

Recent studies published in the Institute of Medicine (IOM) report have shown that patient safety links with concepts of a high reliability organization (HRO) (Tamuz and Harisson, 2006). The high-reliability design did not originate as a discipline of healthcare, but the concepts of healthcare are following high-reliability design and its evolution over the years. Adverse events are risks that have high stakes, and any risk of failure can cause great damage to life and other systems. Patient safety system hence demands a high-reliability system that is designed considering the nature of the illness to avoid errors of any kind. On a similar note, HRO suggest having a holistic approach to human errors affecting safety and how an organization or system can contribute to preventing individuals from making these errors. Organizations have realized that errors are a part of the system we work in and must be monitored by creating aids to report errors and alert users. Incident reporting (IR) is the most used reporting system in Sweden and many other countries (Nygren et al., 2013). The IR comes with its drawbacks which makes this process ineffective at times.

Healthcare systems cope with extraordinary situations on a daily basis. Weick and Sutcliffe (2001) believe that healthcare systems have adapted and have learnt to deal with challenging and disruptive events to react appropriately to any unexpected situation. The Healthcare systems use HRO's organizing principles in the process of responding to crisis situations (Weick and Sutcliffe, 2001). They state five core principles that guide HROs and are as follows:

1. *HROs monitor small failures:* HROs take into account every small failure and examines them to detect their root cause and its effect on the system.
2. *HROs are reluctant to accept simplification:* To develop order and clarity, simplification is necessary. It helps in developing simple routines for organizations to follow. However, too much simplification can result in lapses and omission of crucial data required for problem solving.
3. *HROs remain sensitive to operations:* HROs should keep focusing on the current operations as it is happening and attend to messy situations. Close calls in a system shows that there is something wrong and right lessons are to be learned from them.
4. *HROs develop and maintain a commitment to resilience:* HROs regularly put systems under massive stress and unforeseen situations which demands them to adapt continuously to these changing circumstances. Weick and Sutcliffe (2001) state three core capabilities of resilience. First, a system is resilient if it can absorb strain and still keep working when things get tough. Second, if it has the ability to bounce back from crisis situations after having learnt from them. Third, possesses uncommitted resources that can be deployed during crisis situations.
5. *HROs practice deference to expertise:* Managing a crisis demands expertise or prior experience dealing with such events from individuals. These individuals should forego the hierarchy and take charge of the situation. To handle the crisis, the focus should be on what the system knows and is capable of handling instead of taking pride in what individuals know.

Adopting a HRO approach for patient safety not only focuses on the learning systems but also fosters a culture that focuses on safety within the organization and the system. Safety culture has been defined in different words, but altogether, it means the same thing. Singer et al. (2009) define it as 'the values shared among organization members about what is important, their beliefs about how things operate in the organization, and the interaction of these with work units and organizational structures and system, which together produce behavioral norms in the organization that promotes safety. Reason (2000) mentions that awareness of the fact that failures will occur is pronounced in HRO and this is met by training staff to recognize and act when failure happens. In this way, the safety culture is made part of shared values among staff members (Schwarz et al., 2021).

In recent years, patient safety has been offering opportunities to improve the care delivered to the patients, however, adverse events often end up unreported (Burlison et al., 2020). Currently, the Green Cross method has gained some light among the hospitals in Sweden. It can be described as an incident reporting system as it is based on a procedure designed to identify risks and potential adverse events at the local level with a structure to summarise events and elevate them to a managerial or organizational level when needed (Schwarz et. al., 2021). The method houses both reactive and proactive components while it conveys the importance of reporting and assessing the seriousness of both incidents and risks (Schwarz et. al., 2021). It was developed at Södra Älvsborg Hospital in 2011. Figure 3.2 shows the process of working with the Green Cross method.

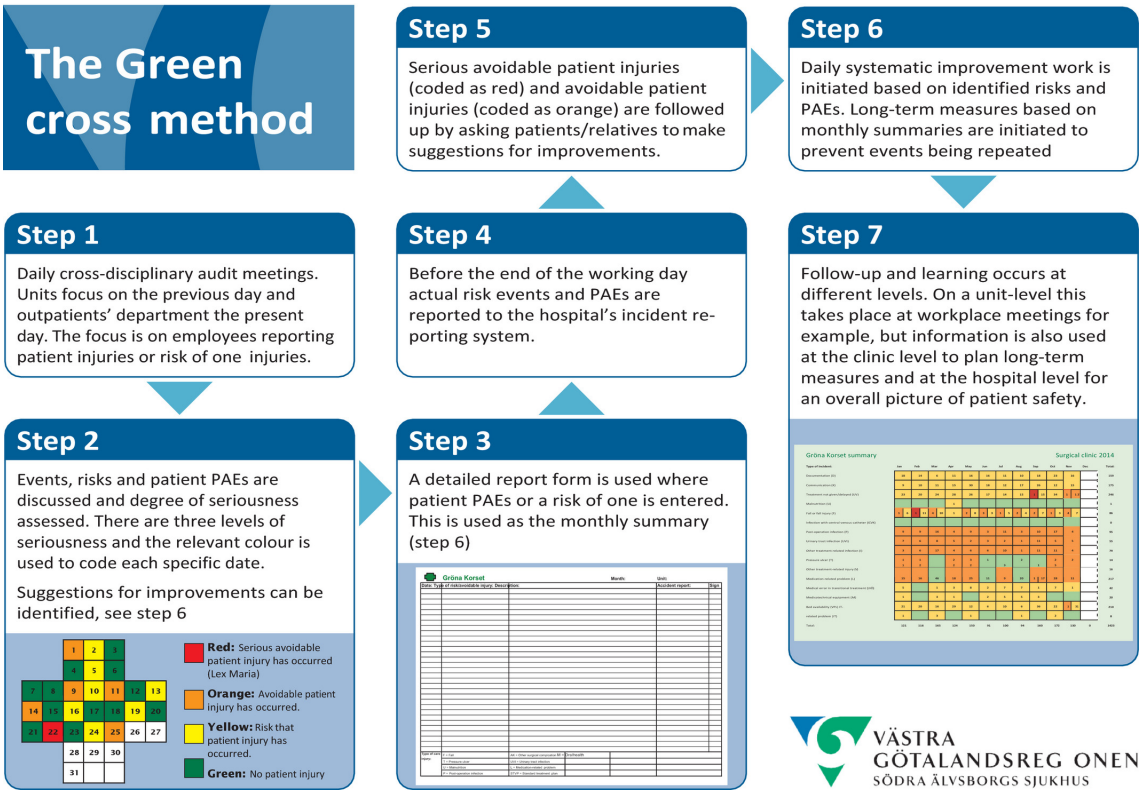

Figure 3.2: Seven steps of the Green Cross Method. (Schwarz et al., 2021)

Adverse events are likely to occur even in well-developed systems owing to latent conditions and active failures. Reason (2000) defines active failures as "unsafe acts committed by people who are in direct contact with the patient or the system", which includes slips, procedure violations, medication errors out of many such acts. Latent conditions refer to the ineffective management of resources, like under-staffing, inadequate equipment, etc. To reduce the occurrence of adverse events and facilitate learning from them, patient safety systems need to be user-friendly. Factors like lack of responsibility, limited organizational support, and not limited to lack of adequate knowledge can hinder the use of these learning systems. On the same note, proper guidelines, role models, and promotion for reporting can facilitate learning.
Safe system design, diagnostic error, and ambulatory sites of care have become the primary focus while improving patient safety (Asan et al., 2021). A triangular communication between doctor, patient and the computer (Electronic Health Records) has changed the dynamics in primary care. The technology has proven to be effective in terms of improving quality of care, patient safety, and decision making. However, the drawbacks of this have also been reported, including the additional burden on the doctors and other surfacing adverse effects. An opportunity for the patients to verify their diagnoses results can help in getting more accurate results which will be of use in care planning. The technology has also introduced new opportunities for error concerning patient safety, including an increase in the wrong patient and wrong medication.

The dependence on health information technology has resulted in a significant decrease in the occurrence of adverse events (Furukawa et al., 2020). A retrospective study carried out by Furukawa et al. (2020) in hospitals by examining the electronic health records and occurrence of adverse events revealed some interesting results. Most of the adverse events reported were acquired in the hospital. Infections, adverse drug events, post-procedural events, and general events are among the few. The results of the study suggested that adopting a fully electronic health record system makes surgery patients less vulnerable to hospital-acquired adverse events.

3.2 Systems Thinking Approach

The inception of the systems approach traces back to the first half of the twentieth century (Checkland, 1999). A group of so-called 'organismic biologists' was working with developed organisms in biology. Process characteristics like metabolism and self-reproduction in organisms were developed by focusing on these organisms as the units of analysis. In the late 1940s, one among the organismic biologists, Ludwig von Bertalanffy argued that these units of organisms could be grouped to see different organisms forming a complex system (Checkland, 1999). Since the mid-twentieth century, the systems approach theory gained light as an alternative approach to traditional analysis techniques (Larsson et al., 2010). The failure of the latter to deal with more and more complex systems opened the doors for systems safety approach. The concepts of systems safety could cope with explaining the social and socio-technical phenomena within a complex system in which the traditional mechanistic thinking approach failed. According to a WHO report by

De Savigny and Adam (2009), the origins of systems thinking were found in diverse disciplines like engineering, economics, and ecology. Karlsson and Hagberg (2015) traced back the concepts of systems safety to a technical research paper published in 1947 and was based on Engineering for Safety. Since then, systems theory has found relevance in many other fields like sociology, psychology, geography, and anthropology (Checkland, 1999). It has established itself as a multi-disciplinary concept that offers multiple languages to communicate subject matter for many different fields.

Rasmussen (1997) states that "a system is more than a sum of its elements". His idea of systems safety is built upon the fact that systems are complex consisting of numerous components (individuals, task, machine) and hence need to be analyzed, modeled, and managed accordingly. The process of modeling a system requires identifying and defining each component within the system along with their interactions and dynamic behavior. On a similar note, Waterson (2010) states that a systems approach consists of a detailed examination of how various components interact with each other and their involvement across different system levels and interfaces (meso and micro levels). An example of a complex system is well represented by hospitals. A hospital consists of a large number of socio-technical components with a variety of professions intended to perform certain roles and duties in collaboration with different technological applications (Electronic Health Records, Incident Reporting). Another understanding of this approach is explained by Arnold and Wade (2015). They state that a system consists of three things: elements, interconnections, and purpose, forming a group of the unified whole of regularly interacting components. Figure 3.3 represents the safety test model developed by Arnold and Wade (2015) to evaluate people's perception and understanding of systems approach based on the existing theory.

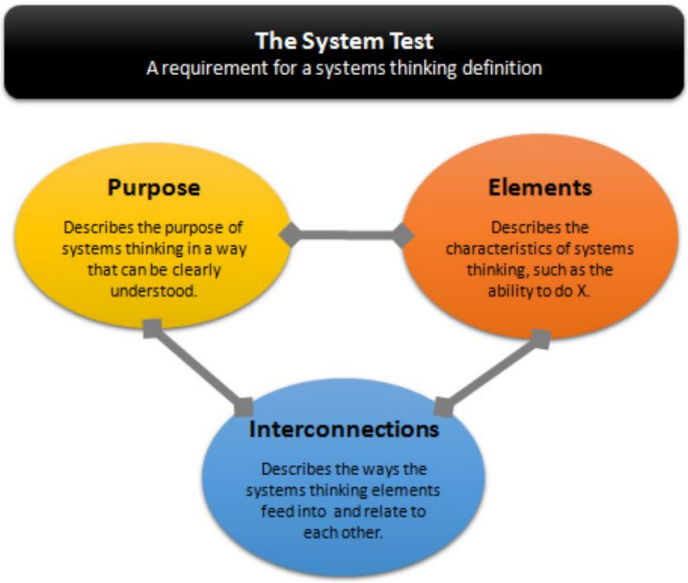

Figure 3.3: The System Test by Arnold and Wade (2015)

The theories or definitions adopted by various authors and organizations are ex-

amined to see whether they have considered the three things listed in the model. Arnold and Wade (2015) believe that an understanding of these three things and their interactions is key in understanding the systems thinking approach.

To better understand the systems thinking approach in a healthcare context, De Savigny and Adam (2009) list out several characteristics of systems. Healthcare systems are self-organizing which means that the behavior of the systems does not depend on a single component or agent but rather is a result of the interactions between these components that determine the system dynamics. Healthcare systems are subject to constant change; the systems are adaptive and hence adjust and readjust at various intervals of time. This renders the system unpredictable and the same ways of working or procedures for a certain process might not be the same anymore. Healthcare systems are tightly linked forming a high degree of interdependence. Any changes or adaptations in one component will positively or negatively affect the other components in the system. Healthcare systems are non-linear, which means that components of the systems do not act in a linear way like a simple input-output process. The components generally display non-linear and unpredictable interventions at the system level. Healthcare systems are dependent on history, meaning, the effects of intervening differs from that of short-term and long-term. Healthcare systems are counter-intuitive suggesting that interventions made for certain settings may not result in the same as they did for other systems however simple and effective. Lastly, healthcare systems are resistant to change. This characteristic does not come as a surprise as most of the systems often resist change. In healthcare, what seems to be an obvious solution to an existing problem may fail and might worsen the situation. To be able to develop something that intervenes with a healthcare system, especially with the actors who have their ways of carrying out pivotal tasks, it is important to have a comprehensive understanding of the system.

In recent years, system thinking developed as a response to increasing complexity in various disciplines other than healthcare (De Savigny and Adam, 2009). The concepts were used to understand the interactions and appreciate the existing relationships within any chosen system. More recently, the healthcare systems have started adopting a systems approach to deal with single issues like obesity and tobacco control (De Savigny and Adam, 2009). Although, not a lot have been successful or have attempted to apply the concepts of systems safety beyond the scope of single issues within healthcare. This can be attributed to the fact that the interactions within healthcare have seemingly increased and led to overwhelmingly complex environments in a system.

The successful application of the systems approach has been well established in domains like aviation, nuclear power, and rail transport (Waterson, 2009). Although, in recent years, the systems approach has gained popularity within the healthcare sector. This is because research groups are getting attracted to the application of human factors and ergonomics within the field of patient safety (Waterson, 2009). Due to increased research output in this field, concepts of the systems approach have been at the forefront. This in turn has established the potential for its application

in patient safety within healthcare settings (Waterson, 2009). Researchers have proposed several models and frameworks that define the path towards the development of existing theories and empirical research on a systems approach to patient safety. One of the many safety models is the System Engineering Initiative for Patient Safety (SEIPS) (Carayon et al., 2006). This model determines how organizational processes and structures affect the overall levels of patient safety within the system. It can be used as a framework to research patient safety as it focuses on both human and engineering aspects of systems by examining how a variety of factors affect patient safety single-handed and when combined (Carayon et al., 2006).

On the other hand, Reason's (2000) Swiss Cheese Model of safety is known to be a widely accepted and well-established systems-based model on patient safety. Reason proposed the Swiss Cheese Model to analyze medical errors and incidents affecting patient safety (Perneger, 2005) by explaining the occurrence of these incidents resulting in adverse events. The model showcases a complex system consisting of several barriers which act as layers of defenses. Across the barriers on one end are the hazards while on the other end, there are losses which are separated by several layers of cheese. These layers of Swiss cheese could be thought of as the barriers and the holes present in these layers of cheese represent the inherent weaknesses of the barriers. The weaknesses can be a result of active failures or latent conditions. These weaknesses in the form of holes are inconsistent and tend to appear and disappear on the block of cheese (Perneger, 2005). However, when all these holes are aligned linearly, the hazards pass through the defense barriers and result in incidents and losses.

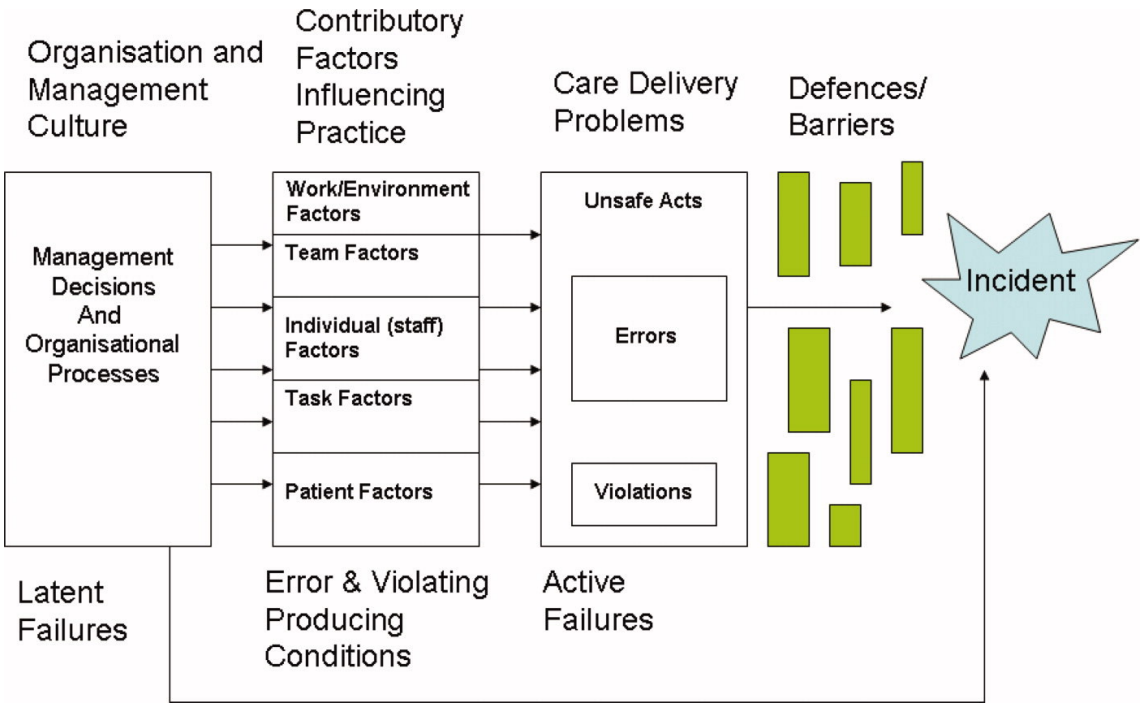

Figure 3.4: A model of organizational accident causation within patient safety by Waterson (2010)

This model presents several variations adapted according to different system conditions and can specially be tailored for patient safety. It helps in uncovering various system-level factors which aid in determining the causes of accidents and errors (Waterson, 2010). One such model was developed by Waterson (2010) which he originally adapted from Vincent's (2011) theory of patient safety and causes of adverse events. Figure 3.4 illustrates the model tailored for current ways of working with patient safety and accounts in the major micro and meso-level factors.

The model presented in Figure 3.4 represents a generic healthcare system consisting of different components at the individual and systems level. The latent failures that exist in the system as a result of the organizational practices and decisions made by the management directly cause incidents. The occurrence of these incidents brings out the latent failures hidden in the system as a product of organizational culture. Governed by the organizational decisions are the various practices to carry out work. However, these practices are influenced by certain factors that affect the components and force them into causing violations and errors. This is highlighted in the second layer containing the different possible factors involved in general healthcare practices. These factors in turn influence the process of care delivery. This is the third layer where the occurrence of active failures surface. When all these three layers are aligned, the inherent weaknesses among them will let risks get the better of them and moves to the final stage. In the end, a set of defense barriers that have been in place as existing reinforcements to deal with the risks might mitigate them. However, not all the risks are avoided, some risks due to the absence of particular defense barriers, make it through them and lead to adverse events. It is important to identify these risks and monitor them while they are still premature. This will help in setting the right defense barriers at the right time to avoid the occurrence of incidents leading to adverse events.

The systems thinking approach comes with a set of challenges when applying in an organizational context. De Savigny and Adam (2009) believe that many organizations think that the application of systems perspective is too complicated for practical purposes. They have devised a list of challenges which they think are predominant in a healthcare context. However, only a few of them will be discussed as the others are not relevant to this research. Out of the ones being discussed, the first one is the ability to manage and coordinate established partnerships and expectations with system stakeholders. The application of systems perspective results in various supporting partnerships to strengthen the healthcare system. These partnerships pose a challenge while coordinating with stakeholders and their expectations when developing interventions. Different stakeholders will promote different priorities and perspectives which might all be true. The challenge here is to effectively manage the contributions made by the stakeholders. Another challenge in complex systems is the resistance to new policies and procedures. As healthcare systems exhibit a non-linear property with no fixed ways of working, workers are accustomed to their ways of interpreting things and working with them. Interventions while applying systems perspective can generate certain policies and procedures which might be daunting to the workers, hence offering resistance. Last out of many, is

the capability of the workers to interpret the concepts of a systems perspective and understand the purpose behind it. This requires establishing the right competencies and experience among the workforce. Systems thinking is something very different from what healthcare workers specialize in. Hence they need to possess good learning and knowledge sharing skills and establishing this with the existing workforce is a challenge.

3.3 Design Thinking

The origin of the term 'Design Thinking' can be traced back to the late twentieth century when Rowe (1987) used it as the title of his book. It was based on the process of systematically designing structures in architecture and urban planning. Five years later, the first design thinking research symposium took place which explored the design methodology from a design thinking perspective (Dorst, 2011). Since then, design thinking has evolved into different theories and models mainly offering a wide array of perspectives on design methodologies. Dorst (2011) states that design thinking has been gaining popularity in recent times owing to its exciting ways of solving problems in fields like business and medicine. Over the years, the concepts of design thinking developed to be used in both theory and practice (Johansson-Sköldberg, 2013). Kimbell (2011) highlights the aspect of how thinking has always been a part of a design process, although the term design thinking has become prominent over the first decade of the twentieth century as a result of the intangible work done by various designers. Liedtka (2018) carried out a seven-year study where 50 projects across sectors ranging from business to healthcare were examined. The results of this study showed how design thinking was the new social technology and had the potential to improve processes. Liedtka (2018) made a comparison of how total quality management transformed the manufacturing industry, similarly, design thinking will transform the innovation industry.

Design Thinking has become one of the new ways of problem-solving methods in the innovation process at various established organizations (Kupp et al., 2017). It fosters innovation and can be used in any organization (Carlgren et al., 2016a). This approach is mainly a problem-solving technique and is considered more of a way of thinking than a process. It is a creative process that yields great innovation results if used in the right way (Carlgren et al., 2016a). It can be used in diverse organizations, and also there are cases where design thinking has been applied within an organization to facilitate business processes and also between different projects (Carlgren et al., 2016a). It emphasizes a certain set of principles, like framing problems, learning through prototyping, creating stories instead of ideas, and having collective curiosity. Often design thinking starts as a separate process that is handled by a team that is well versed with this technique. The process demands building a team with diverse backgrounds who can bring different perspectives to the table. Having a different mindset and personality will help the team in generating a wide array of ideas and will create a wider solution space.

The process of design thinking should follow these three stages of development: In-

spiration, Ideation, and Implementation (Brown, 2008). Inspiration seeks to identify problems, opportunities, and sometimes both which creates the desire to find solutions. Ideation focuses on the process of finding potential solutions by generating, developing, and testing numerous ideas. Implementation deals with establishing the solutions and creates a pathway for improvement iterations for direction changes and refined ideas. Figure 3.5 explains in detail the design thinking framework charted by Brown (2008).

Figure 3.5: The Design Thinking Framework, adopted from Brown (2008)

This framework lays out details of the processes involved from start to end and gives the reader clarity about the concept of design thinking. This framework has been the guide for design thinking practitioners to execute projects across organizations and produce desired outcomes. Similarly, Roberts et al. (2016) use the design thinking framework to manage healthcare and innovation. Developing empathy, radical collaboration, and rapid prototyping are the most widely accepted and applicable

core methods used in design thinking within healthcare (Roberts et al., 2016) However, the core methods can change among different practitioners and organizational settings.

In a healthcare setting, **the first** and most crucial step for the team is to **empathize** with the different user groups. The objective is to develop a deeper understanding of the desires and values along with uncovering the explicit and latent needs of the user groups. Brown (2008) suggests that people often tend to say something different than what they do, hence making it difficult to identify the real needs. He suggests practitioners indulge in their daily lives to examine and observe their working space, methods, and behaviors within the organizational context. Roberts et al. (2016) describe a set of activities that can help practitioners in empathizing with the user groups out of which the first one is *contextual observations*. This activity involves mapping the day-to-day tasks of target user groups. This allows the practitioners to generate insights from different perspectives which would not have been possible otherwise. The second activity in developing empathy is called *self-documentation* and involves taking pictures and videos of work spaces, audio recording, and written notes to document every experience of the target group. Following which, is the activity of exploring *extreme users*. It involves understanding the stories of the populous that exist outside the territory of normal users. This can include users, not limited to, with additional responsibilities and work burden. The challenges captured from these users can help in generating insights to make effective interventions in the healthcare system. In the end, *analogous scenarios* involves asking the user groups how they could improve the situation or if they had seen other organizations take certain steps to improve. This way of producing alternative scenarios can help empathize with the user groups.

The second design thinking method proposed by Roberts et al. (2016) is called **radical collaboration**. The basis of this method is that no single discipline can address problems in healthcare systems as they are complex systems involving multidisciplinary interactions. Like the previous method of empathizing, Roberts et al. (2016) list few activities that can guide radical collaboration. The first one is called *Outside-in participation*. This activity usually consists of inviting team members from different groups. For example, in a healthcare setting, nurses, assistant nurses, doctors, and admin staff can join the meeting. Observing them interact and work with the other group members while exposing them to new ideas and experiences will help capture valuable insights. The second activity is called *stop brainstorming*. Roberts et al. (2016) state that the traditional way of brainstorming can hinder creativity. They instead suggest carrying out a more disruptive way of brainstorming technique where inputs and perspectives are generated from a more diverse group of people. The final activity in radical collaboration is the *introduction of constraints*. Design thinking being a creative process, it seems meaningless to put constraints in place. However, too much creativity offers limitless perspectives and hence paralyzing the creative minds of the stakeholders. It is necessary to strike the right balance by testing different constraints and adjusting them according to how team members reframe the problem to develop a range of potential solutions.

The third and final design thinking method proposed by Roberts et al. (2016) is **rapid prototyping**. The idea behind this method is to develop rapid prototypes instead of suggesting theoretical ideas. The prototypes are built-in rapid iterations to evaluate alternate ideas before going on to select the final best option. This method is a tangible way to realize ideas and learn something new about user groups and their approach towards them. Roberts et al. (2016) suggest some activities for rapid prototyping. The first activity in the chain is to *identify variables*. This activity insists on utilizing the existing qualitative and quantitative data to identify a certain set of variables for testing. Although the prototypes are not full-scale, the small-scale prototypes can help in understanding particular aspects of the solution and mindset of the user groups. The second activity is *contextual prototyping*. This activity involves testing and refining the prototype by involving the user and working with it in daily work environments. The goal is to let the user groups experience the prototype with minimum explanation and capture their interactions with the prototype. And finally, the last activity, however an important aspect throughout the rapid prototyping process is *user-driven prototyping*. It suggests involving the user groups in the prototyping process rather than just inviting them to evaluate or experience a prototype. This will help in understanding a diverse set of perspectives and needs of different user groups.

The design thinking approach comes with certain limitations. Kupp et al. (2017) state that design thinking often comes off as an abstract and messy way of developing solutions within an organizational setting. Although, Brown (2008) suggests that the process might seem chaotic for the first time, working continuously on the project will start making sense and yield desired results. On the other hand, The design thinking process is so fast-paced that there are times when the teams tend to lose focus from long-term goals. The teams often go on a path of divergent thinking, the team usually gets a lot of freedom which results in them losing track of the key business goals and getting knocked out into a whole new area (Carlgren et al., 2016b). As a consequence of this, while working on projects, the teams experience a constant fear of rejection and thereby produce abstract solutions to be not held accountable for failure (Carlgren et al., 2016a). Design thinking is sometimes found difficult to implement in organizations with a strong culture and hierarchy (Rauth et al., 2014). Cultures are defined by goals, values, and norms set by the organization. Design thinking works best when a diverse group of people comes together to solve a specific problem. But in organizations with a strong hierarchy, it becomes difficult to collaborate between the different departments. Design thinking fosters a flat hierarchy that is completely contradictory to the above-defined organizations. Also, organizations that are very keen on achieving productivity, performance and that nurture silos offer hindrance while implementing design thinking (Dunne, 2018).

3.3.1 Customer Needs

Companies advance their innovation process with inputs in the form of clearly defined customer needs. Ulwick and Bettencourt (2008) state that, understanding

customer needs is the key to innovation. Although, they mention that less than 5 percent of the companies they surveyed, said to have an agreement on what a customer need is. Even though most companies understand the approach to product and service innovation, they fail to understand the customer needs appropriately. Ulwick and Bettencourt (2008) argue that there are two reasons for undermining voice-of-the-customer, 1) There is no standard definition of what a 'need' is, and 2) Companies fail to understand the customer inputs that are essential to succeed at innovation. They hence introduce a set of standards that define the structure, content, and purpose of a customer need. These standards are applicable to any company that wishes to make their processes predictable and can hence benefit from it.

Customer needs are used by companies to inform and guide their development decisions and hence it is crucial to extract the right information. These needs are critical in the creation of customer value. Opinions and statements provided by customers are not enough to extrapolate the needs, customer inputs should possess certain characteristics for it to be useful; Ulwick and Bettencourt (2008) identify six characteristics that a statement should possess.

1. *Customer's definition of value should be reflected in their statements:* The inputs should reflect the defined and measured value from the customer's perspective. It should not be a direct translation or interpretation of what the customer values. Also, the statements should not reflect the company's perception of how customers measure value, or how they think it should be measured by customers.
2. *The statement must have universal acceptance:* A customer need must be applicable to all the customer irrespective of their geographic location, income group, and gender.
3. *The statement must have relevance in the present and future:* The customer needs should not be situational and change quickly after a period of time. The requirements should hold the same meaning when reviewed in any point of time.
4. *The statement must elicit a cause of action:* In order to develop solutions, customer needs should be able to indicate specific actions that needs to be taken. Inputs like, 'the solution should be easy to use' will not be effective in guiding towards solution.
5. *The meaning of the statements must not be open for interpretation:* The requirements should be transparent and should mean the same as what the customer perceives. The needs should be stated clearly and precisely so that there is no room for misleading interpretation.
6. *The statements must not influence the prioritization of other statements or needs:* The requirements should not include terms which hint towards solutions, this influences in prioritizing statements causing confusion on which is important and which is not.

Ulwick and Bettencourt (2008) mention that, to drive predictable results, require-

ment statements must possess the above-mentioned characteristics. Although, they argue that, these statements must be structured in a disciplined manner and hence have defined a set of rules for the content and structure of these statements.

1. In the process of capturing customer requirements, the focus should be on the fundamental goals that the customer is trying to accomplish by performing certain job.
2. Companies when talking with customer to capture their needs, they must ensure to not include any solutions, technology, product or service features in the statements.
3. The need statements captured from customers should be clear and not include any ambiguous terms.
4. The need statement should be clear and brief. It should not be lengthy and include any process words.
5. The words used in the need statements should be consistent throughout and should mean the same to both the customer and the company.
6. The last rule states that the need statements should follow a standard structure, content and format.

Ulwick and Bettencourt (2008) discuss about some of the best ways of uncovering customer needs and capture desired outcomes. The first step is to perform personal interviews to understand the job a person is carrying out. The second step is to conduct several observational interviews to get a deeper understanding of the context and environment in which the customer is getting the job done. The third step is to organize group interviews prompting customers to share information on how they measure success after performing their job. The final step is to perform more interviews to fill up the gaps and missing data. It also helps in validating the statements with the customer to check if that is what they meant, and if not, try to get more clarity on them.

3.4 Visual Management

The traces of visual management and data visualization goes back to Ca 2500 B.C. when the Egyptian Royal Cubit was widely used in construction projects as a measuring standard to provide information with the help of visual stimulus (Tezel et al., 2009). In the early years of the twentieth century, a lot of researchers developed visual tools to understand data in a simpler way (Tezel et al., 2009). Gantt charts, visual control devices, process mapping, and visual worksheets were some of the early discoveries. During the mid-twentieth century, the Toyota Production System (TPS) started evolving and along with it, new visual management practices emerged (Eaidgah et al., 2016). TPS developed manuals and standard operating procedures in a visual format and stuck them above the workstations to help the supervisors inspect workers if whether they were following the standard procedures (Tezel et al., 2009). After TPS started gaining attention, in 1953, they employed the kanban production and synchronization system in their machine shop (Tezel et al., 2009). Right after this, the first Fishbone diagram was used by Kaoru Ishikawa.

He claimed that 95 percent of the issues in quality could be solved with the seven visualization tools developed back then (Tezel et al., 2009). The concepts of visual control and workplace structuring started to emerge in the mid-1950s, while in 1961, poka-yoke, a mistake-proofing device was invented (Eaidgah et al., 2016). All the mentioned visual tools were not invented by Toyota but rather used as a part of TPS to visualize and enhance information flows.

Visual Management started as theoretical concepts which later were adopted by organizations to improve their system. Tezel et al., (2009) define Visual Management as a measurement system that focuses on enhancing organizational performance through collaboration and alignment of organizational culture with management practices like work processes, stakeholders, and the individual elements in the system by employing a stimulus function that directly addresses at least one of the human senses. It is an arrangement of all the tools, practices, process flows, and performance indicators at one place which can be glanced at by the work elements to understand the status of the system (Narusawa and Shook, 2009). These visual management tools help in directing and guiding work elements to appropriate locations and activities through visual cues (Goodson, 2002). Another definition proposed by Liker (2004) suits the work processes in a healthcare system. He defines visual management as a communication tool that provides real-time information on work processes. A glance of this visual tool lets the work elements visualize the processes and current status of processes to see if it is conforming to standards. Raab (2014) in their research defines Visual Management from the perspective of Stewart Liff and Pamela Posey, whom he calls Visual Management experts. They say Visual Management is a tool that converts organizational information, customers, and performance into graphical displays to get a visual depth of the organizational vision and mission.

Researchers have offered different versions of their definition of Visual Management, however, all the researchers have acknowledged visual management as a tool to visualize information in different forms. The application of Visual Management can be found in two domains depending on the type of information being visualized (Eaidgah et al., 2016). The first domain uses visual management to build informative tools that are solely used to visualize information and does not account for any performance management implications. Visual boards of plant layout, station name, employee tags, process maps like value stream maps, process flows are some of the examples of Visual Management tools under this domain. The second domain has a strong focus on performance management (Eaidgah et al., 2016). In this domain, Visual Management is applied as a directive tool. This tool in addition to displaying information also displays requirements, standard directions, and guides in taking action. Kanban cards, work instruction sheets, visual management boards consisting of key metrics and indicators are some of the examples of applied Visual Management techniques in this domain. To utilize the benefits of Visual Management, it should be included in the bigger plan (Eaidgah et al., 2016). It has to be employed in the performance management initiatives where process data is the input for the Visual Management tool, which in turn feeds the continuous improvement process. This way through a continuous improvement cycle, visual management fully benefits

the organization. Visual Management has established itself as a tool to regulate the flow of information and use it to make decisions at low costs. Several researchers have described functions of visual management that make it a useful tool across different organizations and are collated by Eaidgah et al., (2016). Visual Management,

- Simplifies the flow of information.
- Provides real-time information.
- Empowers the employees to become responsible for their processes.
- Facilitates continuous feedback and communication.
- Increases transparency by letting all employees gain information about the organizational processes.
- Improves discipline by reflecting the reality of the organization and conveys insightful messages to people.
- Creates shared ownership and develops team performance.
- Promotes management by data to manage people and processes by making data-driven decisions.
- Boosts morale by letting people share ideas and experiences.
- Supports in continuous improvement by developing feedback systems.

3.4.1 Performance Management

Performance management is a process of accomplishing, executing, and carrying out defined tasks and future activities (Eaidgah et al., 2016). This can be used to overview the processes in the organization and make interventions if necessary. Performance management is an iterative and dynamic process where work elements of the system together with their manager define goals and review results. They visualize the results to take corrective actions in the system or to reward good performances, building the morale of the work elements and further enhancing organizational performance. Eaidgah et al., (2016) state that several models describe the process of performance management, but in all the models, these three elements are found fundamental in building performance management tools.

1. *Performance Planning and Implementation:* The main purpose of this element is to build an effective visual management tool and establish periodic targets based on current and desired conditions. To achieve this, the element focuses on identifying and defining the key metrics, setting goals, and periods of review at first. Then, setting up processes for data collection and decisions on how the data should be viewed and discussed follows. In the end, it also involves establishing a feedback loop for review and discussion of key metrics.
2. *Performance Measurement:* This element focuses on measuring the performance of established key metrics during the end of review periods.
3. *Performance Evaluation and Continuous Improvement:* This element focuses on evaluating the performance of the system for the established targets. This phase offers the chance to generate feedback and recognize and appreciate a good performance. However, performances not up to the mark need to be reviewed, analyzed, and improved. In the end, generating action plans to en-

force continuous improvement marks the end of this process.

A well-defined performance management tool should be able to provide data-driven decision-making insights from process information. It should aid teams in developing a better process understanding and provide process information through benchmarking (Eaidgah et al., 2016). Other functions of the performance management tool should include, assisting managers to identify success or failure and help them in the process of measuring improvements. Performance dashboards are most widely used to establish performance management programs in an organization (Yigitbasioglu and Velcu, 2012).

Dashboards are visual devices meant to improve decision-making by capitalizing on human cognition and perceptual capabilities (Yigitbasioglu and Velcu, 2012). They also state that a performance dashboard might help in overcoming the information overload problem as it is an aggregated solution to monitor performance management metrics like business insights, scorecards, and process maps in one place. The function of a dashboard is to collect, summarize, and present data from multiple sources (Yigitbasioglu and Velcu, 2012). The data presented in the dashboard can be attributed as just the tip of the iceberg, however, to solve problems users need to perform further analysis of the data to identify causes of failures. Yigitbasioglu and Velcu (2012) have described certain purposes and uses of the dashboard which they have adapted from distinguished researchers. A dashboard,

- Is a graphical interface consisting of various business performance measures that enable managerial decision making.
- A visual performance management tool helps in visualizing the most important information in one screen that helps organizations achieve their objectives.
- Allows user groups to identify, explore and discuss various problems in the system that needs collective action.

Pauwels et al., (2009) have also described few purposes of the dashboard and ways in which it can help an organization. A dashboard helps in,

- Monitoring performance in both evaluative and developmental forms. The metrics in it provide early indicators of performance.
- Planning goals and strategies based on performance.
- Communicating with important stakeholders about the performance and organizational values as a result of the performance of key metrics.
- Establishing commonality between different regions and markets.

The development of dashboards consists of five stages defined by Pauwels et al. (2009). These have been discussed in brief below.

1. *Identifying and Selecting Key Metrics* - The author defines two approaches in selecting key metrics, General and Tailored. The general metrics are some of the standard metrics which can be applied across every setting and it enables benchmarking across different business verticals, companies, and time intervals. The tailored approach is more suited for organizations that have their

metrics to measure their performance towards defined objectives.

2. *Populating the dashboard with data* - An economical way of populating the dashboard is to use the existing metrics. Data overload has been a problem in large organizations, however, priority should be given to data most impacting performance targets.

3. *Establishing relationship between the dashboard items* - Identifying the underlying relationship between the selected metrics determines the purpose of the dashboard. It is either to visualize available data or to get an in-depth understanding of the process and decision-making system. To improve the performance of the business, it is important to establish a relationship between metrics. Random metrics cannot address the cause and effect relationship between the data.

4. *Forecasting and Scenarios* - This helps managers make data-driven decisions through what-if analysis to help them in scenario planning and budget setting. Appropriate metrics can predict the service demand approximately to which managers can deploy resources to fulfill it.

5. *Connecting to financial consequences* - The last stage in the development process is to draw a comparison between initial and final activities in terms of financial consequences. Although in healthcare, the financial consequence is substituted by patient safety outcomes. Aligning the key metrics with a view on patient safety is critical in this stage.

4

Results and Analysis

This chapter will first focus on offering the empirical setting of the surgical ward. It will then present the results of the data collection process and will discuss the key insights gained from interviews, shadowing, focus groups, and data analysis. With combined knowledge of theory and results presented, a customer-focused solution will be proposed. In the end, the process of bringing the solution to life by prototyping will be presented.

4.1 Skaraborg Hospital Group

The Skaraborg Hospital Group (SkaS) is a specialist hospital group in the Skaraborg region. It consists of four hospitals in the towns of Lidköping, Skövde, Mariestad, and Falköping. SkaS offers healthcare services including acute and planned care in 30 different medical specialties and has two emergency departments at the Skövde and Lidköping hospitals. All the four hospitals together have a capacity of around 673 beds which keeps fluctuating based on the demand and employs around 4,400 people.

4.1.1 Surgical Ward - Lidköping

As discussed earlier in chapter 1, the point of focus will be on the surgical ward at Lidköping. The surgical ward focuses on offering care to patients before and post surgeries. The capacity at the ward during the time of research was 21 beds. Although, the number of beds keeps changing according to the season. The beds are further divided and categorized into different colored groups for ease of operations and follow the same processes of providing care. Table 4.1 shows the distribution of beds across the different colored groups.

Group	Number of Beds
Blue	7
Green	7
Pink	7

Table 4.1: Distribution of surgical ward capacity at the Skaraborg Hospital.

However, the ward has the capacity to add two more beds in overcrowded situations. According to the unit manager, the allocation of patients to these colored groups is based on availability and random, except that of green as the group usually consists

of severely ill patients. All the colored groups are located on the same floor and the rooms are marked with respective group colors.

Currently, the ward has a total of 17 nurses and 15 assistant nurses working across 3 shifts, i.e. morning, evening, and night shifts. Apart from them, there are doctors and few students who are acquiring training at the ward. Each shift is of 8 hours and has a minimum demand for nurses and assistant nurses during each shift and as shown in Table 4.2 below. During a particular shift, at full capacity, each nurse is responsible to manage 7 beds within a group while the assistant nurses support the nurses with carrying out routine tasks.

Shift	Nurse	Assistant Nurse
Morning	3	4
Evening	3	3
Night	2	1

Table 4.2: Demand for nurses and assistant nurses.

The deployment of nurses and assistant nurses for different shifts is currently managed manually by the operations coordinator. Figure 4.1 shows a shift-wise schedule and names of the personnel displayed on a whiteboard over one day.

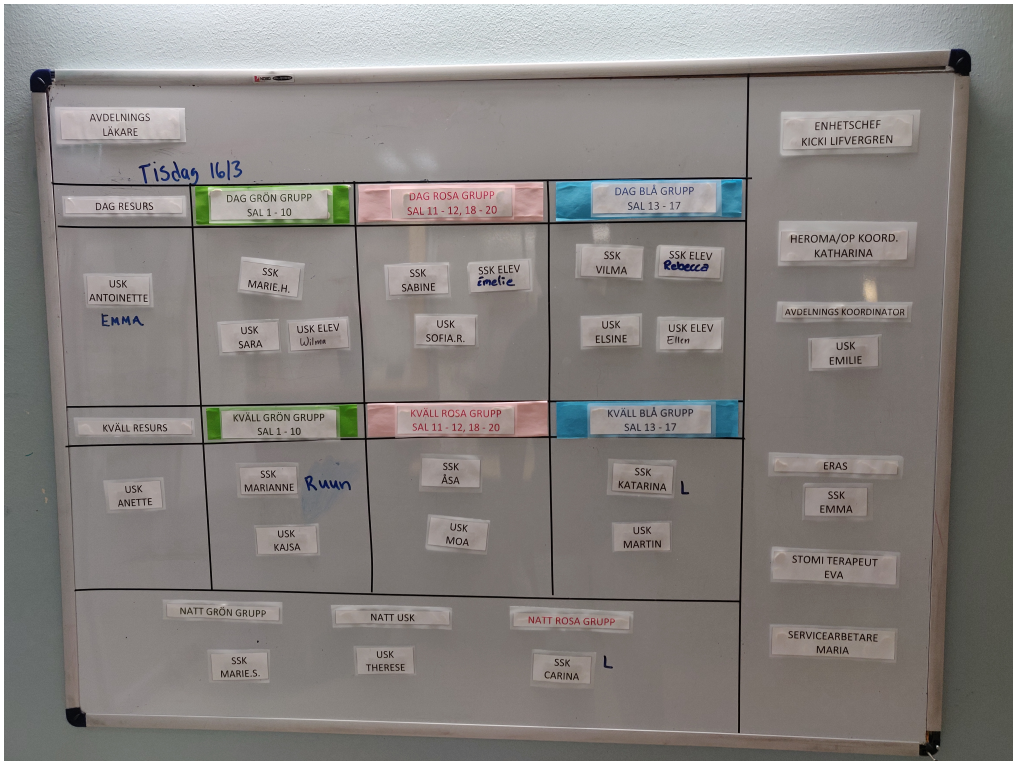

Figure 4.1: A visualization of schedule for nurses and assistant nurses at the surgical ward in Lidköping.

A 10-week schedule is prepared based on the availability offered by the nurses and

assistant nurses. However, additional resources are deployed in cases of emergency and high burden. The board is placed in the ward near the admin room and is accessible to all and at all times.

4.2 A Description of Processes at the Ward

The current working system at the ward houses various processes concerning the care process. From the moment a patient enters the hospital till the moment he/she is sent back home with quality care, numerous processes concern the safety of the patient. These processes were viewed from both individual and systems perspectives and will be discussed below. Also discussions on various initiatives introduced to manage patient safety at the ward will be discussed.

4.2.1 Care Process: Through the Lens of a Nurse

The process of patients receiving care at the surgical ward is illustrated in Figure 4.2 and is divided and explained in four stages. It starts with patients arriving at the hospital through different sources like emergency, out-patient department, different hospital, and sometimes directly from home.

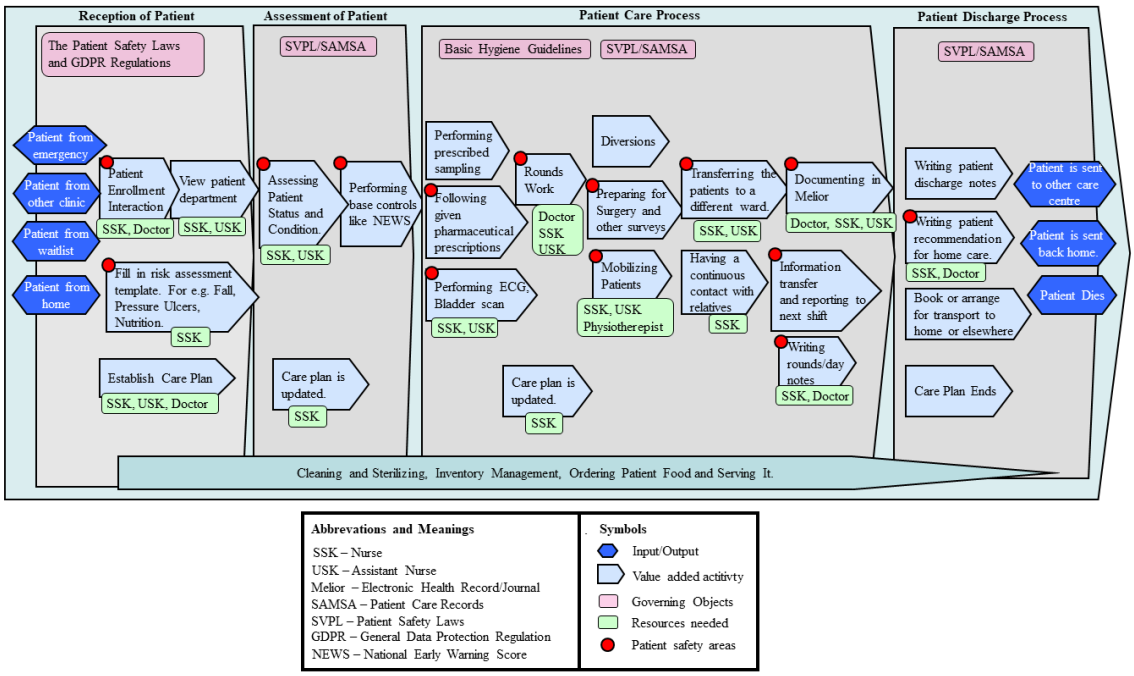

Figure 4.2: Care Process at the surgical ward in Skaraborg Hospital Group, adapted from SkaS.

Stage 1: The details of the patient are enrolled into the Melior journal and are assigned a department based on the sickness background. The patient is then examined on the various procedural parameters like allergies, pre-existing conditions (mouth ulcers, swallowing capabilities, etc.), anthropometric measurements, and blood type by a nurse and assistant nurse. Once that is done, the nurse evaluates

the patient risks and generates an aggregated risk number considering all the different risks. After all the examinations, patients are sent to their respective wards. The doctor, nurse, and assistant nurse then prepare a care plan considering the assessment results, aggregated risk number, current condition of the patient, and care history. The care plan is then given a score, which is referred to as 'vårdtyngdsmätning' (care burden) at the hospital (See Appendix A for vårdtyngdsmätning scoring guide). The data collected from the patient and their health data are protected by the patient records act, GDPR, and patient safety laws of Sweden.

Stage 2: Next step in the process is the assessment of patient condition and status. The assigned nurse and assistant nurse meet the patient and speak to them to make them feel comfortable. While doing that, the nurse performs base controls procedures. This involves examining body temperature, pulse rate, blood pressure, blood sugar levels, and other conditions like oxygen saturation and respiratory rate to finally generate a NEWS score. The NEWS is a tool that aids in detecting the clinical deterioration of a patient and helps improve responses towards it. (The NEWS scoring guide is found in Appendix B). The scores are updated on Melior and the care plan for the patient is modified based on the score and recommendations by the doctors. This happens on the first day and also every following day, the NEWS score is generated twice a day and updated on Melior.

Stage 3: As the patient gets well settled at the ward and continues receiving care, there are routine operations carried out by the nurses, assistant nurses, and doctors in this stage. Depending on the prescription for the patient, the nurses and assistant nurses perform various tasks like taking the patients for an X-ray, blood test, and to the operation theatre. Other prescribed tasks might include performing an ECG and Bladder scan by both nurse and assistant nurse. They also have the responsibility to provide medications and nutrition in the form of food or intravenous at prescribed time intervals. The nurses and assistant nurses go on rounds along with doctors during their shifts and talk with patients and understand their conditions. They interact with patients experiencing pains and generate a pain scale score from 1-10, 1 being the lowest pain and 10 being the highest. Other responsibilities of nurses and assistant nurses during their shift include transferring patients to a different ward, preparing the patients before surgery, and carrying out certain surveys regarding their condition. They also help patients move around in the ward so that are not sitting or sleeping all the time while constantly keeping in touch with the relatives of the patient and informing them about the patient's status. During and at the end of their shifts, the nurses and assistant nurses indulge in documenting, all relevant patient condition data is updated on the Melior. Meanwhile, they also take down notes during the rounds regarding the care needs of every patient they handled to report it to the nurse and assistant nurse of the following shift.

Stage 4: The final part of the care process is discharging the patient and sending them back home or to a care center. The nurse and assistant nurse spend time on writing a discharge report which is documented in Melior. They also write a care report for the patient to take with them, this will constitute information on the

type of care provided at the hospital and instructions for further care at home or care center. The care report is referred to as SAMSA at the hospital. The assistant nurse helps the patient order a transport back home or arranges for one by contacting their relatives. If the condition of the patient demands a home nurse, the nurses and assistant nurses at the hospital indulge in knowledge transfer to compliment SAMSA with the home nurse over Skype. This marks the end of the care process from a nurse and assistant nurse's perspective.

Meanwhile, in the background and across all stages, the nurses and assistant nurses devote some time to stocking medical inventory, ordering and serving food to the patients. They also spend time attending meetings and certain formal and informal discussions about the care process with colleagues.

4.2.2 Care Planning

The process of care planning begins the moment patients are administered into the ward. After the initial assessments and examination of the patient, the vårdtyngdsmätning score is generated. This score determines the care burden, meaning, how many nurses and assistant nurses are required to take care of the patient and also to what extent the patient needs the help. For example, helping the patient in terms of mobility, like taking the patient to the restrooms, or taking them around for a walk.

Figure 4.3: A visualization of vårdtyngdsmätning at the surgical ward in Lidköping.

The vårdtyngdsmätning score plays a major role in resource planning, the aggrega-

tion of individual scores will give the demand of nurses and assistant nurses required at the ward. Figure 4.3 shows the whiteboard installed next to the admin office displaying the vårdtyngdsmätning scores for individual patients across different colored groups. Based on the vårdtyngdsmätning scores, the administration sends out the demand to the operations coordinator, who in turn, deploys nurses and assistant nurses across different groups. As mentioned in section 4.1, nurses and assistant nurses work in shifts and have a 10-week schedule planned.

On a normal day, assuming no new patients are being admitted to the ward, the care planning starts when the nurse and assistant nurse of a particular colored group arrive for their shift. They spend the first 45 minutes with the nurse and assistant nurse of the previous shift gathering all the information about the patients in charge. They take down notes about the care needs of various patients and prepare a care plan for the shift. The nurses and assistant nurses use visual management techniques to manage the care process at the ward. They have their working station within their group where they operate from. They also have a whiteboard, Figure 4.4, at their station which displays various data about the patient.

Figure 4.4: A visualization of the care plan for group Blue of the surgical ward at Lidköping.

The data on the whiteboard consists of the name and room number of the patient and corresponding to it is a list of prescribed procedures or tasks to be carried out on the patient during the day, which they fill out based on the information gathered from the previous shift's nurses and assistant nurses. The board also displays the status of the patient concerning medicines, tests, nutrition intake, bowel movements, and

various activities carried out by the patient. This board also encompasses the patient risks and is represented in the last column. Magnets with patient risk stickers on them are placed in respective boxes of patients. Based on the information available on the board, the nurses and assistant nurses chart down a list of activities or procedures to perform in chronological order and execute them. After carrying out all their duties during the shift, the assistant nurses and nurses go on round to collect information about the patient's condition by talking to them. They take down notes about different aspects of care to be given and fill out the S-BAR sheet. S-BAR sheet is about the patient where S stands for situation, B for Background, A for Aktuell Bedömning which means current assessment, and R for Recommendations. As the final act of their shift, they report all information about the patient to the nurses and assistant nurses of the following shift.

4.2.3 Patient Safety Initiatives

The surgical ward has been working to improve the domain of patient safety in recent years. They have adopted various theories and methods in managing patient safety at the micro-level. However, there is a lot of scope for improvements at the meso-level with new, better, and proven ways of handling patient safety. The ward currently has several patient safety initiatives in place and has been actively working with them. Some of the prominent ones have been discussed in the following sub-sections.

4.2.3.1 Patient Safety Reinforcements

The ward has introduced certain measures to deal with patient risks and subsequently avoid the occurrence of adverse events. These reinforcements are in place to decrease the probability of the occurrence of adverse events and however not to completely avoid them. Some of the commonly identified risks at the ward are fall risks, pressure ulcers, and medication errors. Numerous steps are taken to avoid a patient from falling, it starts with making fall-risk patients wear a pair of high grip socks. Also, patients with fall risks have a mat next to their bed on the side where they get out from. This mat is attached with a sensor that alerts the responsible nurse that the patient has gotten out of the bed and needs attention. At places other than the bed, there are cameras installed throughout the ward for continuous monitoring of patient movement. Patients with the risk of pressure ulcers are provided with soft fabric clothes and are checked by the nurses and assistant nurses daily. They also indulge in mobilizing the patients so that they are not in the bed all the time which induces pressure ulcers. Medication errors are initiated from the workers' side which results in affecting the safety of the patient. To avoid mixing and giving the wrong medication to the patients, the medications are attached with a patient name sticker on them. The nurse or assistant nurse verifies the sticker name on the medicine with that of the medicine prescribed in Melior before it is fed to the patient. Although, these reinforcements sound assuring they are not enough. There are many instances where the reinforcements have not worked and have led to adverse events. These instances will be explained and analyzed later in this chapter.

4.2.3.2 Patient Safety Discussions

The nurses, assistant nurses, and doctors along with the unit manager organize meetings to discuss the patient safety issues at the ward. The nurses bring up the patient risks present at the ward and share their experiences about issues in dealing with it. A discussion takes place on topics like resources, working behavior, special cases, and work burden. For resources, a list of prospective resources required in the near future is put forward by the ward workers, i.e. nurses and assistant nurses. Special cases are practically new to the nurses at the ward, procedures related to after-surgery care are some of them. The nurses ask for directions from the doctors and expect them to be clear about the procedure as it encompasses the safety of the patient. The workers also discuss the current burden across different groups and demand additional help in the form of an extra nurse or assistant nurse to assist them during the shift. Other discussions include general administrative impediments in dealing with patient safety. All issues related to patient safety are communicated to the unit manager, who in turn reports it to the health inspector. The result of these discussions provides a better understanding of the patient safety risks present at the ward and ways of dealing with them.

4.2.3.3 Green Cross

The green cross has been gaining attention from different hospitals in Sweden. It is defined as an incident reporting system and is used to report the occurrence of adverse events and identify potential risks at the micro-level. The surgical ward adopted this method during mid-February and has been working with it since then. The ward started with managing fall risks and reporting fall incidents till the end of March. From the beginning of April, the focus was moved from fall risk to nutrition risk and was supposed to continue till the end of the month. Table 4.3 displays the numbers from green cross in terms of colors representing types of incidents. Initially, the ward had misinterpreted the colors and their representations, however, they have been adjusted according to their real meaning.

Months	**Green**	**Yellow**	**Orange**	**Red**
Feb 15-28	12	1	1	0
March 1-30	25	1	4	0
April 1-15	10	3	1	0
Green - No patient injury				
Yellow - Risk that patient injury has occured				
Orange - Avoidable patient injury has occured				
Red - Serious avoidable patient injury has occured				

Table 4.3: Green Cross Data for Fall and Nutrition Risks

4.3 Patient Safety Challenges

In recent years, the focus on patient safety has been of paramount importance to the ward. They have indulged in developing the current state by introducing and adopting new methods of working with patient safety. Like the adapted Swiss cheese model by Waterson (2010), Figure 3.4, the ward has established certain patient safety practices and procedures. They have also set in place numerous defense barriers which have been discussed in Section 4.2.3.1 as patient safety reinforcements. Although these methods have been of help in developing a level of safety, they have not been fool-proofed and have resulted in adverse events. In an interview, the Unit Manager states

"The working behavior of healthcare workers plays a major role in the occurrence of adverse events. Errors and unsafe acts are the tips of the iceberg."

A testament to this claim made by the unit manager was found in an interview with Nurse A. Nurse A recites a scenario in which a patient was harmed because of an unsafe act by co-workers.

Nurse A mentioned:
"A patient with fall risk was taken to the lab for certain check-ups, while they were moving the patient from the bed, they removed the fall alerting mat that was beside the bed. Once they came back from the lab and left the patient on the bed, they forgot to place back the fall alerting mat. The next time the patient stood up, the nurses were not alerted and the patient fell".

These unsafe acts and errors can be attributed to the lack of system understanding in the ward. In the scenario narrated by Nurse A, had the co-workers knew about the fall risk or the purpose behind having the alerting mat next to the bed, the outcome might have been different. An element of the systems thinking approach makes sure that every worker in the system is aware of all the safety practices and repercussions of their acts. In another interview with Nurse A, a different scenario was described where a nurse had made an error.

Nurse A narrates:
"During round work, a nurse was asked by the patient if they were going to give medication, as the patient was receiving it for the past few days, but the nurse had missed it when they were supposed to give it".

The unit manager says *"there are several adverse events like these which could have been avoided if the ward had a good understanding of the system".*

The hospital lists 7 patient risks that could result in adverse events if they are not monitored regularly. These risk areas have been generalized in most of the healthcare systems as they occur quite often (Donaldson et al., 2000).

1. Fall Risk
2. Pressure Ulcers
3. Medication Error
4. Post-Operative Infections
5. Port Infections
6. Urine Infections
7. Nutrition Risk

The last-mentioned one is a relatively new risk recognized by the ward and has been acknowledged. The inability to manage these patient risks has led to the occurrence of a large number of adverse events which will be discussed in the following section.

4.3.1 Analysis of Adverse Events

With the help of electronic health records, raw secondary data on the occurrence of adverse events was fetched. However, the data displayed a lot of inconsistencies and missing fields. The past two years contributed to the majority of the data, while the years before it had very few in comparison. This hints towards the fact that work on patient safety has been prominent and growing in only the last couple of years and was not much focused on before that. The data was cleaned and all the inconsistent fields were adjusted, based on the relevancy, it was either removed or categorized into a separate field called "Other", see Figure 4.5.

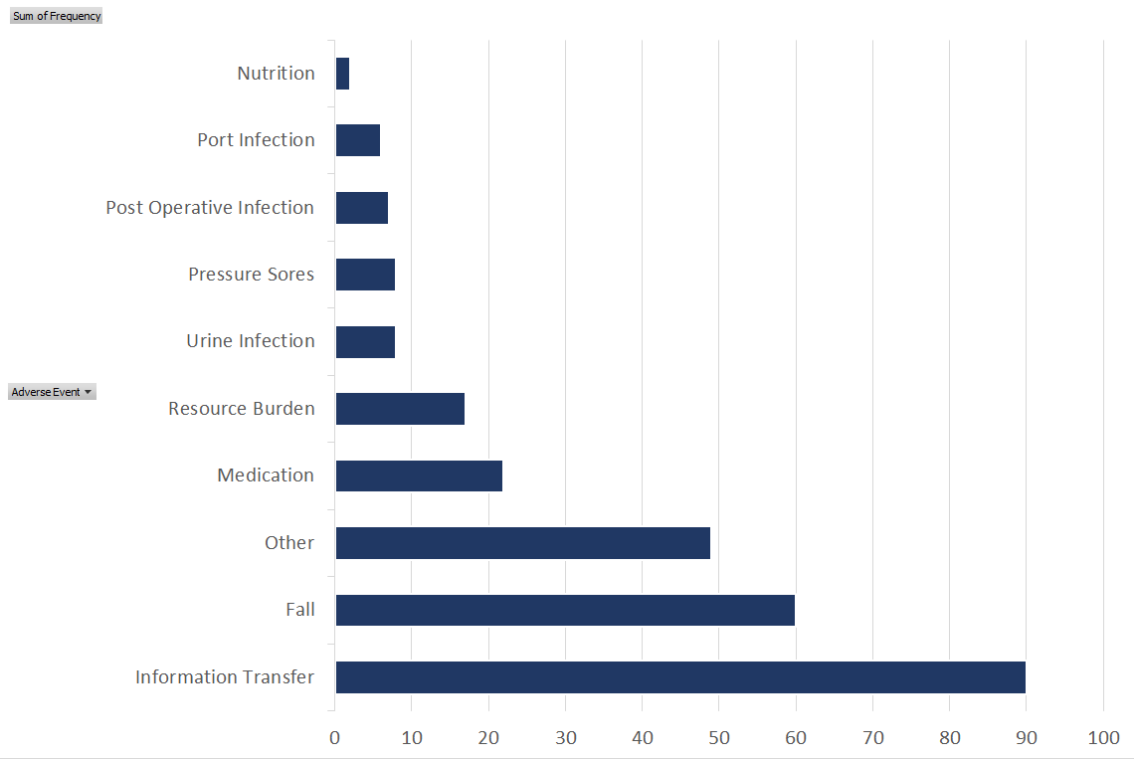

Figure 4.5: Frequency Distribution of Adverse Events

The cleaned data consists of 262 occurred adverse events over the past 5 years along with their causes was listed. Through this, a list of commonly occurring

adverse events was identified. Besides, the data also complied with the list of adverse events led by commonly identified patient risks by the hospital. However, there was a large number of adverse events resulting from factors other than the listed patient risks like information transfer and resource burden. Figure 4.5 displays a bar chart representing the frequency distribution of occurred adverse events in which information transfer is the major contributor. Out of the listed patient risks, adverse events as a result of fall risk makes up 22 percent of the total. Nutrition risk contributes by just a percent to the occurred adverse events which can be owed to the fact that it is a relatively new risk. The adverse events led by other patient safety risks will be discussed in the following sub-sections. The adverse events are classified into two categories based on the cause of their occurrence. First is the adverse events due to the listed patient risks and the second is due to the working behavior and organizational factors.

4.3.1.1 Patient Risks Leading to Adverse Events

Almost 50 percent of the adverse events are a result of 7 patient risks listed by the hospital. The adverse events have been further categorized based on whether an injury was caused or not. Although, the incidents that did not injure the patients are still considered adverse events as they had the potential to harm the patient.

Fall risk has been the prominent one out of all the patient risks contributing to 60 adverse events, out of which 32 patients sustained injuries, refer to Figure 4.6.

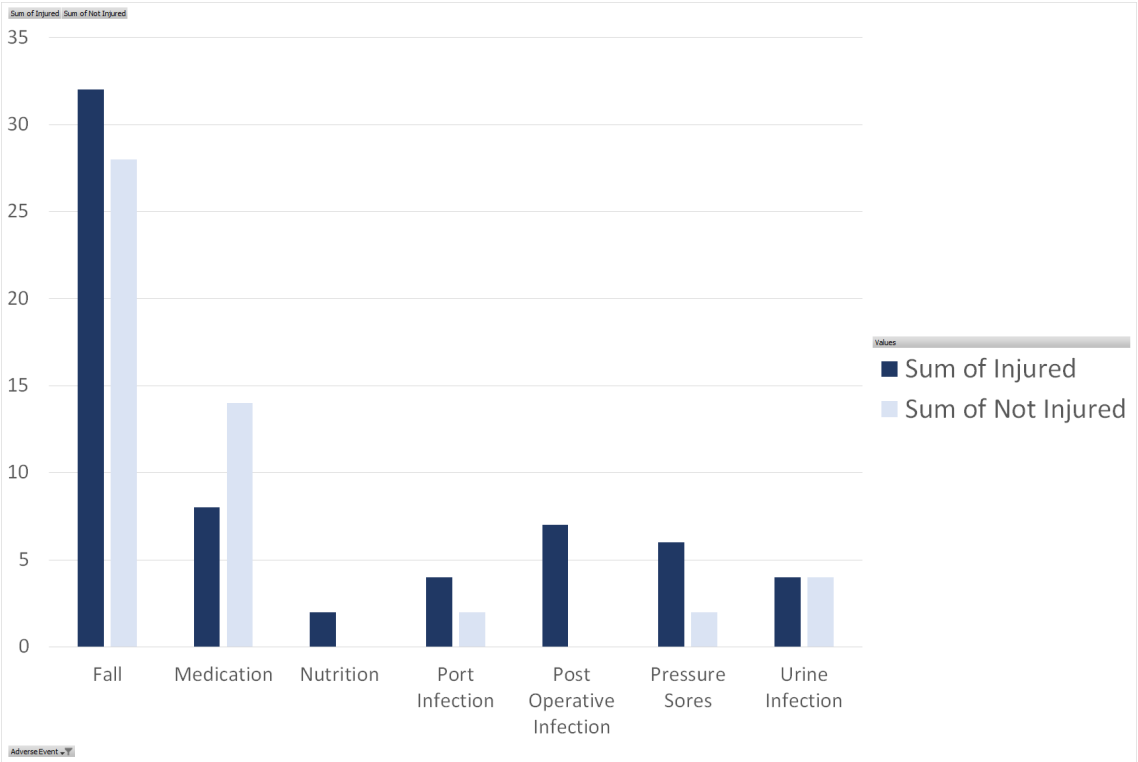

Figure 4.6: Effects of Adverse Events - 1

Patients with fall risk require mobility aid. Depending on the severity, they either

use a roller as support or the nurses help them move around. In a focus group discussion, Nurse C narrated a scenario where a patient with fall risk had to use the restroom and there was no one around. The patient chose to go by themself and in a hurry to use the facility, the patient rushed and ended up falling, which resulted in injuring their elbow. There are instances where patients with fall risk ended up falling but did not sustain any injuries, this is indicated by the light shaded bar above fall on the graph in Figure 4.6. Although the patients were not injured physically, they did experience some minor pain and a hit to their confidence.

Medication risk has the second-highest number of adverse events under its belt. According to the data and the graph in Figure 4.6, more adverse events have resulted in non-injuries than injuries. However, this remains a very critical patient risk as errors in medication can severely affect the patient. During a shadowing process, the question was asked to understand what were the common medication errors.

Nurse B mentioned:
"Some of the medication errors are, not giving medication on prescribed time, giving the wrong medicine to the wrong patient, giving the wrong dose of medicine, over dosing a patient, i.e. there has to be a gap of 8 hours between antibiotic doses, however, due to changes in shifts, nurses fail to stick to the timeline".

Another instance of medication errors was stated by Assistant Nurse A while empathizing in an online interview. The Assistant Nurse A feels *"When a patient's condition deteriorates, we contact the doctor, but the doctors do not respond on time. Although we know which medication to give, we feel helpless as we do not have the authority to do so".* All these errors and unsafe acts can lead to adverse events, and sometimes severely injure the patient if their condition is critical.

Nutrition risk, as mentioned earlier is a newly identified risk and not much data had been reported on this. Although, there were 2 cases of adverse events both of which resulted in patient injury, see Figure 4.6. Patients are classified as having a nutrition risk when they fail to consume a prescribed amount of calories in a day due to their inability to eat or drink with their mouth or even if they could, they would have had their digestive system operated which makes it difficult to eat or drink the normal way. Patients are also considered having nutrition risk if they are prone to malnourishment due to a lower BMI value. During an interview with Nurse A, it was described that *"3 patients had developed mouth fungus which made it difficult for them to consume through the normal mouth. Although treatment was given, it was not effective and had a lot of pain, the patients were hence given calorie boosting nutrition shots".* This probably avoided the patient from being classified as having nutrition risk.

Port Infection is a patient risk which applies to almost all the patient at the ward. This infection happens where the intravenous port is attached to the skin. This is the point of entry into the body for all the medications and nutrition if not consumed through the mouth. Every patient with a port has the potential of acquiring

an infection. Figure 4.6 shows that port infections have led to more injuries than not. During the shadowing process, Nurse B explains about port infection: *"Every time we provide medicine or nutrition to the patient, we first clean the port using a solution and check if there are any signs of blood leak. But often, the blood leaks go unnoticed and prolonged leaks result in clots and infection"*. An infection like this can cause injury to the patient in the form of physical discomfort and pain. The light shaded bar of not injured patients in Figure 4.6 represents the patients with blood leaks but got noticed at the right time and corrective actions were taken but are still considered as an adverse event.

Post operative infections are common to all patients in a surgical ward. According to Figure 4.6 and the data, all reported adverse events have resulted in injuries sustained by the patient. Assistant Nurse A states that *"Post operative infections are hard to detect and often goes unnoticed until something bad happens"*. After surgery, when patients are being cared for at the ward, routines inspections are done to see if there are any infections. However, minute infections have always been very difficult to detect as the location of surgery is dressed up with plaster. These infections only surface when it gets worse and ends up prolonging stay at the hospital to receive additional care.

Pressure Ulcers also known as pressure sores is a damaged condition of the skin. These are caused by staying in a bed in the same position for a prolonged time. Figure 4.6 shows that adverse events caused by pressure sores have resulted in more injuries than not. Pressure sores cause pain and physical discomfort when they are not treated at the right time. Although, as discussed in the previous sections, measures to prevent pressure sores have been taken by the ward, they have not resulted in avoiding it completely.

Urine Infections have resulted in adverse events equally injuring and not injuring the patient, see Figure 4.6. These infections are caused by certain bacteria that enter the patient's urinary tract and attack the excretory organs. The ward is currently taking measures to monitor the excretion rate of the patients based on simple input-output math which helps in understanding if the patient is building up any fluids inside. Failing to monitor this or test for urine infections on time can lead to adverse events like blood in urine, leakage, and fever which will not only cause discomfort to the patient but will also prolong their stay at the hospital.

4.3.1.2 Other Factors Leading to Adverse Events

Information transfer related incidents have contributed the most towards the occurrence of adverse events. Around 90 out of 262 occurred adverse events are caused due to various sorts of issues with transferring information between different components of the system. The ward is the system here and all the healthcare workers are the components. Although the number of adverse events concerning information transfer is high, the number of patients injured is almost half of that of not injured patients, see Figure 4.7.

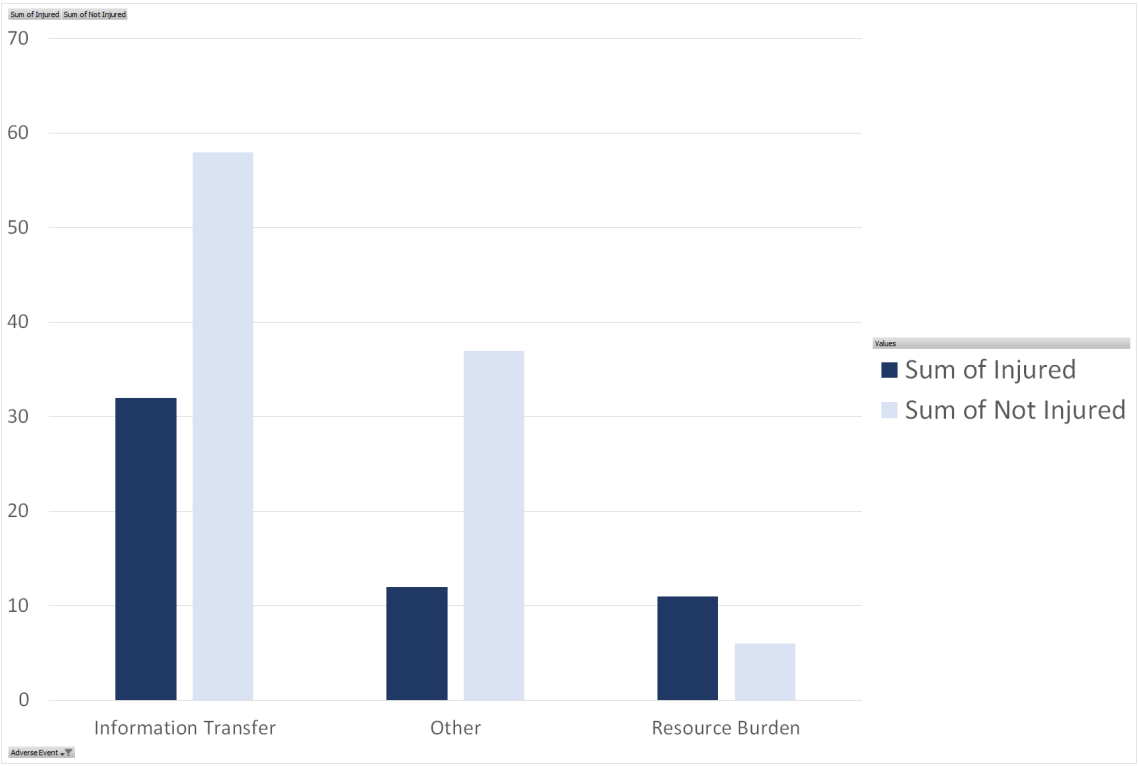

Figure 4.7: Effects of Adverse Events - 2

As discussed in the previous section of care planning, the nurses and assistant nurses start their shift by attending a meeting with the nurses and assistant nurses of the previous shift. This process was observed and noted during the shadowing process. When the workers of the previous shift explain their notes about the patients, the new working group of nurses and assistant nurses take down notes. Only the important points are noted, and they discuss any points which they doubt. A critical observation was made where the nurses or assistant nurses do not summarize or verify their noted points once the meeting is done. There's a high chance that the nurse or assistant nurse might have missed taking certain must-know points. During another participant shadowing with Nurse B, a potential information transfer incident was experienced. Nurse B performs routine checks on Melior to check the status of medication given to the responsible patients. Nurse B notices that 2 medicines that were supposed to be given 4 hours ago weren't updated on Melior. This made Nurse B call the assistant nurse to confirm if they had given it. The assistant nurse confirms that the medicine was given and that they had forgotten to update it on Melior. The instant thought of Nurse B to call the assistant nurse to confirm before medicating the patient by themself avoided a potential adverse event. On the contrary to this are many incidents that have led to such a high number of adverse events.

Other Risks include a diversity of sources from which adverse events have resulted. Also, apart from the listed causes in the data, this category consists of data with missing causes or reported adverse events with no history of it. Although, from

the listed causes, it can be seen that the origin of adverse events is from sources like administration, the technology used, and also some related to data protection. These also have causes like incompetency, hygiene, unsafe acts, and errors not related to patient risks. Figure 4.7 shows that the ratio of patients injured to not injured is relatively less. Most of the adverse events have resulted in non-injuries. However, the psychological impact of these adverse events arising from data protection and other administrative sources is not known. Due to its inconsistencies and not enough evidence on the actual causes of events, the data in this category can be further looked into.

Resource Burden is one of the commonly reported issues throughout the data collection process. Although the data does not show enough adverse events, see Figure 4.7, the impact of resource burden is high but is somehow managed by collaborating and helping each other at the ward. In an interview with the workers, Assistant Nurse A narrates an incident, *"During a shift, a patient was critical and in a very bad condition. The patient had a very high NEWS score and needed a lot of care and attention. It was at that time, few nurses and assistant nurses from another group came to help us and got the situation under control and the patient recovered"*. The adverse events caused by resource burden are more likely to injure the patient than not, see Figure 4.7. The main reason for resource burden from the perspective of the workers is the fact of managing 7 patients in one group by just a nurse and an assistant nurse. Nurse A quotes in an interview *"It feels at times that the nurse cannot do it anymore. While managing 7 patients, if 2 are critically ill, and need constant attention, it feels like splitting in 2 to help them"*. Situations like these have triggered the occurrence of adverse events. Even though the workers share their workload by helping each other in times of need, things do not turn out the same every time.

4.4 Customer Need Analysis

In developing a customer-focused solution to monitor patient safety in real-time, it is important to understand who the customers are and what their needs are. Insights from interviews and other data collection methods point towards the main stakeholders of patient safety which includes all the healthcare workers at the ward. Besides, the data from adverse events show that nurses and assistant nurses play a pivotal role in managing patient safety at the ward. Apart from doctors, nurses and assistant nurses are responsible for delivering care to the patients at the ward and hence are the baseline from which most of the adverse events originate. They perform patient safety practices within their confined groups and are prone to come across care delivery problems. On the other hand, the individual responsible for the organization and management of the nurses and assistant nurses is another key stakeholder in maintaining patient safety in the ward. This is very similar to the adapted Swiss cheese model by Waterson (2010). As the first block of cheese, the person who manages the workers is the one who drives the organization and management culture. While the second block of cheese is workers that act as contributing factors influencing patient safety practice and the ones who face patient safety prob-

lems. So, the customers being focused on for this thesis are the nurses, assistant nurses, and the unit manager. The needs of these customers will be deduced from an individual and systems perspective in the following sections.

4.4.1 Nurses and Assistant Nurses

The basic needs of nurses and assistant nurses are to provide quality care to the patients at the ward and especially seamless care for ailing patients. The data collection process has provided quality insights into the needs of these workers. The empathizing process has revealed the various pain points in the system during the care delivery process. The nurses and assistant nurses have shared their emotions in different interviews and participant shadowing regarding their troubles with managing patient safety which has eventually led to the occurrence of adverse events. A few of the important statements by the nurses and assistant nurses are quoted below. These statements were captured in response to questions about problems the nurses and assistant nurses encounter while managing patient safety.

Nurse B states *"Sometimes we have to handle 7-8 patients and it gets tough when these many patients are assigned"*.

Assistant Nurse B states:
"When we are assigned, we feel that the care burden is sometimes not considered. When we have a high burden, we feel we do not have the resources and competence when a patient gets critically ill. Also, the doctors do not respond on time when care is needed, and we end up asking help from other group nurses and assistant nurses".

Nurse A states:
"If the pressure on the nurse is high, the emotion is carried throughout the day and next shift. When the doctor does not listen to our requests, we feel annoyed. Especially when a patient is very sick, we need to wait for long times before the doctor responds. We feel guilty and responsible for not helping the patient".

The statements above go to say that the nurses and assistant nurses have been feeling burdened during times of high workload. The need for them can be formulated as 'to be able to manage resources during crunch situations and minimize the stress caused' (Customer Need 1). The assignment of nurses and assistant nurses should be made based on the care burden in respective groups. Also, considering a systems perspective, the needs of the nurses and assistant nurses can be formulated as 'to be able to visualize the burden of other groups so that they can go help them and not wait until they come asking for help' (Customer Need 2). This goes without saying that they want to monitor the care burden and patient risks not only in their group but also in the other two groups. Below are few more statements from nurses related to problems other than work burden.

Nurse C states:
"A lot of communication is lost through SAMSA. SAMSA is like care documenting

the program. When a patient gets home, there is no proper communication between the hospital nurse and the home nurse. For example, during Skype meetings, there is a lot of miscommunication. The sick people feel sad and afraid of staying at home without proper care plan".

Assistant Nurse A states:
"We get very limited time at the beginning of the shift to prepare a care plan. It's like less than 10 minutes per patient and there is so much to learn about their current condition. Also, we have to retrieve the data from previous shift workers. There is very little time to understand the patient and their needs. The doctors trust the nurses to give them the right information and for this, we need to be well prepared. This is one of the major factors affecting patient safety".

The above two statements are about communication between different nurses and assistant nurses, and also managing the information flow. The information transfer between the nurses and assistant nurses of changing shifts has been a pain point. The workers feel they need more time to get a deeper understanding of the patient's needs which they are not getting now. This forces them to quickly learn about various care needs of the patient in a very short time. There are at times, trivial details have been missed about patient risks and have ended up resulting in adverse events. Their need can be formulated as 'to be able to acquire information about various patient needs and learn them before they meet the patients' (Customer Need 3). Last out of many, a statement about the issues faced by nurses and assistant nurses with technology and visualization of various parameters is discussed below.

Nurse B states:
"Every time we offer care to the patient, it needs to be documented in Melior. For instance, when we provide medicine to the patient, we update the time and type of medicine given. Sometimes, nurses or assistant nurses fail to update it on Melior. Every time a nurse or assistant nurse has to use Melior, they have to come to the computer station and update it. But sometimes, after providing the medicine, the nurse or assistant nurse gets busy with something else or some other emergency comes up, this happens especially during high burden times".

The issue with the current working environment at the ward is that the nurses and assistant nurses need to traverse across the ward every time they have to update something on Melior. This is a cumbersome process given the high workload of the nurses and assistant nurses. During times of high burden, it especially gets tough for nurses to keep a track of the procedures and care needs of the patient. Expecting them to run to their care planning board every time they want to visualize patient risks is a tiring process. The needs of the nurses and assistant nurses can be formulated as 'to be able to visualize the patient risks in real-time and see how the other groups are doing in terms of managing the risks' (Customer Need 4). This can help them get inspiration from nurses and assistant nurses from other groups on managing patients with similar risks.

4.4.2 Unit Manager

The responsibility of the unit manager is to smoothly run and foresee the care delivery process at the ward. Within the bounds of organizational and management culture, the unit manager strives to facilitate the work on patient safety by effective decision making and efficient resource management. Although, there has always been scope for improvement in the care delivery process concerning monitoring and managing patient risks to reduce the occurrence of adverse events. The pain points of the unit manager have been uncovered during the initial empathy-building interviews. Several other interviews with the unit manager have helped in generating key insights about their needs. Few statements highlighting the needs of the unit manager have been quoted below.

The unit manager states:
"As a unit manager, I would like to monitor the level of patient safety at the ward. One way of doing that is by monitoring the different patient risks at the ward and managing them. But currently, there are several boards in the ward for care planning and patient risks, one for each group and one overall for vårdtyngdsmätning. I would like to visualize all this at one place instead of going around in the ward to look at different boards".

The unit manager is specific about their needs when it comes to monitoring patient safety. The explicit needs of the unit manager can be formulated as 'to be able to monitor patient safety in real-time for the entire unit and as well as individual patients' (Customer Need 5). The unit manager should be 'able to visualize the aggregated and individual patient risks in the system' (Customer Need 6). Another statement was extracted from interviews with the unit manager, where they shared their response on the issue of resource burden and its management.

The unit manager states:
"Resource burden is subjective and depends on the perspectives of the nurses and assistant nurses. As some of the nurses are relatively new and are still learning, their perception of workload will be different from that of an experienced nurse. Competent nurses manage multiple severe patients without a problem. Visualizing the present risks and competencies will help me manage the level of patient safety at the ward".

Based on the statement, the need can be formulated as 'ability to visualize the different patient risks and competence of workers at the ward' (Customer Need 7). A comparison of the aggregated risks in the ward against the resource competencies will help make better decisions in managing the nurses and assistant nurses. Another need of the unit manager is formulated as 'to be able to monitor the care burden on the nurses and assistant nurses' (Customer Need 8) so that when it reaches beyond the threshold, the unit manager can inform nurses and assistant nurses from other groups to help out and pick each other slack. The unit manager had mentioned several explicit needs and have been quoted below.

The unit manager mentioned *"I would want to have a visual signal to alert high risks*

and monitor them real-time. I would also want to monitor the information transfer process or rather know what information has been passed".

All these needs are based on a systems safety approach where the unit manager and as well as the nurses and assistant nurses will be aware of the happenings in the entire system and not just their group. The unit manager's need can be formulated as 'to be able to get alerts when there is high risk at the ward' (Customer Need 9) so that they can deploy the required resources and try to bring things under control. Currently, the approach in the ward is more reactive, meaning, it is only at that time the unit manager knows when some incident has occurred and then action is taken. While on the other hand, visualizing patient risks in the ward and their current situation will trigger a proactive approach towards high-risk conditions at the ward bringing things under control and avoiding the occurrence of adverse events. The unit manager also sheds some light on the use of Green Cross and its scope for improvement.

The unit manager states:
"Green Cross is helping us to identify patient safety risks and preventing them. We meet before the evening shift and collaborate with different colored groups to understand and learn from one another. Currently, we have a board on which we mark the days with different colors based on the type of adverse event and its impact on the patient".

The Green Cross is another method of visualizing the existing risks in the system and identifying ways of managing them. However, the Green Cross right now is just a physical board stored at the break room and not all discussions are documented to be viewed again. The need of the unit manager can be formulated as 'to make Green Cross and information about specific events that occurred on several days accessible to everyone at the ward' (Customer Need 9). Integrating it with different boards of care planning would be a one-stop destination to monitor patient risks.

To summarize, the unit manager along with the nurses and assistant nurses want to visualize patient risks, along with care burden, Green Cross, and all related data at one place rather than having to log into or view it at different places. All the customer needs have been consolidated at one place and can be found in Table 4.4. The customer needs analysis has been of help in developing the solution which will be discussed in the following section.

Customer Need 1	To be able to manage resources during crunch situations and minimize the stress caused.
Customer Need 2	To be able to visualize the burden of other groups to offer help in times of need.
Customer Need 3	To be able to acquire information about various patient needs and learn them before meeting patients.
Customer Need 4	To be able to visualize patient risks in real-time and see how other groups are managing the risks.
Customer Need 5	To be able to monitor patient safety in real-time for the entire unit and individual patients as well.
Customer Need 6	To be able to visualize the aggregated and individual risks in the system.
Customer Need 7	Ability to visualize the different patient risks against competence of care workers at the ward.
Customer Need 8	To be able to monitor the care burden on the nurses and assistant nurses.
Customer Need 9	To be able to get alerts when there is high risk at the ward.

Table 4.4: Formulated Customer Needs

4.5 Dashboard Development

As discussed, the one possible effective solution to handle the patient safety issues at the ward. Currently, the ward does not have any dashboards concerning patient safety and hence it is a new addition to the patient safety initiatives. The dashboard development process consisted of the five stages proposed by Pauwels et al. (2009). As suggested by the theory of design thinking, all important stakeholders were involved in the process of designing the dashboard. This collaboration helped in staying on track and focus purely on developing customer-centric designs of the dashboard. The dashboard as a solution is just design recommendations whose prototypes were made for users to understand the concepts of visualization and contents of the dashboard. A full-scale dashboard will not be developed for this thesis, but recommendations for developing it will be discussed in the conclusion chapter. However, the contents of the dashboard will remain the same as it was in the prototypes, although the architecture might change. The dashboard being developed is an interactive dashboard with multiple items to visualize data from different elements of the system. This is done so that the stakeholders have a complete system understanding and not just the process summary of the ward. Visualization of care plans, collective care burden, resources deployed, patient risks, among others, at an individual and aggregated level strengthens the approach of systems perspective on safety.

Stage 1: The process of *identifying and selecting key metrics* is the first step in the development framework. Based on the results and need analysis, few main pain points were established which delineated the customer needs. From the unit

manager's perspective, the need was to visualize the information on care burden measurement (vårdtyngdsmätning), and along with it, all the patient risks present at the ward. Also, the unit manager wanted to understand the distribution of resources against patient risks and monitor the care planning process in all three wards. From the nurse and assistant nurse's perspective, they need the operations coordinator to make the workload even across all groups. Simultaneously, they want to monitor the care burden and patient risks at the other groups to lend a helping hand during high workloads and to discuss with the other group ways of managing similar risks in each group. Based on these needs, and an in-depth discussion with the stakeholders, the key metrics were selected using a tailored approach as different users had different needs, see Section 4.4. These metrics listed in Table 4.5 provide an overview of the situation at the ward. They function as performance indicators for various pain points discovered earlier. These indicators help the unit manager in monitoring the real-time status of the ward and take required actions when needed.

Serial Number	***Key Metrics***
1	Number of Beds Utilized
2	Capacity Utilized in Percentage
3	Number of High Risk Patients
4	Nurse Burden in Percentage
5	Assistant Nurse Burden in Percentage
6	Days Since Last Incident
7	Number of Incidents this Month
8	Number of Critical Incidents this Month

Table 4.5: List of key metrics

Stage 2: The next step in the process is *populating the dashboard with data.* The data relating to metrics defined in the previous stage was used to populate the dashboard. As mentioned above, for workers to gain a systems understanding of the ward, multiple tabs will be used in the dashboard to display data only related to key metrics defined above. The data that will be displayed on the dashboard is shown in Table 4.6 along with its source of origin.

Serial Number	***Data Name***	***Data Source***
1	Vårdtyngdsmätning	Administration
2	Patient Risks	Melior
3	Resources	Operations Coordinator
4	Information Sharing	S-BAR, SAMSA, Raportmall
5	Green Cross	Ward
6	Medicines and Nutrition	Melior
7	Charts	Med-Control

Table 4.6: List of dashboard data

Choice of data has been through cross-functional collaboration between different users through interviews, prototypes, and continuous feedback.

This data will be measured to assess the performance of the system and indicate the current status with the help of key metrics. Based on the metrics, the dashboard should provide actionable insights to the users on the recommended future steps. The idea is to get real-time data fed into the dashboard, meaning, every time something changes in the data source, it gets updated and displayed on the dashboard. For instance, If a new patient risk is identified in one of the groups, it gets updated in Melior first and then reflects on the dashboard for all users in the system to know. Likewise with all the other items on the dashboard.

Stage 3: This step involves *establishing relationships between the dashboard items.* Displaying random data on the dashboard which does not associate with any key metrics will only make it difficult to address the cause and effect relationship of the data which is important to improve the performance. Hence a lot of effort has been put into selecting the data to establish a relationship between the items on the dashboard. With the help of cross-functional collaboration through interviews and prototyping, users were asked to brainstorm a cause-and-effect relationship between the different items on the dashboard. As a healthcare facility is a complex system, various cause and effect relationship exists. Especially when applying systems thinking, it was important to consider all these relationships. One example of an established cause and effect relationship can be seen in Figure 4.8. It shows how various items, on the left, contributes to nurse burden, and the effect of which can be seen as the occurrence of adverse events.

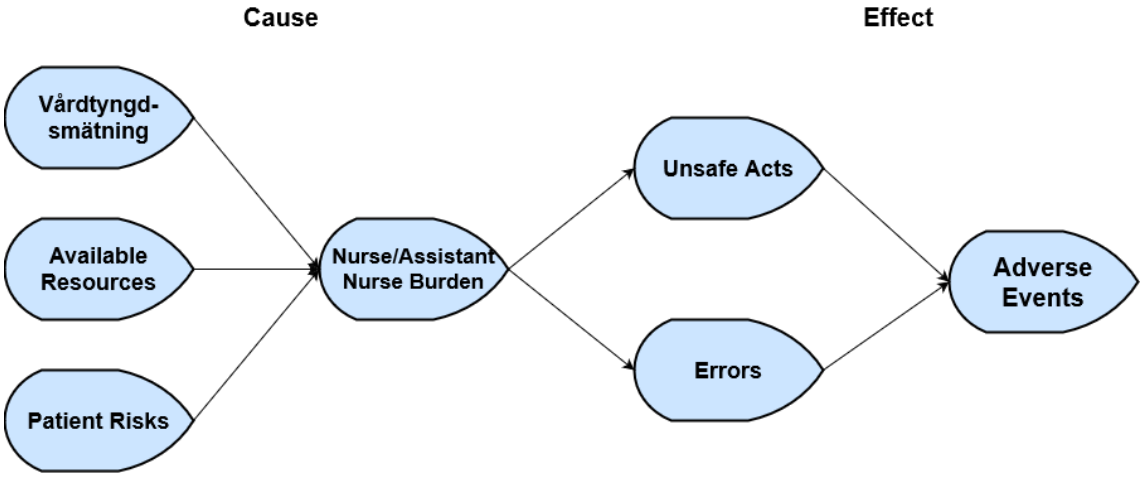

Figure 4.8: Cause and Effect Relationship Example

Stage 4: This step in the process deals with forecasting and scenario building as a way for managers to perform what-if analysis to evaluate their options and make well-informed decisions. However, the dashboard does not offer the forecasting options which could help managers plan ahead of time. A reason for this is the complex nature of the healthcare system; the future state and outcomes are difficult to predict, but, managers can take an intermediate step of performing what-next analysis by visualizing the metrics selected. As the dashboard is meant to visualize the current state and existing patient risks at the ward, the users can see various

performance indicators which alert them proactively to take required action; for instance, if the care burden is potentially set to increase due to the addition of a new patient, the unit manager can deploy more resources to balance out the workload.

Stage 5: The final stage of the development process dictates the step of connecting the dashboard to financial consequences. However, in this case, as mentioned in the theory chapter, the financial consequences will be replaced by patient safety outcomes as it is more important to the organization than financial gains. Patient safety outcomes can be measured in terms of adverse events that occurred at the ward. The data on the Green Cross tab on the dashboard will help realize the distribution of adverse events across different days of the month. Also, the key metrics provide information on the number of adverse events that occurred and the severity of it. Another part of this stage is to create value for the stakeholders and help them make interventions in the systems to align current processes to goals. The key metrics are selected to inform and indicate users of the current situation so that they can act upon it, and for the unit, manager to deploy additional resources when needed. This might directly help in managing patient safety risks and reduce the occurrence of adverse events at the ward.

The proposed dashboard is a real-time visualization tool for the current population of patients at the ward that considers different categories of patients, risk factors, and possible complications. This tool will be used to get an overview of the aggregated risks that must be dealt with during the day to avoid care-related damages and adverse events. The overview information should be used to match the demands and balance the available resources that need to be in place to manage these risks. In the end, with the help of this tool, by balancing the demands against the available resources on a real-time basis, risks and adverse events can be predicted and avoided altogether. The proposed dashboard makes use of retrospective data. To make the dashboard real-time, it demands continuous data input from different sources like Melior, Med-Control, SAMSA, and other relevant systems in use. The details of data to be extracted from the mentioned sources will be discussed in next section.

4.6 Rapid Prototyping

The process of prototyping the dashboard was carried out using the design thinking approach. This approach houses two methods of prototyping, the first one is the low-fidelity prototype and the second one is the high-fidelity prototype. The former focuses on building rough models of the solution with the help of simple materials like paper, cardboard, or sketching. Making these prototypes do not consume a lot of time and can be easily modified based on the feedback from rapid iterations. However, it does not provide a sense of realistic feel to the users nor does it offer control. On the latter part, the high-fidelity prototypes resemble and closely operate like the final product. Prototypes like this allow users to interact with the product and get a feel of how the final product might be. This type of prototype helps in engaging the stakeholders and indulges them in an experience of visualizing their vision come to life. Another benefit of this method is, the process of building a high-

fidelity prototype involves the user groups in the prototyping process feeding design considerations constantly. Both methods of building prototypes have merits and demerits. However, for the thesis, a balance was struck between the above-mentioned types and the decision to develop a medium-fidelity prototype was taken considering the nature of the dashboard and its components. Medium-fidelity prototype like the high-fidelity prototype is a physical presentation of the solution. The prototype looks real and has enough functionality with respect to user interface for the user to understand how it operates and functions. Unlike the high-fidelity prototype, these prototypes exhibit certain voids but are realistic enough for the user to confidently criticize it.

Several medium-fidelity prototypes of the dashboard were built in rapid iterations. A total of 4 iterations including feedback cycles took place before arriving on to a final prototype of the dashboard. As discussed in the previous section, the focus of the design was with respect to the content of the dashboard and little importance was given on the appearance. However, aspects of visual perception and stimulus have been considered while building the prototype. The choice of R Shiny was made to build the dashboard prototype as it was a good option to achieve the desired level of realistic feeling. R Shiny could make the dashboard interactive allowing users to get a hands-on experience of it. Also, based on the feedback, this method allowed to make modifications to the source code to incorporate the changes. Although, this method certainly offered some limitations like laborious process, complications in syntax were among others. The different contents and aspects of the dashboard will be discussed with the help of the final prototype and feedback generated throughout the process. Few of the items that are found in the final prototype may not exist in the prototypes built during the initial iterations as those items were generated through feedback. The journey of various metrics and items through several iterations will be discussed as follows. Also, the data being displayed on the dashboard are not indicative of the status at the ward, they are just populated for demonstration purposes and do not carry any significance.

Key Metrics: The key metrics tab on the dashboard displays the different metrics that were selected during the first stage of dashboard development, see Figure 4.9. These metrics indicate the current state of the system and helps the unit manager take necessary actions. Displaying these metrics on the tab provides a systematic understanding of the system. This tab was not included in the initial iterations of these prototypes. Based on feedback from the unit manager stating, *"It would be good to get overview values of key metrics in the beginning"*, the key metrics tab was introduced in the later iterations. The key metrics tab consists of value boxes that display real-time values of listed metrics. Upon clicking the value boxes, it will take the user to the data sheet corresponding to the performance of the metrics. For instance, if the metric of 'number of incidents in this month' is clicked, it will take the user to the green cross page. These value boxes are updated every time something related to metrics changes in the system. These are aggregated values for the entire system consisting of all the three groups at the ward. The value boxes use colors to enhance visual perception to indicate to the users about their current status. For instance, the value box displays red color when the resource burden

Figure 4.9: Dashboard - Key Metrics

goes above a certain value indicating danger, while the orange color indicates that the value is approaching to danger and the green color indicates the system is safe. These indicators will trigger the unit manager to deploy additional nurses to ensure the level of patient safety is maintained.

Vårdtyngdsmätning: The second tab displays the Vårdtyngdsmätning, which is nothing but care burden measurement of the ward, see Figure 4.10.

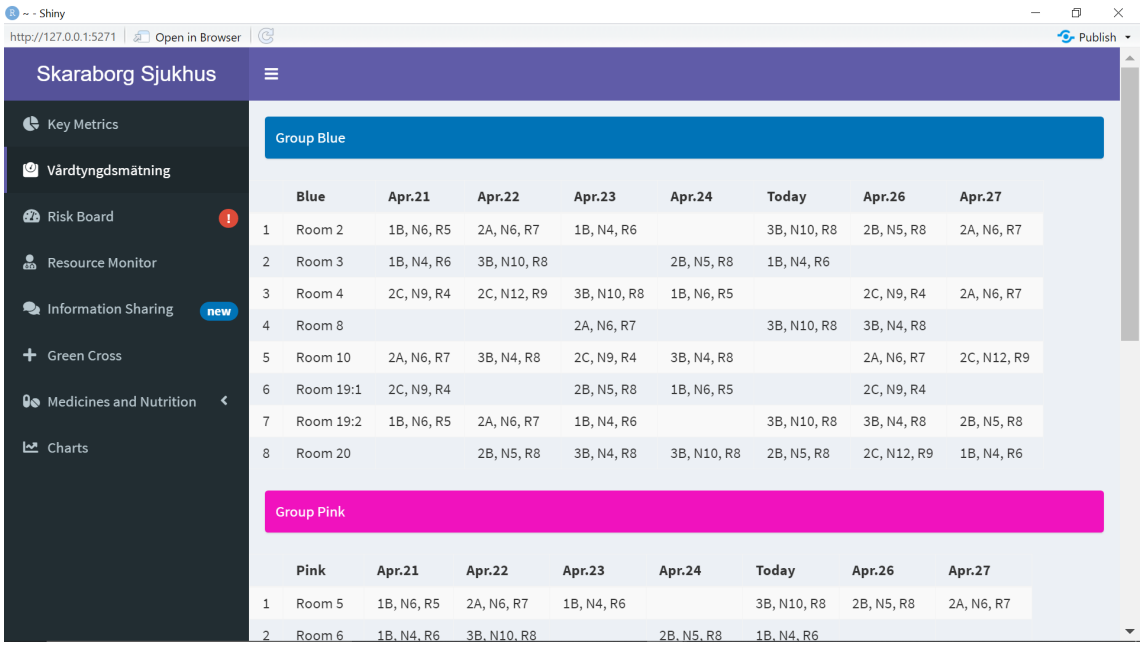

Figure 4.10: Dashboard - Final Iteration Vårdtyngdsmätning

The data is visualized on an individual level at the ward. This is more or less as per the already existing physical board of vårdtyngdsmätning as shown in Figure 4.3. The difference here is that it is accessible by every person in the ward from any place they are at. The tab displays different groups highlighted by color. The room numbers are listed under each group and corresponding to these are the vårdtyngdsmätning scores during different days of the week. The idea behind this tab was to help nurses and assistant nurses visualize the care burden not only in their group but also in other groups by establishing a systems approach. During the initial iterations, only the Vårdtyngdsmätning score was displayed corresponding to room numbers, see Figure 4.11.

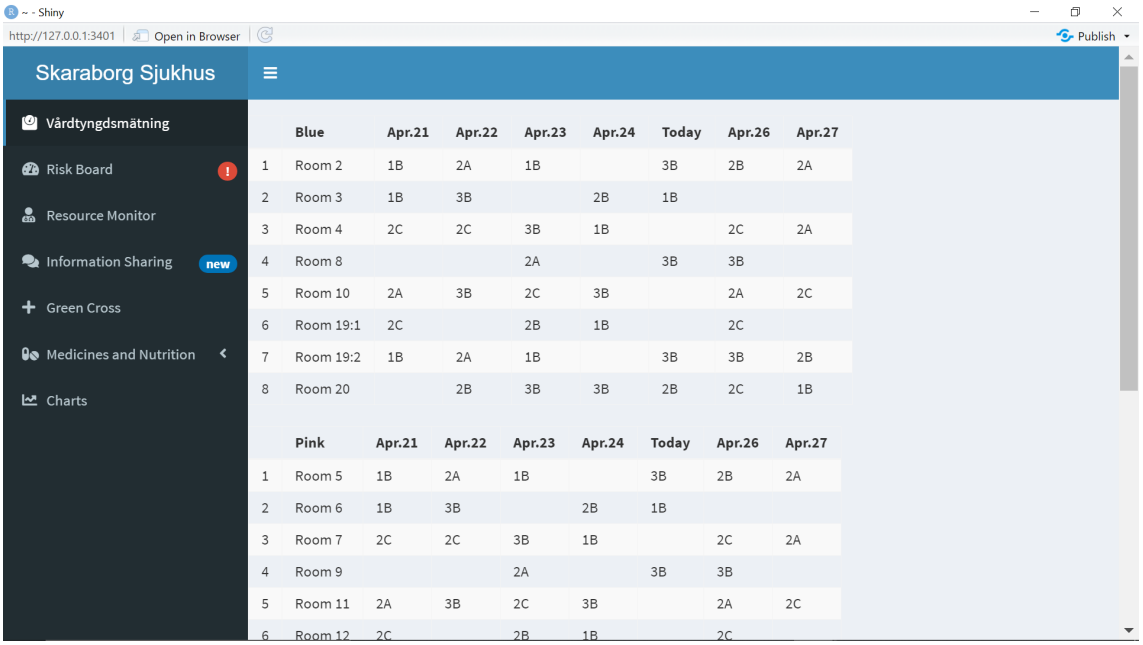

Figure 4.11: Dashboard - First Iteration Vårdtyngdsmätning

Based on feedback from both nurses and assistant nurses few additions were made. Quoting assistant nurse A, *"We get very little time to prepare about the patient needs when we start our shift. Vårdtyngdsmätning score along with NEWS score and Patient Risk Number helps us get a better understanding of the current situation of the patient, and it is even better if we read this together in the Vårdtyngdsmätning tab"*. This made sense to include NEWS score (NX) and aggregated patient risk number (RX) in the coming iterations, see Figure 4.12. Figure 4.10 only displays group blue fully, but as one scrolls down in the dashboard, the other groups can be seen, helping the users monitor at an individual yet systems level.

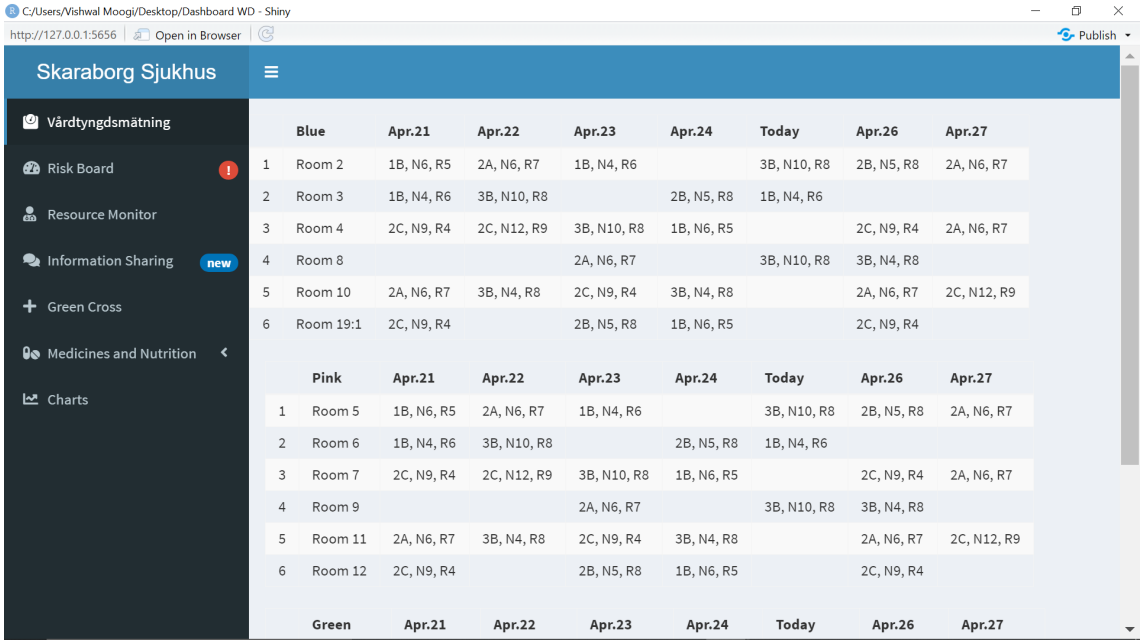

Figure 4.12: Dashboard - Second Iteration Vårdtyngdsmätning

Risk Board: The risk board displays the identified patient risks in the system across different colored groups, see Figure 4.13. The architecture of the tab is similar to the Vårdtyngdsmätning tab, where room numbers are listed and corresponding to it are the patient risks.

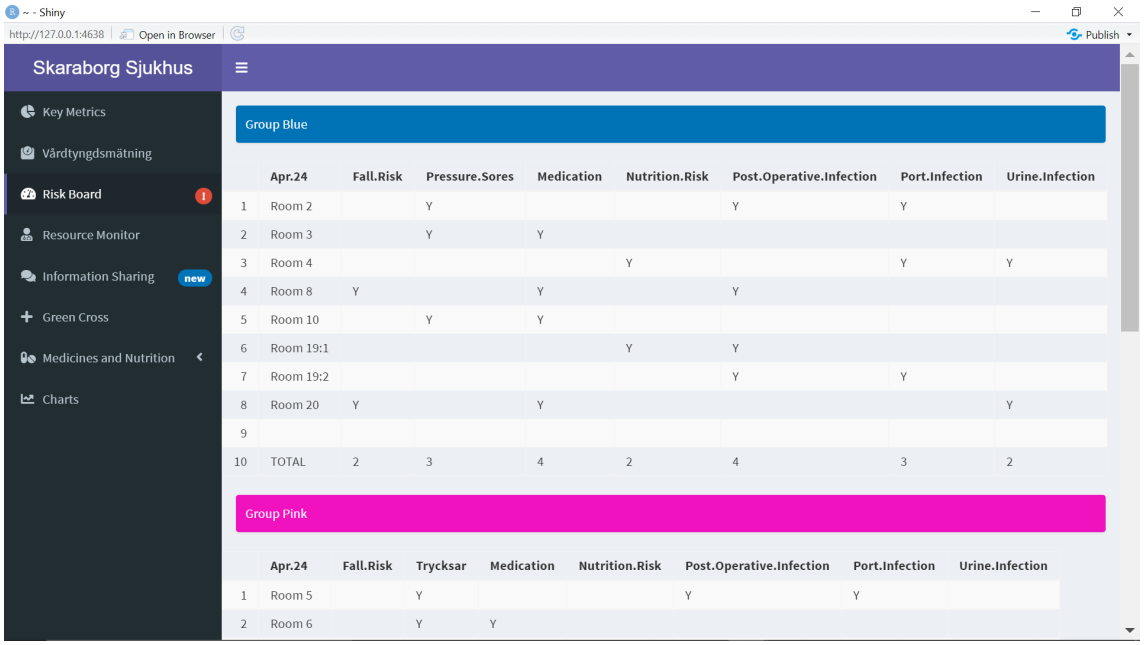

Figure 4.13: Dashboard - Final Iteration Risk Board

The risks displayed on the tab are for a particular day, unlike the Vårdtyngdsmätning tab where data is on a week level. "Y" marks are displayed on cells to indicate patient risks in particular rooms. The tab also provides a total number of risks

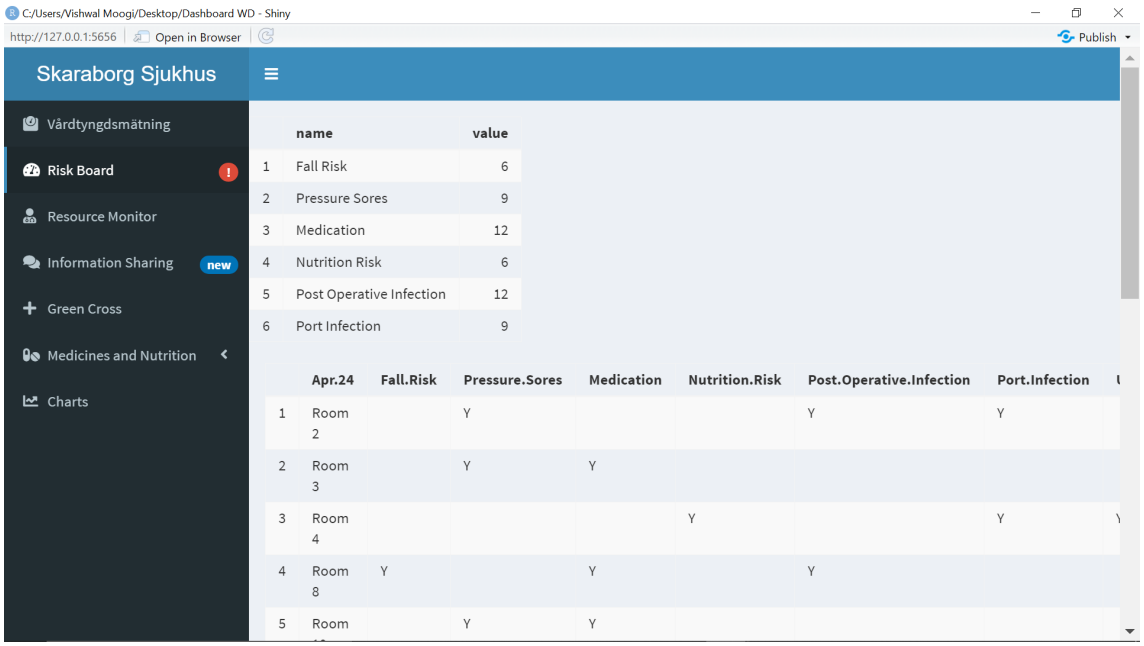

Figure 4.14: Dashboard - Third Iteration Risk Board

across the groups and the entire system which helps the nurses and assistant nurses manage them. Also, it lets them know if someone in the other group has a patient with similar risks as theirs so that they can discuss ways to manage it. This tab has not changed much during the iterations, although a separate table of aggregated risks was present in the third iteration, see Figure 4.14, which was later integrated into the main table and few colors were added to represent the groups in the final iteration, see Figure 4.13. Scrolling down on the dashboard will let users visualize patient risks in all three groups.

Resource Monitor: The resource monitor board is meant to display information about the resources in use, see Figure 4.15 (in the following page). This includes nurses, assistant nurses, and the doctors in charge of different shifts across different colored groups for the day. The displayed data provides information about the demand drawn based on the existing care burden at the ward. The tab is arranged to display data shift-wise, beginning from the number of nurses working in the morning shift across different groups and then continues till the night shift for them, see Figure 4.15. Similar to this follows the data for assistant nurses working in different groups across shifts. The data is displayed for a week, as it was discussed earlier that the schedule for 10-weeks is planned ahead of time, and hence the same data is used to display here. The unit manager has a budget for employing nurses and assistant nurses and has to stick to it. The resource monitor tab also provides the total number of nurses or assistant nurses deployed to match the demand. This helps the unit manager make decisions about either deploying or resting few workers based on the demand and supply. This tab has not been challenged enough during the iterations and remains almost the same as proposed in the initial stages. There are certainly a few minor adjustments here and there but not worth a discussion.

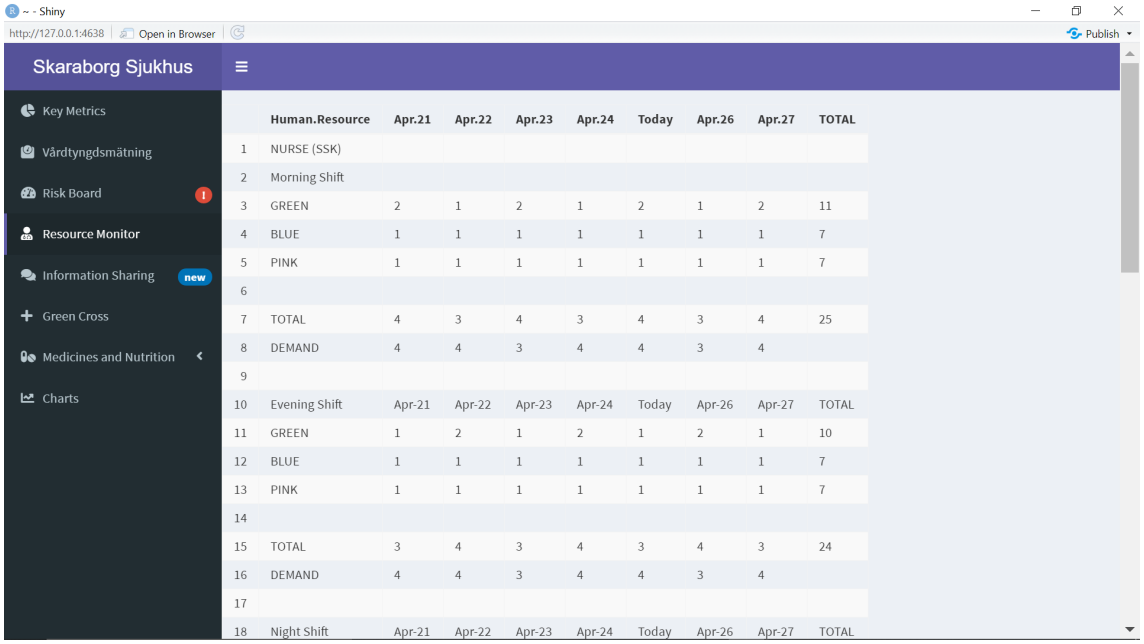

Figure 4.15: Dashboard - Final Iteration Resource Monitor

Information Sharing: The information-sharing tab on the dashboard is meant to take the first steps towards achieving an effective information flow between the nurses and assistant nurses of two shifts. This tab displays the S-BAR sheets filled out by the nurses and assistant nurses during their round work and which is then handed over to the nurses and assistant nurses of the following shift, see Figure 4.16.

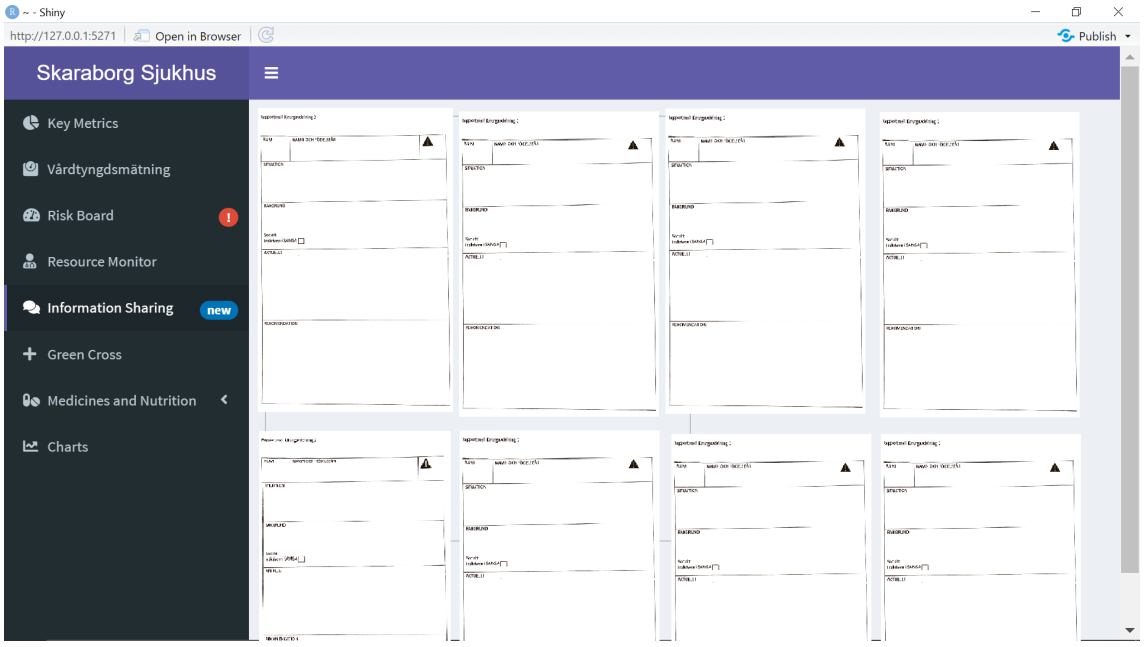

Figure 4.16: Dashboard - Final Iteration Information Transfer

Blank S-BAR sheets have been used to demonstrate it on the prototype, but in the real dashboard, it will be the original ones written by the workers. Having the

S-BAR displayed on the dashboard will help the nurses and assistant nurses of the incoming shift to glance through it and get a minimum idea about the patient care needs before arriving at the hospital. This might save preparation time which the nurses and assistant nurses claimed to be very high given the limited time availability. This would also create transparency for other groups to read the status of patients and get inspiration on how to provide care for patients with similar ailments, hence cementing systems thinking approach on safety. At the meso-level, the unit manager can monitor these information transfers to see if things are being communicated effectively and deal with miscommunications. During the initial phases of this prototype, it became challenging for us to identify what part of information transfer was necessary to monitor. After several discussions, it was decided on visualizing the S-BAR first, and then integrate few more data in future development activities. Although, visualizing the S-BAR requires nurses or assistant nurses to capture a picture of their filled S-BAR sheet on a link which then feeds the image into the dashboard. An alternative approach to this was also discussed, but due to various constraints at the ward, it will be a part of the future development program (see Chapter 5).

Green Cross: The Green Cross is displayed in this tab. The purpose of visualizing the green cross on the dashboard is to let the users know about the occurrence of adverse events and their severity in terms of harm caused to patients, see Figure 4.17.

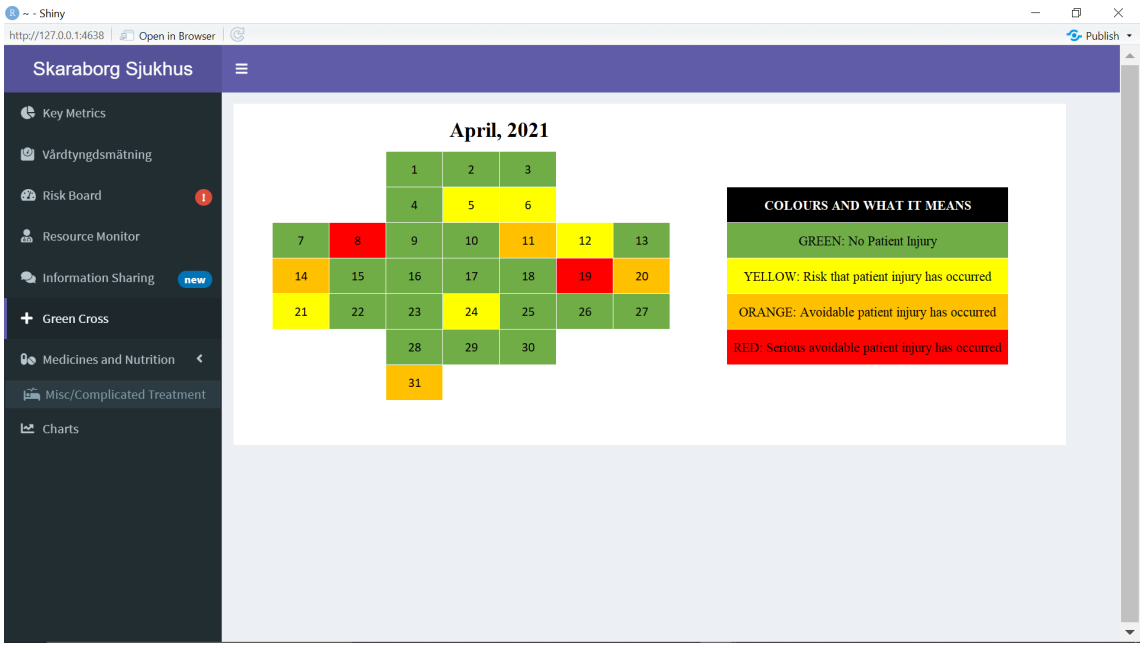

Figure 4.17: Dashboard - Final Iteration Green Cross

This tab also contributes to three key metrics listed in the first tab. The ward works with a manual green cross that is stored in their break room, the place where all the workers get together and discuss the patient risks and adverse events in the system. This tab provides a digitized version of the board which is accessible to all from

any place. Upon clicking the days on the green cross, the dashboard is meant to display the details about the adverse events that occurred on that particular day if any. For instance, if the user clicks on the date 19, the dashboard will display information on adverse events that occurred during that day and what actions were taken which justifies the use of red color. During the initial iterations, the colors were not added and just the blank cross was demonstrated, see Figure 4.18. However, colors were later added in the final prototype for visual perception, see Figure 4.17. The significance of different colors in the green cross has been displayed to help people who are unfamiliar with it.

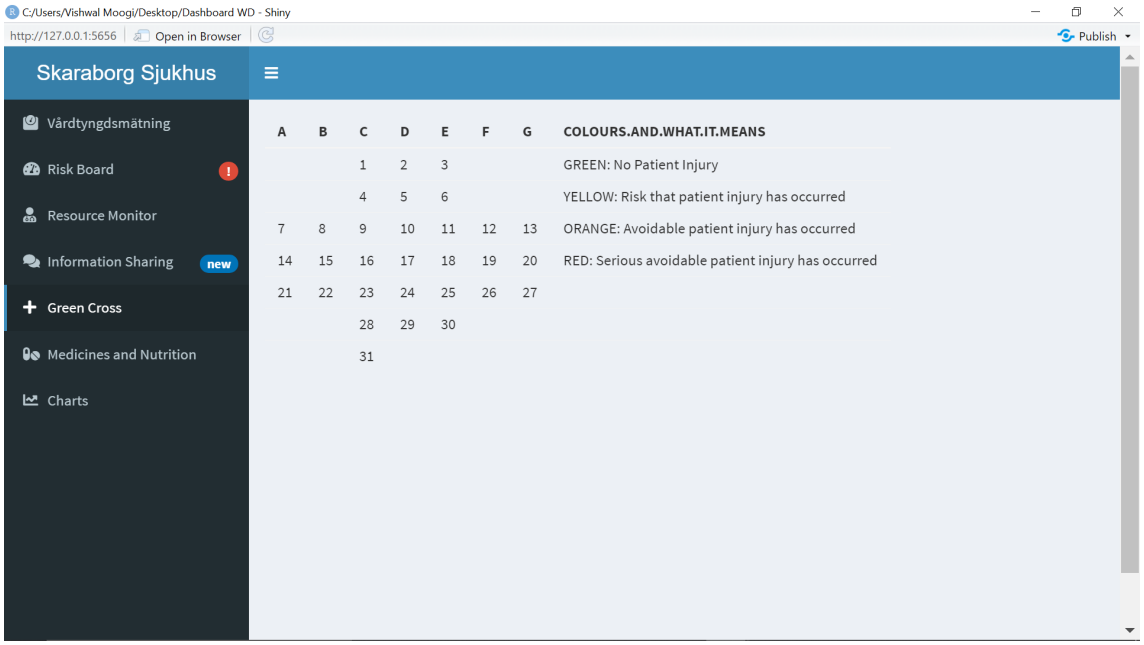

Figure 4.18: Dashboard - Second Iteration Green Cross

Medication and Nutrition: The tab of medication and nutrition is to make the nurses and assistant nurses aware of the scheduled doses. This tab consists of three tables, each for a group. The table is made up of rows indicating the room numbers and columns representing the different classes of medicines and nutrition, see Figure 4.19. The class of medicines selected are just for demonstration purposes and are subject to change based on the requirements of the ward. Corresponding to the rooms numbers are times of the day when medicines and food are generally consumed. The table employs the use of colors to offer a visual perception of the status. A tick mark is always in green stating that the dosage has been completed. While a yellow cell with 0 means that there is a scheduled dose to be given to a patient. While the red one with a cross mark indicates the nurse or assistant nurse has missed to provide the dose on time or completely missed it. The red ones are the point of errors and unsafe acts that can potentially lead to the occurrence of adverse events. These colored indicators can be seen by all the nurses and assistant nurses across different groups which will trigger them to investigate the red colors and inform the nurse in charge if they have missed providing a dose to the patient. This instills a systems thinking mentality within the ward and among the workers.

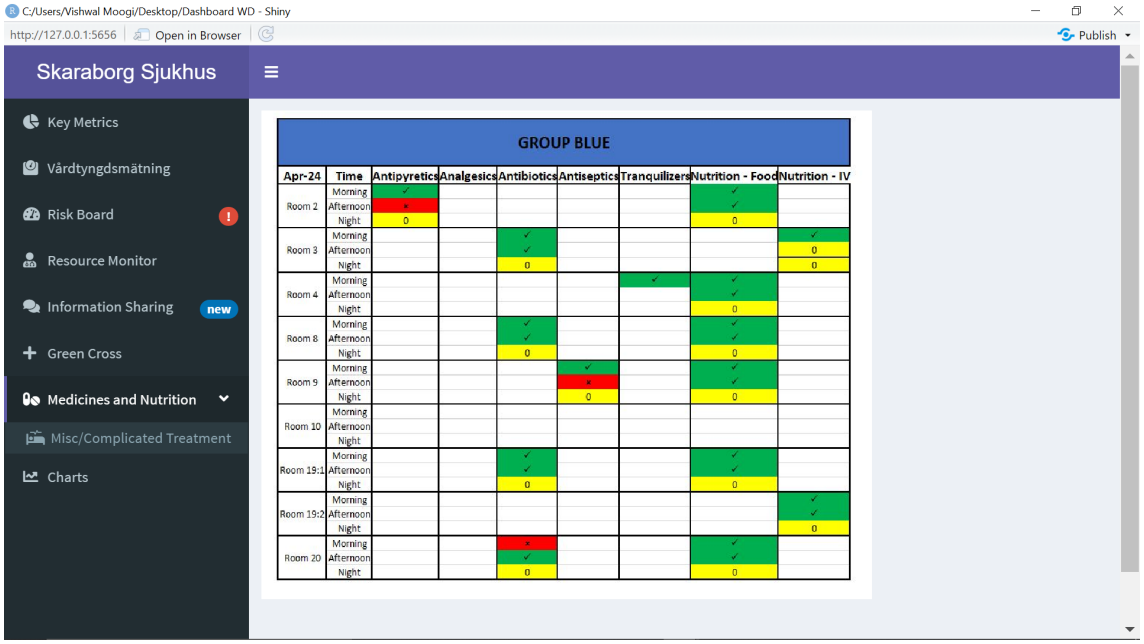

Figure 4.19: Dashboard - Final Iteration Medication and Nutrition

It will also help the unit manager investigate the red cells and alert in charge nurse or assistant nurse to follow up on it and complete the dose if not given yet. The initial iterations of the prototype did not involve the use of colors and were only incorporated in the later stages based on the feedback. Also, assistant nurse A states, *"There are some cases of patients who have recently undergone surgery and require us to clean the operated part to avoid infections. These are not normal and are very difficult to perform. It would be good to know such details on the dashboard so that we can prepare for it well in advance"*. Based on this feedback, during the final iteration, a new sub-tab that says Miscellaneous/Complicated Treatment was incorporated in the prototype to display any special requests like those.

Charts: The last tab in the dashboard is meant to display real-time charts made to visualize current process variations and key metrics. Although, the charts to be displayed are not yet decided because of the ambiguity on what process parameters to visualize. The plots displayed in Figure 4.20 are meant for demonstration purposes and do not hold any significance to this tab. Over the iterations, discussions on what data to visualize as charts were made. It is important to choose the right data amongst a pile of raw data. For now, the ward wanted to just get a demonstration of how the charts would look on the dashboard and decided to build their charts by carefully selecting the parameters in the future.

Figure 4.20: Dashboard - Final Iteration Charts

The proposed prototype was developed with inputs from the customers in the form of needs. These needs were formulated in Section 4.4 and have been mapped to dashboard features in Table 4.7. The uncovered customer needs are listed on the left of the table, and adjacent to it are the dashboard tabs that fulfills the needs.

Customer Needs	***Dashboard Tab/Feature***
Customer Need 1	Vårdtyngdsmätning
	Resource Monitor
Customer Need 2	Resource Monitor
	Vårdtyngdsmätning
Customer Need 3	Information Transfer
Customer Need 4	Risk Board
Customer Need 5	Key Metrics
	Vårdtyngdsmätning
	Risk Board
	Resource Monitor
	Charts
	Medication and Nutrition
Customer Need 6	Risk Board
Customer Need 7	Patient Risks
	Resource Monitor
	Vårdtyngdsmätning
Customer Need 8	Vårdtyngdsmätning
Customer Need 9	Key Metrics
	Charts

Table 4.7: Mapping of customer needs to the dashboard features.

The final prototype certainly has few limitations, but its intended purpose was served. The users were very happy with what they saw and experienced while using it. To quote the unit manager, *"This is exactly how I wanted to visualize the data to monitor the patient risks. The key metrics tab will be very helpful for me to understand the process parameters whose performance can affect the level of patient safety at the ward. It is good to see the resource burden value so that I can deploy more resources if it gets high"*. There is yet a lot of scope for improvement and potential to make it better. This dashboard will be the first of its kind in the ward to monitor patient safety and has fulfilled the need of taking the initial steps to monitor patient safety in real-time. This study has successfully increased the awareness on monitoring patient safety in real-time at the organization and can be considered as the first step towards an online patient safety management system.

5
Discussion

This chapter will focus on discussing the results and analysis in relation to the literature. In addition, future recommendations to continue the work on the proposed solution will be provided.

5.1 Discussions

Patient Safety and Systems Thinking
Patient safety practices have been offering various opportunities to improve the care delivered to patients, although, its performance has not been up to the mark and adverse events often end up unreported (Burlison et al., 2020). However, researchers within this field believe that adopting systems thinking perspective can foster a holistic approach towards patient risks affecting patient safety and how healthcare organizations by careful monitoring and management of these risks can prevent the occurrence of adverse events (Reason, 2000; Emanuel et al., 2009). In this way, a safety culture will be established and made part of shared values among the healthcare workers (Schwarz et al., 2021). Recommendations on how to adopt a systems safety approach in a healthcare setting to increase patient safety have been provided by Karlsson and Hagberg (2015). Among one of the recommendations, they state "There are no tools today that allow for identification and visualization of the boundaries of acceptable level of performance. The organization should focus on identifying and monitoring the parameters that affect the patient safety in the system". Hence, this thesis attempts to develop a real-time patient safety monitoring tool to manage patient risks at a systems level and reduce or completely avoid the occurrence of adverse events.

The theory proved to be of use in understanding the concepts of patient safety and the systems thinking approach. The healthcare workers at SkaS had a clear understanding of the patient safety practices established by the Agency for Healthcare Research and Quality (Leape et al., 2002). Although not everyone might have an understanding of patient safety and systems thinking, the provided theory on it offers enough information to educate them. The empirical setting and analysis of the care process at the surgical ward at SkaS aligns with the claims made by various authors regarding patient safety and healthcare as complex systems. Reason (2000) suggests that adverse events occur in well-developed systems owing to latent conditions and active failures. The findings and analysis of adverse events suggest likewise, a part of the adverse events were the result of latent conditions while the

other part was due to unsafe acts like falls, slips, medication errors, and more, which altogether is classified as active failures. These two parts can be linked to the study by Karlsson and Hagberg (2015) who claim that establishing safety at a systems level focuses on improving and balancing two dimensions, 1) working behaviour, which comprises of active failures like unsafe acts and errors as stated above, and 2) managing internal and external environmental and operational conditions, which are the latent conditions in the organization like information transfer and resource management.

De Savigny and Adam (2009) suggest that healthcare systems are self-organizing whose system dynamics are determined by the interactions between various components of the system, hence rendering it unpredictable. The empirical setting at the ward displays similar characteristics of system dynamics as suggested by De Savigny and Adam (2009). The interactions between the components at the ward are currently limited and as a result, there are inconsistencies like inefficient information transfer in the care delivery process which lead to adverse events. Waterson (2010) proposed an adapted Swiss Cheese Model which helps in uncovering various system-level factors that aid in determining the causes of adverse events. This model acted as a framework to identify and categorize the different findings on causes of adverse events and analyze them to develop a customer-focused solution around it. De Savigny and Adam (2009) claim that many organizations believe the application of systems thinking perspective is too complicated for practical purposes stating that managing different stakeholder priorities is a major challenge. However, this did not pose a challenge during the thesis as the stakeholders expressed collective needs in managing patient safety at the unit. The analysis of these needs formed the basis for developing a real-time dashboard to monitor patient safety as a solution. Farukawa et al. (2009) suggest that the use of health information technology can significantly reduce the occurrence of adverse events. Although technology has proven effective in improving patient safety and quality of care delivered, a lot of drawbacks towards it have been reported, additional burden of having to work with multiple methods being one of them (Asan et al., 2021). However, the additional burden on the healthcare users, in this case, will be known only when the dashboard is implemented. The development stages of the dashboard will be discussed in the following sections.

Design Thinking and Customer Needs

The theories on design thinking have especially proved to be worthy in the data collection and dashboard development process. The three steps proposed by Brown (2008) of carrying out a design thinking project are empathizing, radical collaboration, and rapid prototyping. In this thesis, the process of empathizing with the user helped in uncovering the implicit and explicit needs of the healthcare workers in managing patient safety. There was very limited time to make a prototype for the proposed design of the dashboard, however, rapid prototyping made it possible to accomplish it. The concepts of rapid prototyping made it possible for users of the dashboard to experience it and also get involved in the process of building it.

The theories of uncovering customer needs by Ulwick and Bettencourt (2008) served as a framework to identify and analyse the customer needs, see Section 4.4. They have proposed a certain set of characteristics and rules that need statements should possess in order to be effective and aid in the development of solution. These rules were of help while framing the customer needs in this thesis. It ensured that need statements were clearly expressed and did not focus on expressing solutions or the use of technology in them. Ulwick and Bettencourt (2008) mention that the need statements must be relevant in the present and future. However, in the context of a healthcare system, the statements might change based on varying needs of the customer owing to the fact that healthcare is a complex system with several complex interactions making it unpredictable. The outlined practices of uncovering the needs especially led to insightful customer interactions that generated quality inputs.

5.2 Further Recommendations for the Proposed Solution

The final proposed prototype is a medium-fidelity one. Although, recommendations on developing and implementing it in future has been provided. This section aims at offering an in-depth understanding of the functions intended to be present on a fully functional dashboard. The recommendations provided should help the team that will be carrying over the proposed prototype to build a fully functioning dashboard. The recommendations are given in terms of the proposed tabs on the dashboard (see section 4.6 or Figure 4.9) and are as follows.

Key Metrics: The tab displays several value boxes indicating the agreed-upon metrics. These value boxes are dynamic and interactive. The value box should be able to change its color based on the value its displaying, and as well alert the user through means of visual signals when certain metrics go beyond a set limit. It should also be able to direct the user to the source data when they click on specific metrics.

Vårdtyngdsmätning: The tab displays a data table that is very similar to what is shown on the prototype. Although, the architecture can be made more visually engaging by using different colours. The data table should be interactive and should direct the user to source data when clicked on certain cells. In this case, clicking on the room number should give the user details about the patient, or either prompt the user to view the patient journal. A click on the vårdtyngdsmätning score cell should give details about patient risks, complications and current condition based on recent assessment.

Risk Board: The tab displays various patient risks at an individual and aggregated level. The tab can be made more visually engaging by using tick marks instead of letters. A click on the aggregated risks should display the demand of resources required to manage them. This can be based on the pre-defined conditions of what and how much resources are required to manage certain risks.

Resource Monitor: The tab displays a data table containing information about the various resources deployed at the ward during the day. It should also provide an aggregated demand based on the vårdtyngdsmätning and aggregated patient risks to help the unit manager balance the distribution of resources. The tab can be modified to make it visually engaging by using colours. A click on the resource cell should display the name of the resource and the patients they are managing.

Information Sharing: The tab displays the S-BAR sheets prepared by each group during the end of their shifts. The proposed method is based on the use of existing systems and technology available at the ward. Although, a better method of doing this is to provide each group with an iPad which they carry during their rounds and write notes on it and fill out the S-BAR sheet which gets directly saved on the server. The digital S-BAR sheet can be fetched from the server to be displayed on the dashboard in real-time for the users to view. This is just an idea and presented as a future recommendation based on the feedback from the unit manager.

Green Cross: The tab displays the green cross board. The prototype has covered most of the visual features and can be replicated in the dashboard. Although, the cells on the green cross needs to be interactive. A click on one of the cells should display a detailed set of information regarding the adverse events that occurred on the selected day if in case there were any.

Medicines and Nutrition: The tab displays an interactive table that helps users visualize the medical and nutritional needs of patients in the system throughout the day. The table should use visual cues to indicate and alert the users about the status of the patient on whether medicine or nutrition was taken. A click on the cell should display the details of the medicine or nutrition prescribed in terms of dosage and the time it has to be given. The sub-tab of miscellaneous needs should display the special care needs prescribed by the doctor as data tables with all details mentioned.

Charts: The tab displays several real-time graphs based on the predefined metrics by the ward. The graphs are meant to be predictive that can forecast the demand and values based on historic data using forecasting models relevant for the healthcare context. The tab can be made visually engaging by using different colours and as well the graphs should display the source data based on a click.

6

Conclusion

The purpose of this thesis is to develop customer-focused solutions for online monitoring of patient safety in real-time using design and system thinking approach. With the help of the literature and empirical data, an overview of existing ways of monitoring and managing patient safety uncovered several pain points and user needs to which a solution is proposed, thus fulfilling the purpose. This chapter aims at answering the formulated research questions and providing a set of future recommendations for the implementation of the proposed solution.

6.1 Research Questions

RQ1: What are the challenges faced by the healthcare workers in managing patient safety at the ward?

The focus on healthcare workers has been narrowed down to three specific users; the Unit Manager, Nurses, and Assistant Nurses. These users have different roles and functions in the system and hence face different challenges in managing patient safety. Although, the challenges of nurses and assistant nurses have been combined due to their similarity in nature. The challenges have been described from the perspective of each user as follows.

The Unit Manager's Challenges:

1. The surgical ward lacks an overall systems understanding of how adverse events occur and what factors affect patient safety.
2. The ward also lacks evidence-based principles and methods to establish systems thinking approach to manage patient safety.
3. Patient safety at the ward is managed through instructions and traditional ways of managing patient risks where the system depends on independent individual components.
4. The ward follows an offline approach of reactive root-cause analysis to examine adverse events once they have occurred. The offline methods pose challenges in monitoring patient safety at different groups and demand the unit manager to indulge in an expedition across the ward every single time they need to know the level of patient safety at the unit.
5. Furthermore, the unit manager is not aware of interactions and information transfer related to patient safety that happens between the workers at the ward and only knows about them during daily meetings or when an adverse

event has occurred.

Nurses and Assistant Nurses: Several challenges are encountered by them during the process of providing care to the patients.

1. The working behaviour of nurses and assistant nurses plays a major role in the occurrence of adverse events. Unsafe acts and routine errors in the process of providing care is a challenge in managing patient safety at the ward.
2. The excessive workload has been a major challenge to all the nurses and assistant nurses. However, the perception of workload is subjective and changes from one nurse to another.
3. At full capacity of patients occupied, resources are overwhelmed and workers pick each others slack.
4. The burden of information transfer in a limited amount of time adds to the workload and stress. Nurses and assistant nurses get very limited time at the start of their shift to learn about the patients and their care needs. This affects the care planning process for that particular shift and overwhelming emotions are carried throughout the day.
5. The nurses and assistant nurses at times lack certain competencies to manage special care needs prescribed by the doctors.

RQ2: What are the needs of the healthcare workers when monitoring patient safety in real-time?

Although the users faced different challenges in managing patient safety at the ward, they have collective needs as a ward when it comes to monitoring patient safety in real-time. The most basic need for healthcare workers is to be able to provide quality and seamless care to the patients and maintain a high level of patient safety at the ward. To be able to do so, there are several needs described by the healthcare workers.

The current offline approach in managing patient safety needs to be complemented with an online approach to monitor patient risks and care needs. In addition to this, the interaction and information transfer between various users and the accessibility to critical resources need to be continuously monitored and managed to match the collective care needs of the patients at the ward. Additionally, the need is to monitor patient risks and care burden in real-time across the ward to make data-driven decisions that might avoid the occurrence of potential adverse events.

The healthcare workers have a set of needs when monitoring patient safety in real-time using an online approach. At first, the need to visualize the current state of the system and the status of the care process for a patient displayed in one place and accessible to all is predominant. Additionally, the need is to monitor key metrics associated with the care process that affects the level of patient safety at the ward. These metrics should be able to indicate if there is a need to take necessary actions and alert the users about potential errors and unsafe acts. Next, the healthcare workers demand an assignment of even workload, and to deploy additional

resources during times of high care burden. The healthcare workers also need to visualize the vårdtyngdsmätning (care burden) at the tip of their finger so that they can either deploy additional resources or assign some workers to help their fellow mates.

One among the other needs of the workers is to be able to monitor the patient risks across all the groups in the ward. The need of the healthcare workers is to gain inspiration on ways of managing patient risks by establishing interactions between workers from different groups. Along with this, is the need to visualize data on occurred adverse events and facilitate learning through visualizing the green cross which contains all the information about the adverse events and recommendations on how to avoid similar incidents in the future. The healthcare workers tend to come across special care needs which they sometimes lack the desired competence to offer care, hence they need to visualize this on a systems level to help prepare themselves or seek assistance.

6.2 Limitations and Future Work

Limitations of this thesis can be viewed as opportunity for future work.

Lack of time - The time span for the thesis was short to develop a fully functioning dashboard or at least a high-fidelity prototype. Implementation of this dashboard would have helped measure the performance of this dashboard and evaluate its effectiveness in improving patient safety.

Inconsistent Data - The data on adverse events were extracted from one of the incident reporting systems at SkaS. The data consisted of several missing fields and very small sample size of data was available. Also, the data from incident reporting systems could have been supported by extracting sampled data from electronic health records which would contain information about adverse events which were not reported. This did not happen due to time constraint and resource availability.

Data Collection - The process of data collection could not be performed as desired. Very few participants were available for interviews, among other methods. This was because of the restrictions set by the hospital due to the ongoing pandemic. Interviewing more participants with different competencies would have helped understand their perception of nurse burden, and as well of various other things.

Based on the challenges and needs of the healthcare workers, an online dashboard as a customer-focused solution was drawn. The proposed dashboard displays the current population of patients at the ward and their varying care needs along with available resources in real-time. The dashboard will help SkaS balance their resources concerning personnel, competencies to match them against the combined needs of the patients, and not limited to medical and safety equipment. The dashboard development stages have been discussed in Chapter 4 along with the process of prototyping it in rapid iterations.

The proposed dashboard is exclusively designed for the surgical ward considering their specific needs. However, different wards at SkaS can adopt this dashboard by selecting the key metrics based on the uncovered needs of the workers at respective wards. The language used to display contents on the dashboard is English. However, the language of the dashboard should be changed to Swedish as it is their preferred choice and business language. The proposed solution does not consider various national data laws and regulations in the design process, which however should be considered as future work.

The implementation of the dashboard can be done in several steps following a iterative Plan-Do-Study-Act (PDSA) cycle. To not overwhelm the users with so much to process at once, the dashboard can start with small things, like visualizing the current population of patients and their care needs at the ward. Slowly, the proposed tabs can be added to the dashboard based on the feedback generated from the PDSA cycle.

In the future, it is advisable to include patients while implementing the dashboard in iterative PDSA cycle. This will help in enhancing the features of the dashboard and at the same time lets patients be a part of their care process. The involvement of patients in care process can potentially facilitate reporting of adverse events. They can provide accurate information about their medical history, allergies, and risks which help care providers in avoiding errors and unsafe acts. Also, the patients can notify about any difficulties or lapses in care like not getting medicine on time. The collaboration of patients in patient safety efforts can foster empowerment and enhance their perception of care quality. Besides, it will also help the organization establish a systems view on patient safety.

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A

Appendix 1

Vårdtyngdsmätning Kirurgavdelning 2 (Care Burden Score)

Bakgrund
Tidigare har vårdtyngd endast mätts utifrån patientens behov ur ett ADL och omvårdnadsperspektiv. För att ge en bättre bild av hur mycket resurser en patient behöver för att erhålla bästa möjliga vård kompletteras patientens omvårdnadsbehov även med medicinskt behov.

Syfte
Vårdtyngdsmätning skall ske på ett strukturerat och jämförbart sätt för att skatta patientens omvårdnads och medicinska behov. Utfallet/resultatet skall användas som stöd/underlag vid fördelning av de personalresurserna som finns att tillgå under arbetspasset.

Arbetsbeskrivning
Enhetens vårdtyngd är dynamisk och utvärderas minst två gånger per dag, kl 14. 00 och kl 21.00 samt vid behov. För att bedöma vårdtyngden tilldelas varje patient en bokstav och en siffra.

• Siffran (1–3) beskriver vårdtyngden, en patient som har en 1:a klarar sig bra själv och en 3:a behöver hjälp av två eller flera personer

• Bokstaven (A-C) talar om hur mycket medicinska insatser som en patient kräver, där A är lättare insatser och C där patienten behöver mycket medicinskt stöd Vid bedömning är 1A är lättast och 3C är tyngst, rutinen beskriver vilka aktiviteter som ligger under framtagna kriterier.

Omvårdnadstyngd 1:
• Sköter ADL självständigt eller med handräckning

Omvårdnadstyngd 2:
• Mobilisering med stöd av 1 personal, sköter ADL med handräckning
• För personalen lätt emotionellt och psykiskt tidskrävande patient

Omvårdnadstyngd 3:
• Mobilisering med stöd av 2 eller fler personal
• Behov av hjälp med nästan all eller all sin ADL

- För personalen mycket emotionellt och psykiskt tidskrävande patient
- Calicivirus
- Vård i livets palliativa slutskede

Medicinsk Vårdtyngd A
- Läkemedel per os
- Cirkulatorisk stabil
- NEWS enligt rutin
- SAMSA oförändrat

Medicinsk Vårdtyngd B
- NEWS poäng >5
- Stöddropp/parenteral nutrition
- Infusioner/injektioner enstaka tillfällen/arbetspass
- Måttlig smärtproblematik
- Cirkulatorisk stabil
- SAMSA ny/ändringar

Medicinsk Vårdtyngd C:
- NEWS poäng >7
- Vätskebalansrubbning som kräver aktiv och omfattande åtgärder
- Infusion/injektioner upprepande tillfällen/arbetspass
- Svår smärtproblematik
- GI blödning
- SAMSA ny/ändringar som kräver mer insatser t.ex. vpl på plats
- Cirkulatorisk instabil
- Vård i livets palliativa slutskede
- patient

Extra observandum vid > tre 3:or eller två 3C överväg att använda handlingsplan

Handlingsplan
Åtgärderna är benämnda 1 – 4. De är inte åtgärder som behöver tas i turordning utan kan väljas ut vilka som är lämpliga vid varje tillfälle.
1. Omfördela gränsdragningarna var vårdlagens arbetsområde börjar och slutar.
2. Fördela resurser utifrån vårdtyngden.
3. Vid sjukdom, överväg om ersättare behöver ringas in.
4. Vid extremt läge har ledningsansvarig sjuksköterska befogenhet att ringa in en extra personal.

B

Appendix 2

National Early Warning Score Guide

The National Early Warning Score is a tool that was developed by the Royal College of Physicians that helps in improving the detection and response to clinical deterioration occurring in adult patients. This tool has been fundamental in improving patient outcomes and has been key in improving patient safety.

The Skaraborg Hospital Group has adapted the NEWS 2 framework and have published their ways of assessing the NEWS 2 score. The following sheets consists of the NEWS 2 framework developed by the Skaraborg Hospital Group.

Rutin

National Early Warning Score 2 (NEWS 2)

VÄSTRA GÖTALANDSREGIONEN
SKARABORGS SJUKHUS

Barium-id 41520 **Giltigt t.o.m.** 2022-11-03 **Version** 3

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Publicerad av: Skarabords Sjukhus

Revideringar i denna version

Tillägg om att NEWS2-bedömning också ska göras inom 24 timmar före utskrivning.

Bakgrund, syfte och mål

National early warning score 2 (NEWS2) är ett verktyg som är skapat för att systematiskt bedöma patientens vitalparametrar. Genom att patientens vitalparametrar poängsätts och därmed summeras får man en totalpoäng som i sin tur ger en indikation om patientens risk för försämring (1, 2).

Så kallade early warning scores har funnits sedan mitten av 90-talet och infördes i Sverige första gången 2003. Det finns mer än 50 olika system men aktuell forskning har visat att NEWS2 är i nuläget det system som har bäst förmåga att förutspå ökad risk för försämringar hos patienten (3). Bedömning av vitalparametrar inom 24 timmar före utskrivning har dessutom visat sig korrelera till risk för både återinläggning och död inom 30 dagar (4,5).

Syftet med NEWS2 är att tidigt identifiera försämringar i tillståndet hos en patient samt initiera tidig bedömning av tillståndet.

Målet med NEWS2 är att minska risken för allvarliga skador under vårdtiden på SkaS, återinläggningar och dödsfall.

Avgränsningar

- NEWS2 är inte anpassat för barn under 16 år. Patienter under 18 år bör Pediatric early warning score (PEWS) användas istället.
- NEWS2 är inte anpassat för gravida.

För patienter i livets slutskede bör nyttan av övervakning relaterad till obehag och störningar bedömas.

Arbetsbeskrivning

NEWS2 ska bedömas på alla patienter över 18 år som inte är gravida. Behandlande läkare kan alltid frångå NEWS2 och ordinera annan frekvens för kontroller av vitalparametrar alternativt avsluta kontroller. Dessa beslut ska dokumenteras i patientens journal.

Oro för patienten väger alltid tyngre än NEWS2-poäng.

Tillvägagångsätt

Patientens NEWS2-poäng bör bedömas i samband med inskrivning till vårdavdelning. Patienter med NEWS 5 eller mer (eller 3 poäng på en enskild parameter) på akutmottagning bör ha en tydlig ordination om fortsatta NEWS-bedömningar och åtgärder på vårdavdelning. Detta för att minska samtal till ansvarig läkare från vårdavdelningen direkt vid ankomst.

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Vid ankomst till vårdenheten kontrolleras andningsfrekvens, syremättnad (saturation), blodtryck, puls, medvetandegrad, temperatur samt om patienten har tillförd syrgas. Därefter summeras de enskilda poängen med hjälp av NEWS2 tabellen och totalpoängen jämförs med åtgärdstrappan för vidare handläggning.

Ny bedömning skall alltid genomföras vid förflyttning av patienten mellan vårdenheter.

Om patientens poäng leder till läkarkontakt enligt åtgärdstrappan eller allvarlig oro för patientens tillstånd ska alltid ansvarig avdelningsläkare/jour tillkallas i första hand.

Läkarbedömningen på avdelningen bör utföras med ansvarig sjuksköterska för att utforma en plan om fortsatt omhändertagande.

NEWS2 ska också kontrolleras och dokumenteras inom 24 timmar före utskrivning.

Patienter med låg habituell syremättnad
Patienter med sjukdomar som sedan tidigare har nedsatt syremättnad bör efter läkarbeslut bedömas enligt raden ”Syremättnad 2” i NEWS2 tabellen.

Dokumentation

- Mindre än 5 NEWS2-poäng samt inga enskilda vitalparametrar som ger 3 poäng dokumenteras normalt sett bara under mätvärden NEWS2” i Melior.
- Om 5 poäng eller mer samt vid 3 poäng i en parameter ska mallen NEWS2 startas för att samla dokumentationen om den fortsatta hanteringen av situationen. Mallen ska startas av patientansvarig sjuksköterska och vara utformad för att samla läkarnas samt sjuksköterskornas dokumentation.
- Beslut att undanta patienter från monitorering enligt NEWS2 ska dokumenteras i Melior mallen ”NEWS2 SKAS”. Vem som har tagit beslutet ska alltid dokumenteras.

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Relaterad information

NEWS 2 tabell

National Early Warning Score (NEWS 2)

Fysiologiska parametrar	3	2	1	0	1	2	3
Andningsfrekvens	≤8		9-11	12-20		21-24	≥25
Syremättnad 1	≤91	92-93	94-95	≥96			
Syremättnad 2 (används på läkarordination*)	≤83	84-85	86-87	88-92	93-94 med syrgas	95-96 med syrgas	≥97 med syrgas
Tillförd syrgas		Ja		Nej			
Systoliskt blodtryck	≤90	91-100	101-110	111-219			≥220
Pulsfrekvens**	≤40		41-50	51-90	91-110	111-130	≥131
Medvetandegrad***				Alert			CVPU
Temperatur	≤35,0		35,1-36,0	36,1-38,0	38,1-39,0	≥39,1	

*Syremättnad 2 används endast efter läkarordination vid låg habituell syremättnad, t.ex. KOL. **Om hjärtfrekvens mäts ska detta användas i stället för pulsfrekvens i denna parameter.
***Medvetandegrad: A=alert, C=confusion (nytillkommen eller förvärrad förvirring, V=voice (reagerar med ögonöppning, tal eller rörelse vid tilltal/kraftiga tillrop) P=pain (reagerar vid smärtstimulering) U=unresponsive (reagerar ej vid tilltal/smärtstimulering).

Åtgärdstrappa Skas

NEWS2-poäng	Övervakningsfrekvens	Åtgärd
0	Senast inom12h	- Fortsätt övervaka NEWS2 enligt rekommenderad frekvens. - Försök om möjligt planera kontrollerna för att inte störa nattsömn. - Kontroll var 8:e timme på infekterade samt bukopererade patienter.
Totalt 1-4	Senast inom 4-6h	- Informera ansvarig sjuksköterska om NEWS-värdet. - Ansvarig sjuksköterska bedömer om övervakningsfrekvens ökas samt behov av läkarbedömning.
3 poäng i en parameter	Senast inom 1h	- Ansvarig sköterska ska informera ansvarig läkare - Brådskande bedömning av ansvarig läkare samt eventuellt kontakt med jourhavande narkosläkare. - Avsteg från övervakningsfrekvensen kan göras av ansvarig läkare efter bedömning av patient.
Totalt 5-6	Senast inom 1h	- Ansvarig sjuksköterska ska omedelbart informera ansvarig läkare. - Brådskande bedömning av ansvarig läkare samt eventuellt kontakt med jourhavande narkosläkare. - Avsteg från övervakningsfrekvensen kan göras av ansvarig läkare efter bedömning av patient.
Totalt 7 eller mer	Överväg kontinuerlig övervakning	- Ansvarig sjuksköterska ska omedelbart tillkalla ansvarig läkare. - Överväg kontakt med jourhavande narkosläkare. - Överväg att flytta patienten till högre vårdnivå.

Version 1.1 (SWE) VGR12916

Käll- och litteraturförteckning

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C

Appendix 3

This section contains a list of questions asked during the data collection process. The questions were prepared for the initial empathizing interviews with several nurses, assistant nurses and the unit manager. Few of the questions were asked in a different ways based on the participant and their responses.

C.1 Interview Guide

1. How long have you been working at SkaS?

2. What is your background and role in the care process at the surgical ward?

3. Describe your routine in a chronological order in terms of the different activities you perform.

    (a) Does the process of delivering care at the ward have standard guidelines and instructions?

    (b) How many patients do you handle in a day on an average?

    (c) Who is responsible for assigning patients to the nurse/assistant nurse?

    (d) What factors are considered while assigning patients? (Experience, Competence)

    (e) What frustrates you during your shift?

    (f) When/Why are you dissatisfied with the care process during your shift?

    (g) Are there any issues like bottlenecks, miscommunication, process variations, or lack of instructions?

    (h) How often do you take rounds?

4. Are the resources well balanced between nurses and assistant nurses?

5. Describe your perception of patient safety and systems thinking.

6. What are the patient safety initiatives currently in use during the care process?

7. Who is responsible for managing patient safety at the ward?

8. What are the challenges faced in managing patient safety?

9. How is Green Cross helping manage patient safety at the ward?

10. What are the commonly occurring adverse events at the ward?

    (a) What are the causes?
    (b) Who is responsible for the causes?
    (c) How are these causes managed?
    (d) How are the adverse events documented?

11. What are the commonly found patient risks at the ward?

    (a) How are they managed?
    (b) Are they monitored regularly?
    (c) Who keeps an account of the aggregated risks in the system?
    (d) What happens when these risks are not monitored?

12. How do you transfer information to nurses/assistant nurses of incoming shift?
    (a) Is there a standard format?
    (b) How much time do you get?
    (c) What information is shared?
    (d) Are there any issues in this process?

13. Can you share your opinions on ways of better managing patient safety at the ward?

14. How do you follow-up with patients who have returned back home after receiving care?

    (a) Who is responsible?

(b) Is there a predefined timeline for that?

(c) What do you communicate about?

(d) How is it documented?

15. What is your opinion about monitoring patient safety in real-time?

(a) How will it help you in your care process?

(b) Would you want to monitor the patient risks across the entire unit?

(c) Are you willing to change your approach towards managing patient safety?

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