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Improvement of patient alarms at Region Skåne

Degree project of bachelor of fine arts, 15p

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Improvement of patient alarms at Region Skåne

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Abstract

This industrial design bachelor project aimed to improve the functionality of patient alarm systems in hospitals across the Skåne region. The project was conducted through nurse surveys, interviews with patients and nurses, as well as research into inclusive and universal design. The research found that there were three main problems with the current alarm systems. The primary issue was an abundance of false emergency alarms, which caused unnecessary stress and fatigue for healthcare providers. The second issue was a lack of flexibility and accessibility in the alarm system design, which made it difficult for different departments to adapt the system to their specific needs. Finally, there was a problem with hygiene and hardware longevity, as the alarm systems were difficult to clean and prone to wear and tear.

To address these issues, the project developed a product family consisting of both add-on products and a redesigned alarm device. The products offered different solutions to the three main problems, enabling different departments to tailor the solutions to their specific situation. For example, some departments have a lot of false emergency alarms which might require a completely new alarm button with tactile, auditory and visual feedback, to reduce the number of false alarms. Other departments that have patients with mobility issues might however only need to implement the solutions for flexibility and accessibility.

The final results of the project were satisfactory, and the final usability test was successful. The new alarm system design was well received by both patients and healthcare providers, who found it easier to use and more reliable than the previous system. The project demonstrated that an inclusive and universal design approach can significantly improve the functionality of patient alarm systems in hospitals, which can ultimately lead to better patient outcomes and a safer healthcare environment for both patients and healthcare providers.

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1. Introduction

1.1 Background

Alarm fatigue is a common problem in healthcare, which occurs when healthcare workers become desensitized to the constant sound of alarms, leading to decreased responsiveness to real emergencies. In hospitals, emergency alarm systems are critical for ensuring patient safety and enabling timely medical intervention during emergency situations. However, outdated and poorly designed alarm systems can lead to unnecessary alarms, which can cause alarm fatigue, resulting in increased nurse workload and decreased patient safety. The causes of alarm fatigue can vary and can include equipment malfunction, device misplacement, user error and incorrect alarm settings. The consequences of alarm fatigue can be dire and can include delayed medical intervention, patient harm, and even death. In the context of hospitals in Region Skåne, the outdated emergency alarm systems are causing emergency alarms to be sent during non-emergencies often caused by user error, leading to increased nurse workload and decreased patient safety. Considering the current understaffing and nurse burnout plaguing the healthcare system, the problem of alarm fatigue must not only be rectified, but the alarm system has to help the staff prioritize patients effectively.

1.2 Objective

The objective of this undergraduate project is to conduct research and identify problems in the current patient alarm system in Region Skåne's hospitals, with specific emphasis on the Birth center in Malmö. Based upon the findings the end goal is then to provide one or multiple solutions that improve the functionality of the alarms. These solutions must meet the following criteria.

1. Reliability: The patient alarm system must be reliable and have minimal malfunctions, reducing the risk of missed emergencies.
2. Ease of use: The patient alarm system must be easy to use and understand, reducing the risk of user error and ensuring prompt response times.
3. Accessibility: The patient alarm system must be easy for patients to access at all times
4. Customization: The patient alarm system must allow for customization, allowing hospitals and departments to tailor the system to their specific needs and requirements.
5. False alarm reduction: The patient alarm system must have features in place to reduce the occurrence of false alarms and improve the overall response process.

1.3 Target group

The target group consists of healthcare professionals in hospital settings, with special emphasis on nurses and assistant nurses who frequently come into contact with patient alarms, hospital cleaning staff, as well as patients who rely on the alarm for more efficient medical care.

1.4 Demarcation

Due to the COVID-19 pandemic, it was not feasible to arrange a department visit to gather detailed information about the current systems technologies and document the user interaction in real time. Instead, the focus will be on gathering user feedback, conducting literature reviews, surveys, interviews and user testing. Recruiting a diverse user sample for surveying hospital staff may however pose a significant challenge.

To gather information for the project, staff and patient knowledge will be relied upon. However, the research methodology is not without limitations. Gathering information about healthcare equipment is notoriously difficult, therefore the extensive reliance on user feedback can lead to potential bias and limited knowledge of the current system's technical aspects. Because of this, there will be no analysis of current technological aspects, device prices or technical integration. The specific functionality and alarm systems may also vary depending on the hospital and department. Some details in the current functionality might therefore not be correct, however this will not impact the project as a whole, since the emphasis is not on accurately portraying the current patient alarm system, but rather documenting its pitfalls and creating solutions that might alleviate them.

1.4 Method

The research methodology consists of gathering research through interviews with staff and patients, internet research and surveys. Through this approach, the aim is to identify both systemic faults and operational errors that may arise, ultimately enabling the creation of tailored solutions. The chronological order of the project outline and methodology is as follows.

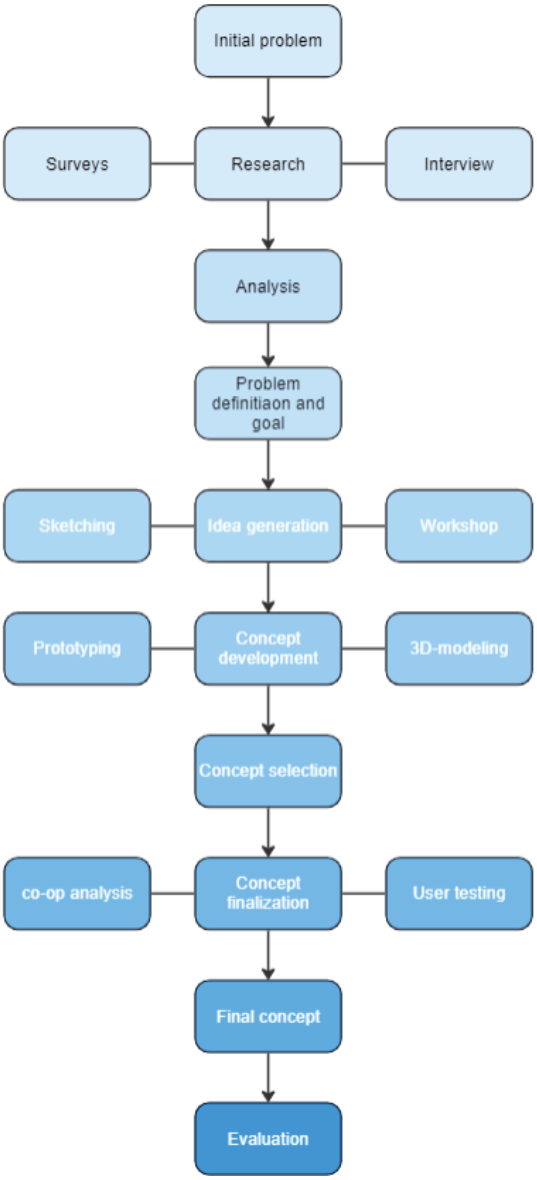


Image 1: Workflow overview (source: own work)

2. Research

2.1 Alarm fatigue

Alarm fatigue is a phenomenon that occurs in healthcare settings where healthcare professionals become desensitized to the alarms from patient monitoring systems due to their frequent occurrence. This can result in healthcare providers ignoring or delaying response to an actual patient emergency, as they may perceive the alarm as a "false alarm" or non-urgent situation or they might not even register the alarm occuring. Alarm fatigue can occur in various medical devices, such as cardiac monitors, ventilators, patient alarms and infusion pumps, among others. The consequences of alarm fatigue can be severe, as it can lead to medical errors, patient harm, and even fatalities. (Woo M, Bacon O. (2020) “Alarm Fatigue”)

Furthermore, false alarms or unnecessary alarms can also contribute to alarm fatigue. False alarms are when an alarm goes off, but there is no actual emergency or clinical reason for the alarm. For instance, patient monitors can produce false alarms due to poor electrode placement or signal interference. Frequent false alarms can lead to increased stress levels among healthcare providers, decreased patient satisfaction, and higher healthcare costs. In addition, false alarms can cause unnecessary patient interventions, such as administering medications or performing diagnostic tests, leading to discomfort and anxiety for the patient. (Woo M, Bacon O. (2020) “Alarm Fatigue”)

2.2 Hospital staff stress and burnout

Hospital staff with an emphasis on nurses are among the professional groups that face the highest levels of work-related stress. In fact, healthcare workers experience up to four times more sickness absence related to stress compared to other professions. Hospital staff burnout is a common problem in healthcare, particularly among nurses, physicians, and other frontline workers. Burnout occurs when healthcare professionals experience chronic emotional, physical,

and mental exhaustion and stress due to the demanding nature of their work. It can manifest in several ways, such as decreased job satisfaction, increased absenteeism, and emotional detachment from patients. (Peterson, 2008)

The causes of hospital staff burnout are multifactorial and can be both internal and external. Internal factors may include excessive workload, long working hours, lack of control over work schedules, inefficient workflow and inadequate resources. External factors may include organizational culture, insufficient support from management, and high patient acuity and complexity.

Other factors that may contribute to burnout include the emotional toll of caring for critically ill patients, challenging family dynamics, and dealing with ethical dilemmas. Additionally, the COVID-19 pandemic has further exacerbated burnout among healthcare workers due to the increased workload, uncertainty, and exposure to the virus.

2.3 Importance of streamlining healthcare whilst maintaining human contact

Streamlining healthcare and reducing miscommunication can help to mitigate staff burnout by improving efficiency and reducing the workload of healthcare professionals. By optimizing workflows, healthcare organizations can eliminate unnecessary tasks, reduce the likelihood of errors, and improve communication between healthcare providers, which can promote a more efficient and effective healthcare system.

However, it is important not to streamline healthcare to the point of losing the human contact between patients and healthcare professionals. Maintaining a strong patient-provider relationship is essential for promoting positive health outcomes and enhancing patient satisfaction. For instance, providing patients with personalized care, listening to their concerns, and providing emotional support can all enhance the patient experience and promote better health outcomes.

To strike a balance between streamlining healthcare and maintaining human contact, healthcare organizations can use technology and good design to improve communication and reduce administrative burdens while still prioritizing direct patient care. For instance, the use of care telecare can provide patients with convenient access to care, while still enabling healthcare providers to engage with patients in a meaningful way. Regularly identifying staff burdens and workflow problems across different departments and hospitals can help healthcare workers focus on their job duties instead of spending time trying to work around solvable issues, thus reclaiming time for patient care. (Olsen, 2021)

2.4 Hospital staff survey

A survey was conducted to gather information about the patient alarm systems used in different departments across Region skåne hospitals. The survey aimed to gather information on hospital staff experiences with patient alarm systems, including how often emergency alarms are triggered, how easy they are to use, and any issues or challenges they have encountered. This was done in order to identify potential problem areas, in order to better understand how it can be improved.

The survey was conducted by a google forms questionnaire. The survey was sent out via Linkedin to employees at Region Skåne. A total of fifteen answers (n17) were collected from five different departments, fifteen of the responses came from nurse staff and two from assistant nurses. The following questions were asked in the questionnaire (Swedish to english translation):

1. **What department do you work at?**
   This question was asked so that we could know what kind of healthcare the participant practiced and where.

2. **What is your job title?**
   This question was relevant since the perception of the hospital alarms as well as the day to day patient contact may vary strongly between Doctors, nurses and assistant nurses.

3. **Do you find that you get a lot of false emergency alarms in your department? If yes, estimate how many there are per shift?**
   This question aims to identify if the staff is exposed to a large number of emergency alarms on a daily basis, since alarm fatigue is a large issue for hospitals around the world.

4. **What proportion of the emergency alarms you receive in the department would you Are estimates false alarms?**
   This question seeks to identify if there are any recurring problems with the communication between patients and hospital staff when using the alarm.

5. **Do you inform the patients regarding the functionality of their patient alarm?**
   This is relevant since a lack of information may lead to miscommunication when utilizing the alarm or it may also lead to the complete lack of alarm use.

6. **Is the alarm easy for patients to understand?**
   The answers to this question can only gauge how the staff perceives the patient's understanding.

7. **Have you observed that patients are reluctant to call for help during non emergencies?**
   The answers to this question can not be precise since it can only gauge how the staff perceives the patients experience, however it may give an insight to the daily operations and possible issues.

8. **If the answer to the previous question was yes, explain why.**
   This question has the same framework as nr.7.

9. **Is it easy to cause a fake emergency when operating the alarm as a patient?**
   This question in aims to explore if the fake emergencies are due to human error and or lack off information on behalf of the patients and how it might be resolved

10. **If the answer to the previous question was yes, explain why.**
    This question had the same motivation as question nr.9.

11. **Is it easy to make a mistake that causes a fake emergency when operating the alarm as a caregiver?**
    This question in aims to explore if the fake emergencies are common due to human error on behalf of the staff and how it might be resolved

12. **If the answer to the previous question was yes, explain why.**
    This question has the same motivation as question nr.11.

13. **Do you feel that the current design of the handheld alarm button may lead to problems?**
    For example:
    - **-The patient is lying on the alarm button**
    - **-Cord twisted around lamp/bed,**
    - **-Difficult to place where patient wants it/can reach it**

    This question is included to gather feedback on potential issues related to the current design of the handheld alarm button and the surrounding infrastructure.

14. **Is the patient alarm flexible? Meaning it is easy to place where a patient finds it accessible or intuitive.**
    This question is asked to assess the flexibility of the patient alarm system in terms of its ease of placement. It aims to determine if the alarm can be conveniently positioned where patients find it accessible and intuitive to use.

15. **How would you rate the patient alarm at your department?**
    This rating question is designed to gather an overall assessment of the staff's perception of the patient alarm system's effectiveness in improving patient safety. By obtaining a rating, it helps to quantify their satisfaction and provide a general understanding of the system's impact on enhancing patient safety within the department.

2.4.1 Survey results

The results are listed as diagrams and graphs in Appendix I, but here is an interpretation of the most relevant results.

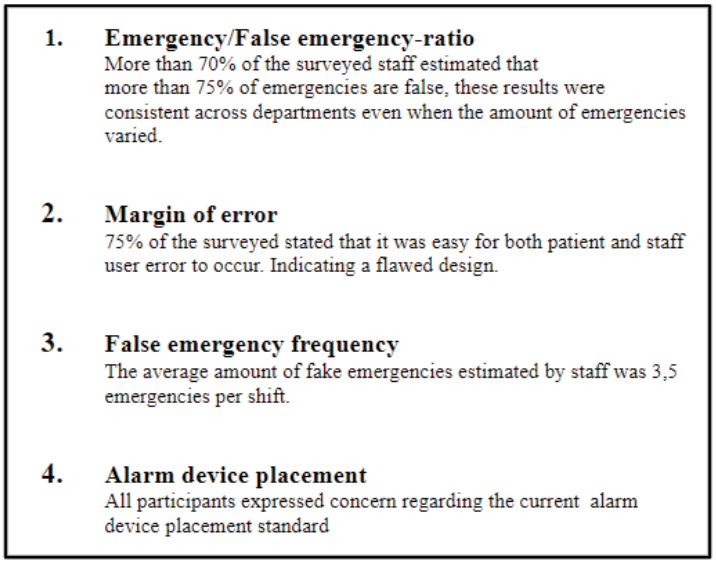


Image 2: Findings listed by perceived importance (source: own work)

2.5 Interviews

This segment comprises interviews with six individuals, including both patients and nurse staff. The interviews were conducted to gain insights into the utilization, perception, and challenges associated with the patient alarm system in various departments. A summary of the most significant points from each interview is provided to offer a comprehensive understanding of the subject matter.

2.5.1 Nurse interviews

Three interviews were conducted with nurses in different departments. The first interview was with a female nurse from the maternity department. The second interview was with a male nurse from the infectious disease department. The third interview was with a female nurse from the pediatric department and the fourth one was done with an Emergency department nurse from Kristianstad. Three of the four interviews were recorded and transcribed and the full interviews will be linked in Appendix II.

Maternity department nurse interview

In this interview, we spoke with a female nurse who works in the maternity department regarding patient alarms. Our interviewee provided insights into how patient alarms are used in the maternity department, how they prioritize and respond to patient alarms, as well as the daily challenges they face. We discussed the challenges and potential solutions for reducing alarm fatigue, improving communication, and increasing flexibility and ease of use in the maternity department.

The main issue that arose in the interview was that of fake emergencies. She described an alarming amount of fake emergencies that occur every day which has resulted in a decreased sense of urgency when responding to the calls. She told us about how most of the staff is under constant stress and how many of them are only working part time because of it. The causes of these false emergencies vary but the most common reason is staff forgetting to reset the alarm after a call followed by patients pressing the alarm a second time after not receiving immediate help and patients sitting or laying on the alarm button.

A secondary issue that arose was concerning the alarm button placement. Some of the patients at the department are in a lot of pain with mobility difficulties in addition to sometimes being confined to the bed by order of medical staff. These factors create a need for more flexibility in alarm button placement than currently afforded.

Department for Infectious disease nurse interview

In this interview, we spoke with a male nurse who works in the department for infectious disease regarding patient alarms. Our interviewee provided insights into the daily operations at the department for infectious disease, how they use patient alarms, as well as what problems may occur on a daily basis. Our conversation touched upon several key areas, including alarm hygiene, positioning, and the occurrence of fake emergencies.

One significant concern that emerged from the discussion was the importance of alarm device hygiene. Given the nature of the infectious disease department, where infection control is paramount, maintaining a high level of cleanliness is crucial. The nurse emphasized the need for alarm devices that are easily cleanable, with smooth surfaces and minimal crevices where dirt or

bacteria could accumulate. Ensuring proper hygiene protocols for alarm devices contributes to a safer and healthier environment for both patients and healthcare professionals.

Another topic that arose was the positioning of alarm buttons. In the context of the infectious disease department, where patients may experience pain and have limited mobility, it becomes essential to have flexible options for alarm button placement. This allows patients to access and activate the alarms comfortably, even when confined to beds or experiencing physical discomfort. Enhancing the flexibility and adaptability of alarm positioning can help improve patient convenience and expedite response times.

Additionally, the interview touched upon the occurrence of fake emergencies. While not the primary focus of our discussion, the nurse acknowledged that fake emergencies do happen quite frequently. The nurse mentioned that they encounter approximately two fake emergencies per shift. These instances often result from staff forgetting to reset the alarm after responding to a call or patients pressing the alarm button a second time if immediate assistance is not received.

Pediatric department nurse interview

The interview was conducted with a female nurse working at a pediatric department in Malmo. Her role involves providing care to sick children who visit the department for checkups and treatment. The nurse expressed that, overall, the patient alarm system is working well in their department, and they did not observe any significant issues with it.

The nurse reported receiving approximately one fake emergency alarm every two weeks during her shifts. She also mentioned that some patients, particularly new ones, may have difficulty understanding the alarm system. Patients who are familiar with the system tend to press the button without hesitation, while others may feel unsure or intimidated by the large red button.

When it comes to alarm prioritization, the nurse explained that they handle alarms in the order they are received without considering differences in urgency. They noted some annoyances with the alarm system, including the placement of the alarm button and the inflexibility of the connecting cord. As a workaround, the nurse mentioned hanging the alarm from the bed frame or using alternative tying methods. She also pointed out wire damage caused by tying knots and expressed concerns about hygiene related to the design of one of the main two alarm devices.

Overall, while the patient alarm system is deemed effective, the nurse identified areas that could be improved for convenience and usability. These include device placement and flexibility, wire durability, and addressing hygiene concerns.

Emergency department nurse interview

During our interview with a female nurse from the emergency department in Kristianstad, we explored the challenges surrounding patient alarms and the unique considerations in this fast-paced setting. Key topics discussed included the difficulty of identifying which patient in a shared room is calling for help, the removal of patient-initiated emergency calls, incidents of fake emergencies in neighboring departments, and the need for safe alarm device positioning.

One major challenge highlighted was the inability to pinpoint the specific patient requesting assistance in shared rooms. Given the urgency of emergency care, quickly identifying the source of an alarm is crucial. However, with multiple patients present, it becomes challenging to respond promptly and prioritize care. Enhancing patient-specific identification within shared spaces emerged as a vital improvement area.

To prevent constant emergency alarms triggered by patients experiencing intoxication or psychosis, patient-initiated emergency calls have been removed in the department. This decision ensures that staff members can initiate genuine emergency calls, maintaining a controlled environment while placing added responsibility on the staff to monitor and respond effectively.

Although our focus was on the emergency department, the nurse mentioned incidents of fake emergencies in neighboring departments. This highlights the broader challenge healthcare facilities face in distinguishing genuine emergencies from false alarms, emphasizing the need for interdepartmental communication and collaboration to optimize alarm systems and minimize disruptions.

Considering patient safety, the nurse raised concerns about corded alarm devices that could pose a risk for patient self-harm. Exploring cordless alternatives emerged as a potential strategy to mitigate this risk and improve patient safety within the department, prioritizing both ergonomics and efficient communication. She did however go on to mention that the logistics of a cordless device would be very difficult to manage safely and accurately.

2.5.2 Patient interviews

Patient interview, appendix surgery

In this interview, the patient stayed in the hospital for seven days for an appendix removal. The patient used the patient alarm during their stay but found it difficult to have it near them or press on it comfortably.

The patient mentioned that the alarm was not easily accessible when needed due to a long wire that made it hard to place on a small table without it falling. The nurses tied the alarm to different equipment, but it was easy to lose or press the button unintentionally. The patient did not have a solution to this issue.

The patient felt that the alarm helped them feel somewhat secure, but they were not informed about the different kinds of situations and alarms where they should press it. They received minimal instructions on how the button works and learned about its emergency functionality from a nurse friend over the phone.

The patient did not experience any issues with the alarm's actual functioning. Suggestions for improvement included easier access to the alarm without the need for tying and having two buttons for different types of alarms. The patient said there was no type of feedback from the alarm.

Overall, the patient was not satisfied with the functionality of the alarm. She mentioned difficulties for older individuals or those with limited mobility and cognitive abilities, saying,“If I had issues as a 20 year old, I can imagine the struggle for older and less mobile people.”

Patient interview, open heart surgery

During the interview, the male patient shared valuable insights regarding his hospital stay after undergoing open heart surgery. He reported a hospitalization period of five days, followed by a four-week recovery phase. When asked about his mobility during his stay, he mentioned being immobile for the first three days post-surgery, gradually gaining permission to make slight movements and sit up in bed.

The patient acknowledged using the patient alarm during his hospitalization. He was asked about his perception of the alarm system and whether he received any explanation from the staff. Interestingly, he stated that his previous experiences with hospital visits for his heart condition made it unnecessary for the staff to provide an explanation.

Regarding the accessibility of the alarm, the patient mentioned that it was not within his reach at all times. He explained that the alarm was often moved by the cleaning staff as it was mounted to the lamp above his bed. This prompted him to request its repositioning when needed.

When asked about his usage of the alarm, the patient expressed that he pressed the button only when necessary, since he felt others needed the focus more. He did not feel the alarm provided any noticeable feedback upon pressing, indicating a lack of confirmation that the signal was received.

The patient suggested improvements in both the positioning and feedback of the alarm system. He recommended having a hook on the side of the bed to ensure the alarm is always within reach and preventing its movement. Additionally, he suggested the inclusion of a simple indicator, such as an LED light or vibration, to provide feedback upon pressing the alarm button.

While the patient acknowledged that the alarm system generally worked well for him, he emphasized the need for changes to reduce worry and inconveniences.

2.6 Maternity department emergency alarm statistics

This dataset provides valuable insights into the frequency and types of alarms that are triggered at the Maternity center at the Skåne University Hospital in Malmö, and whether they are genuine emergencies or false alarms. The data has been compiled to help better understand the impact of false alarms in hospital operations and patient care. There were a total of 150 Emergency alarms triggered during 40 separate shifts of which 146 were false alarms intended to be so-called "assistance calls". The statistics show an average of 9 false emergency alarms per day in relation to the 0.2 real emergency alarms per day average. This comes out to over 2500 fake emergencies per year for the department. The complete data sheet can be found in Appendix IV

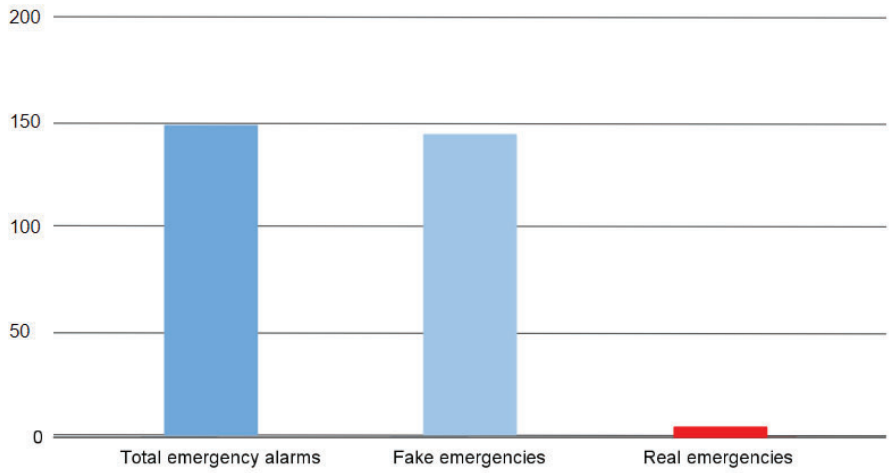


Image 3: This image shows the Maternity departments emergency alarm statistics in a bar chart. (source: own work)

2.7 Current alarm systems in use at Region Skåne hospitals

In this chapter, we will delve into the workings of the patient alarm system at hospitals in the Skåne region. Through surveys and interviews, it was discovered that the alarm functionality differs from hospital to hospital. As such, we will focus on the patient alarm functionality at the maternity department in Malmö. As mentioned in the demarcation, there has been no official visit to the hospital and contact with manufacturers of the alarm system was unsuccessful. The functionality, and design illustrated below is as explained, photographed and measured by the nurse contacts. Through our analysis, we aim to shed light on the strengths and weaknesses of the system and suggest potential improvements for the future.

2.7.1 How the alarm system works in practice

The patient alarm system has three separate interfaces consisting of the patient alarm button connected via a cable to the wall behind the patient, a staff console placed on the wall by the entrance to the patient room and an information screen located in the hallways and offices. Information about the alarm systems functionality was collected by speaking to nurses working at Region Skåne.

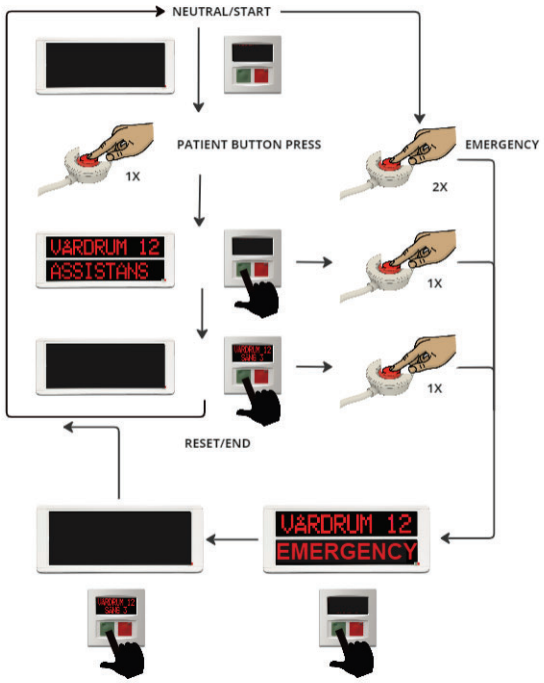


Image 4: This image illustrates the practical functionality of the patient alarm. The neutral state of the alarm is used as the starting point of this illustration. Once the patient presses the alarm button once, the information screen is lit indicating in what room a patient is in need of assistance. Once a staff member has responded to the call they press the green button on the staff console to deactivate the information screen in the hallways as well as activating a small screen on the console to see other potential calls while in the room. Once the patient has received help, the staff member is required to press the green button again to reset the system back to neutral. Unless the system has been reset, a subsequent singular alarm button press will lead to an emergency call. (source: own work)

2.7.2 Alarm device designs

At the hospitals in the Skåne region, two different alarm devices have been identified for use. One of these devices has a round shape, while the other is square in shape. They have the exact same functionality, but vary in shape and size.

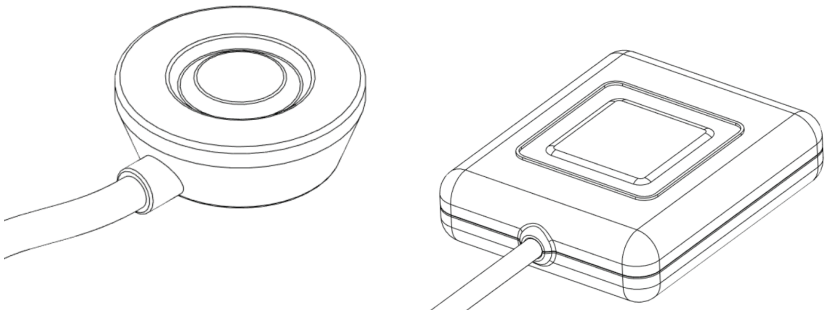


Image 5: This image shows the two most common designs of patient alarms used at Region Skåne hospitals. The leftmost design comes from an unknown supplier and has a round case measuring 18 mm in height, 50mm in top diameter, 40mm in bottom diameter and a wire thickness of 6mm. The male connector that attaches to the wall has a 90 degree bend. The button on this design is recessed slightly. The rightmost design is made by Best Teleprodukter AB and has a square case with rounded corners that measures 15x50x40mm. This design also has a ridge around the button. The male connector that attaches to the wall has a 90 degree bend (source: own work)

2.7.3 Routine difficulties

Patient alarms present routine difficulties across various departments in healthcare settings. One common challenge is the occurrence of fake emergencies, which can lead to a decreased sense of urgency when responding to genuine alarms. Staff members may experience constant stress and, in some cases, work part-time due to the strain caused by these false emergencies.

Another issue revolves around alarm button placement, particularly in departments where patients experience pain, mobility difficulties, or are confined to their beds. These factors demand flexible and accessible positioning of alarm buttons to ensure patients can easily reach them and alert healthcare professionals when needed.

In the infectious disease department, hygiene plays a crucial role. The need for easy cleaning and maintenance of alarm devices is paramount to prevent the spread of infections. Regular disinfection protocols should be in place to ensure patient alarm systems remain hygienic and safe to use, protecting both patients and healthcare workers.

In the emergency department, the challenge lies in identifying which specific patient in a room is requesting assistance. Due to cases of intoxication and psychosis, patient-initiated emergency alarms have been removed to prevent constant false alarms. Only staff members have the ability to trigger emergency alerts in this department. However, neighboring departments may still face frequent fake emergencies, highlighting the need for effective measures to address this issue.

Additionally, considerations regarding alarm device positioning and design are essential to promote patient safety. Cordless alarm devices can help mitigate the risk of patients self-harming by unintentionally using the cord. These design choices prioritize patient well-being and minimize potential hazards.

To address these routine difficulties, designers and healthcare professionals must collaborate to develop patient alarm systems that strike a balance between addressing specific departmental challenges, ensuring hygiene, and meeting the needs of both patients and healthcare workers. By incorporating user feedback, analyzing outcomes, and maintaining open lines of communication, improvements can be made to enhance the effectiveness, efficiency, and usability of patient alarm systems across diverse healthcare settings.

Image 6,7 and 8: Pictures from the meternety department and Kidney department showcasing some of the many mounting strategies used by staff and patients.

2.7.4 Human factors, user error and their causes

User error is the most frequent cause leading to false emergency alarms. One common scenario is when the alarm button is accidentally pressed twice by the user. The patient alarm systems are designed such that two presses of the alarm button create an emergency call. However, in a high-stress environment, such as a busy hospital setting, it's possible for a nurse or caregiver to accidentally press the alarm button multiple times, resulting in an unintended emergency call. This also occurs because of a lack of information given to the patient.

Another scenario where user error can cause fake emergency alarms is when a nurse forgets to reset the alarm system after attending to a patient. The patient alarm systems require a nurse to press a button to reset the alarm after addressing the patient's needs. However, in the fast-paced and hectic environment of a hospital, a nurse may inadvertently miss resetting the alarm, resulting in subsequent unrelated singular presses of the alarm button causing emergencies to be triggered, even when there is no actual emergency. An emergency call requires all available nurses to attend to the patient as well as retrieve the emergency crash cart, which consequently leads to some nurses leaving their non-emergency patients without resetting the alarm.

This is a recurring issue at the Maternity department in Malmö where the false alarms tend to create a chain reaction. As the maternity nurse explained, “When you are helping a patient and an emergency happens you need to run, you almost never have time to reset the alarm or remember to do so after.” The combination of user error, time constraints, and the high-stress nature of the department contribute to the occurrence of fake emergencies and the subsequent strain on the nursing staff. Urgent measures are required to address this issue and ensure a more accurate and reliable patient alarm system in the Maternity department and other similar healthcare settings.

2.8 Market research

Image 6:In the left picture, there is a hospital patient alarm from BEST currently in use at Regin Skåne hospitals, it has a simple and streamlined button, but the button's dual functionality is neither easy to use or possible to intuitively understand. Despite its straightforward design, the button's dual functionality leads to confusion and inefficiencies in communication between the patient and nursing staff. It could lead to unanswered emergencies as well as false emergency alarms. Source: unknown

Image 7:In the right picture, the hospital patient alarm has a lot of buttons which accommodates all the patient wants and needs but it creates unnecessary confusion. The buttons are not well-labeled, and their functions are not clear, which could lead to delays in communication and potentially dangerous situations for the patient. This design is overwhelming and could easily cause confusion for both patients and nursing staff, making it less effective in its intended main purpose. Source: *Direct request® - nurse call system by westcall: Medicalexpo* (no date)

3. Analysis

3.1 Needs and wants

Patient alarm systems in hospitals play a crucial role in alerting healthcare workers when a patient requires urgent attention. However, the design of these systems must balance the needs of patients and healthcare workers with the wants of both groups to create a functional and effective system that does not compromise fast response times or create confusion.

3.1.1 The needs and wants of patients and healthcare workers

Designing patient alarm systems requires a deep understanding of the unique needs and challenges faced by patients and healthcare workers. It is crucial to conduct thorough research, gather feedback, and analyze patient outcomes to inform the design process. The ultimate goal is to create a system that enables patients to communicate their needs effectively while maintaining a calm and organized healthcare environment.

The primary objective is to ensure swift response to patient alerts while minimizing confusion and unnecessary noise. A well-designed system should be intuitive and seamless, allowing patients to convey clear and concise messages to the appropriate personnel without disrupting the comfort of others or causing chaos. The communication needs vary, encompassing both non-emergent assistance and emergency aid.

In this design process, it is essential to balance the wants and needs of patients and healthcare workers. Patients may desire an alarm system that is comfortable, user-friendly, and offers a range of functionalities. On the other hand, healthcare workers may prioritize a streamlined and efficient system that focuses primarily on the core communication needs. However, reconciling these wants and needs can be challenging, as they often contradict each other and clash with the primary objectives.

Finding a harmonious solution requires innovative approaches that strike a balance between meeting critical needs and accommodating reasonable wants. Fast response times should not be compromised, but the system should also provide a comfortable user experience. It is important to acknowledge the potential conflicts between the desires of patients and healthcare workers, while ensuring that the system serves its primary purpose of facilitating effective communication in healthcare settings.

3.1.2 Needs and wants not met by the current alarm system

The current patient alarm device fails to meet the needs of the users, including nurses, assistant nurses, cleaning staff, and patients. Each group has specific requirements that are not adequately addressed by the device.

Nurses play a critical role in responding to patient emergencies, and their needs for prompt and reliable alerts are not met by the current alarm device. This lack of timely and accurate notification can lead to delays in providing necessary medical assistance, potentially compromising patient safety.

In addition to prompt alerts, nurses also require a clear and intuitive interface that allows them to quickly assess the urgency of a situation. The current device may lack a comprehensive display or indicators that provide crucial information about the patient's condition. This limitation can make it challenging for nurses to prioritize their responses efficiently and may result in confusion or errors in providing appropriate care. However the nurse information interface lies outside of the project scope, it will therefore not be a continuation moving forward.

Cleaning staff has the responsibility of ensuring a hygienic and safe environment. However, their needs are often overlooked in the device's design. For cleaning staff, it is essential to have a device design that is easily cleaned in a few swift motions. Sharp corners and crevices in the current alarm device by BEST do not meet these requirements due to the large parting line on the sides as well as the ridge surrounding the button. These allow for dirt and bacteria buildup and are hard to clean using regular cleaning rags.

Patients, the primary users of the alarm device, have their own set of needs that are not adequately met. Patients rely on the alarm system to call for help during emergencies, and their

need for assurance and feedback is crucial. The absence of feedback to confirm whether their signals have been received, creates uncertainty and anxiety. There are a

3.2 Usability analysis

Feedback

From the interviews with staff and patients,it is evident that the patients expressed a significant concern regarding the lack of feedback from the alarm devices. They consistently mentioned the absence of any indication, such as sound, lights, or vibration, to confirm whether their signals had been received. This lack of feedback created uncertainty and made it difficult for patients to ascertain whether their emergency calls were being attended to or if the alarm system was functioning properly. The absence of feedback from alarm devices creates uncertainty and anxiety as well as undermines trust in the device for patients who rely on them during emergencies.

Furthermore, the patients also emphasized the significance of clear instructions and information regarding the alarm devices. They reported receiving minimal instructions on how to use the alarm button and were not adequately informed about the different situations or emergencies where they should press it. This lack of guidance hindered their understanding of the alarm system's functionality and potential use, leading to suboptimal utilization and potential missed opportunities for prompt assistance.

Addressing these issues are in direct correlation with being able to decrease the number of fake emergencies occurring on a daily basis.

Flexibility

The current alarm device severely lacks flexibility in its positioning, requiring staff and patients to find creative solutions by tying it to other hospital products. The device's limited mounting options restrict its adaptability, making it challenging to place it in convenient and easily accessible locations.

To overcome this limitation, staff and patients have resorted to innovative methods to ensure the alarm device is within reach when needed. They have ingeniously tied it to various hospital

products such as lamps, drip bags, tables, bed frames, and chair frames. This makeshift approach allows them to position the device closer to the patient, enhancing their ability to trigger alerts during emergencies.

However, this reliance on makeshift solutions poses potential risks and inconveniences. Tying the alarm device to other objects can create entanglement hazards, hindering movement and increasing the likelihood of accidents or unintended alarm triggers. Moreover, the process of securing the device to different items adds unnecessary complexity and time-consuming steps, diverting attention from providing immediate care to patients.

The lack of flexibility in the alarm device's positioning not only imposes inconvenience but also compromises patient safety and hampers the efficiency of healthcare professionals. It is crucial to address this issue by developing alarm systems that offer versatile mounting options, allowing for easy placement in optimal locations. This would enhance the device's functionality, improve response times, and eliminate the need for makeshift solutions that may introduce additional risks.

Hygiene

The current patient alarm device fails to meet hygiene requirements, posing challenges in maintaining cleanliness and preventing the spread of infections. Several aspects contribute to this limitation.

Firstly, the device may not be resistant to common cleaning solutions and disinfectants used in healthcare settings. This lack of resistance can lead to damage or deterioration of the device when exposed to cleaning agents, compromising its functionality and longevity.

Additionally, the device is not adequately waterproofed considering the button sensor placed on the outside is only a sticker covering the hole making it vulnerable to damage from liquid spills and cleaning over longer time periods. The hole for the chord and parting lines are not designed to resist water either. The ridge around the button sensor is also hard to clean and allows for bacterial buildup. These limitations in combination with each other poses a significant hygiene risk as it hampers thorough cleaning and disinfection, allowing potentially harmful bacteria or pathogens to persist on the device's surface.

To improve the hygiene of the alarm device, the choice of materials becomes crucial. Utilizing

materials that are resistant to cleaning solutions and disinfectants, such as medical-grade plastics, silicone or stainless steel, would enhance the device's durability and ease of cleaning. Moreover, incorporating waterproofing features or designing the device to be easily detachable for cleaning purposes would facilitate proper sanitation, reducing the risk of bacterial growth and cross-contamination. Furthermore, considering antimicrobial properties when selecting materials for the device can aid in reducing bacterial growth.

By addressing these hygiene-related shortcomings and integrating appropriate materials and design considerations, an improved patient alarm device can be created, providing a safer and more hygienic environment for patients and healthcare professionals alike.

3.3 Problem definition and design goals

The current patient alarm device in healthcare settings fails to meet the needs of users, including nurses, cleaning staff, and patients. The device lacks flexibility in positioning, compromising accessibility and convenience. Additionally, it does not provide adequate feedback, leading to uncertainty and difficulties in determining if emergency calls are being attended to or if the system is functioning properly. Furthermore, the device falls short in meeting hygiene requirements, hindering effective cleaning and posing a risk for bacterial growth and infection transmission.

Design Goals:

1. Flexibility: Develop a product family that includes mounting accessories designed to provide flexible positioning options for the alarm device. These accessories should allow for easy attachment to different surfaces and equipment commonly found in healthcare settings. The goal is to enhance accessibility and ensure that the alarm device can be conveniently placed where it is most needed without compromising safety or causing inconvenience.
2. Improved Alarm Device Design: Create a new alarm device that addresses the feedback issues identified in the current device. The design should incorporate clear and intuitive feedback mechanisms such as sound, lights, or vibration to confirm receipt of emergency

signals. This will provide reassurance to patients and facilitate effective communication between patients and healthcare professionals.

3. Hygiene Considerations: Design the alarm device and its accessories with hygiene in mind. Ensure that materials used are resistant to cleaning solutions and disinfectants commonly used in healthcare environments. Incorporate waterproofing features to facilitate proper cleaning and prevent damage from liquid spills or moisture. Consider antimicrobial properties of materials to reduce bacterial growth and the risk of infection transmission.

By focusing on these design goals, a new product family can be developed that offers flexible mounting options, improved feedback mechanisms, and enhanced hygiene features. This will result in a patient alarm system that better meets the needs of nurses, cleaning staff, and patients, facilitating efficient communication, maintaining cleanliness, and promoting a safe healthcare environment.

3.4 Requirement list

Patient safety
-Easy to communicate accurately
-Intuitive emergency button
-Accomodation for varying patient cognition
-Accomodation for varying patient technical ability
-Offer inclusive feedback to patients with varying physical ability
-Affordances that are clear
-Easily identifiable at all times

-Not in the way during an emergency

Hygiene
-Easily sanitized
-Minimize areas of dirt and bacteria buildup
-Needs to withstand exterior aqueous solutions and alcohol cleaning

Flexibility
-Easily moved
-Flexible positioning
-Minimize the compromisation of surrounding equipment

Longevity
-Minimize damage to alarm device
–Minimize damage to alarm chord
-Minimize damage to alarm wall attachment
-Minimize damage to surrounding equipment
-Allow for easy assembly and disassembly
-Design for simple repairs in order to keep cost down

4. Ideation

After the requirement list was established, the next phase began, which involved the development of different solutions. The workflow for generating the various concepts is explained below. The chapter ends with a presentation of the sub- concepts that idea generation and evaluation resulted in

4.1 Methods

4.1.1 Idea generation

Moodboarding:
A moodboard was used during the project, aimed at providing creative inspiration for product development. This moodboard did not put emphasis on a particular form language, but rather aligned with the project's problem definition. It was a way of visualizing the issues discovered during the research and analysis phase.

Brainstorming/discussions
Brainstorming was utilized as a method to generate ideas for concepts. Ideas were written down and discussed with peers and hospital staff. Sketches were only made to aid explanations of some ideas. The initial goal was to generate as many solutions as possible for each problem area, and subsequently, the focus shifted towards overall solutions without getting into overly specific details.The brainstorming was conducted over the course of a week, with regular input and suggestions from healthcare professionals.

4.1.2 Concept development

The project followed a systematic approach to transform brainstormed ideas into concrete design concepts. The ideas were reviewed and categorized based on themes and similarities, with a focus on the problems they aimed to solve. The concepts were then refined and combined through sketching, 3d modeling or prototyping, making them more tangible and testable.

The refined concepts were evaluated based on usability, feasibility, and complexity. User tests were then conducted, and feedback was gathered from actual users as well as nurse contacts. These discussions and feedback sessions provided valuable insights that helped further refine the concepts. This method ensured that the final concepts were well-informed and aligned with the project objectives.

4.2 First ideas

During the idea generating phase, a range of solutions and concepts were formulated to address identified problem areas. This section presents these ideas, some of which went on to become fully fledged concepts later on.

4.2.1 False emergency alarms

Single or dual alarm buttons?

During a discussion with one of the nurses, it became clear that there was a need to make it impossible for an intended assistance call to become emergent. The margin of error in the current system is very low, since the dual functionality of the singular alarm button is hard to understand. We discussed how to decrease the margin of error by implementing feedback in the alarm device and including the reset function in the first button press on the staff console (see 2.7.1). However we also discussed how having dual buttons would be advantageous due to a more clear communication, minimized risk of response time. The usability might also be improved for individuals with limited dexterity or cognitive abilities. Overall, we concluded that dual buttons offer a more effective and reliable solution for patient alarms in most departments. The exception however, is in the departments where the emergency function is removed completely. A design that allows for easy adaptation depending on the department requirement is therefore required.

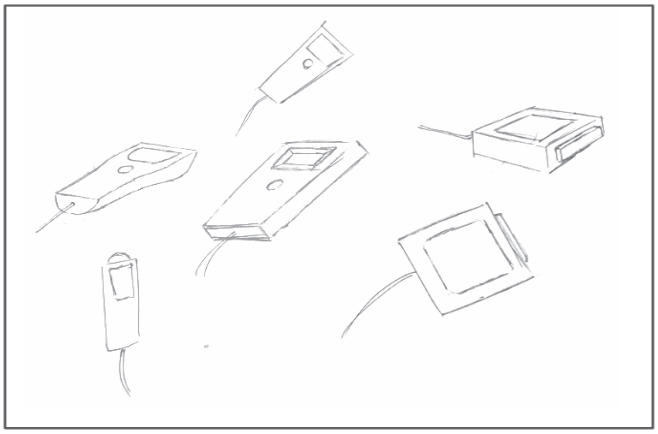


Image 8: Early sketches, alarm devices with dual buttons. (source: own work)

Alarm device feedback

The patient alarm device can be further enhanced by incorporating different types of feedback. Visual cues, such as LEDlights, auditory cues like distinct alarm sounds, and tactile cues like vibrations, can provide clear communication even in busy environments. This multimodal feedback ensures that patients of all cognitive and physical ability are able to utilize the device without compromise. When discussing feedback with the nurses and patients, it became clear that the complete lack of feedback in the current system created confusion. The proposals to feedback inclusion were that of using buttons with an auditory and tactile click, using LEDs incorporated in the buttons or case, and having different distinct sound cues for emergent and non-emergent alarms.

Visibility

Incorporating LEDs that are lit at all times but change colors depending on the button input is a great way of not only giving feedback, but also increasing the alarm device's visibility. Considering the patient's lack of control and options regarding alarm device placement, being able to clearly distinguish it from its surroundings despite of lighting conditions

Alarm device affordances, mapping and hierarchy

Mapping, hierarchy, and affordances are essential aspects of effective user centered design. While discussing, it became clear that having two different buttons made the visual and physical cues that indicate how buttons should be used all the more important. There needs to be no question regarding which button does what, which can be done by using color, icons, and size. There also needs to be a clear hierarchy and an ergonomic and cognitive pull towards the emergency button, since there is no room for overthinking in an emergency situation. We concluded that calling for assistance should need a certain amount of consideration, whilst the emergency button should not.

Infographics

The use of infographics was discussed as a solution to reduce false alarms. By creating visually appealing and easy-to-understand graphics, the patients can gain a better understanding of when and how to use the alarm system. However, difficulties may arise in creating infographics that are understandable for people speaking different languages which is a common occurrence in Swedish hospitals where neither Swedish or English can be exclusively used. To address this, translations of the infographics may be necessary, along with developing easily understandable icons. This solution is highly dependent on departments having the same alarm functionalities.

4.2.2 Alarm device placement

Wireless alarm device and staff pagers

One early discussion was regarding having wireless alarm devices which was suggested as a solution in the staff survey. This solution has a few clear benefits such as negating equipment damage and increasing flexibility but it might also decrease the safety risks associated with intoxicated and self harming patients. However the solution would create a pletera of new issues such as charging, non functioning alarms, misplacement, theft and increased pricing. The issues presented with this proposal would severely increase the headache already associated with the alarms for the staff. The idea was therefore not developed at all. The same applied for our discussion regarding personal pagers for the hospital staff.

Gooseneck

One solution to ensure flexible placement is to incorporate a gooseneck into the design. A gooseneck is a flexible, bendable arm that can be easily adjusted and positioned to the user's preference. By adding a gooseneck as an external ad on to the patient alarm device, caregivers can position the device exactly where they need it to be, whether that's on a table or next to the patient's bed. This can improve the device's functionality and ease of use, while also enhancing the overall user experience. For this to be effective and applicable, the gooseneck needs to be mounted quickly and easily onto different surfaces such as square tabletops, tubes, bed frames etc. It also needs to stay in place while bending the gooseneck. A lot of different clamping methods were considered such as flexure mounts, c-clamps and spring clamps.

The mounting and dismounting of the actual alarm device to the gooseneck was also important to consider for this solution to be viable, since even the slightest inconvenience might sway a user from actually utilizing it at all.

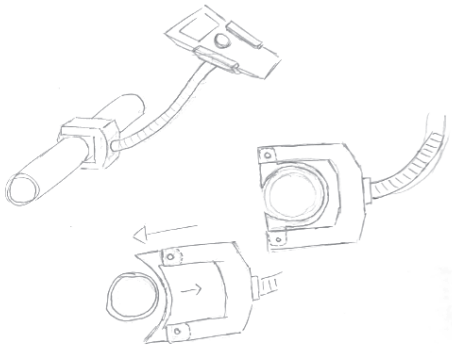


Image 9: Early sketches, alarm device placement using gooseneck.

Cord mount

A lot of the current placement solutions created by the hospital staff where the alarm device is tied around things like lamps, bed frames and drip stands are actually quite intuitive and offer an adequate degree of flexibility. However the method of attachment is inefficient and can cause damage to both the chord and surrounding equipment. A few ideas within this category were created to increase this flexibility further and make it more efficient, some of which include using organizing clips, hooks, velcro and clamps.

Magnetic mounting

This design proposal would involve incorporating small magnets fit onto the alarm device, allowing it to be easily attached to a variety of surfaces, such as bed rails, lamps or medical equipment. The magnets could either be attached with adhesive or embedded into an external alarm device casing.

4.2.3 Longevity

Cord collection

A cord collector can be a practical solution to reduce the damage of a patient alarm chord and minimize clutter in the patient's room. The design proposal involves either incorporating a retractable cord reel close to the alarm device outlet or putting a manual wind fixed to the wall, allowing the user to easily extend or retract the cord as needed. By keeping the cord neatly stored the risk of damage to the cord from being caught on objects or people can be reduced, while also freeing up space and minimizing clutter in the immediate environment.

Straight male cord connector

The current alarm device uses a 90-degree male connector in the wall outlet which is good for cramped spaces and cable management. However, it is important to be aware of the potential risk of damage to the charging port if the cable is violently pulled out. The angle of the cable can put additional stress on the port, causing it to bend or become damaged over time rendering the port unusable. To prevent this one could first minimize the amount of violent pulling by not firmly fixing the alarm device to the patient bed and have better cable management. But another simple solution is to simply not use a 90-degree connector, but instead change it to a straight one.

5. Concept I-Gooseneck

The following chapter shows the development, prototyping, and testing of three design proposals regarding how to mount the alarm device to a gooseneck. The introduction of a gooseneck with a good mounting system aims to increase the flexibility and accessibility of
the alarm device.

5.1 Gooseneck mounting proposals

The exploration process began with a multitude of creative brainstorming sessions, which generated a wide array of mounting ideas. These concepts encompassed various approaches, ranging from traditional clamp mechanisms to velcro, suction cups, and magnetic attachments. Each proposal was evaluated with the help of healthcare staff and other users based on its feasibility, practicality, and overall effectiveness in securing the patient alarm device to the gooseneck, offering easy mounting and dismounting. Following the ideation phase, the selected design proposals were then visualized using computer-aided design software (CAD). The following proposals were the three most promising ones after considering sanitation, cost-effectiveness, complexity, and usability.

Press fit mount

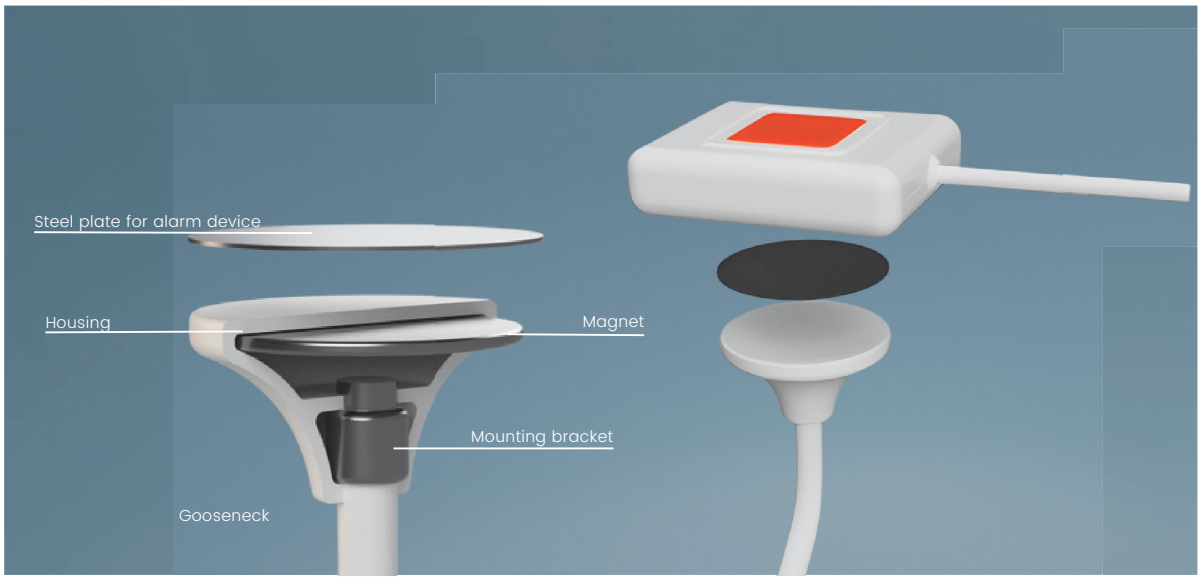
The first gooseneck proposal consisted of a plastic mount where the alarm device was mounted by press-fitting it onto the gooseneck. Many different iterations of this approach were made and tested to identify the most efficient designs before user testing. The initial perceived benefit to this design is in its ability to hold the device firmly in place. The designs
that were tested to be the easiest for mounting and dissmounting in addition to being durable and stable are shown indevidually.

Chord press fit mount

The second gooseneck proposal consisted of a silicone clip mount where the alarm device cord can be mounted by press-fitting it onto the gooseneck. Three different iterations of this approach were made to test its ability to hold different cord diameters. The initially perceived benefit to this design is in its relative affordability, silicone bacterial resistance, and the ability to mount both square and round alarms anywhere along the cord, allowing for them to be hung.

Magnetic mount

The third gooseneck proposal consisted of a magnetic mount where the alarm device is fitted with a thin steel plate that is then placed on a magnetic mount point on the gooseneck. The initial perceived benefit to this design is in its

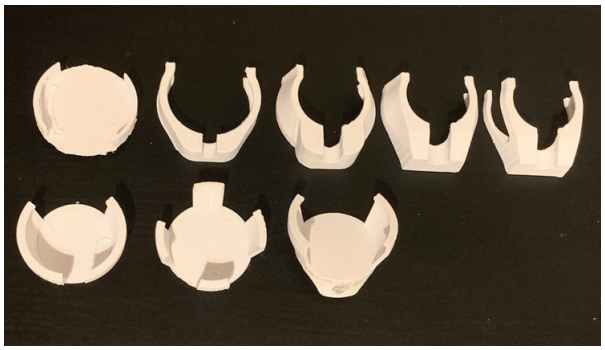


5.2 Prototyping gooseneck mounts

Following the ideation phase, the selected design proposals were translated into tangible prototypes. Utilizing a combination of computer-aided design (CAD) software and 3D printing technology to bring the ideas to life. This iterative process allowed for the refinement and optimization of each design, addressing potential challenges and identifying areas for improvement.

Prototyping-Press fit mount

All prototypes for press fit mounts were 3d-printed using an Anet ET5X. The prototypes were printed in white PLA plastic using CAD-models created in Fusion 360. The 3D-prints had very little post processing work done to them with the exception of correcting some tollerance errors by shaving or sanding away small amounts of plastic in order to make the alarm devices fit.



Prototyping-Magnetic mount

The magnetic gooseneck mount had to be redesigned during the prototyping phase due to not being able to access magnetic plates of the required size for the design. The single magnetic plate was replaced with 4 smaller magnets mounted to a steel plate to achieve an even mounting force. The prototype was then 3D-printed in three separate parts. The plastic parts were then assembled with the magnets inside after which they were welded together using a soldering iron.

The magnetic mount prototype was not well suited atop the aftermarket gooseneck due to its 8mm diameter. A slimmer gooseneck was therefore temporarily created by braiding three 1.5mm steel wires.

Prototyping-Chord press fit mount

The second gooseneck proposal consisted of a silicone clip mount where the alarm device cord can be mounted by press-fitting it onto the gooseneck. Creating a prototype in silicone would have been much too time-consuming for fast prototyping. The solution to this was to 3D-Print the part using flexible plastic filament which had similar strength and flexibility to silicone.

Five different printed parts were created with varying wall thickness and size in order to make the mount and dissmount action as smooth as possible. The final flexible plastic part was then friction fit the aftermarket gooseneck.

5.3 User test I

Once the prototypes were ready, rigorous testing was conducted to assess their performance and functionality. Meticulously examination was done regarding factors such as the stability of the mounting system, pricing, ease of installation and adjustment, and the device's overall security when attached to the gooseneck. The testing was conducted with the help of two nurses and three random users representing the patients. The users tested the alarm devices about the three different gooseneck concepts and provided feedback regarding their usability. The user feedback was taken into account to ensure that the chosen design would meet the needs and expectations of healthcare professionals and patients alike. The resulting perception showed that the magnetic mount had the most potential and had much greater usability in comparison to the other two concepts, however at a higher complexity and therefore also price. However, after some consideration, the cheaper price of the other two concepts was not enough, since the lower usability could lead to them not being used at all the magnetic mount was chosen to be further developed.

The main point of critique for the magnetic mounting concept was regarding the difficulty to angle the mount as desired. The users instinctively used the mount as a grip when trying to bend the gooseneck. Since the mount was rigid about the gooseneck, the mating surface between the mount and the alarm device was hard to angle as intended. The whole gooseneck had to be bent to achieve the desired positioning, this put a lot of stress on the parting line between the two halves of the mount housing since the force was applied from the user clutching the mount. The second critique of the magnetic mount was that the gooseneck was too weak. The weak gooseneck made it spring back when attaching and removing the alarm device, whilst also not being able to support the alarm device and chord without bending. Solving these issues was critical to creating a solution that has a higher level of usability. However, it needs some rethinking since a thicker gooseneck would exacerbate the first issue further.

5.4 Concept refinement

Magnetic mount prototyping V2

To attach the magnetic holder onto the gooseneck a ball joint was adopted to provide more flexibility and a better range of motion as well as to reduce unnecessary stress on the split line. The wires were covered with shrink tubes to create a cleaner, finish and reduce some of the wobbly spring back. The effect is somewhat similar to the shock absorber and coil spring in a car suspension.

The new magnet housing prototype was 3D-printed in two separate parts. The accompanying ball joint was also 3d printed after which it was melted onto the steel wire gooseneck. The housing was then assembled with the ball joint and magnets within. The use of a shrink tube and the adoption of a ball joint were essential in improving the functionality and aesthetics of the prototype gooseneck mount.

5.5 User Test II

Once the revised design was ready, a second user test was conducted to evaluate its effectiveness in addressing the previously identified flaws. Users were provided with the updated mounting system and were asked to perform various tasks, such as adjusting the angle, attaching and detaching the alarm device, and ensuring the stability of the setup.

The user test served as a critical validation process, allowing the team to verify whether the design modifications successfully resolved the issues identified in the previous test. It provided valuable insights into the revised solution's usability, functionality, and overall user experience. The revised concept proved much easier to angle correctly and the spring back of the gooseneck was lessened after adding the shrink tube. However, even though the flexibility was perceived as excellent, the grabbing of the mount while adjusting still strained the split line. This finding proved to be important in the development of the final iteration, The gooseneck itself was also still not strong enough, but because the gooseneck will be provided by another company, it was decided that no further emphasis would be put on improving it.

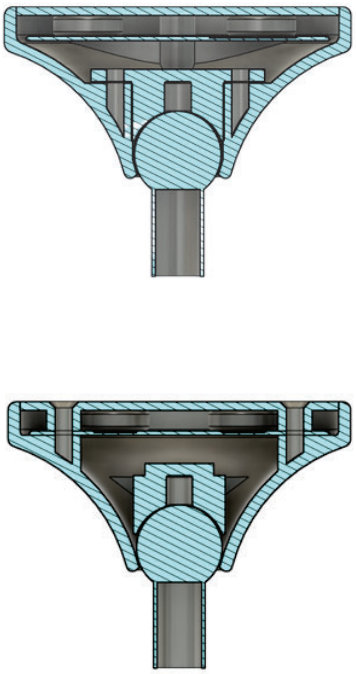
5.6 Final concept

Magnetic mount-Final assembly

With the user test results and insights in hand, the final phase of development was focused on working on refining the magnetic mount housing to address the strain on the split line.

The final iteration of the design aimed to alleviate the remaining issue by removing the split line by entirely redesigning the assembly. The ball joint cavity needed to be the most durable part of the magnetic housing, and it was therefore designed as a single larger plastic part for strength combined with a smaller part for keeping the ball in place. The smaller part will not be subject to any stress or strain in the new configuration, thus decreasing the points of failure. By doing it this way, the number of plastic parts needed went up from two to three since a top cover was also needed.

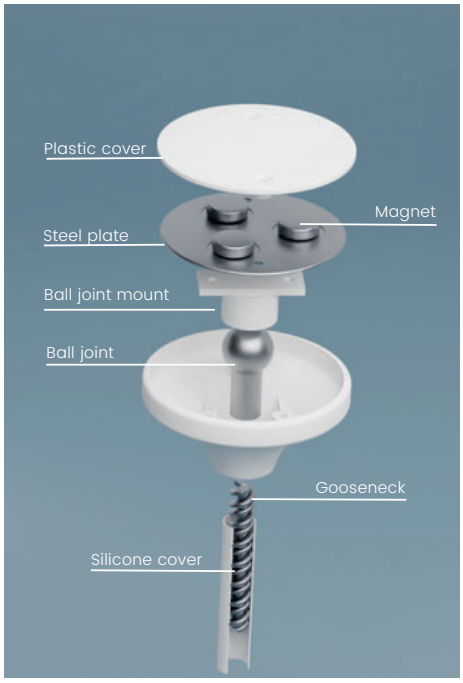
Through the evaluation of the second user test and rethinking the assembly, a solution that effectively addressed the identified flaws was achieved.



Magnetic mount-Design for disassembly

In the final concept, the magnet housing uses a total of 4 screws for assembling it onto the ball joint, and the ball joint itself is prior to assembly crimped onto the gooseneck after which a silicone cover is applied.

Design for disassembly refers to the idea of designing products in such a way that they can be easily taken apart at the end of their life cycle, making it easier to recycle or reuse the materials. The desig choices made for the final concept makes it easy to take the product apart, allowing for simple recycling or reuse of materials. Additionally, the use of screws rather than glue or other adhesives makes it less difficult for consumers to repair the product themselves if needed.



Magnetic mount-Manufacturing

Magnets, hardware, ball joint and gooseneck would all be purchased from another manufacturer since these products are readily available. However the three plastic parts would all need to be manufactured specifically for this product. The plastic parts are all designed for a two-piece injection molding process. They were simplified as much as possible to reduce mold complexity. The chosen material is Polyactic-acid (PLA) because of its stiff and strong mechanical properties and resistance to cleaning solutions used in hospitals. Technical drawings can be found in Appendix VIII

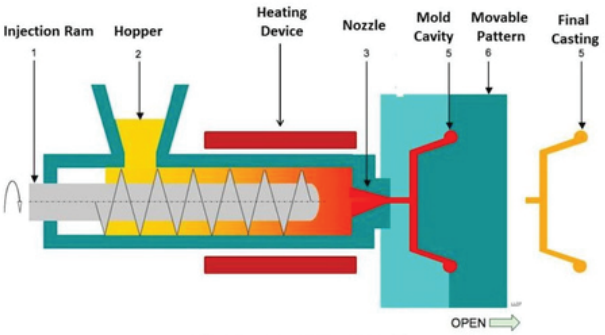


Image 10: (Admin, C.S.M. 2020)

Image 11: (Bhutajata, 2017)

Magnetic mount-Cost estimation

Cost estimation for the magnetic mount involves analyzing the costs of the three injection molded plastic parts, silicone cover, and the ball joint which are all manufactured for this specific product. It also involves gathering prices for the magnets, hardware, and gooseneck which would all be purchased from another manufacturer. Other factors include tooling, equipment, labor costs, and overhead expenses. The estimated retail price for this product in a 5000-unit production run is about 180 SEK. For a full cost breakdown, see Appendix VII.

Approximate unit price:
180 SEK

Alarm device- CMF

The chosen color for the magnetic mount is Bright white (Pantone, 11-0601 TPG), which aligns with the clean and sterile environment commonly associated with healthcare facilities. The white color not only blends well with the surroundings but also promotes a sense of cleanliness and hygiene.

In terms of surface finish, a semi-gloss finish has been implemented for the full mount assembly. The semi-gloss finish also allows for easy cleaning and maintenance thanks to the smooth surface, ensuring that the mount remains free from dust and contaminants.

6. Concept II-Quick attachment

The following chapter shows the development, prototyping and testing of design proposals regarding how to mount the alarm device to existing surfaces in the patient room. The introduction of a small and simple mounting device is aimed to cheaply increase the safety and efficiency at which the nurses and patients can mount the alarm device to existing surfaces.

6.1 Quick attachment proposals

Cable clamp

The first proposal consisted of a spring clamp fitted onto the alarm chord to easily mount it to a multitude of surfaces with different size requirements. The chord is connected to the spring clamp via a clip.

Image 12: (Cable clips 8mm black, no date)

Image 13: (Plastic clip, no date)

Press fit clip

The second proposal consisted of a plastic mount where the alarm device is mounted by press-fitting it onto a holder that has some kind of mounting device on the back. Many different iterations of this approach were made and tested to identify the most efficient designs before doing the user testing. These included using magnets, hooks, and clips.

Image 14: (unknown source)

Cable clip

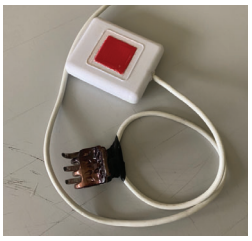
The third proposal consisted of a flexible clip that would be mounted to the cable and attached easily to external surfaces of varying sizes. The clip flexes and deforms to accommodate both flat and rounded surfaces of varying sizes such as tables or tubes. This larger clip is in turn attached to the cable using a smaller clip.

Image 15: (Tool clips: Spring steel clips, no date)

6.2 Prototyping quick attachments

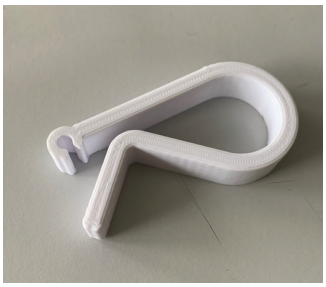
Cable clamp

The cable clamp proposal was created with the minimal viable product strategy in mind. It was made by simply taping a hair clip onto the alarm device cord. The prototype allows for easy mounting on surfaces of different sizes. And was able to afford users with enough information to evaluate the idea.



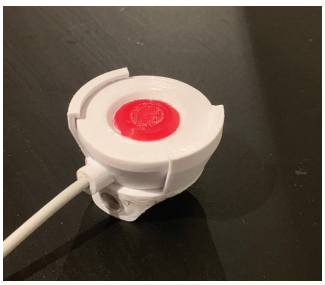
Cable clip

The cable clip proposal was created using CAD software and a 3D-printer. It was made out of ABS-plastic in order to allow for the desired part flex. The first prototype was not flexible enough to directly compare with the other two concepts regarding efficiency, refinement and flexibility. However it gave enough information to evaluate the ideas in terms of user imput and what is needed for the interaction.



Press fit clip

The press fit clip proposal was created with the minimal viable product strategy in mind. It was made by gluing a plastic hook to a previous press fit mount used in the gooseneck prototype exploration. This prototype allows for easy hanging on certain vertical surfaces but sacrefices ergonomy and variability in the devices cable management and placement customizability.



6.3 Concept selection

During the selection process, three prototype concepts were considered: the cable clamp, the cable clip, and the press fit clip. After some evaluation, the chosen concept was the cable clip. There were several factors that influenced this decision. Firstly, the cable clip was much simpler than the others only having a single part. This simplicity in manufacturing would likely result in cost savings and easier scalability for mass production.

Secondly, the cable clip demonstrated a longer life expectancy because of the fewer complications. Made from ABS plastic, it provided the desired flexibility while maintaining durability. This durability ensures that the clip will withstand repeated use without breaking or losing its functionality over time, enhancing its overall lifespan.

Furthermore, the cable clip was designed for easy cleaning and operation in a single motion which a spring clamp or press fit mount would not. This user-friendly feature simplifies the interaction process for patients, allowing them to easily attach and detach the alarm device without any hassle. The seamless operation contributes to a smoother and more efficient experience for both patients and healthcare staff.

6.4 Concept refinement

The cable clip underwent an iterative improvement process, where changes were made to its dimensions, material, and geometry to enhance its functionality and usability. This iterative approach allowed for the creation of new working prototypes using 3D printing. This rapid prototyping approach enabled quick testing and evaluation of design modifications, gathering feedback, and making further refinements until the desired functionality and usability were achieved.

As part of the improvement process, the cable clip was also separated into two parts: a main body and a smaller flexible silicone clip. This design change was implemented to make mounting and removing the cable clip easier and more convenient for users. The smaller silicone clip provided the necessary flexibility and grip, allowing users to securely attach and detach the cable clip from the alarm cable as needed.

The geometry and material of the clip was changed repeatedly. This was done in order to strike a good balance between easy mounting, strength of the grip, resistance to cleaning solutions and simple manufacturing.

6.5 Final quick attachment concept

Cable clip-Final concept

The cable holder for the patient alarm device is a convenient accessory designed to keep the alarm chord organized and easily accessible. It features a flexible plastic clip that can be bent to securely attach to tables, tubes, or other surfaces with a diameter of up to 30mm. This versatility allows the cable holder to be conveniently positioned wherever it is needed. The plastic clip is seamlessly mounted to the alarm device using a silicone rubber clip, ensuring a secure and reliable connection.

With the chord holder, healthcare professionals can easily attach the alarm device to various surfaces, ensuring that it remains conveniently accessible when needed. This simple yet effective accessory enhances the usability and functionality of the patient alarm device, providing a practical solution for managing the alarm cables in a safe and efficient manner.

Cable clip-Manufacturing

Image 16: (Overmolding for Custom Plastic Injection Molding,2022)

Image 17: (Bhutajata, 2017)

The chosen matereal for the chord clip is Polypropylene (PP) because of its mechanical properties and resistance to cleaning solutions used in hospitals. The plastic needs to have a high elastic deformation with a relatively high youngs modulus which Polypropylene does. The plastic body of the clip is manufactured by injection moulding in a two part mould, the silicone rubber part is then overmoulded onto that part. Technical drawing can be found in Appendix VIII

Cable clip-Cost estimation

Cost estimation for the chord clip involves analyzing the costs of tooling for the injection molded plastic part and the silicone rubber over mold. Other factors include equipment, materials, labor costs, and overhead expenses. The estimated retail price for this product in a 5000 unit production run is about 30 SEK. For a full cost breakdown, see Appendix VII

Alarm device- CMF

The chosen color for the cable clip is Bright white (Pantone, 11-0601 TPG), which aligns with the clean and sterile environment commonly associated with healthcare facilities. The white color not only blends well with the surroundings but also promotes a sense of cleanliness and hygiene.

In terms of surface finish, a semi-gloss finish has been implemented for the cable clip. The semi-gloss finish also allows for easy cleaning and maintenance thanks to the smooth surface, ensuring that the cable clip remains free from dust and contaminants.

The material used for the cable clip is Polypropylene (PP). Polypropylene is a versatile and durable thermoplastic polymer that offers several advantages for this application. It has excellent strength, flexibility and resistance to impact. Additionally, Polypropylene is known for its chemical resistance and ability to withstand repeated cleaning without degradation.

7. Concept III-Alarm device

The following chapter shows the development, prototyping and testing of the reworked alarm device. The alarm device needed to work in combination with the gooseneck and wire clip concepts as well as fulfill the requirements listed in the analysis (3.4).

7.1 Alarm device shape exploration

In the process of designing a patient alarm, shape exploration played a pivotal role in achieving an optimal balance between aesthetics, functionality, and user comfort. The exploration process involved varying levels of complexity and ergonomics to create an alarm system that not only fulfilled the necessary specifications but also enhanced the overall user experience.
To facilitate shape exploration, computer-aided design (CAD) and 3D printing were utilized. Using hard foam was considered as an option for prototyping shapes faster, but cad was decided upon since scale and shape could be changed iteratively and seamlessly. The 3D printer also reduced the hands-on time spent on prototyping.

Once promising design iterations was identified through the virtual exploration, the focus shifted towards transforming these digital representations into physical prototypes. This was achieved using an Anet ET5X and Ender 3Plus 3D printers.

With the physical prototypes in hand, they were reiterated scale and shape-wise. Once optimized, they were then narrowed down into the most promising shapes. The shapes had different aspects that were considered desierable such as simplicity, manufacturability, ergonomics, aesthetics, button placement and compatability with the magnetic mount.

7.2 User test I

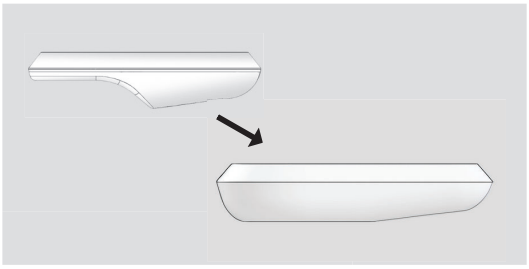
The 3D-printed models provided a tangible representation of the alarm system, enabling users to interact with the design and provide valuable insights. These iterative improvements were crucial in refining the alarm's shape, addressing ergonomic considerations, and optimizing user comfort and ease of use.

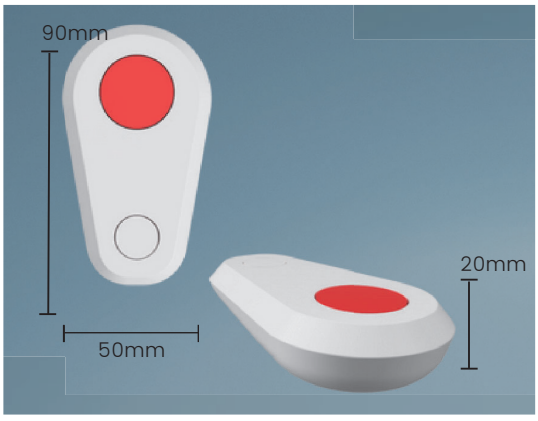
When presented with the eight prototype shapes, the users were asked to rank them based on ergonomy and compatability with the magnetic mount. They were also asked to identify most and least intuative button placements for each. The answers allowed for narrowing down the options to the three options seen bellow. The results represented in Appendix VI

7.3 Shape, size and button placement

Following the user test, the final narrowing down phase was undertaken by the designer, taking into account various considerations. The goal was to select the design shape that balanced multiple factors, including manufacturability, ergonomics, button placement, aesthetics and copatability with the magnetic mount. This was done to ensure that the chosen design could be efficiently produced, guaranteeing user comfort and ease of interaction with the device.

The "middle ground" shape was considered the most well rounded concept and was therefore used as the basis for further refinement. During this refinement phase, the recess for the magnetic mount was removed for easier manufacuring, nicer aesthetics and better ergonomics. The scale was also increased slightly.





7.4 Button icons and colors

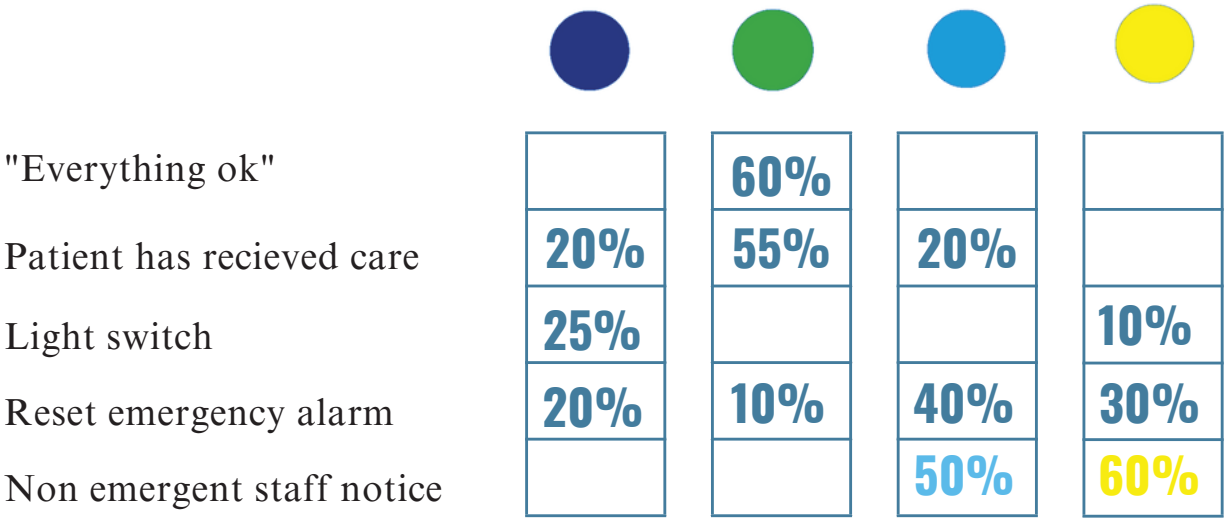
Buttons play a pivotal role in user interaction with the patient alarm device, designing buttons that are easily identifiable, accessible, and responsive is crucial for ensuring a seamless user experience. This section delves into the considerations for button design, including size, placement, color, and icons, to maximize usability and reduce errors in the high stress healthcare environments.

Color association survey

A comprehensive survey was conducted to determine the most suitable color for theassistance button on a patient alarm device, excluding red due to its association with emergency functions. The primary objective of this survey was to gather insights on biases and intuitive responses towards different button colors and their perceived functions.

Participants were presented with situational/functional options and asked to select the one they associated most strongly with the color that was presented. Multiple-choice options were provided, and only responses that received a frequency above 10% were included for analysis, ensuring a substantial representation of preferences.

The survey aimed to capture participants' intuitive understanding and preconceived notions regarding button color and its relation to specific functions. By gathering this valuable information, the study aimed to identify a color that resonated most strongly with users and conveyed the concept of assistance effectively.



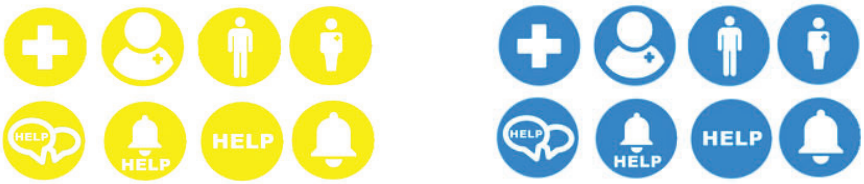
The survey results showed that blue and yellow were the colors most associated with the function of a nonemergent staff notice (assistance call). Neither blue nor green had any participants that associated it with the wanted function. The results were however not conclusive, one more survey needs to be conducted to cement the user preferences. The survey results can be found in Appendix V.

Icon association survey

A survey was undertaken to gain insights into biases and intuitive perceptions regarding button icons and their associated functions. Participants were presented with two scenarios: one described as an emergency situation and the other as a non-emergent situation. They were then provided with a selection of 12 different icon options and asked to choose the icon that they associated most strongly with each given scenario.

To determine the most suitable color for the non-emergent icon, participants were presented with icon options in both yellow and blue as per the color survey results. They were then asked to select their preferred color option for the given situation.

Through this survey, the goal was to leverage user insights to make informed design decisions that align with users' expectations and contribute to an intuitive and user-centric interface for the patient alarm device.



Based on the survey results, option number 11 emerged as the clear preference for the emergency situation, receiving 58% of the total votes. It significantly outperformed the second most preferred option, which garnered only 11% of the votes. In terms of the non-emergent situation, icon number 2 was the most popular choice, with 40% of the votes, while icon number 10 received 20% of the votes, making it the second most preferred option.

The survey results revealed a distinct preference among participants for the blue icons, which received an overwhelming 88% of the votes. In contrast, the yellow icons, representing the other color option, garnered a modest 12% of the votes. These findings underscore the strong inclination towards the blue icons and emphasize the need to prioritize this color scheme in the design of the patient alarm device.

The survey results and questions can be viewed in Appendix V

7.5 Feedback

Tactile feedback

Tactile feedback plays a crucial role in inclusive design. Inclusive design aims to create products and experiences that cater to the needs of a diverse range of users, including those with varying abilities and sensory perceptions. Incorporating tactile feedback into a patient alarm ensures that individuals with visual impairments or those in high-stress situations can effectively interact with the device.

By incorporating tactile elements, such as textured buttons, vibrations or raised symbols, users can receive haptic cues that provide confirmation of their actions. This feedback enhances the usability and accessibility of the patient alarm, enabling users to navigate the interface confidently and accurately without relying solely on visual cues. It was decided that vibrations and tactile buttons with a distinct click were to be included in the alarm design.

Audible feedback

Audible feedback is vital for inclusive design. By incorporating sound cues and alerts, individuals with visual impairments or those in busy environments can effectively interact with the device. Audible feedback enhances usability, provides reassurance, and promotes inclusivity in healthcare technology design. for this design, it was decided to include an audible click for the buttons as well as a loud alarm sound for the emergency button and a non aggressive confirmation sound for the assistance call.

Visual feedback

By incorporating visual cues and indicators, individuals with varying abilities and visual impairments can effectively navigate the interface. The use of clear and distinct visual feedback, such as highlighting the selected button or providing visual confirmation of an action, enhances the usability and accessibility of the patient alarm. It allows users to easily identify and track their interactions, providing a sense of control and reducing the risk of errors or confusion.

Two visual feedback options were considered for the final design. The first option involved an LED strip around the alarm housing, illuminating white when no button was pressed and changing to the corresponding color when pressed. This option offered visibility from all angles, especially in low-light conditions. The second option incorporated RGB LED lights into the buttons themselves. The buttons emitted a white glow when not in use and changed color when pressed, similar to the LED strip. This option provided clearer feedback on the pressed button and improved distinguishability, particularly at night.

Both options had their advantages. The LED strip provided visibility from different angles and in low-light conditions, while the RGB LED buttons offered clearer identification and differentiation of buttons at night. The chosen visual feedback design would strike a balance between these considerations, ensuring effective functionality and usability in various lighting conditions.

7.6 Working prototype

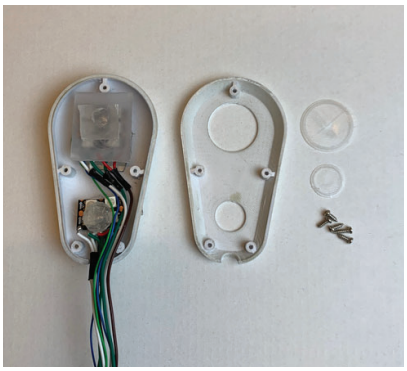
Housing

The housing for the prototype was created in PLA plastic using the Anet ET5x printer using a layer height of 0.1mm to reduce post-processing time. In order to achieve a perfectly smooth finish the housing was wet sanded, primed, and painted for a total of 6 cycles. No post-processing was done on nonvisible surfaces.

The silicone button covers were prototyped using a clear and flexible filament that could be counter sunk and press fit into the holes. These were then covered with inkjet printed icons.

Hardware

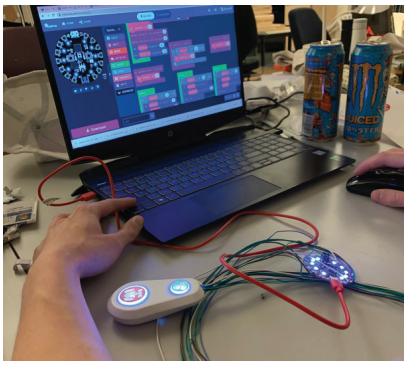
The hardare was created in 3 seperate parts Two parts were what were reffered to ass LED and button assemblies, and the third one is the controll unit. The assemblies consisted of Neopixel LEDs that were wired in series of 4 or 6 indevidual neopixels. and placed on a square plate. This plate was then attached on top of a momentary switch. These were then soldered and connected to the a controll unit called Adafruit playground express.



Programming

The code for controlling the two Neopixel assemblies was created using Adafruit's block programming software. Once the prototype is connected to power, buth neopixel assemblies turn white. When one of the buttons was pressed, the dedicated Neopixel assembly changed color from white to either red or blue, based on the button pressed. If the button for the red Neopixel assembly was pressed, the blue assembly could not be activated, but if the blue assembly was activated first, it could be overridden by the red assembly. Specific audible feedback (alarms) were programmed for each button and assembly.

In order to evaluate the functionality of the final prototype, it was important that the feedback worked as intended. An external button was also included for resetting both assemblies and silencing the audible feedback. Overall, this prototype was designed to be a user-friendly way to control multiple Neopixel assemblies with buttons and audible feedback.



7.7 Final concept

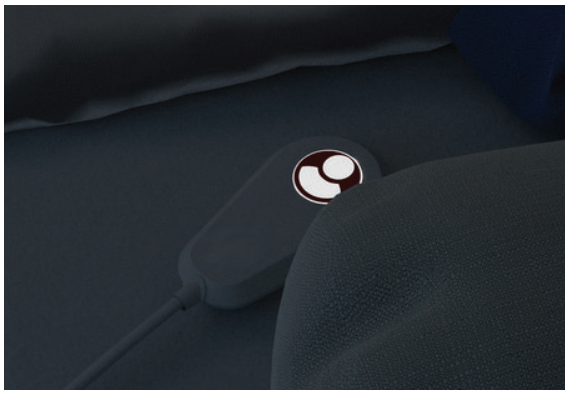
Dual-button alarm device

The final alarm device concept features two separate buttons: one for emergencies and the other for general assistance. Tactile buttons and a slight vibration provide feedback when pressed, while vibrant LEDs confirm signal receipt. The buttons are covered in medical-grade silicone, resisting bacterial growth, and the seamless design ensures easy cleaning. device improves communication accuracy, hygiene, and patient safety. The housing is designed to be water proof and made with material that is resistant to cleaning solutions and dissinfectants.

Single-button alarm device

The single-button alarm device concept is developed for use in departments where the patient is not allowed the privilege or responsibility to call for emergency help themselves. The primary use would be in departments such as the ER where the frequency of people suffering from intoxication, withdrawal, or mental instability is commonly found. which would make them likely press the emergency button constantly without needing it. The device therefore simplifies patient communication by focusing on a single button for general assistance. The blue assistance button from the dual button concept is utelized here also, but in red. The tactile button provides feedback, while vibrant LEDs confirm signal receipt.

The one-button device share all its parts with the dual-button device with the exception of a different top housing that accomodates one less LED/button assembly.



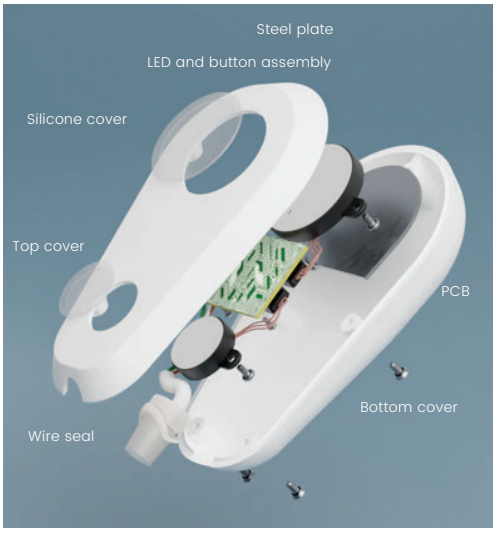
Alarm device combination with Cable-clip and Gooseneck

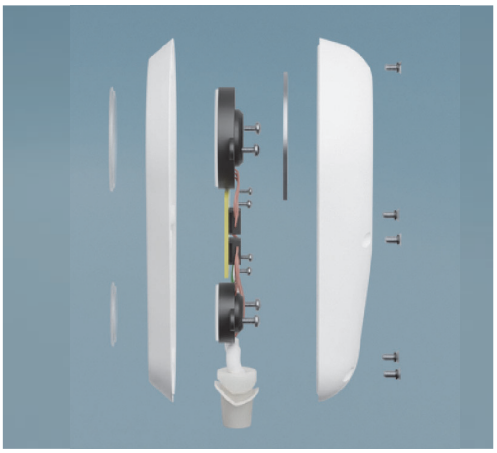
Alarm device-Design for disassembly

In the final concept, the alarm device consists of a two-part housing, modular LED/button assemblies, a PCB, a metal plate (for the magnetic mount), and additional hardware.

The top part of the housing includes silicone button covers that are molded onto the plastic piece in order to make it water-resistant, these silicone pieces should display the actual icons. The LED/button assemblies are fastened to the top housing with two screws each and are easily connected to the PCB via an RGB connector. The PCB itself is also fastened to the top housing but uses 4 smaller screws. The steel plate is press fit into the bottom housing using undercuts. In the case of a single-button alarm device, all components remain the same except for the top housing which would simply exclude the smaller secondary button aswell as change the larger button icon to make it more inviting. The PCB dettects weather there is one or two LED/button assemblies connected and adjusts the functionality accordingly.

The modular design allows for easy disassembly and replacement of individual parts, prolonging the lifespan of the device and decreasing long-term costs. When the product is no longer usefull, the design also allows for simple recycling or reuse of materials.





Alarm device- Cost estimation

Cost estimation for the magnetic mount involves analyzing the costs of the three injection molded plastic parts, silicone overmoulding, and the electronic components made for this specific product. It also involves gathering prices for the hardware, chord and wall connection which would all be purchased from another manufacturer. Other factors may include tooling, equipment, labor costs, and overhead expenses. The estimated retail price for this product in a 5000-unit production run is about 300 SEK. The overhead is not concidered for this application since most of the work would be outsourced. For a full cost breakdown, see Appendix VII.

Approximate unit price:
300 SEK

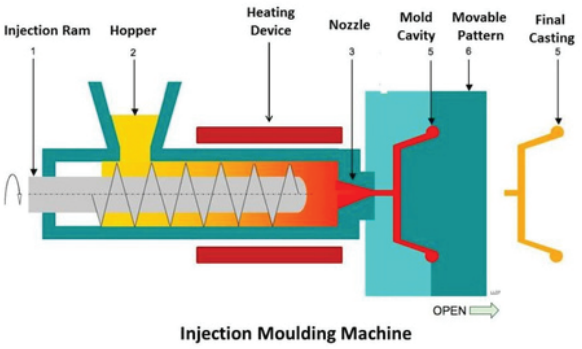
Alarm device-Manufacturing

The three housing parts, as well as internal electronics, would all need to be manufactured specifically for this product. The plastic parts are all designed for a two-piece injection molding process. They were simplified as much as possible in order to reduce mold complexity. The chosen material is Acrylonitrile styrene acrylate (ASA) because of its stiff, impact-resistant mechanical properties and resistance to cleaning solutions used in hospitals.

The steel plate used for mounting to the magnetic gooseneck would be stamped out of a steel sheet using a blanking process.

The LED/button assembly would require a multitude of manufacturing techneques. The housing would be two-part injection molded after which already established LED button technology would be applied to fit within the housing.

The PCB would need to be ordered from a custom PCB supplier such as PCBway or PCBAstore. The functionality included would be that of three soldering points for power ground and signal, aswell one seperate pring connector for each LED/button assembly. Technical drawing can be found in Appendix VIII



Injection Moulding Machine

OTHER

Alarm device- CMF

The chosen color for the Alarm device is Bright white (11-0601 TPG), which aligns with the clean and sterile environment commonly associated with healthcare facilities. The Bright white color not only blends well with the surroundings but also promotes a sense of cleanliness and hygiene. The button colours are the red and light blue seen in the pantone images.

In terms of surface finish, a semi-gloss finish has been chosen for the alarm device. The semi-gloss finish also allows for easy cleaning and maintenance thanks to the smooth surface, ensuring that it remains free from dust and contaminants.

8. Concept evaluations

To assess the effectiveness of the final product family and its potential as an improvement over the current patient alarm system, a user test was conducted. The test aimed to evaluate the performance and user experience of the magnetic mount and chord clip in combination with both the existing alarm device and the new alarm device concept. This evaluation involved simulating a patient or staff situation to try and replicate the actual usage scenarios.

8.1 Product family usability test

The usability test was conducted to assess the effectiveness and usability of the product family. Two nurses who would be participating in the test also helped with creating a more accurate replication of the healthcare environment. This helped to facilletate a closer resemblance to the real interactions with the products in actual care rooms and associated facilities.

Prior to the evaluation of the final products, users had the opportunity to test the existing alarm system and its mounting strategies. This step allowed for a direct comparison between the old system and the new products.

The main test began with participants performing the task of positioning a mockup of the current alarm device for a bedridden patient using the chord clip. This was done without any instructions to assess the intuitiveness. The same was then repeated but using the magnetic gooseneck mount.

Following the initial tests on alarm device positioning, participants were introduced to the new alarm device concept. They were presented with scenarios resembling either emergent or non-emergent situations and instructed to operate the alarm device based on their intuition. This allowed for an assessment of how well the participants could instinctively interact with the new alarm device in different situations.

8.2 Product family usability test results

During the testing process, it became evident that the new alarm system, in conjunction with the accessory products, offered clear benefits and advantages over the existing setup. Users recognized the improved functionality, flexibility, and ease of use provided by the two positioning products. The intuitiveness of the alarm device also proved to be satisfactory. However one of the users intuitively pressed the emergency button during a nonemergent situation. This might have been due to a lack of focus since the participant was not looking at the device but rather pressed the first button she touched. This can be viewed either as a failure or success since the most intuitive button placement was chosen for the emergency button to enable activation without a second thought during periods of stress.

9. Reflection

9.1 Methods

The methods used in my industrial design thesis to enhance the patient alarm system in hospitals within Region Skåne were seemingly effective, but it is important to evaluate their strengths and limitations.

Surveys collected an adequate amount of data from a wide range of participants, allowing for statistical analysis. However, they may have lacked depth and nuanced responses due to participants' interpretations. The research would also have benefitted hugely by increasing the sample size.

In-depth interviews with staff and patients provided valuable qualitative insights into their experiences and perspectives. However, the limited number of interviews conducted might have restricted the diversity of perspectives captured.

User testing played a crucial role in evaluating the usability and functionality of the proposed designs. Direct observations and user feedback contributed to valuable insights. However, the sample size might have been limited, potentially overlooking certain user demographics or specific contextual factors. Constraints on physical visits to departments limited the gathering of firsthand information and observationstesting with actually admitted patients. While efforts were made to compensate through general user testing with varying age groups, direct observations were missed, impacting the depth and richness of the data collected.

Surface-level manufacturing and cost analysis provided initial insights into feasibility and cost implications. However, a more comprehensive analysis would have strengthened the understanding of practical implementation, including materials and detailed cost breakdowns.

In conclusion, the methods employed successfully gathered diverse data and perspectives, informing the design process. However, limitations such as potential sampling biases, the need for more extensive manufacturing and cost analysis, and the absence of in-person visits should be acknowledged. Future research should aim to expand sample sizes, conduct comprehensive manufacturing and cost analyses, and prioritize in-person visits for comprehensive data collection and observation.

9.2 Results and future improvements

The evaluation of the final patient alarm system in combination with the accessory products, demonstrates positive outcomes with valuable user feedback. However, certain considerations and areas for improvement have been identified.

The final user test was conducted successfully and received positive feedback from two nurses who participated in the test, as well as eight additional users. The clarity of the functions associated with the patient alarm system and the magnetic gooseneck mount and chord clip, was evident and well-understood by all users. This indicates that the design effectively communicates its intended purpose to users. The resulting intuition observed among users when utilizing the patient alarm system in combination with the accessory products is encouraging. This outcome aligns with the objective of creating a user-friendly and efficient system.

Feedback from users revealed some apprehensions regarding the selection of a single-button or dual-button alarm configuration. It appears that there may be a need for further clarification and guidance for departments to make an informed decision based on their specific requirements. Addressing this concern will contribute to a more adaptable and versatile product solution.

One nurse expressed concern regarding the force required to operate the gooseneck mounting clamp. They mentioned that patients who could benefit from the mount might not have the physical capability to do the initial mounting themselves, thus necessitating the nurse's assistance in the initial mounting process. Exploring design modifications or alternative solutions that allow for easier adjustment without compromising stability could enhance the overall usability and accessibility of the product.

The testing of the current alarm system and its mounting strategies allowed for a direct comparison with the new products, demonstrating the clear benefits and advantages of the latter. However, there still remains a worry of staff reverting to old practices regarding the positioning of the alarm device. This can only be adequately examined in a real larger scale test at different departments.

In conclusion, the final products, as validated through user testing, have received positive feedback, with users finding the functions clear and the overall experience intuitive. However, addressing the concerns related to the selection of alarm configurations and the force required for the gooseneck mounting clamp will further enhance the usability and inclusivity of the system.

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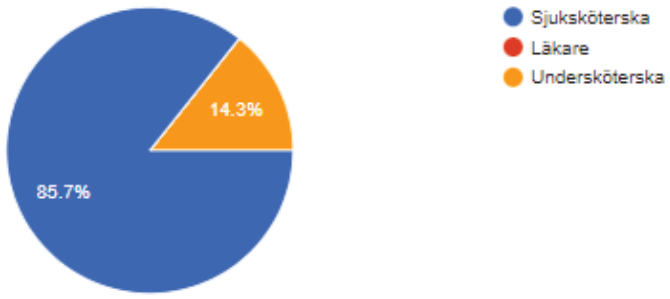
Appendices

Appendix I - Hospital staff survey

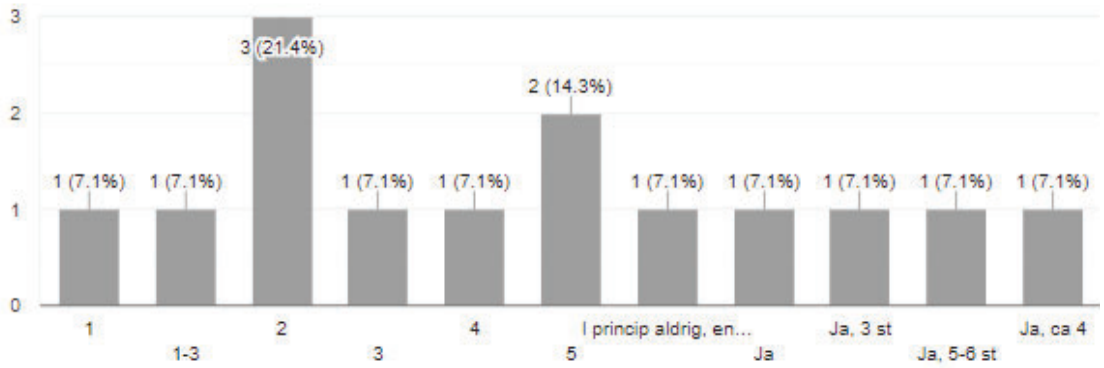
Question 2: What is your work title?

14 responses



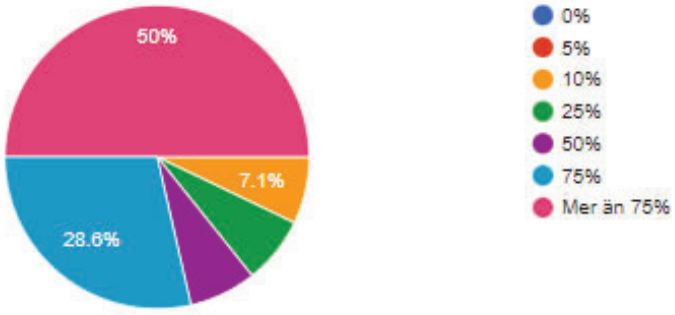
Question 3: Do you find that you get a lot of false alarms in your department? If yes, estimate how many there are per shift?

14 responses



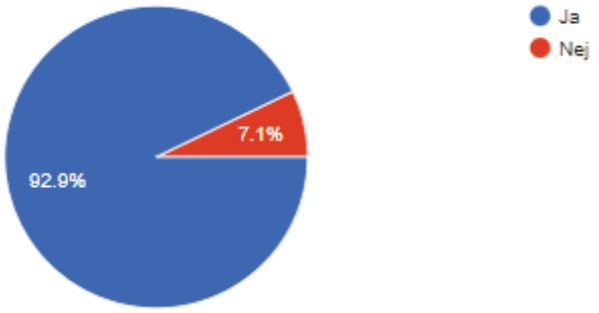
Question 4: What proportion of the emergency alarms you receive in the department would you estimate are false alarms?

14 responses



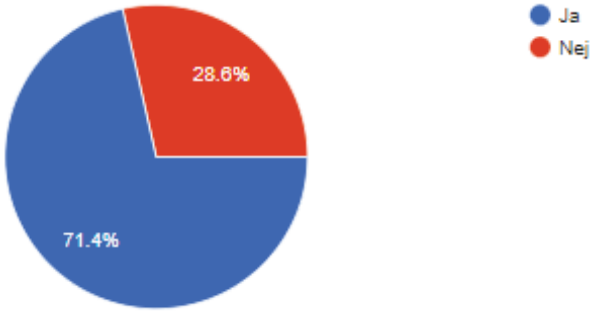
Question 5: Do you inform the patients regarding the functionality of their patient alarm?

14 responses



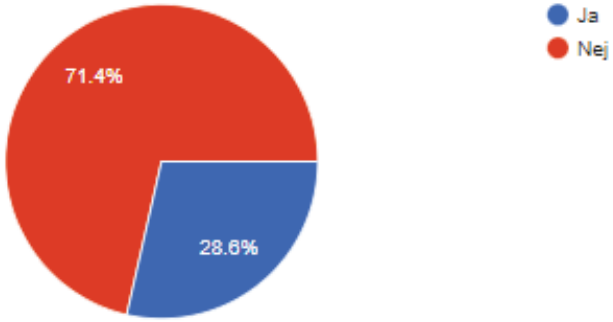
Question 6: Is the alarm easy for patients to understand?

14 responses



Question 7: Have you observed that patients are reluctant to call for help during non emergencies?

14 responses



Question 8: If the answer to the previous question was yes, explain why.

3 responses

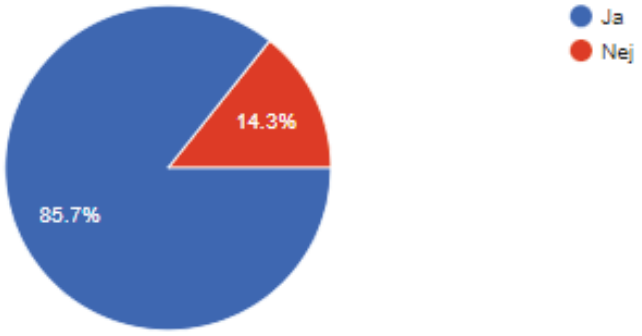
Skulle det vara så att det har råkat gå till ett akutlarm när patienten egentligen bara skulle ringt som vanligt så är de flesta rädda att ringa igen senare ifall samma situation skulle uppstå

När en patient råkar orsaka falsklarm och vårdgivare kommer springande blir de nervösa eller rädda. Många gånger tvekar de därför att be om hjälp igen.

För de blir rädda att göra fler falska larm

Question 9: Is it easy to make a mistake that causes a fake emergency when operating the alarm as a patient?

14 responses



Question 10: If the answer to the previous question was yes, explain why.

Om man inte trycker på att starta om larmet när man har hjälpt patienten och lämnar rummet kommer inte patientens första larm tryckning tas bort, nästa gång de behöver hjälp blir det därför en akut dubbeltryckning.

Om man inte trycker ut sig blir det falskalarm nästa gång de ringer

Inte larmet i sig, men att glömma "trycka ut" sig förekommer ofta

Om man svarar på ett larm men glömmer återställa systemet eller "trycka ut sig" kommer det bli akutlarm nästa gång patienten tryker på knappen.

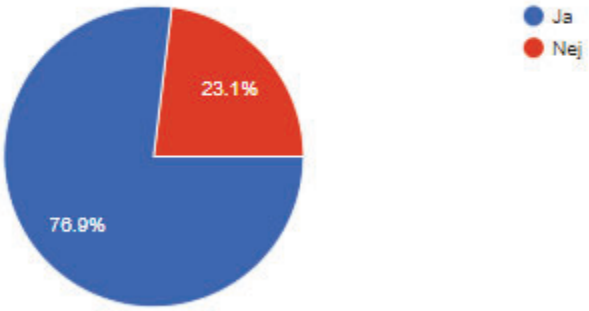
Man glömmer trycka ut sig när man varit på ett rum

att glömma "trycka ut sig" vilket ställer om systemet. Detta kan leda till att patientens nästa tryckning blir akut.

Vi behöver trycka in våran "närvaro", ibland glöms det bort att trycka ut sin "närvaro". Om patienten larmar (ej akutlarm) när "närvaro" är intryckt blir det akutlarm.

Question 11: Is it easy to make a mistake that causes a fake emergency when operating the alarm as a caregiver?

13 responses

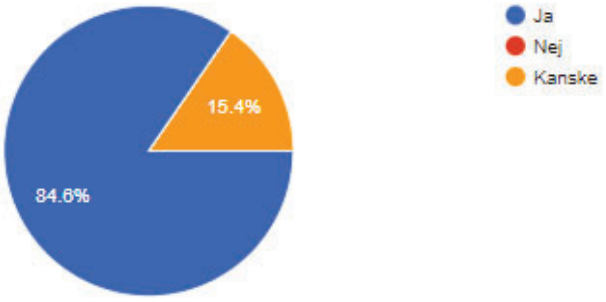


Question 12. If the answer to the previous question was yes, explain why.

Om man inte trycker på att starta om larmet när man har hjälpt patienten och lämnar rummet kommer inte patientens första larm tryckning tas bort, nästa gång de behöver hjälp blir det därför en akut dubbeltryckning.
Om man inte trycker ut sig blir det falskalarm nästa gång de ringer
Inte larmet i sig, men att glömma "trycka ut" sig förekommer ofta
Om man svarar på ett larm men glömmer återställa systemet eller "trycka ut sig" kommer det bli akutlarm nästa gång patienten tryker på knappen.
Man glömmer trycka ut sig när man varit på ett rum
att glömma "trycka ut sig" vilket ställer om systemet. Detta kan leda till att patientens nästa tryckning blir akut.
Vi behöver trycka in våran "närvaro", ibland glöms det bort att trycka ut sin "närvaro". Om patienten larmar (ej akutlarm) när "närvaro" är intryckt blir det akutlarm.

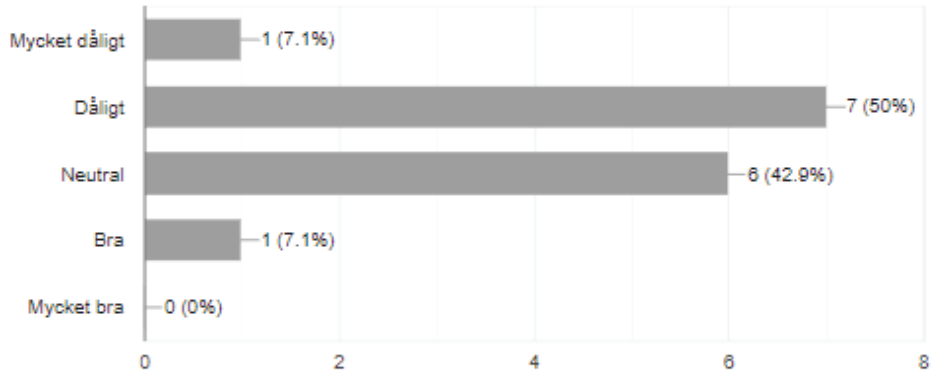
Question 13: Do you feel that the current design of the handheld alarm button may lead to problems?

13 responses



Question 14: How would you rate the patient alarm at your department?

14 responses



Question 15: Do you have any suggestions on how the patient alarm system may be improved?

9 responses

nej

Vet inte

Göra det tydligare på larmpanelerna var man trycker vid ett "vanligt" larm och var man trycker vid akutlarm. Förslagsvis 2 olika knappar tydligt markerade på engelska så att alla förstår, även de med språkförbindelser. O göra det omöjligt att det ska kunna gå till akutlarm bara för att vi i vårdpersonalen varit "intryckta" sedan innan.

Göra det omöjligt för ett akutlarm att förekomma om man inte menar att larma.
Göra patientens larmknapp mer enkel att hantera

Trådlösa larm

Ha två separata knappar för akut och vanligt larm.

Man skulle kunna ha ett chip som går igång när man går in i pt rummet vid närvaro. Ha den som en flyttbar klämma som borde vara trådlös.

Appendix II - Nurse interview transcripts

Interview 1

Interviewer: Rasmus Ljungdahl
Interviewee: A female nurse in her twenties, working at the Pediatric department in Malmö
Interview setting: The interview was conducted over the phone.
Affiliation with interviewee: The interviewee is a friend of the interviewers partner

(Start of interview)

Interviewer:
Okay, so let's start. Where do you work?

Nurse:
I work at the Pediatric Department here in Malmo.

Interviewer:
What do you do at the Pediatric department?

Nurse:
We give care to sick children, mostly those who do not have long term stay, but more so come to visit for checkups and treatment.

Interviewer:
Okay. Do you feel that the patient alarm is working well at your department?

Nurse:
Well, I think it's working well. I don't see any glaring issues with it.

Interviewer:
Okay. Do you get a lot of fake emergency alarms during the day?

Nurse:
No. I get about one every two weeks or so..

Interviewer:
So if you would account for the time that you don't work, would it be reasonable to assume it happens maybe once or twice a week in your department?

Nurse:
Yeah, that's reasonable. I think that's about right.

Interviewer:
Okay. Do you get stressed out as a result of the patient alarms? Both regular ones and emergencies.

Nurse:
No, not at all.

Interviewer:
Okay. Do you feel like the alarm system is easy for the patients to understand?

Nurse:
Both yes and no, because sometimes when they come, a lot of the patients have been there a lot of times already, so they know and we don't explain it to them. But sometimes we get a new patient and we don't really mention it, and it might be hard for them to understand that they can call for help for smaller things. Some people just see a big red button and then they get scared to press it. And so they don't press it at all. But most patients have no problems. They just press it and see if the staff comes. They don't think about it very much because it's a lot of children also. So if they need something, they're going to press until they have it. But we don't have a lot of long term stays, they're mostly there during the day. So we don't get a lot of regular alarms either, not just emergencies. So yeah.

Interviewer:
What is the most common reason for patients pressing the alarm button?

Nurse:
From my point of view, it's probably that they're just immobile at that time. Maybe we have put some restrictions on them for any reason and they want something. They want a pillow, something to eat when it's not a designated time. Maybe they want pain medication if it's a longer stay, maybe ask a question, just stuff like this.

Interviewer:
Which one is the most common?

Nurse:
I don't really know, but that's the gist of it.

Interviewer:
Okay. What is the most common reason for an emergency alarm sounding in the department? I don't mean only real emergencies, I mean also fake.

Nurse:
Well, we have basically no real emergencies. Almost all of them are fake. When they happen, maybe once a week, once every two weeks, it is usually a fake one. That usually has to do with either the patient pressing the button twice because pressing it two times without us responding creates an emergency alarm. It's either that or a lot of the time people just, for example, lay on the button and it accidentally

presses it. There's been times where a patient is asleep and the alarm goes off. Those are probably the most common ones for emergency alarms.

Interviewer:
I see. How do you prioritize alarms at your department?

Nurse:
Well, if there's a regular alarm, we just try to take the one who called first. So we would look at the boards and see. If we're doing something. We sometimes keep doing that because a regular call is non-emergent, so we just try to take one after the other. There's no real way that we prioritize them.

Interviewer:
If you are interrupted by an emergency that is then resolved, do you go back to prioritizing the first patient that called or do you just help one and don't really think about it?

Nurse:
Well, we wouldn't think about it that much at that point. And we don't really during regular shifts either. We just take the one that we think has called first.

Interviewer:
OK, that seems reasonable. Is there any way for you to gauge if there is a difference in priority for the patients?

Nurse:
No, there's not really any way for us to gauge outside of there being regular alarms and emergency alarms. So if one person had a lot of pain and really needed pain medication or some other type of care, but they're stubborn, for example, and they won't call for an emergency. They're prideful, let's say, and someone else calls as well at the same time. And they just want some sort of amenity, like a pillow or, you know, they need help to change the TV channels, you know, whatever. There's no way for us to gauge the difference there. We just go with the flow, so to speak.

Interviewer:
Ok. Since you don't have a lot of emergency alarms as a problem, for example, do you feel as if there are any other smaller issues with the alarm? For example, maybe the placement of it? Is it easy to place where the patient wants it? Is it flexible enough for you? Are there any problems that can arise from the current design of the alarm?

Nurse:
Yeah, there are some annoyances I would say. For example, the alarm button is connected to a pretty thick string, so if you want to place it on the bedside table, it won't stay there because the cable is too heavy, so it's just going to fall off. And as I mentioned before, we don't really like the patients having it in the bed

because that causes unwanted alarm presses. So the options are basically that they hold it in their hand or that we usually just hang it from their bag of drip, from a lamp or from the bed frame.

Interviewer:
Ok. How do you go about doing that? How do you actually hang it from the bed frame, for example?

Nurse:
Well, we just tie a knot around it or we just circle it around the frame. Most of our alarms actually have a tied knot on them, just kind of like a hanger so we can hang it on hooks and stuff like that.

Interviewer:
Do you feel as if that offers enough flexibility?

Nurse:
Well, both yes and no. We shouldn't have to do that. Sometimes a patient can't reach the alarm at all times, which is a problem because we don't want to have to untie it or similar stuff all the time, and that can for sure be a problem, but it's more so an annoyance than something that usually causes any larger issues. Also, some of the wires have kinks in them and they're kind of damaged because we keep tying them.

Interviewer:
I know you don't work with a lot of people that are long term stayers or in very much danger at the current moment. They're more so there for treatment, right?

Nurse:
Yes, that's right.

Interviewer:
For example, let's say there is a patient who was very sick and couldn't move very well, so a hypothetical question that's maybe more applicable to other departments. Do you think the lack of flexibility in alarm device placement could lead to things worse than inconvenience then?

Nurse:
Well, if there is a patient like that, they're usually hooked up to monitoring systems, so we're going to see if their condition worsens anyway. But some issues don't show up on these systems. So sure, it could definitely cause issues in that case.

Interviewer:
Are there any other additional problems regarding the alarm?

Nurse:
No, I wouldn't say so. Or well yes, but it's just kind of an annoyance. For example when we try to clean, one of the alarm devices has this kind of ridge alongside the button which can cause bacteria to build up, which is something I've thought about. It's kind of a shitty design. There shouldn't be a lot of edges for

direct and debris and stuff to build up. But I don't think that's a large issue. We just have to spend a few more seconds cleaning it along the edges.

Interviewer:
Okay. So if i have understood correctly your patient alarm works fairly well at the pediatric department. But there are a few areas that could be improved for your convenience, those being device placement and flexibility, wire kinking, and hygiene. Is that a fair interpretation?

Nurse:
Yes definitely, I haven't really thought of those things in that way. It has just become something that we live with and try to improvise solutions ourselves.

Interviewer:
That's the whole problem! You shouldn't need to spend time on working these things out, it should just work. But I think that's all of my questions that I have for today. So I thank you for participating.

Nurse:
Okay, thank you for listening

Interview 2

Interviewer: Rasmus Ljungdahl
Interviewee: A female nurse in her twenties, working at the Maternity department in Malmö
Interview setting: The interview was conducted in person
Affiliation with interviewee: The interviewee is the interviewers partner

Interviewer:
Hello! Thank you for taking the time to talk with us today. Can you tell your role in the maternity department?

Nurse:
Hi there! Sure thing. I work as a nurse in the maternity department, taking care of moms and their little ones.

Interviewer:
Great! Now, let's dive into the topic of patient alarms. How are patient alarms used in the maternity department? Can you give us some insights into that?

Nurse:
Well, when it comes to patient alarms, we use them to stay alert and respond quickly when there's a need for assistance. These alarms can be triggered by patients themselves or by the monitoring systems we have in place.

Interviewer:
I see. And how do you prioritize and respond to these patient alarms in your department?

Nurse:
It can be a juggling act. When an alarm goes off, we try to prioritize them based on the urgency of the situation. If it's a real emergency, like a mom or baby in distress, we drop everything and rush to their aid. But if it's a less urgent matter, like a patient needing a pillow or some extra help, we do our best to attend to them as soon as we can.

Interviewer:
I understand. Now, let's talk about the challenges you face when it comes to patient alarms. What are some of the daily challenges you encounter in relation to these alarms?

Nurse:
Well, one big challenge is the number of false alarms we get. It can be frustrating and even lead to a sense of complacency among the staff. We're so used to false alarms that sometimes we don't react with the same urgency we should. It's like crying wolf, you know?

Interviewer:
Absolutely. False alarms can certainly be a challenge. Can you tell us more about the causes of these false alarms? What are the common reasons behind them?

Nurse:
Oh, there are a few reasons we see them happening. First, sometimes our own staff forgets to reset the alarm after responding to a call. So when a patient presses it again, it triggers a false emergency. The second reason is that some patients are just impatient if they don't receive immediate help and end up pressing the alarm multiple times.

Interviewer:
Considering how you still need to treat every emergency call as a real one, do you feel as though the fake emergencies can, how do I put this? Become a bad cycle? Since you might not have time to reset the alarm before running to help?

Nurse:
Absolutely! When you are helping a patient and an emergency happens you need to run, you almost never have time to reset the alarm or remember to do so after.

Interviewer:
Thank you for sharing those insights. It's important to understand the root causes of false alarms. But, let's talk about the placement of the alarm buttons. Is that something that can affect the fake emergencies?

Nurse:
Sure, There are cases where patients accidentally sit or lie on the alarm button, setting it off unintentionally.

Interviewer:
Okay, any other issues regarding alarm device placement?

Nurse:
Oh, definitely. We do face some challenges with the placement of the alarm buttons. Some of our patients are in a lot of pain and have mobility difficulties. Plus, at times, they're ordered to stay in bed by the medical staff. So, we need more flexibility in where we can place those buttons to ensure they're within reach and easy to use.

Interviewer:
I understand the need for flexibility in alarm device placement. It can make a big difference for patients in pain or with limited mobility. Based on your experience, what are some potential solutions or improvements that could address this challenge?

Nurse:
Well, one idea could be having adjustable or detachable alarm buttons that can be easily positioned wherever the patient needs them. That way, we can accommodate different situations and ensure the buttons are within reach, whether the patient is in bed or moving around.

Interviewer:
That sounds like a practical solution. Thank you for sharing your insights and experiences with us today.

Interview 3

Interviewer: Rasmus Ljungdahl
Interviewee: A middle aged male nurse, works at Department for infectious disease in Malmö
Interview setting: The interview was conducted in person
Affiliation with interviewee: The interviewee is an acquaintance of the interviewer

Interview 4

Interviewer: Rasmus Ljungdahl
Interviewee: A female nurse close to retirement, works at the emergency department in Kristianstad
Interview setting: The interview was conducted in person

Appendix III - Patient interviews

Interview 1

Interviewer: Rasmus Ljungdahl
Interviewee: A middle aged female patient who underwent an appendix surgery and
Interview setting: The interview was conducted through Facetime for Iphone.
Affiliation with interviewee: The patient was an old colleague of the interviewer. They got in contact after hearing of her long hospital stay.

(Start of interview)

Interviewer:
How long was your hospital stay, and what was it for?

Patient:
I stayed in the hospital for a total of seven days prior to and after I had my appendix removed.

Interviewer:
Have you ever used the patient alarm during your seven day hospital stay?

Patient:
Yes, I have.

Interviewer:
How did you perceive the patient alarm? Was it easy to use and understand?

Patient:
It was quite easy to use, but I felt that it was hard sometimes to actually have it near me or in that comfortable way, like an easy way to press on it.

Interviewer:
Okay. My next question was actually if the patient alarm was easily accessible to you when you needed it?

Patient:
I would say no to that.

Interviewer:
Okay, what was the issue with accessibility?

Patient:

Well the device has a long wire that makes it impossible to lay on the small table because it will fall. So you need to put it in your bed, but then it's easy to lose it or press on the button sometimes when you're not supposed to do it, which I did once.

Interviewer:
Okay, did you have any solution for this issue? How did you solve it?

Patient:
I did not. All the nurses just tied it on different equipment near me, so it just hung on different equipment. They just tied it around the bed maybe or the drip bag, I did move it once from the drip bag to the bed frame though...

Interviewer:
Did the patient alarm help you feel more secure during your stay?

Patient:
I would say yes and no because I only used it when I needed to take my medication and stuff like that. But they didn't tell me when to press it in serious situations. So they didn't initially inform me enough to know about the different kinds of situations and alarms.

Interviewer:
Okay, so did they give you any instructions on how the button works?

Patient:
Not at all. Not at all. They just said press the button if you need some help. It was only when I spoke to a nurse friend of mine on the phone that I was told of the emergency functionality. I have issues with anxiety so she talked me through my worries instead of me asking the nurses in the hospital.

Interviewer:
Okay, were there any issues with the alarm not functioning properly?

Patient:
No, not that I know of.

Interviewer:
Were there any improvements to the alarm itself that you think would be helpful in the future?

Patient:
Absolutely. I would say an easier way to access it so that you don't need to tie it. And I would also say to maybe have two buttons so it's easier to know when you just need to call for help or when it's a serious alarm, like a serious situation.

Interviewer:

Okay. When it comes to feedback, when you press the actual button, did you get any feedback in the sense of feeling the click or some sort of sound or visual feedback?

Patient:
I would say that I felt a small click, but I think it would be nice to maybe have different lights maybe just to know if you have pressed the button, maybe a red light so it's like, "Okay, I actually pressed it," I think it would be easier to actually get a confirmation that you have pressed the button.

Interviewer:
Did you get any sounds from it or nothing at all?

Patient:
No sounds either.

Interviewer:
Would you say that you're satisfied with the overall functionality of the alarm?

Patient:
To be honest, no. Well, in my case, I would say something, just because I wasn't seriously ill. But if I maybe were older, like maybe 60 I think I would find it hard to know. I would find it hard to trust that the nurses would take my situation seriously if I pressed the button just. And also it's not easy to know when you have pressed the button or not. So I would say overall no, but on my occasion yeah it was OK. If I had issues as a 20 year old, I can imagine the struggle for older and less mobile people.

Interviewer:
Would it be fair to say if I summarized your experience like this. That the alarm worked as intended, you got the help when you needed it, but there was not enough information to begin with for you to know how the alarm worked? There wasn't any actual feedback when you pressed the button, so you didn't know if the staff had gotten your call.

Patient:
Exactly!

Interviewer:
And also the accessibility of the button itself was not to a level that you desired, and especially if you were older and your cognition and physique was not where it used to be, it would be very difficult.

Patient:
Well not only for older people, in my case as well because I had an appendix surgery so I had a hard time to actually move. Sometimes when they came and cleaned where my bed is, they actually put the alarm on a different spot. So when I really needed some medication just to stop my hurting, it wasn't where I left it, so it was quite hard to find it and I needed to get up from the bed and it was quite hard because of my surgery. So yeah, I would say that you did summarize it quite well.

Interviewer:
Ok, thank you. That's all I have for today.

Patient:
Thank you very much.

Interview 2

Interviewer: Rasmus Ljungdahl
Interviewee: A middle aged male patient who underwent open heart surgery
Interview setting: The interview was conducted through Facetime for Iphone.
Affiliation with interviewee: The interviewee is a relative of the interviewer

(Start of interview)

Interviewer:
So if we start off with how long was your hospital stay and what was it for?

Patient:
I stayed in the hospital for a total of five days, after which I had a four week recovery period and I was in for an open heart surgery.

Interviewer:
Okay, open heart surgery and were you immobile for a lot of the time you were there?

Patient:
Well, yes and no. I wasn't allowed to move for the first three days after my surgery and after that I was just allowed to make slight movements and sit up in bed and stuff like that.

Interviewer:
Okay, did you use the patient alarm during your stay at the hospital?

Patient:
Yeah, of course. How did you perceive the patient alarm? Was it easy to understand or did you get some sort of explanation from the staff?

Interviewer:
Well, no, I really didn't need an explanation since I am used to being to the hospital for my heart..

Interviewer:
Would you say that the alarm was within your reach at all times?

Patient:

No. No, it wasn't. I don't know what else to add to that.

Interviewer:
OK. Was it not available to you because it was placed too far away from you? Or was it just at an angle where you couldn't reach it due to your surgery?

Patient:
Well, uh, both I guess. Because uh, it was moved around quite a bit by uh, the cleaning stuff. My alarm was uh, mounted to the lamp above me. So when the cleaning staff came in, they usually just moved stuff around and I had to ask for it to be moved back to where I could reach it.

Interviewer:
In the first parts of your recovery, did you need a lot of assistance or were you not using the alarm button very much?

Patient:
Well, I kind of feel like even though I had heart surgery, there are probably people that need help more than I do. So I didn't press the button unless I really needed something, which was mostly just to get some water or something when the drip bag wasn't connected anymore.

Interviewer:
Okay regarding. When you were actually using the alarm button, did you take notice of any sort of feedback that came from the device when you pressed the button? Was there any sort of alarm sound, feeling, or maybe lights?

Patient:
No, no, there is nothing. It basically just feels like pressing or nothing, and you don't really know that your signal is even received.

Interviewer:
So you would say that there's no feedback at all?

Patient:
Yeah, I would say so.

Interviewer:
Okay. When it comes to both the positioning, first of all, but also the feedback of the alarm itself, are there any improvements that you could see being done to help you with both being able to access it more easily and also knowing whether your signals have gone through?

Patient:
Yeah, of course, maybe just having some hook that you can put on the side of your bed so the alarm is always with you and not like on the lamp or on the drip bag because it gets annoying when it's moved around all the time.

Interviewer:
Okay. But when it comes to the feedback, what do you think there?

Patient:
Yeah, well, as you said, just having maybe an LED light that lights up would be good enough for me or just some vibration or something. It doesn't need to be all the stuff you said, but just something that indicates that it's gone through.

Interviewer:
If you were to evaluate your stay, not as a whole, but when it comes to the alarm device, do you feel it was working well?

Patient:
Well, yes, I feel like it was working quite well, but I'm also used to it by now. I've been in for six or seven heart surgeries, so I'm used to the procedure. But there are definitely some things that could be changed to reduce worry and inconveniences.

Interviewer:
Okay, but I think I have everything that I could ask of you today. So thank you for your time.

Patient:
Thank you!

Appendix IV - Patient alarm statistics: Maternity department Malmö

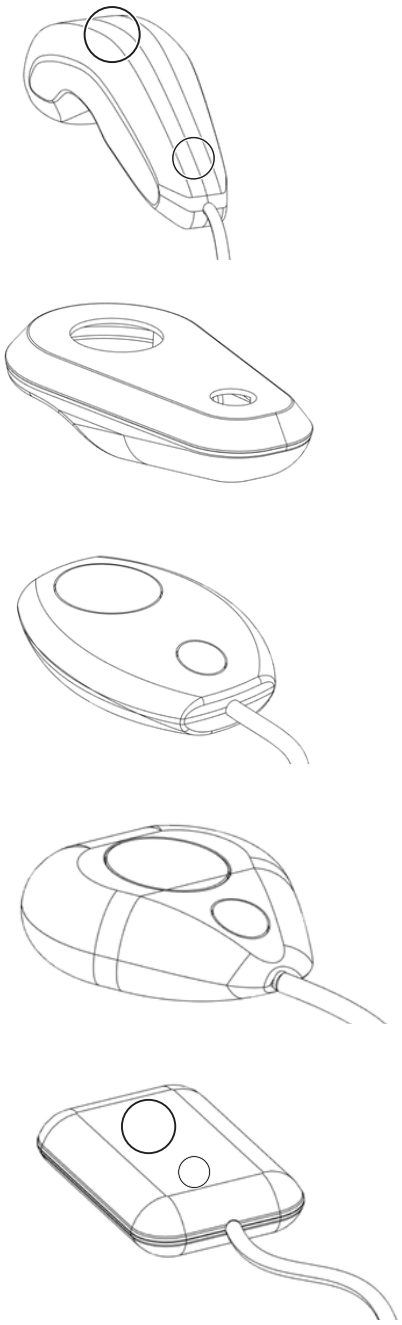
The complete set of data was collected for the patient alarm statistics. The data shows the number of emergencies and fake emergencies that occurred on a specific date and during what work shift.

Date	Work shift time	Fake Emergency	Emergency
2023-01-18	06:45-15:00	3	
2023-01-19	06:45-15:00	5	
2023-01-20	13:00-21:30	2	1
2023-01-21			
2023-01-22	13:00-21:30	5	
2023-01-23	13:00-21:30	3	
2023-01-24			
2023-01-25	06:45-15:00	5	
2023-01-26	06:45-15:00	2	
2023-01-27	06:45-15:00	3	
2023-01-28	13:00-21:30	4	
2023-01-29			
2023-01-30	13:00-21:30	5	
2023-01-31	13:00-21:30	3	
2023-02-01	13:00-21:30	2	1
2023-02-02	13:00-21:30	6	
2023-02-03	06:45-15:00	4	0
2023-02-04			
2023-02-05			
2023-02-06	13:00-21:30	3	0
2023-02-07			
2023-02-08	06:45-15:00	1	0
2023-02-09	06:45-15:00	4	0
2023-02-10	13:00-21:30	5	0
2023-02-11	13:00-21:30	5	0
2023-02-12	13:00-21:30	3	0
2023-02-13			
2023-02-14			
2023-02-15	13:00-21:30	6	0
2023-02-16	06:45-15:00	2	1
2023-02-17	06:45-15:00	5	0
2023-02-18	06:45-15:00	2	0
2023-02-19	06:45-15:00	3	0
2023-02-20	13:00-21:30	4	1
2023-02-21			
2023-02-22	13:00-21:30	5	0
2023-02-23	13:00-21:30	3	0
2023-02-24	13:00-21:30	5	0
2023-02-25	13:00-21:30	6	0
2023-02-26	06:45-15:00	2	0
2023-02-27			
2023-02-28	06:45-15:00	0	0
2023-03-01	06:45-15:00	3	0
2023-03-02			
2023-03-03	06:45-15:00	5	0
2023-03-04	06:45-15:00	2	0
2023-03-05	13:00-21:30	5	0
2023-03-06	13:00-21:30	4	0
2023-03-07	13:00-21:30	3	0
2023-03-08			
2023-03-09			
2023-03-10	13:00-21:30	6	0
2023-03-11	13:00-21:30	2	0
SUM		146	4
AVERAGE		3.65	0.1379310345

Appendix V - Alarm shape and button placement user test

The users were asked to rank eight different physical prototypes by ergonomy and compatibility with the magnetic mount. They were also asked to identify the most and least intuitive button placements for each. Some of the prototypes were similar enough to be grouped for comparison. The button placements are shown on the illustrations themselves. The chart contains rankings of ergonomy, manufacturability, and compatibility with mount

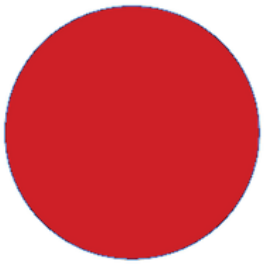
Ergonomy	Mount compatibility	Manufactuarability	Total:
1	**5**	**5**	**11**
2	1	4	7
3	4	2	9
4	3	3	10
5	2	1	8



Appendix VI - Alarm button surveys

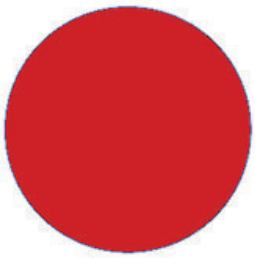
Color association survey questions

Question 1:
The top button is large and red to call paramedics in an emergency. What do you think the little green button is for?

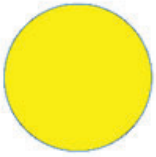


-"everything ok"
-Patient has received help
-Reset emergency alarm in the event of a misprint
-Call staff, not emergency situation
-Turn on/off lamp

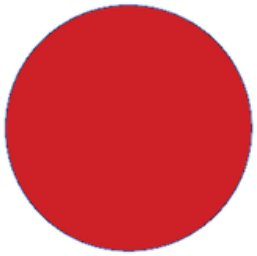
Question 2:
The top button is large and red to call paramedics in an emergency. What do you think the little yellow button is for?



-"everything ok"
-Patient has received help
-Reset emergency alarm in the event of a misprint
-Call staff, not emergency situation
-Turn on/off lamp

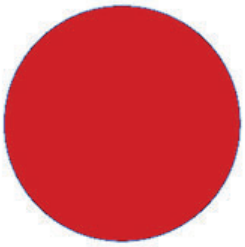


Question 3:
The top button is large and red to call paramedics in an emergency. What do you think the little light blue button is for?



-"everything ok"
-Patient has received help
-Reset emergency alarm in the event of a misprint
-Call staff, not emergency situation
-Turn on/off lamp

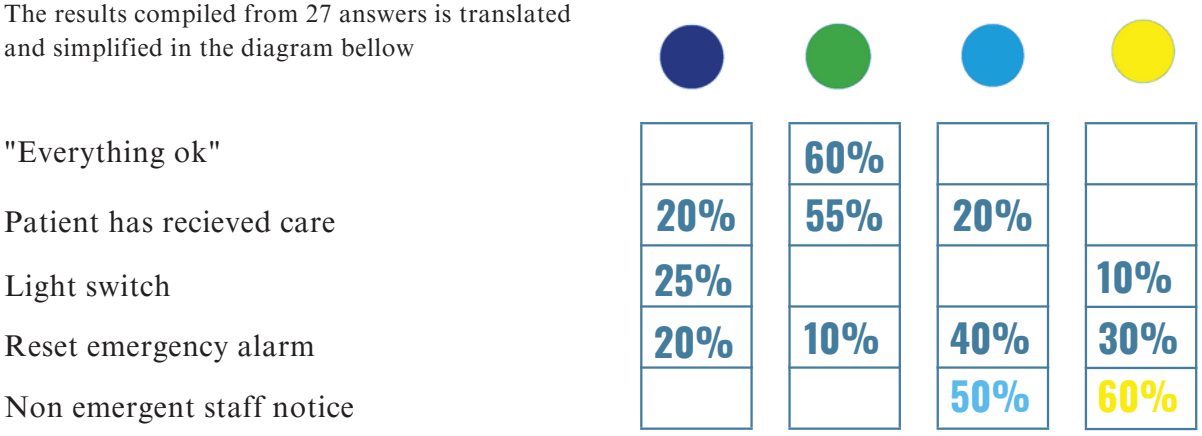
Question 4:
The top button is large and red to call paramedics in an emergency. What do you think the little dark blue button is for?



-"everything ok"
-Patient has received help
-Reset emergency alarm in the event of a misprint
-Call staff, not emergency situation
-Turn on/off lamp

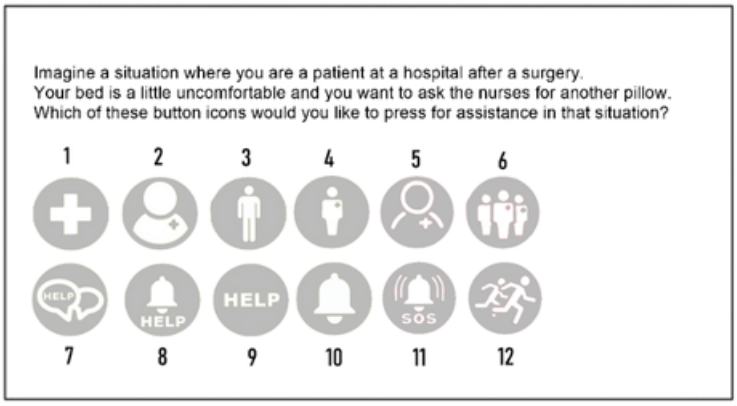
Color association survey results

The results compiled from 27 answers is translated and simplified in the diagram bellow

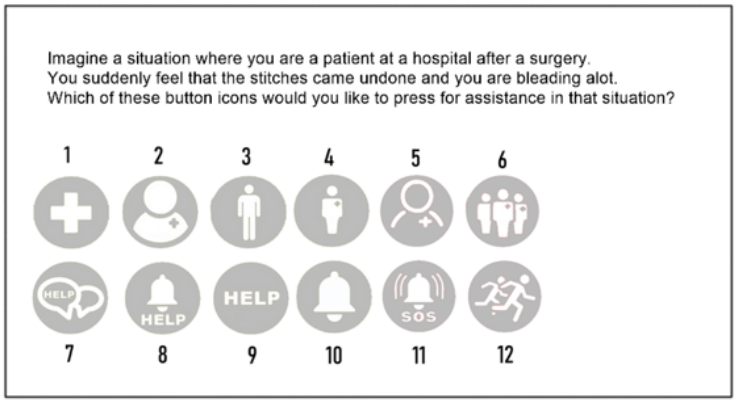


Alarm button icon survey questions

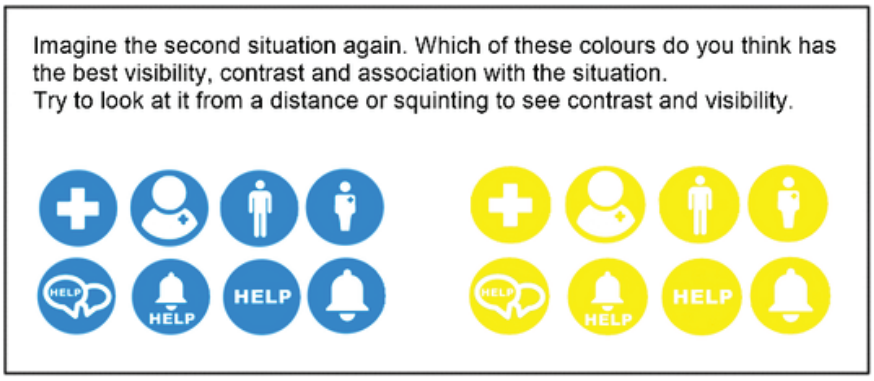
Question 1:



Question 2:



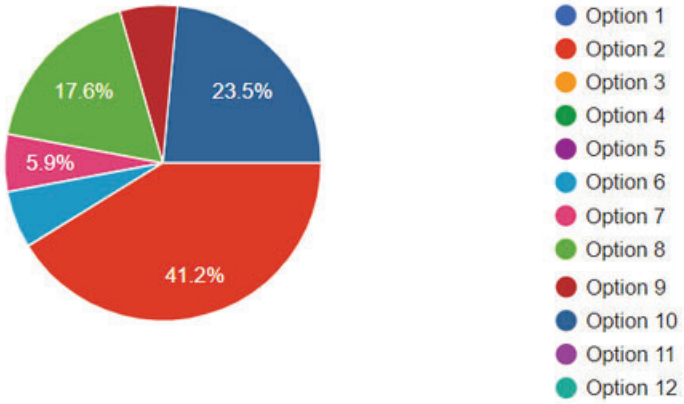
Question 3:



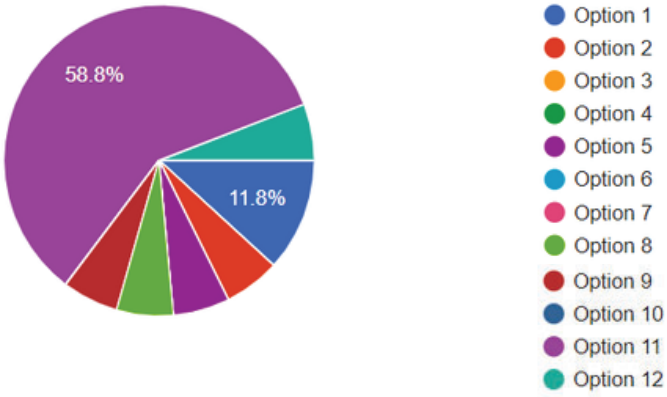
Alarm button icon survey results

The results compiled from 34 answers is visualized in the pie charts below

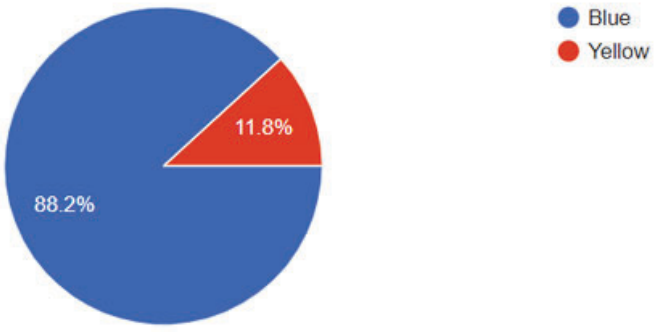
Question 1: Results



Question 2: Results

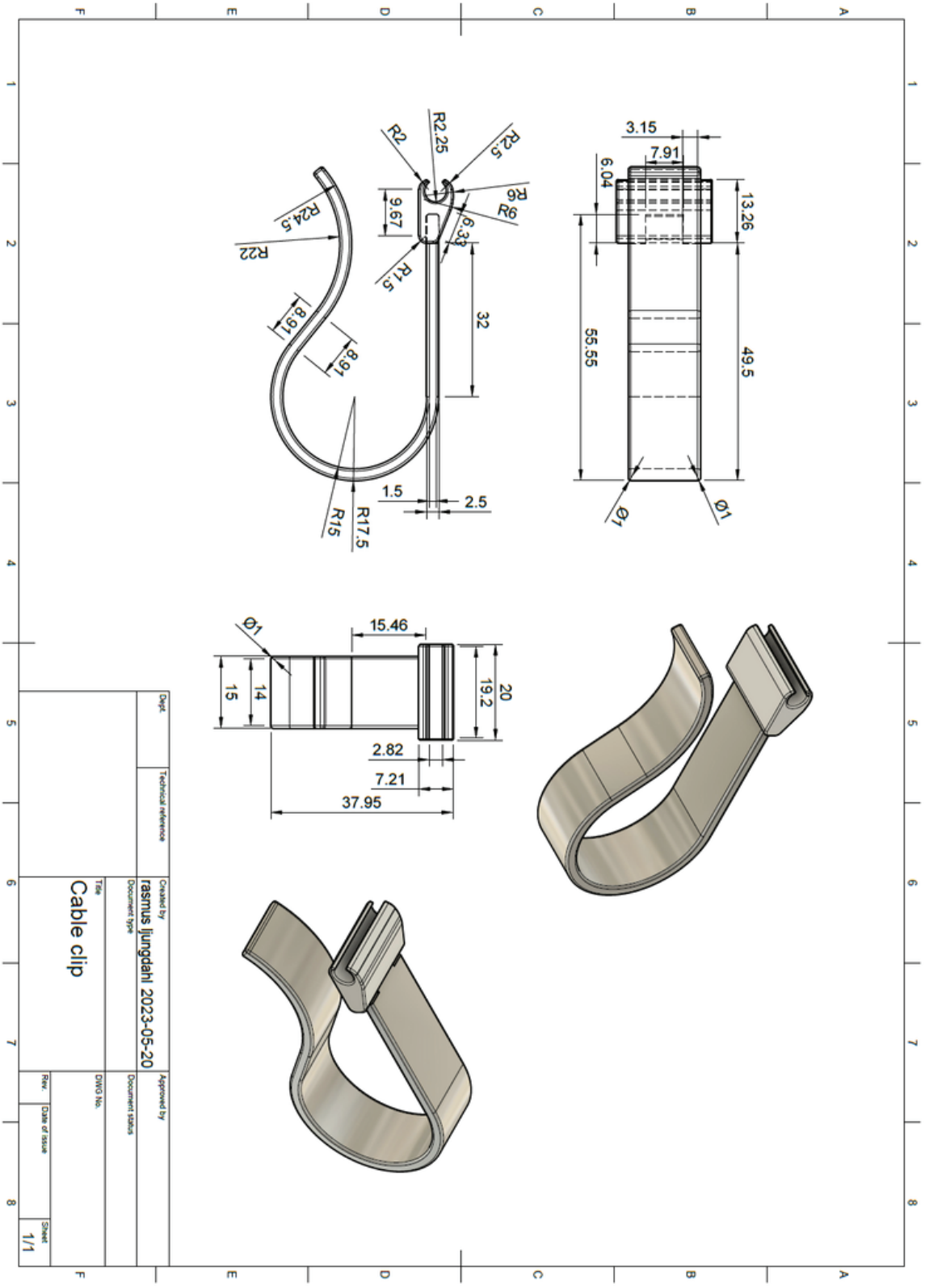


Question 3: Results

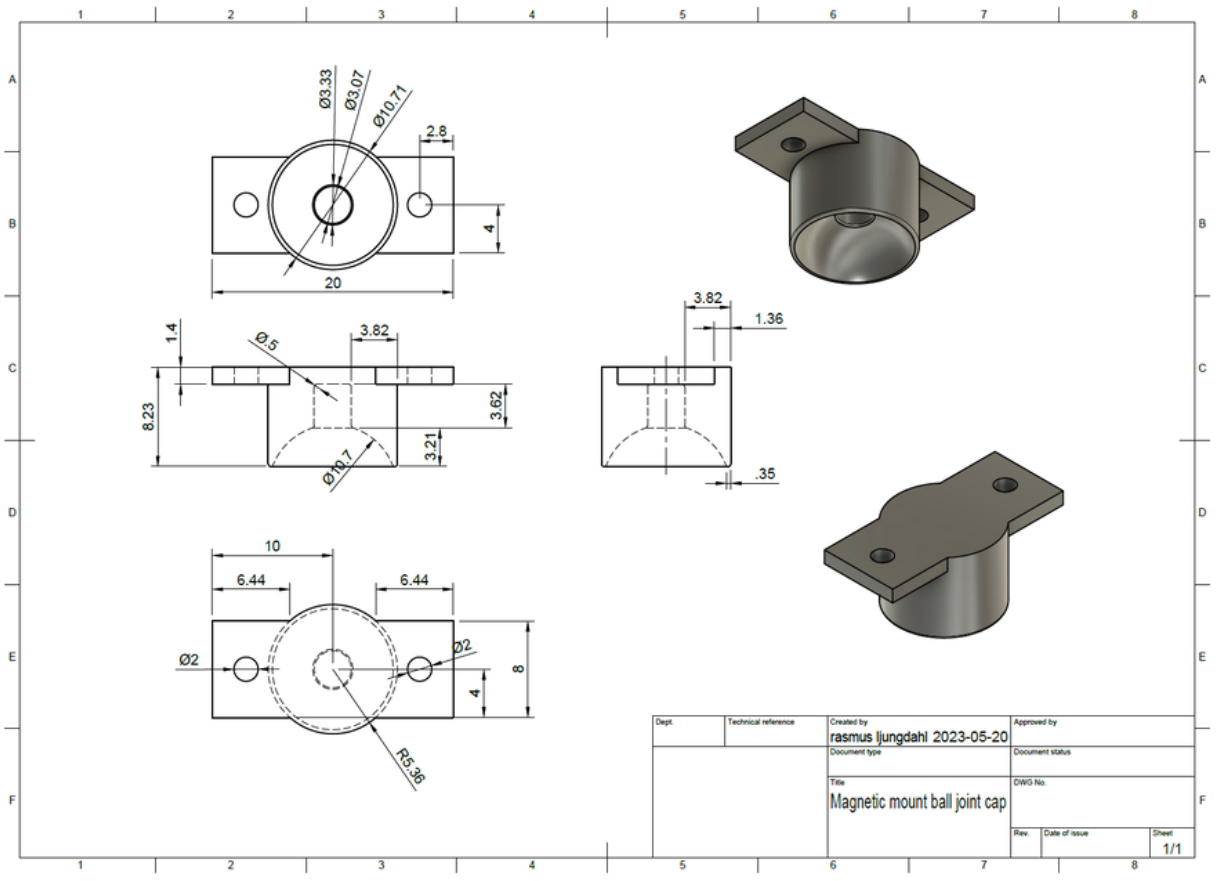


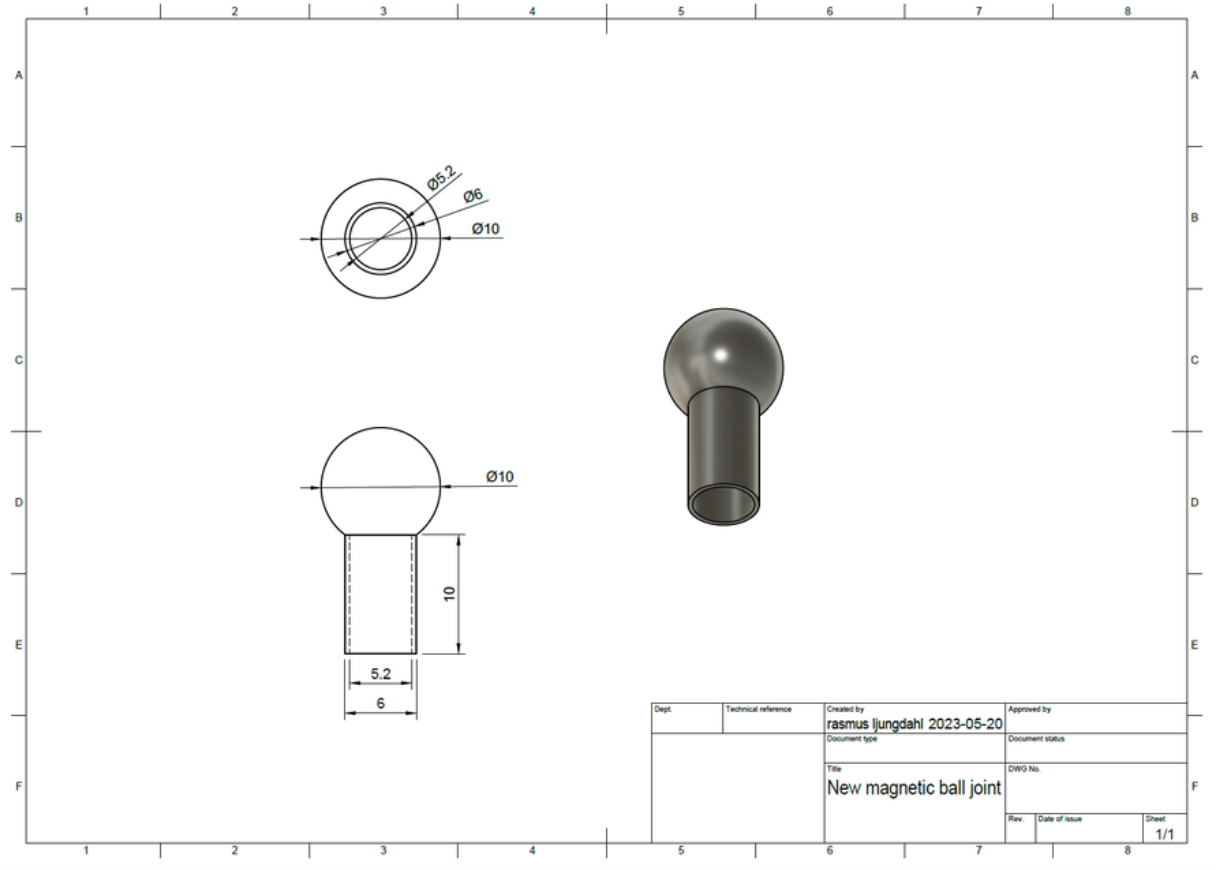
Appendix VIII - Technical drawings

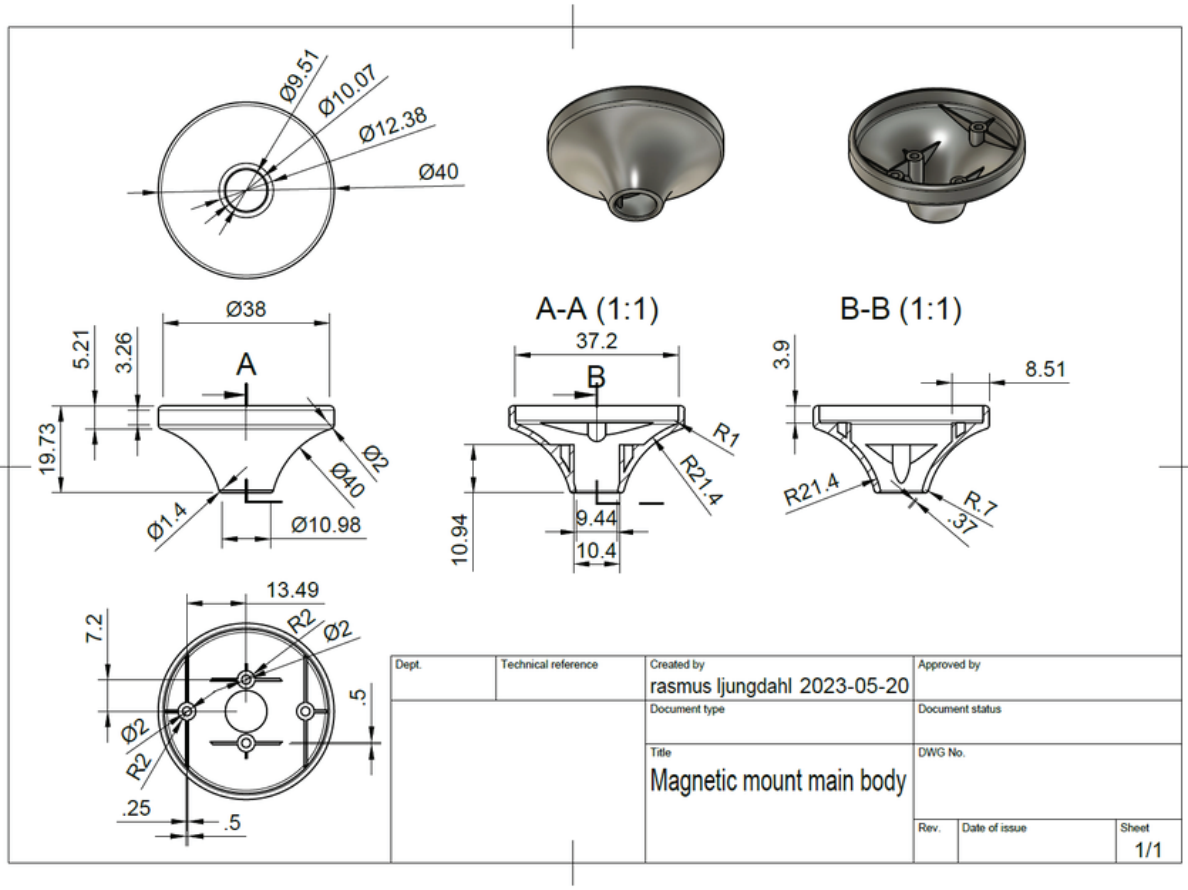
Technical drawing-Cable clip

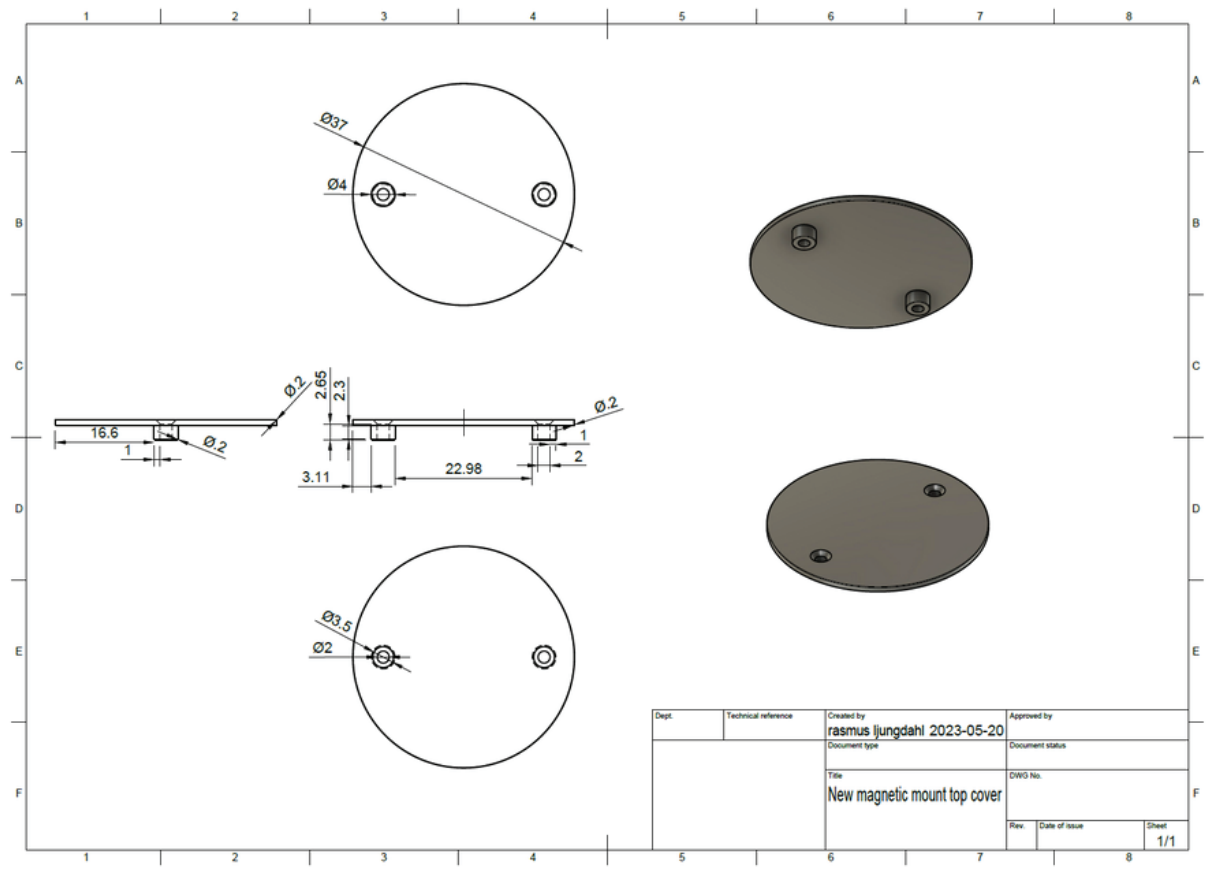


Technical drawings-Magnetic mount






Ø9.51
Ø10.07
Ø12.38
Ø40
Ø38
5.21
3.26
A
19.73
Ø2
Ø40
Ø1.4
Ø10.98
A-A (1:1)
37.2
B
R1
R21.4
10.94
9.44
10.4
B-B (1:1)
3.9
8.51
R21.4
R.7
.37
13.49
7.2
R2
Ø2
.5
Ø2
R2
.25
.5
Dept.
Technical reference
Created by
rasmus ljungdahl 2023-05-20
Approved by
Document type
Document status
Title
Magnetic mount main body
DWG No.
Rev.
Date of issue
Sheet
1/1


Ø37
Ø4
Ø2
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2.3
16.6
1
Ø.2
3.11
22.98
1
2
Ø3.5
Ø2
Dept.
Technical reference
Created by
rasmus ljungdahl 2023-05-20
Approved by
Document type
Document status
Title
New magnetic mount top cover
DWG No.
Rev.
Date of issue
Sheet
1/1

Technical drawings-Alarm device