IT-UNIVERSITETET I KØBENHAVN

Digital Wayfinding Systems: Bispebjerg Hospital

Exploring navigation challenges experienced by first-time or non-regular visitors using current wayfinding systems at Bispebjerg Hospital

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Abstract

Navigation in large and complex hospital environments can be particularly challenging, especially for infrequent visitors. The aim of this thesis is to investigate the challenges that first-time and non-regular visitors encounter using current navigation systems at Bispebjerg Hospital and how digital technology can improve visitors' experience.

Firstly, we reviewed papers from previous studies to examine the findings and related gaps. Secondly, we chose the qualitative method to generate data from recruited participants through in-situ observations and semi-structured interviews. We created eight unique vignettes using three manipulated variables for our participants to perform. Subsequently, we clustered the results using an affinity diagram, identified problems through a diagnostic map, and generated solutions using a virtual map.

The results of our findings indicate that navigating in unfamiliar places with only static signs and maps is considerably challenging for first-time or non-regular visitors who are not familiar with the environment. Inconsistent and similar visual design elements on the onsite hospital maps with overloaded information are one of the main challenges our participants experience.

To improve the navigation experience at Bispebjerg Hospital, we created a prototype for a mobile-based web application following Nielsen's design principles and conducted usability testing. The prototype can be used as a blueprint for the creation of a web-based digital wayfinding solution in the hospital.

Keywords: first-time and non-regular visitors, hospital wayfinding system, prototype, mobile wayfinding systems

Table of Contents

1 Introduction

This section presents the research background on what wayfinding is in today's world, focusing on hospital environments. It discusses the previous empirical studies conducted in hospitals where people try to find their way using current wayfinding systems. For further investigation, we focus on selecting the target group of hospital visitors in our thesis. In addition, we develop research questions to succeed in the research aim, i.e., what are the pain points first-time and non-regular visitors encounter when they try to find their destination inside hospitals and how the technology could improve their wayfinding experience.

Our research examines the Bispebjerg Hospital, which is located in the city of Copenhagen, Denmark. To generate the data from our target users and answer our research questions, we adopt a combination of in-situ interviews and shadowing based on vignette techniques.

1.1 Research Background

The navigation of hospitals, particularly those comprising multiple buildings distributed over a vast location, can frequently pose difficulties for visitors. Although there are current wayfinding systems such as signs, maps, and indicators to assist visitors, these can still be confusing (Arthur & Passini, 1992) and raise the user's anxiety level (Ulrich et al, 2010). In addition, many hospitals requiring expansion need to update their wayfinding systems because they consist of several old and new buildings and are in the middle of renovations. The development of new technology and the widespread use of smartphones can provide users with new dimensions of digital wayfinding solutions (Sadek, 2015). When used in conjunction with appropriate wayfinding design, the implementation of effective signage within hospitals can greatly improve navigability, which leads to an overall enhanced end-user experience. Hence, this research aims to investigate the wayfinding issue at the hospital for the purpose of enhancing the hospital's services and improving visitors' needs with well-designed digital systems that are faithful to the hospital's initial duty.

1.2 Research Questions

The definition of research questions is needed to determine the exact scope of the research as well as its nature. Research questions can be grouped into three categories, *"what"*, *"why"*, and *"how"* (Blaikie, 2009). "What" questions are used to identify and describe patterns and traits. The "why" questions seek to understand the causes and factors that led to the appearance of these traits in a given phenomenon. The "how" questions, on the other hand, are more focused on enacting change through useful results and interventions (Blaikie, 2009). To maintain simplicity and achieve correspondence with the three main categories of research purposes, i.e., description, explanation, and change,

we define our research questions and, therefore, the areas that our project explores, following Blaikie's approach.

As we present in our literature review part, previous studies have indicated that mobile wayfinding applications are quite useful among other wayfinding systems with recommendations to improve the interface design reducing information recognition issues providing up-to-date level information, and providing estimated times for the user's travel (Hughes et al., 2015, p.6). However, rather than the underlying phenomenon regarding the challenges, the current thesis is guided by the following "*change*" question "***How can digital technology improve the wayfinding experience at the Bispebjerg Hospital for first-time and non-regular visitors?****"* while also considering the aforementioned recommendations. To answer the *"how"* question, which is the main research question of our thesis, we need to explore the "*what"* and "*why"* questions that are described below.

We investigate the challenges that first-time and non-regular visitors encounter when they try to find their way inside Bispebjerg Hospital using the current systems. Therefore, our "*descriptive*" question is ***"What are the pain points for first-time and non-regular visitors using the current wayfinding systems to navigate at Bispebjerg Hospital?"***

To explore the causes that it happens, we generated data from the users by conducting in-situ interviews and shadowing to discover the "*explanatory*" question **"*Why do these challenges affect finding a destination in Bispebjerg Hospital?".***

As most of the previous studies focused on a broader target group, namely all kinds of visitors to a hospital, our target users are narrowed to first-time and non-regular visitors at Bispebjerg Hospital. To address the above research questions, we generate data from our target users using the qualitative methodological approach: in-situ interviews (based on an interview guide), and shadowing to understand human practices in a real-world setting (Merriam, 2002). This way we explore the opinions, experiences, and issues of our target users (Hancock et al., 2001). After generating the data, we transcribe, analyze the findings, and apply Jakob Nielsen's theory to design a high-fidelity prototype for our proposed wayfinding digital solution at Bispebjerg Hospital.

The below section presents a review of earlier studies on hospital wayfinding systems, followed by explaining the theoretical framework. The next sections dive deep into how we generate the data, analyze them, and apply Nielsen's heuristic principles to our problem domain. Subsequent sections visualize the proposed solution's interface design by constructing the high-fidelity prototype and validate the usability of the system by conducting usability testing. Finally, we conclude our thesis by presenting our findings, reflecting on our work, and suggesting further research in the future.

2 Literature review

This section discusses and evaluates prior studies relevant to our investigation of digital wayfinding in hospitals. It describes how we searched for papers that emphasize the hospital's indoor and outdoor environments.

In order to present the findings and pinpoint the gaps and limitations of each examined paper, we created tables **(**see **Appendix 1)** that provide critical and brief information about the paper, such as the *title*, *authors*, *published year*, *source*, and *keywords used* to search those papers. Each table also includes information on the methodology used to generate the data, explanations of the findings, and suggestions for future research.

Finally, we summarize the findings **(**see **Table 1)** and identify the gaps **(**see **Table 2)** in the related work that are addressed by this thesis.

2.1 The Search for Papers

The papers were found by using Harzing's Publish or Perish (Windows GUI Edition) software as the main tool to filter the results using *Google Scholar* and *Research Gate* sources. In total, 10 keywords were used; *Digital Indoor wayfinding, Designing wayfinding systems, Wayfinding in hospitals, Digital wayfinding, Hospital wayfinding, Wayfinding system, Hospital wayfinding literature review, Designing digital wayfinding systems, Digital wayfinding in hospitals, and wayfinding.* The keyword search included *titles* and *keywords*. Papers published before 2010 were excluded from the search in order to focus on recent studies. After reading the abstracts, we chose six papers that were relevant to our research questions.

2.2 Related work and findings

Some key findings are that onsite navigation systems such as signage and color-coding might be inconsistent and difficult to read which can create confusion for visitors. In addition, the diversity and volume of information can be fragmented and overwhelming (Hughes et al., 2015). Moreover, digital solutions often delay information loading and lead visitors, especially the older ones, to lose their trust (Morag & Pintelon, 2021).

Mobile apps for wayfinding would be the best fit for hospital visitors (Hughes et al., 2015, p. 4), including diverse users (Prandi et al., 2021). Recommended mobile app features include up-to-date level maps, walk time estimates, and interface design to reduce information recognition issues (Hughes et al., 2015, p. 6). Additional recommendations to enhance the navigation experience and usability of mobile apps are a universal search function, the ability to find a help desk, and a map with appropriate orientation (Harper et al., 2020). We present the findings revealed from the six examined papers **(**see **Table 1)** We categorized our findings based on the related research questions that help us investigate.

Table 1: Findings from related work

Related Research Question	Findings from literature
What are the pain points for first-time and non-regular visitors using the current wayfinding systems to navigate at Bispebjerg Hospital?	• Inconsistent in color and icon signage, creates confusion and information recognition issues for the readers (Hughes et al., 2015, p. 6). • Difficult to read the signage in linking corridors for hints (Hughes et al., 2015, p. 4). • Lack of awareness & information recognition of routes with color-coded (Hughes et al., 2015, p. 4). • Portable devices lack images in real-time & user's difficulty with which orientation to gaze at the loaded image (Morag & Pintelon, 2021, p. 3). • Fixed computerized terminals are hard for older people to use because they find it challenging to perceive the information on screens due to font size (Morag & Pintelon, 2021, p. 3). • Delays in information is where most people find difficulties using digital systems and communication interruption because multiple users access servers at the same time (Morag & Pintelon, 2021). • The success of wayfinding is greatly influenced by environmental elements, including the destination's name practices, the quantity of signage, visibility, and position (Hughes et al., 2015).
Why do these challenges affect finding a destination in Bispebjerg Hospital?	• People (especially older) are more under stress when information is processed slowly and lose trust in technology (Morag & Pintelon, 2021). • Diversity and volume of information can be fragmented and overwhelming (Hughes et al., 2015). • Inconsistent and hard-to-read signage creates confusion for visitors to find directions (Hughes et al., 2015).
How could digital technology improve the wayfinding experience at Bispebjerg Hospital?	• Mobile apps for wayfinding would be the best fit for hospital visitors (Hughes et al., 2015, p.4), including diverse users (Prandi et al., 2021). • Recommended mobile app features include up-to-date level maps, walk time estimates, and interface design to reduce information recognition issues (Hughes et al., 2015, p. 6). Additional recommendations to enhance the navigation experience and usability of mobile apps are a universal search function, the ability to find a help desk, and a map with appropriate orientation. Lastly, the system should match the environment since recognizing surrounding cues makes the navigation experience better (Harper et al., 2020).

2.3 Related Studies and Gaps

Complex environments, such as hospitals with many buildings, should provide individuals with wayfinding aids to find their destinations quickly and efficiently. However, even with the assistance of wayfinding systems, navigation in complex environments that people are unfamiliar with can cause stress and frustration (Harper et al., 2020).

Digital technology can contribute to improving the navigation experience for hospital visitors, and even though some studies have partially reduced the gap in accommodating different user groups using systems in terms of user perspective, design, and how it operates, there is still room for improvement (Morag & Pintelon, 2021). Furthermore, the implementation of new technologies can also present new challenges, such as ensuring that patients and visitors have access to the necessary hardware and software and ensuring that the technologies are intuitive and easy to use.

Most papers in the existing literature suggest the development of a mobile app (Prandi et al., 2021). A heuristic analysis of a mobile application was conducted by four researchers, composed of twenty dimensions and six categories, including language, the effectiveness of wayfinding instructions, consistency between the environment and application, interface interaction, accessibility, and cognitive workload (Harper et al., 2020). The authors recommend a universal search function, the ability to find a help desk, and a map with appropriate orientation as features to enhance the navigation experience and usability. However, there are remaining knowledge gaps with regard to evaluating mobile applications that provide real-time orientation or mapping (Harper et al., 2020). In our thesis, we address the gaps from the above paper and create a prototype following modern design principles. By applying **Nielsen's** heuristic principles and conducting **usability testing**, we verify the usability of our digitalized solution.

Lastly, compared to the approach of the examined papers, our research scope is smaller and deeper. We plan to conduct a case study for a single hospital, delving deeply into how digital technology could improve the wayfinding experience and what the main pain points of the current systems are for first-time and non-regular visitors.

To summarize this section, Table 2 shows the two gaps we identified in the hospital wayfinding literature, their significance, and how they will be addressed in our thesis.

Table 2: Gaps in the Hospital Wayfinding Literature

Gap	Why is it important?	How do we address it?
(1) Lack of knowledge of first-time and non-regular visitors. Previous studies focus on a broader target group, namely all kinds of visitors to a hospital.	Differences in the user group's perceptions of "newcomers vs. those experienced" with the hospital setting," (Morag & Pintelon, 2021, p. 3) vary.	We combine observations, in-situ interviews, and usability testing to gain insights into first-time and non-regular visitors.
(2) Lack of knowledge with regard to evaluated mobile applications that provide real-time orientation or mapping	With the advance of GPS technology, expectations have changed (Hackett, 2017). The ideal wayfinding application would provide real-time location and direction (Harper et al., 2020).	We create a prototype following modern design principles and real-time orientation. In addition, by applying Nielsen's heuristic principles and conducting usability testing, we verify the usability of our prototype.

3 Methodology

After reviewing the literature on hospital wayfinding, it is important for us to generate data from our target users to gain insights into the research aim. This section describes how we generated data using the qualitative approach to identify what challenges first-time and non-regular visitors encounter when using current digital wayfinding systems at the Bispebjerg Hospital and their causes. In the same section, we transcribed and analyzed the collection of data using affinity diagram, diagnostic map, and virtual map to propose a new digitalized solution that enhances the wayfinding experience. Below is a brief explanation of the research method we chose for our thesis.

3.1 Approach

To achieve a comprehensive range of phenomena in our research inquiry, we combined four research techniques for our investigation: vignettes, on-site observation through shadowing, in-depth interviews, and a literature review that was discussed in the previous section. We generated data from our participants to examine how they are involved in different situations in order to understand their behavior. We used the ethnographic approach, as it requires researchers to participate in the day-to-day activities of people in fieldwork (Blomberg et al, 2017). This way, we observed our first-time visitors to see how they interacted when using the current wayfinding systems inside and outside the hospital to know what challenges they faced and why these issues tend to happen.

The main reason we combined the techniques of observations and semi-structured interviews is that during the observations, we gain insights by observing how participants behave or think in that situation from their point of view, and it gives us an opportunity to ask them additional questions related to our observations when we conduct semi-structured interviews (Blomberg et al, 2017).

3.2 Data collection

We conducted an in-depth interview to understand how our users perceive and interpret certain situations while encountering the wayfinding system in Bispebjerg Hospital. To collect the data from our target users, we chose the purposive sampling technique and created a short vignette to empathize with a particular situation (Morrison et al, 2004).

We believe that wayfinding design can provide particularly crucial benefits for users in unfamiliar and complex environments (Kim et al, 2015). Therefore, we intentionally recruited only first-time and non-regular visitors who were not familiar with the current wayfinding systems. In contrast to the random sampling method that aims to include a broad range of individuals across various age groups, backgrounds, and cultures, purposive sampling involves selecting individuals who possess specific characteristics that are relevant to the research question. The rationale behind this method is to gather data from participants who are better equipped to provide valuable insights and information

pertinent to the research objectives (Etikan, 2016). A detailed description of *how* we used these combinations of research methods is provided below.

3.2.1 Vignette

We used vignettes as an initial research design technique to create short narratives before we proceeded with shadowing our participants. Vignettes are short descriptions that are presented to participants to create a realistic situation (Morrison et al., 2004). Each participant was provided with a unique vignette that served as context for making decisions or rendering judgments in actual life situations. (Alexander & Becker, 1978).

3.2.1.1 Vignette Design

Following a similar approach to Van Den Boer, we defined eight unique vignettes (three factors with two values each (2^3) were included in each case) (Van Den Boer et al., 2014). If we include too many factors to define our cases, unique vignettes will rise quickly (Graham et al., 2001). Hence, the manipulated variables we used are ***scheduled appointment, situation complexity*** as task characteristics, and ***available time*** as situational factors (see **Table 3**). The motivation to use the scheduled appointment variable was that visitors are either scheduled or unscheduled, and different information is given in each case. According to Finch, participants get confused and find it hard to remember storylines that include more than three changes (Finch, 1987). Our vignettes might have a change in the story (e.g., participants should first visit the information desk and then go to their final destination). We consider our vignettes either *complicated* or *simple* situations based on whether they include changes in the storyline. Lastly, we added a situational factor, which is the *available time,* because in some cases people need to hurry to find their destination.

Finch claims that stories need to avoid depicting unconventional characters and catastrophic events but instead reflect 'regular' situations. However, it is beneficial to incorporate some 'uncommon occurrences' into the storyline to gain more insights (Finch, 1987). We designed our vignettes as short stories describing typical cases after visiting Bispebjerg Hospital. In some vignettes, we included a few uncommon circumstances (e.g., your hospitalized friend is out of phone battery) to make the situation more complex and make participants ask the information desk to figure out where they need to go (a phone call could give the information otherwise).

Scheduled visitors were those who had an appointment at the hospital and received an email in e-boks mentioning the date, time, location/department, and address. Unscheduled visitors don't have an appointment and usually know the department name or some other information about the department they need to go to (e.g., visit a friend who had appendix surgery). The latter category includes people who either go to the hospital to see a doctor themselves or visit a hospitalized person. Emergency cases are situations where a person

needs to go to the emergency room to see a doctor without an appointment. Upon meeting with the healthcare staff, we were advised to exclude emergency cases from our thesis because they follow some prohibition protocols.

Table 3 below shows the factors and values used to create our vignettes. The column *As expressed in the vignette,* this section shows examples of manipulated variables and how they are expressed in the vignettes we created.

Table 3: Manipulated Variables in Vignettes

Factor	Variables	Manipulation	As expressed in vignette
Task	Scheduled appointment	1. Yes	…you have an appointment in the hospital…
		2. No	…you are asked to visit a friend at the hospital…
Task	Complexity	1. Simple situation	…you need to go to the abdominal department…
		2. Complicated situation	…You need to ask the information desk first to find out where you need to go…
Situational	Available time	1. Plenty of time	…you arrived 40 minutes before…
		2. In a hurry	…you need to hurry because you have 10 minutes…

The vignettes we defined are presented in **Appendix 2**. An example vignette is shown below, with manipulated variables in bold.

Example Vignette

One week ago, Bispebjerg Hospital sent you a note via e-boks requesting additional testing for your health. This note includes the following details (see **Table 4**) and a contact phone number in case you need to change your appointment. Before visiting the hospital, you look up the route on Google Maps and use the hospital website to find the department's address and position information. It is now 10:00, and you should **hurry** to navigate inside the hospital and reach your destination.

Table 4: Details of **Scheduled appointment**

Date	*22 March 2023*
Time	*kl 10:30*
Location	*Tværsektoriel Udredningsenhed*
Address	*Bispebjerg Hospital* *Indgang 60* *Ebba Lunds Vej 44* *2400 København NV*

3.2.2 Shadowing

According to Blomberg, it is believed that in the process of studying human activity in a day-to-day setting, there is a difference between what people say they do and what they really do (Blomberg et al, 2017). We followed our participants as they carried out the vignettes and observed their movements, stares, gestures, and variations in facial expressions as they interacted with the system. At first, we did pilot testing to ensure we capture the information effectively we need and then proceeded with recruiting participants. During pilot testing, we did the note-taking activity so that we can recall while participants finding their way when they started from the East entrance at the site (østlig indkørsel). However, it was hard to remember precisely what we noted down at a specific activity the next day and it resulted in inappropriate decision making missing crucial information. Therefore, we decided to supplement note taking activity using a videotape. We took the consent to videotape from our recruited participants before shadowing and recording them.

3.2.2.1 Observational role, focus & process

We chose the “observer participant” role because it gave us the possibility to interact with our participants while observing how they performed the given vignettes and interacted with existing hospital wayfinding systems. Furthermore, we informed them about our research goals.

Personal focus strategy tends to observe people going through their daily routine/activities (Blomberg et al, 2017). Following the above strategy, we observed how our participants act on the vignettes we created. For instance, in **vignette 4**, we observe the activities after dusk to gain better insights into how our recruited participants used the onsite maps differently during the day and night.

Also, we employed place focus because we want to observe the various activities our participants engaged in a particular location (Blomberg et al, 2017). For instance, we want to get insight into the different systems that our participants used at the Information desk ensuring they reach the department destination instead of getting lost in the middle.

After giving vignettes, four participants were shadowed from the western entrance (vestlig indgang for gående), two from the northern driveway entrance (nordlig indkørsel), one from the eastern driveway near the pedestrian and bicycle bridge (Østlig indkørsel), and two from North-West entrance (nordvestlig indkørsel). Starting from each entrance, we observed their behavior, feelings, and gestures.

In accordance with the "Saydo" axiom (Blomberg et al., 2017), we employed follow-up questions to understand why our participants did not engage with the outdoor system repeatedly. In the subsequent findings section, we present evidence supporting this axiom.

3.2.3 Semi-structured interviews

We conducted interviews to get rich data about our target users' practices and thoughts (*Bjørner, 2015)*. Interviews can be an excellent substitute for participant observation because they enable a thorough understanding of the social actors' interpretations and meanings of their accounts of the social situation (Qu & Dumay, 2011). With the insights from target users' emotions and opinions, we considered the semi-structured interview method to be the proper option for our research *(Bjørner, 2015).* According to *Bjørner "a semi-structured interview guide also allows the researcher to include additional questions in response to participants' answers and reactions to the interview situation" (Bjørner, 2015, p. 87).* To achieve the goal of our thesis about the effectiveness and identification of possible improvements to the wayfinding system in Bispebjerg Hospital, we generated the data from participants who were recruited as first-time or non-regular visitors to the hospital. We utilized purposive sampling methods to select a sample of nine participants based on the variables of our vignette from the data collection. Purposive sampling involves intentionally selecting individuals from a population who are anticipated to possess particular characteristics that are pertinent to the research inquiry. By employing this method, researchers can concentrate on a focused and limited sample size, ensuring that the selected individuals align with the specific objectives of the study (Nikolopoulou, 2022). Since the variables create eight different situations, we needed to recruit eight or more participants to cover all the different combinations.

3.2.3.1 Participants Information

In total, nine recruited participants were asked to perform the activities of written vignettes. Our selected participants were from different age groups ranging from 23 - 44 years old, and of different nationalities.

It is advantageous to have participants of different nationalities because they will have different viewpoints on how they used systems for wayfinding and we address those challenges in our thesis findings.

After observing them, we conducted the interviews inside *Indgang 60* in the lounge area near the kiosk at the hospital site. We took consent from our participants to record the interview process before starting with interview questions from the prepared interview guide. Information about the participants is given in **Table 7**.

Table 7: Summary of participants details

ID	Name	Age	Gender	Nationality	Personal Qualification	Vignette provided	Interview location & Duration
1	kate	25	Female	Danish	Student at ITU	vignette 1	Indgang 60, Bispebjerg 33 min 45 sec
2	Scarlett	27	Female	Greece	Student at ITU	vignette 4	Indgang 60, Bispebjerg 21 min 06 sec
3	John	44	Male	Spain	Employed	vignette 7	Indgang 60, Bispebjerg 26 min 47 sec
4	steve	31	Male	Lithuania	Researcher	vignette 8	Indgang 60, Bispebjerg 26 min 22 sec
5	Dravid	29	Male	India	Researcher	vignette 6	Indgang 60, Bispebjerg 16 min 19 sec
6	Nolan	32	Male	Danish	Student at DTU	vignette 2	Indgang 60, Bispebjerg 24 min 03 sec
7	Jack	23	Male	India	Student at KU	vignette 5	Indgang 60, Bispebjerg 33 min 41 sec

8	Chopra	32	Male	India	Employed	vignette 5	Indgang 60, Bispebjerg 22 mins 40 sec
9	Bae Suzy	31	Female	Korea	Employed	vignette 3	Indgang 60, Bispebjerg 24 min 04 sec

3.2.3.2 Interview guide

We prepared the interview guide with interview questions that addressed our research questions before we began conducting semi-structured interviews. The main goal of the interview guide is to ensure the efficacy of our interviews by providing us with a framework to follow regarding the questions to ask our participants. It also aids in preventing us from veering off course and straying from the scope of our overall research goal. According to Tanggaard and Brinkmann, interview questions can be distinguished into different types as shown below (Tanggaard & Brinkmann, 2015, p. 41).

- **Introductory questions**: Open-ended questions for the participant to express their personal narratives about a situation connected to the research topic.
- **Follow-up questions**: To extend the introductory question by asking participants in-depth relevant dimensions of their narrative.
- **Probing question**: Get a broader understanding of the participant's narration.
- **Direct question**: To obtain a more precise answer to the research question.

Our interview guide started with introductory questions from our recruited participants to express their experiences. For instance, one of our questions was about the navigational experience in Bispebjerg Hospital to reach a destination location.

To keep the aforementioned narrative description alive, we follow up with questions by asking about the various digital systems our participants used or observed during their navigation and whether they found those systems effective and useful in pointing the right direction. This enables us to concentrate on our research questions while listening to what our participants have to say in order to understand the difficulties they encountered when using those systems.

Extended probing questions are framed by fostering a dialogue around a research question to acquire insights into understanding the pain points. For example, when participants report having a negative experience with the current systems, we create extended questions to inquire about the particular challenges they encountered. (e.g., asking participants for details about the features in a system).

After observing the various activities that our recruited participants were completing, we conducted semi-structured interviews using an interview guide on-site in Bispebjerg.

Appendix 3 shows our interview guide, where we made a distinction between our research question and the interview questions (Tanggaard & Brinkmann, 2015). Considering the interview's duration, each semi-structured interview lasted between 16-33 minutes.

3.3 Data analysis

In this section, we present the methods for our qualitative data analysis, which involves data from multiple sources, namely previous studies, observation with shadowing, and in-depth interviews. We use a thematic analysis approach to identify patterns from users in the data (Braun & Clarke, 2006) by manipulating different variables, and these variables are organized into each keyword to answer our research questions.

We begin our analysis by transcribing and coding the data from in-situ observations and in-depth interviews, for example, videos, voice recordings, and observation notes. We then review the documentation of takeaways (see **Appendix 4**) multiple times to identify different categories. As a next step, we compare them with the findings from previous studies to analyze similarities and differences. Through this process, we identify several key findings related to our research questions. These findings include various factors such as hospital maps, information boards, and outdoor/indoor signages which can affect the wayfinding usability for first-time and non-regular visitors at Bispebjerg Hospital.

Overall, our qualitative analysis provides a rich understanding of navigating experiences and user perspectives of nine participants and contributes to the broader literature on wayfinding system design for hospitals.

Below, we describe each strategy we use to analyze our empirical data in detail, with an affinity diagram that focuses on grouping the data according to various keywords and the diagnostic and virtual maps for identifying the problems and potential pertinent solutions.

3.3.1 Affinity Diagram:

The affinity diagram derives insights from a large amount of research data by breaking down data into parts which helps to form a coherent insight (Holtzblatt & Wood, 2005). The generalization is done to identify and cluster similar data so we can differentiate the research data into categories which can be useful to develop the themes.

After we transcribed and documented the key takeaways from our participants' data, we chose to bring the ideas of what each of our participants told us during our interview with regard to a single aspect. This way, the affinity diagram helps us provide an overview of our findings and identify coherent data from our participants.

Following the approach of Holtzblatt, our affinity diagram **(**see **Appendix 5)** is created physically using Post-it notes (Holtzblatt & Wood, 2005). The steps we follow to create the affinity diagram are listed below.

Step 1: Each person reads a different section of the interview data and finds texts where participants express feelings, issues, and motivations.
Step 2: Make affinity notes on yellow Post-its. Each note includes a single observation found in the data.
Step 3: As a group, we cluster post-its by the apparent similarity. Similar observations are placed in a single column.
Step 4: We use a blue Post-it note to label every cluster and place it at the top of the column.
Step 5: Group labels that seem to have related themes.

The keywords are shown in the first column and represent the current wayfinding systems visitors use to navigate at the hospital along with the recommended digital wayfinding systems from our participants i.e. mobile-based web application. The second column includes the shared takeaways from our participants which are categorized into drawbacks and benefits for each keyword. These two categories help us further investigate our Research Questions. Drawbacks of wayfinding systems give us insights into "*What are the pain points for first-time and non-regular visitors using the current wayfinding systems to navigate at Bispebjerg Hospital*" and "*Why do these challenges affect the navigation experience of finding a destination in Bispebjerg Hospital?*" questions, while benefits help us with the analysis and design of our solution and therefore with the question "*How could digital technology improve the wayfinding experience at the Bispebjerg Hospital for first-time and non-regular visitors?*".

3.3.2 Diagnostic Map:

Diagnostic maps are an effective technique that focuses on diagnosing problematic situations (Bødker et al., 2008). This map outlines the *Problem*, *Cause*, *Consequences*, and *ideas for a possible solution* for a problematic situation (Bødker et al., 2008, p. 305). To correct a problematic situation from clustered information in affinity diagramming, we used diagnostic cards on the digital visual team collaboration platform "Miro Board". The template for the diagnostic card is inspired from Bødker and is represented in Figure 1.

Problem	Cause	Consequence	Ideas for solution

Figure 1: Template for the diagnostic card

Firstly, we chose a problematic situation from an affinity diagram, and then we derived the situation in the form of a theme or over the script for the diagnostic card. The same

process is repeated throughout all problematic situations. Following this approach of Bødker, we created four columns on the diagnostic card (see **Appendix 6**):

1) **Problem**: This highlights the difficulties the participant encountered when navigating the hospital environment using different systems. The issues highlighted can help to elucidate our descriptive research question.
2) **Cause**: This column highlights the reasons for the challenges faced by the participants. This contributes to addressing the explanatory research question.
3) **Consequences**: It explains what the causes might lead to. We brainstormed different ideas that affect the participant's problems.
4) **Ideas for solution**: This recommends possible solutions that mitigate the current problems for first-time visitors. We used the "How might we" technique (Nielsen, 2023) to generate different ideas for a specific problem to address our "change" research question.

3.3.3 Virtual Map:

Virtual maps have a similar approach to diagnostic maps with a focus on problematic situations, however, diagnostic maps focus on analysis and diagnosing the problems, whereas a virtual map is forward-looking where the focus is on "how to get out of the problematic situation" (Bødker et al., 2004, p. 282). Inspired from Bødker, the template we used for the virtual map is represented in Figure 2.

Ideas for solution	Actions	Consequences	Evaluation

Figure 2: Template for virtual map

In a diagnostic map, suggested ideas are analyzed in connection to the problems found and actions needed to realize each solution and its possible consequences. In a virtual map, the feasibility of each solution is assessed, this can be through the columns in **Figure 2**, namely *Ideas for solution*, *Actions*, *Consequences*, and *Evaluation* (Bødker et al., 2004, p. 283). Detailed descriptions of each column are described below.

- **Ideas for solution**: The ideas from the diagnostic map serve as a starting point in this column which includes design ideas and broad future situations that others would notice (Bødker et al., 2004).
- **Actions**: Different actions need to be performed to initiate an implementation for a specific idea.
- **Consequences**: This is directly proportional to the actions specified. It ensures the resulting situation is evaluated to justify whether it solves the original problematic situation (Bødker et al., 2004).
- **Evaluation**: It focuses on high-level business aspects related to the estimation of costs and benefits associated with the implementation of the proposed idea.

The virtual map (see **Appendix 7**) provided us with knowledge of what ideas or solutions to consider before we implement our prototype. The themes we identified from our participants' data are covered in the next section.

4 Findings

This section discusses the review of data collection through on-site observations, in-situ interviews, and a literature review for addressing the “How” research question based on “what” and “why”. In addition, we present the findings of our study, including a detailed examination of three main themes through a diagnostic map. The diagnostic map enables us to identify the underlying causes, consequences, and potential solutions for various issues with the hospital wayfinding system. We also discuss the elaboration of these solutions and the feasibility of prototyping for future implementation.

Firstly, based on the data analysis in the previous section, three themes are identified: **Design**(**4.1**), **Informative**(**4.2**), and **Technical**(**4.3**). These themes are developed based on the keywords and findings in the affinity diagram and analyzed in the diagnostic map. At this stage, we return to the interview takeaways from our empirical data to focus on answering our research questions and providing an overview of the key findings.

Secondly, we provide justification for our findings pertaining to the “SayDo” axiom by explicating the dissimilarities in participants’ responses and how they performed each vignette. Specifically, we examine the effects of eight distinct variables on participants’ behavior, elucidating the nuances of their reactions and reinforcing our prior conclusions.

Next, we summarize the possible solutions based on the virtual map before heading to the design phase, namely prototyping. This will address the change research question.

4.1 Design

The findings from our diagnostic map indicate that the effectiveness of the wayfinding system is influenced by several design factors, such as visibility, simplicity, legibility, and consistency. These factors were found to be the most critical in the wayfinding design, not only in the effectiveness of navigational activities but also in the overall impression of the hospital. Based on our interviews, a simple layout and clear visual design were essential in helping them navigate and find their destinations quickly and efficiently. In addition, participants reported that a consistent color scheme, typography, and symbols throughout the wayfinding system also helped them understand the hierarchy of information and identify important landmarks, paths, and destinations. However, some participants also noted inconsistencies in the use of symbols and signage, which led to confusion and misinterpretation of information. Therefore, ensuring that design elements are **consistent** and recognizable throughout the wayfinding system could improve its effectiveness. However, participants noted that certain indoor areas were poorly designed, which made it difficult to read the signage and symbols. Therefore, enhancing visibility in these areas by improving color contrast and increasing the size of the signage and symbols could improve the effectiveness of the wayfinding system.

By incorporating the above design factors in the visual design of wayfinding plans, their effectiveness, and usability can be significantly enhanced.

4.1.1 Layout

The primary design challenge can be seen on the hospital map and information board (see **Figure 3**) at the beginning of the navigation journey. These two types of outdoor wayfinding designs represent essential information about all departments and their locations to guide visitors through a complex hospital environment.

Figure 3: *Map and Information Board near the North Entrance in Bispebjerg Hospital (source: Bispebjerg Hospital)*

However, it is difficult to ensure that the map strikes a balance between containing enough information and maintaining a simple layout design to provide an effective wayfinding experience. From the in-depth interviews and observations, we discovered that most participants were uncomfortable with the map for searching destinations because the overwhelming visual elements were mixed in a single space (see **Figure 4**). This is also related to cognitive impairment, which can differ for each person.

> "*It was really huge, and that was extremely confusing to look at to find. Because it has two numbers on it. I believe that it was the street number and entrance number and it was confusing." (Participant ID1)*
>
> *"It's hard to remember the map. Wait. first, I will take a picture on my phone."* *(Participant ID7)*
>
> *"...Too many numbers and many buildings. It is difficult to understand… There is no intuitive system where we go from this red spot towards…" (Participant ID4*

According to *Vanden*-Eynden & Calori *(Vanden*-Eynden & Calori, 2015), the concept of *"sign typing"* can reduce the complexity of the number of sign units by grouping them into standardized sign types. This concept could be helpful to provide a clear and concise location for users to decide their direction.

Figure 4: *Participant ID7 had difficulties understanding the hospital map due to too many visual elements such as entrance number, street number, and symbols with various colors. (Source: near building 31A, Bispebjerg Hospital)*

4.1.2 Visual Elements

Using consistent visual language throughout the wayfinding system can help visitors understand the hierarchy of information and identify important landmarks, paths, and destinations. For schematic wayfinding design, **visibility** should be taken into account first; for example, contrast can increase the visibility of visual elements by using contrasting colors for text, backgrounds, symbols, and signage. As we observed Participant ID7, he got confused with multiple “i” symbols, where most of them are light gray and one is black. The symbol “i” on the map (see **Figure 5**) was black and overlapped with the building color, making it hard to recognize.

> *“I was matching the Vejno color (black) with the entrance number color as it’s written big here which is blue in color. That’s what I figured with color similarity…” (Participant ID7)*

> **“***I was confused with sign notation. Here in paper map they showed vej.no bigger and in static map it was very smaller. (Participant ID7)*

Hierarchy standard is another factor, where organizing information based on its level of importance, such as using larger fonts or bolder colors for critical information, can help users identify key landmarks or destinations (*Vanden*-Eynden & Calori, 2015). Therefore, the signage design should follow a logical flow as it should be placed in a sequence and correspond to the order of the areas people need to visit.

> **“***I was confused with sign notation. Here in paper map they showed vej.no bigger and in static map it was very smaller. (Participant ID7)*

While visitors are navigating the hospital, they can encounter various colors, symbols, and typography, which are packed into signage (see **Figure 6**). Although the color code and symbols are applied consistently to different types of signage, visitors are not aware of the meaning of each informational graphic.

Simplicity can improve navigation by presenting essential information in a simple and uncluttered design, while consistency in the use of color, typography, and symbols throughout the wayfinding system can improve the overall visual design (Kalra & Lightner, 2020).

> “ *The system should be simple… I want it to show only the information I am interested to learn*”*(Participant ID3)*

Figure 5: *Participant ID7 confused with different "i" symbols on the map with different colours. Recognizing "i" near entrance 60 is difficult as well because of the overlapping colour between the background and symbol (Source: Bispebjerg Hospital).*

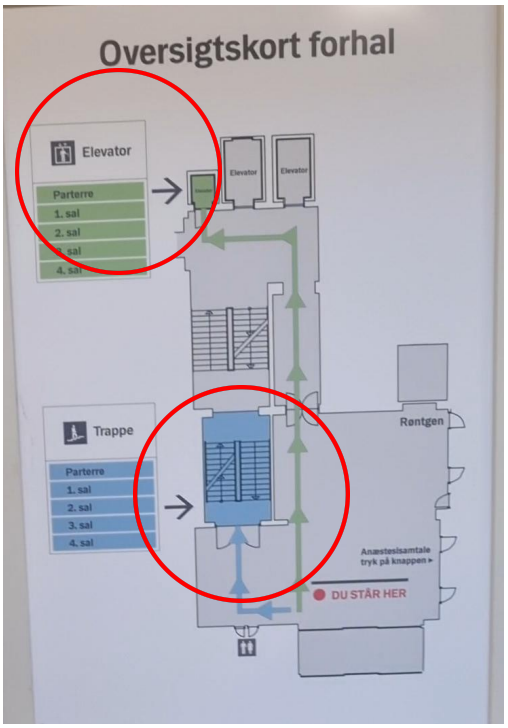
Figure 6: *Most participants are not aware of the difference in the interpretation of the color code on the signage (source: Bispebjerg Hospital).*

4.1.3 Indoor Signage

From our data analysis, it was determined that indoor signage has primary design issues with the wayfinding systems at the hospital. The majority of participants didn't notice the color code (see **Figure 7**) and arrow signs (see **Figure 8**). **Legibility** is crucial, and it can be achieved by using clear and legible fonts, appropriate font sizes, and spacing.

> " *I didn't notice that. It should have clear signs for indoors…" (Participant ID3)*
>
> "*I found the floor easily, but there were a bunch of doors they are not indicated well.*"
>
> *(Participant ID6)*

In this part, we recommend that the current indoor signage (see **Figure 7)** could be improved since visitors tend to depend on on-site information for indoor navigation. Although we decided to focus on the digital solution, the indoor signage could benefit from more straightforward visual design techniques, such as using contrast color and a larger font in a clearer wayfinding design plan.



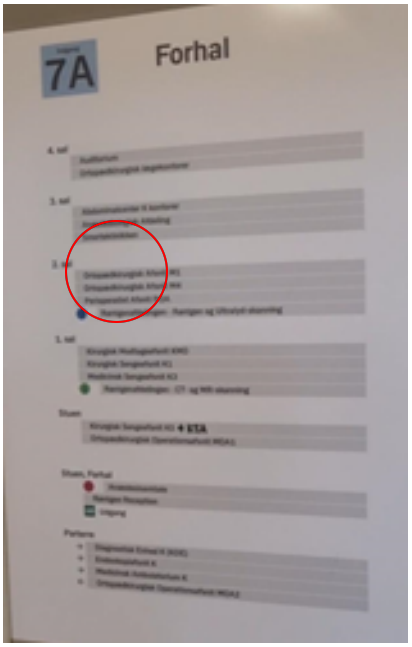


Figure 7: *Participant ID3 didn't have intuitive awareness of the indoor signage due to too small font size and narrow spacing (source: 7A Entrance Bispebjerg Hospital)*

Figure 8: *Participant didn't recognize the arrow signs and the yellow dots on the ground because of its position and improper visual elements(size, shape) (Source: 7A Entrance Bispebjerg Hospital)*

4.2 Informative

This theme explains the difficulties visitors encountered at the hospital in understanding the information present on the existing systems. We identified four sub-themes: Firstly, we discuss the impact of language on visitors' navigation experience. The second theme highlights the challenges related to the information board (see **Figure 9**) at the hospital

site. The third theme discusses participants' feelings when they couldn't find the necessary information on the information board. We also discuss our observational findings regarding participant behavior.

4.2.1 Language barrier

Six out of nine participants have a challenge with translating the language from the information board (see **Figure 9**) at the hospital site.

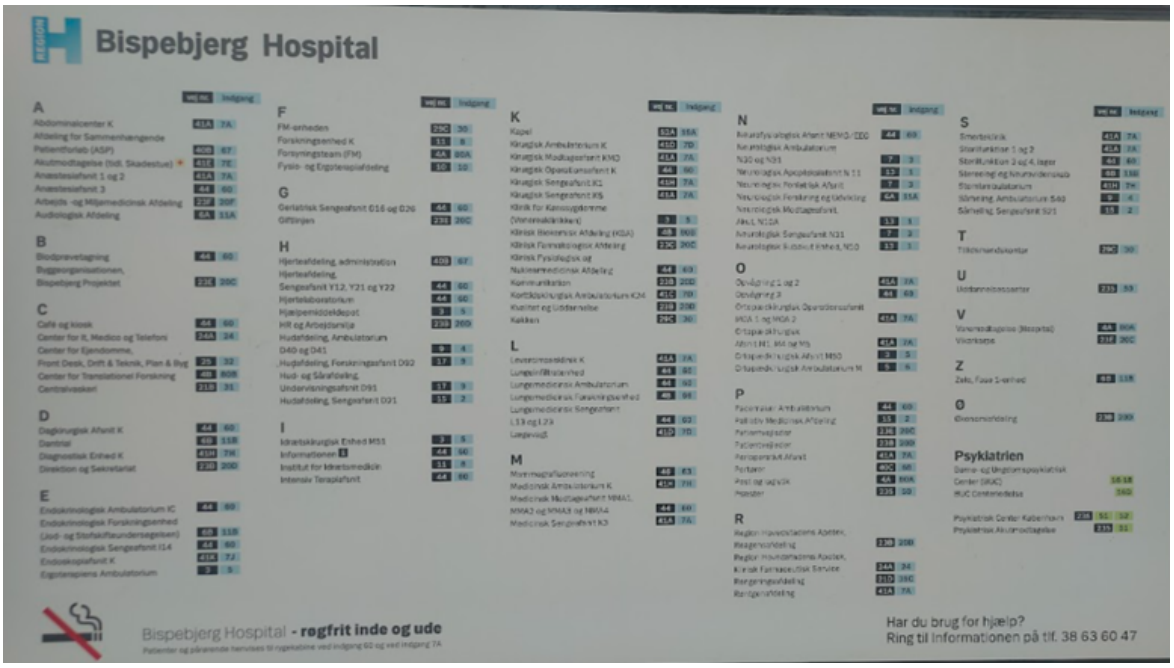


Figure 9: *Information Board at NorthWest Entrance available in Danish (Source: Bispebjerg Hospital)*

When the participants were given the vignettes, we started shadowing them starting from different entrances and the first choice for most of our participants was the hospital map & information board. This theme was one of the first challenges our participants experienced when they tried to understand the information displayed on the Information Board (see **Figure 9**).

For instance, in the interview transcription sequence, *Participant ID7* mentioned

> "*I can use a mobile device to translate Danish...because I don't know Danish a lot, so this is my go-to...I need to look for a big board so to find out where pathology department is there…*" (*Participant ID7*)

Participant ID7 translated the content written in Danish using a mobile device through the web. He also stated that he is not familiar with the Danish language and that's one of the reasons he opts for translation. Additionally, he was also a bit tired of translating every

time he came across the Information Board & street board (see **Figure 10**) at multiple places (e.g., Akutmodtagelse at 7E indgang & Rengøringsafdeling at 31c indgang)

On the other hand, *Participant ID1* didn't have any issue as she was familiar with the language.

> "…*I'm Dane, So I was only looking at the department name. I was able to see the blood and information desk symbols on the map...*" (*Participant ID1*)

Here we noticed that Participant ID7 knows the native language to a little extent but is not very familiar which makes him dependent on using web translation. However, *Participant ID1* is native, and she didn't have any challenges regarding language. Therefore, we emerged a new sub-theme "Language Familiarity," from the subtheme which is the language being a barrier.

Additionally, *Participant ID6* recommended that having an alternative language option alongside the local language would be better.

> "*It is not easy, it's a big place…definitely it's helpful knowing Danish. I never thought before that they only have Danish descriptions on the information board which is a bit surprising…I also kind of think that they had English names…I'm assuming it will be a lot harder, English would be easier for others…" (Participant ID6)*

From one of the above participants, language was one of the problems for the non-native speakers and familiarity is also linked to it. This gives an overview to address the language problem by providing an opportunity for the visitors to select their preferred language through our digital solution.

Figure 10: *Street signage near the Entrance 6 (Source: Bispebjerg Hospital)*

4.2.2 Overloaded information

This theme was developed when we asked participants about the challenges they encountered using the information board system throughout their wayfinding experience. It gave us one of the reasons why textual information on the information board (see **Figure 9**) is hard to read. For instance, the interview transcription from one of the participants is given below.

> *"Ah it looks weird…why is this overloaded? so much information. This really makes me confusing now haha…" (participant ID4).*

Too much information in a limited space is one of the primary reasons that makes it hard for visitors to discover where the destination department's name is located on the information board. From observations, we also noticed changes in their facial expressions that make them a bit annoyed and confused.

To address the above challenge, we could use a search function in the digital solution as discussed in the below technical theme that allows us to directly search via department name, entrance number, street name, street number, etc. so that only precise information can be displayed.

4.2.3 Missing information

This theme is developed based on vignette 5 where we intentionally designed to observe how participants act in finding "Pathology Research Unit" which is not available on any of

the systems such as the hospital map, information board, or street signage at the hospital site. This gave us an insight into what different systems or services our participants used, and we also got insights into the benefits and drawbacks of using those services. For instance, one of our participant's described:

> "*There is a pharmaceutical department, physio, psychiatry, and skin research department. But there is no pathology here…*" (Participant ID7)

Also, after noticing that the information was not available, he misinterpreted the given vignette and decided to move towards the dermatology department. For instance, vignette 5 mentions that research work is in the pathology department, whereas the work is related to treating dermatological conditions.

> *"…Pathology department is not described in map board. Here I could see dermatology in task, so I think I need to go to dermatology department for skin conditions…"* (Participant ID7)

> *"It was a bit hard to find pathology department here. I think pathology department is set up newly I think so…not sure, and the information was not so well mentioned in the maps and in the campus. I mean it took me a long time to actually find…"* (Participant ID7)

As we observed, the overall journey took 40-45 minutes given a vignette of limited time and a hurry situation. We noticed that the unavailability of the information on the systems showed an impact on their journey time. This gave us insights to emerge a new subtheme "Time" from the "Information Unavailability".

Although there are different causes why information is missing, one could be that the system is outdated and another reason might be due to limited space as described in the above 4.2.2 theme (from our participant's data). However, this issue can be addressed through the implementation of a digital system where it incorporates all the latest hospital database information for department names. So, in our prototype design section, we address this by selecting a department name that is missing and providing the necessary information.

4.2.4 Explanation of medical terms

It was a recommendation that our *Participant ID6* suggested when we asked about the challenges he faced performing vignette 2. Even though the participant found his way, it took him some time. He recommended being in the shoes of others with the situation he experienced.

> *"...I was thinking of different cases where it ends and stuff. If you don't know sort of medical terms or what kind of procedure is for way or have any clue about that. You*

will struggle a lot because the map is just with departments and entrances. So if u don't know what procedure is done at what department then you're sort of screwed if you don't figure out that you can just go the information desk and get help…"(Participant ID6)

Non-scheduled visitors often encounter difficulties navigating the hospital site due to imprecise or incomplete information regarding entrance numbers, street names, and department names. This lack of clarity can make it challenging for these visitors to determine which procedures are carried out in a specific department, particularly if they are unfamiliar with the department names displayed on information boards. In contrast, scheduled visitors typically receive clear descriptions in advance and may not experience the same challenges.

This gives us insights into addressing issues regarding familiarity with medical terms in our prototype design, where we try to provide a clear description of the department, and what procedures are carried out. For instance, the *Department of Orthopedic Surgery at Bispebjerg Hospital handles the treatment of disorders in the musculoskeletal system caused by injuries, illness, or as a result of congenital disorders.* Therefore, we use the existing "Bispebjerg Hospital" website and explore the data so we can present it in our design.

4.3 Technical

This theme explores the recommendations we have from our participants regarding a digital solution that could improve the navigation experience at the hospital. More specifically, three sub-themes are identified. Initially, we investigate participants' ideas about the navigation function, which is the main system functionality. Furthermore, we discuss the easy accessibility using a QR code, and participant insights about user registration and authentication.

4.3.1 Navigation

The navigation function is typically the main feature of digital wayfinding solutions and the main aspect we need to investigate to answer our change question. Upon analyzing the findings, we identified two partial features that synthesize the navigation function- *Live location* and *Search function*.

According to all participants, it is very important to know their live location and the distance from their final destination. All participants who used Google Maps mentioned the primary advantage of its live location feature, which includes an arrow indicating directions. Conversely, participants who relied on the on-site map reported difficulties in memorizing the map and identifying their current location. As a result, they resorted to taking a picture of the map and verifying their route using building numbers and outdoor signage.

“Google Maps is easier because you can see your position and destination and estimate the time to get there” (Participant ID5)

“...it is important to know your location live-time and arrows indicating where you have to go.”(Participant ID3)

Most of the participants claim that a search by keyword function (department name, street name, etc) selecting the starting location and destination would be the optimal option. Scheduled visitors can use Google Maps with the exact address, whereas unscheduled ones find it hard to use because Google Maps is not always accurate by searching with keywords.

“First thing, I would search with department then I look for departments with building numbers or vej numbers…It will also be better if it has smart suggestions…Also, I believe it’s more trustworthy…” (Participant ID7)

“The search function can definitely be a plus!” (Participant ID6)

“…I would rather navigate by the actual department name than the street name.” (Participant ID1)

“...Important features for an application would be the search by department and estimated time to your destination...” (Participant ID5)

A map feature with appropriate orientation and a universal search function in a mobile application concept is also recommended by (Harper et al., 2020) to enhance the navigation experience, while a walk time estimates feature (ETA) is recommended by (Hughes et al., 2015, p.4).

The above findings from interviews and a literature review can be used in our digital solution to improve the navigation experience at the hospital and answer our change question. Therefore, based on the virtual map, our indicative solutions are to implement a real-time location, an estimated time of arrival feature (ETA), and a smart search function allowing visitors to search destinations by keywords.

4.3.2 Easy access via QR code

The vast majority of our participants considered accessibility to be important, stating that downloading the new application is an additional step and they probably wouldn’t use it They also recommended easy access by scanning a QR code, which can eliminate the need to download the application.

“Downloading another application is an additional task…” (Participant ID5)

“There is an overview map to get an overview, and then a QR code for the further interactive map. It will be good.” (Participant ID9)

“If I have to download only to navigate the hospital location, I would not want to download an application..." (Participant ID9)

To address visitors' second thoughts about using the digital app, we need to ensure that access to the application will be easy. Therefore, the QR code scanning feature is very useful and should be implemented. The application should be web-based to eliminate the need to store it locally on the device.

4.3.3 User Registration & Authentication

Creating an account and logging in to the system are typically necessary steps. Based on the interview takeaways, participants are discouraged from using a hospital wayfinding application that requires visitor registration and login and consider it annoying. They also claim that these are additional tasks and would prefer to use the current on-site wayfinding systems rather than spend too much time registering and logging in. Additionally, one participant mentioned that he would not like to share credentials to use a navigation system in a public place.

“I don’t think users need to share their third-party credentials in the system because the hospital is a public place…” (Participant ID7)

“If I have to download and login only to navigate the hospital location, I would not want to download an application." (Participant ID9)

“Register and log in the application is annoying” (Participant ID9)

Based on the above transcriptions, it is clear that user registration and authentication work as deterrent factors for hospital visitors to use our recommended digital solution since it would make their navigation experience worse. Due to the fact that maintaining visitor data is not required for the actual usage of the system, we decide not to include registration and login to the application. Visitors can directly use our digital solution without sharing any personal data with the system.

4.4 Environmental effect

Throughout our shadowing, the environment played a pivotal role for participant ID2 who was given vignette 4. She used onsite maps, a paper map, and Google services to navigate from one location to another. Rainy weather had a negative impact on her conduct and led to frustration in searching for her destination. As she describes:

“It was a bit frustrating because it was a very big place with a lot of buildings, and it was hard to navigate. I was confused about the map, and took longer than I expected.”

“Shh...I took a paper map from information desk building, now when I move to find the department…ah, it was the map is getting destroyed…It makes me so

frustrating and I don't feel any interest even to move to department now…" (Participant ID2)

4.5 Saydo

In this section, we discuss the discrepancies between what our participants said in interviews and what we observed when they performed the vignette. In **Table 8** we include details about the *participant*, the *system* that is being referred by the participant, the *location* where we observed our participant, *observation details*, and their *interview transcription* sequence.

Table 8: Differences between our participant actions and interview sequence (source: own)

Participant	System referred	Location of our observation	Observation Details	Interview transcription
Participant ID4	Hospital map	Ebba Lunds vej (Map located on walking space near Akutmodtagelse at Indgang 7E (see **Figure 11**))	Not interested to look into the map for the second time as he feels it makes him even more confused "*I don't want to get even more confused seeing the map again, because I know i need entrance 60…*"	"*It's good that I remember that I need to go entrance 60 because if I have forgotten there is no indication on where to go on the street name…In that case, I would take a look at map again to move to 60…*"
Participant ID4	Hospital map	Nielsine Nielsens vej (at 11A Indgang)	Annoyed and confused to see similarities in some building colors and differences in some. *"Why so many buildings colors are similar. I dont understand and why some are green here…Also*	*"For me, the street name, entrance numbers, vej no was similar to me and my brain was overloaded with it to be honest…I didnt even looked at the color of vej44…* "

			why do we have both entrance number and vej no again, it's a bit confusing again…	

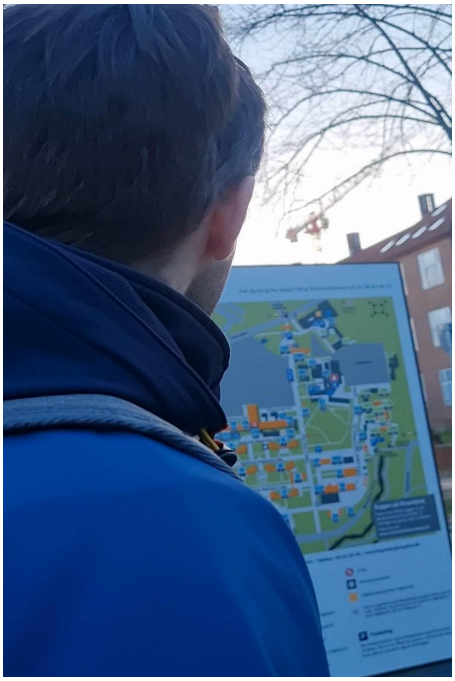


Figure 11: *Participant shows no interest in viewing the Hospital map located on the Ebba Lunds way opposite to 7E entrance on his way moving towards Entrance 60 (source: Bispebjerg Hospital)*.

5 Implementation choices and ER diagram

This section presents the implementation choices we make in terms of technical requirements for our digital solution. Technical requirements are identified by employing the MoSCoW method and are directly implemented in the high-fidelity prototype, which is presented in *Section 6.* It also explains how data flows in the backend of the application using the ER diagram which could be used as a reference for future implementations.

5.1 Designing a web-based mobile interface:

The results of our study indicate that a majority of the participants express a reluctance to utilize a dedicated application solely for hospital navigation purposes. It is noteworthy that our intended audience primarily consists of first-time or non-regular visitors. Hence, it is unlikely that the target users would frequently employ the application. From this idea, we suggest that developing a website with interactive map functionality can be a relevant option for our case. Web-based applications built with technologies have several advantages over mobile applications developed for specific platforms like Android or iOS (Wheeler & Olszewska, 2022). Since web applications can be worked on any platform and are easily scalable to the system structure for updating or developing new features, they are widely used today(Native, Hybrid, or Cross-platform Apps?, n.d.).

Initially, with this approach, whenever users utilize a QR code to access a web application, the web browser requests the user's consent to access their geolocation information. The user has the option to accept or reject the request and may also choose to save the preference for future visits. In case of acceptance, the location details can be retrieved by the web application and any other third-party scripts embedded on the page, enabling the application to track the user's movement and maintain their location (Karabatak & Mustafa, 2018). While web-based applications offer several advantages, our emphasis on accessibility is driven by the opinions of our participants. The user can access the application directly through a QR code and does not need to download or install anything, which can be a deterrent to using the application.

5.2 Technical Requirements

We use the *MoSCoW* method to prioritize our requirements and decide on what is important to be included in the prototype we create for usability testing. We group our identified technical requirements into four categories, namely *Must have*, *Should have*, *Could have*, and *Will not have* (Consortium, 2014). According to Stamelos and Sfetsos, *Must-have* requirements are essential features of the system and cannot be omitted, while *Should-have* requirements are significant to the system but the success of the project does not depend on them. Furthermore, *Could-have* requirements can be omitted if there are time constraints without impacting the project. Lastly, *Will not have* requirements are part of a subsequent release (Stamelos & Sfetsos, 2007).

The prioritization of our technical requirements and what is finally incorporated into our prototype can be seen in ***Table 9*** below.

Table 9: Technical requirements based on MoSCoW prioritization

M	S	C	W
F1 - Search function (by keyword) F2 - Navigation function F3 - Interactive map with clickable icons F4 - Departments information F5 - Language Setting (English and Danish) F6 - ETA (Estimated Time of Arrival)	F7 - Live location button F8 - Accessibility through QR code	F9 - Information desk contact details	F10 - Voice directions F11 - Indoor navigation

5.3 ER Diagram

The entity relationship diagram is created as part of the design process and shows how the data flow to the backend of our application. To create the ER diagram (see **Appendix 8)**, we initially identified the following entities:

- Map icon that can be Entrance, Street number, or Other type of icon. We use the similar map icons that Bispebjerg Hospital map is using.
- Department
- Location
- Step. This entity represents a single step in a Route, such as a turn or intersection.

After defining the entities, we identify the following relationships between the entities.

- An entrance can have many departments, but a department can only belong to one entrance. This is a one-to-many relationship between Entrance and Department.
- Map icons are associated with one or many locations in the hospital. This is a one-to-many relationship between the Map icon and Location.
- Every location has a route to another location and every route has one-to-many steps.

This ER diagram could be used as the basis for designing a database schema for our wayfinding application.

6 Prototype

A prototype is a representation of an envisioned product and is typically used to brainstorm design solutions, reflect on the design, and conduct usability testing to get feedback from the users (Rubin & Chisnell, 2008). The implementation of our solution is out of the scope of the thesis, but in order to visualize our idea and conduct usability testing, we created the High Fidelity prototype that is presented in the current section. We use the Figma tool to create our prototype (see **Appendix 9**), and the chosen functionalities and layout are based on our qualitative research findings and Nielsen's design principles. The current section presents the design of the user interface using screenshots from our prototype. Below we explain in detail about different features of the home screen and then proceed to discuss the navigation function.

6.1 Home Screen

The "Home Screen" represents the most important layout as it is the starting point for our users. There are three main purposes: to show the core feature (interactive map for navigation), to communicate the user's request (search field for various types of user input), and to provide an overview of the other options (department menu, help desk contact).

6.1.1 Search function

The first screen includes two search fields where users can select their starting location (*From*) and their destination (*To*), giving different inputs (entrance numbers, street numbers, and department names). This function can be helpful to both scheduled visitors who already have the exact address and non-scheduled who do not. Users get their current location by selecting the GPS tracker icon next to the *From* field. Additionally, the search field provides a smart-search function that returns all department names related to the alphabet **(**see **Figure 12)**.

Considering "language barrier" as the informative theme in our finding section, we create a language selection feature on each screen to change language depending on the user's preference **(**see **Figure 13)**. This language option can contribute broadly to elevated user satisfaction.

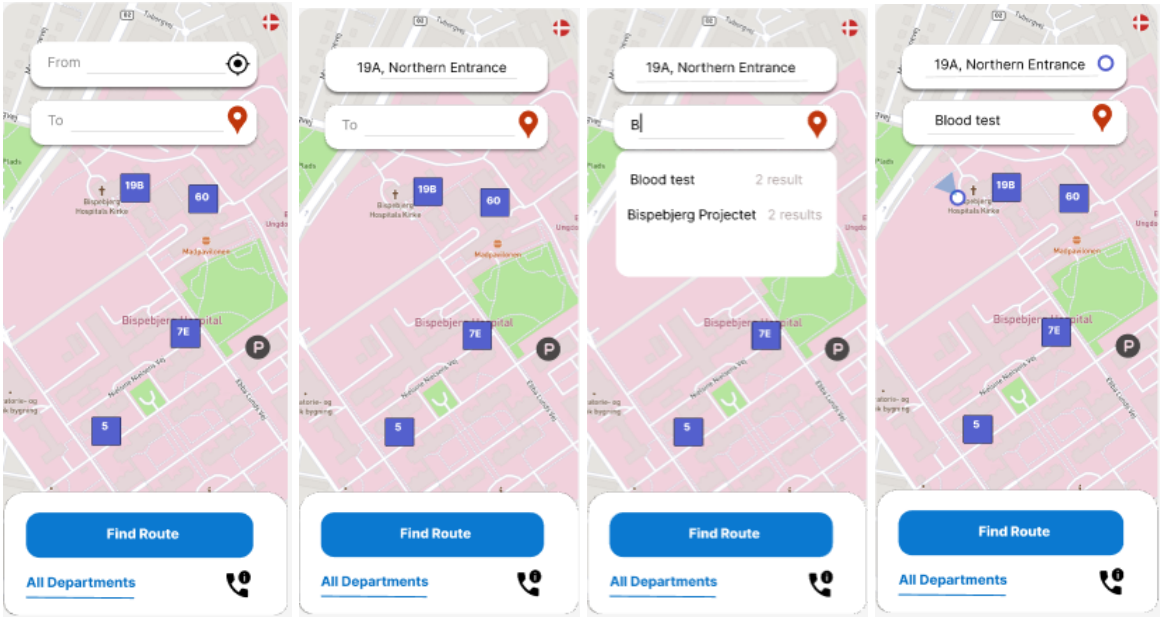


Figure 12: The search process using our navigation system (*source*: *own*)

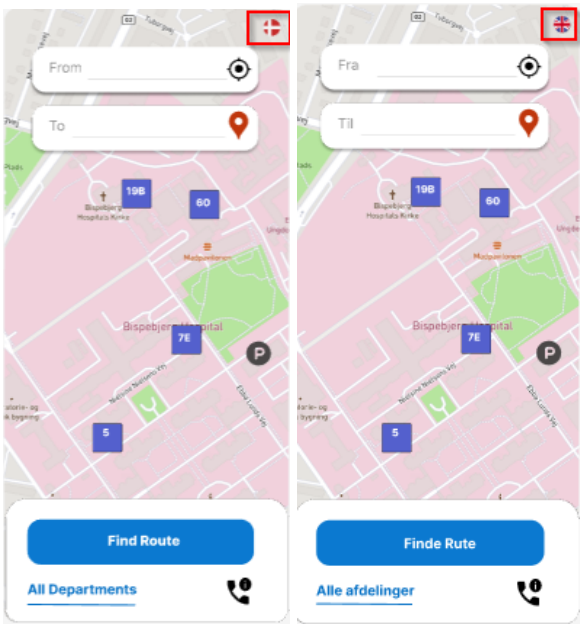


Figure 13: Language settings (*source*: *own*)

6.1.2 Department Information

The "*All Departments*" menu (see **Figure 14**) shows all department names in alphabetical order and provides an “autocomplete” search function for user input. Once the user selects a department, information about that department will display.

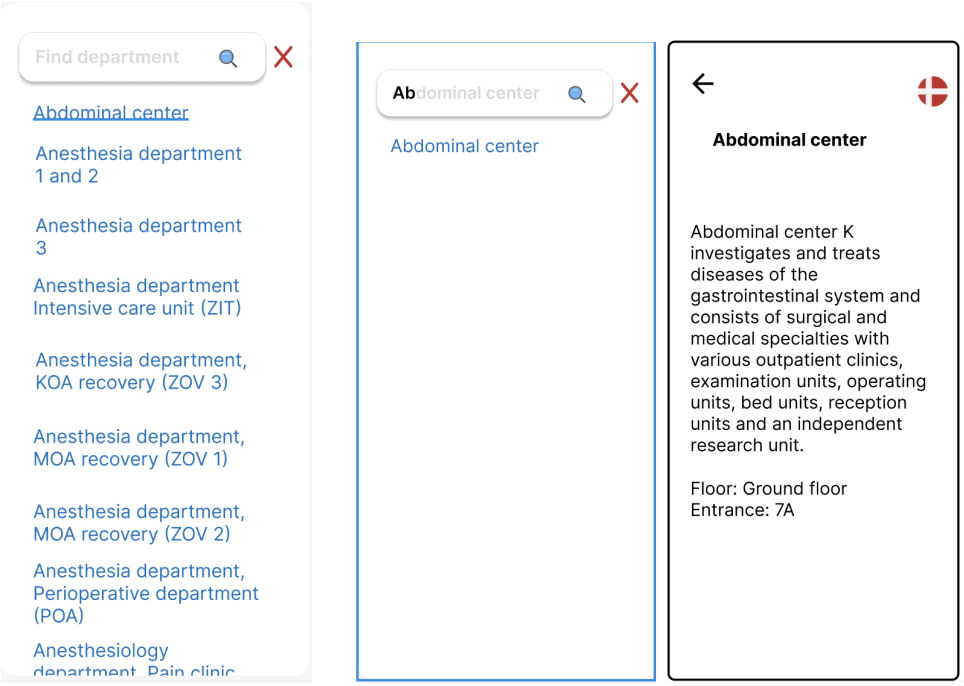


Figure 14: All departments are listed in the menu (*source*: *own*)

6.1.3 Information Desk

We focus on the design of a digital wayfinding solution but still believe that the physical information desk remains a valuable resource for certain users who may encounter issues with the mobile application or require personalized assistance from hospital staff. To accommodate these users, we have included an “Information Desk” button on the home screen of our system. This button is represented by an icon and provides general information about the location. Users can also call the information desk directly from the screen **(**see **Figure 15)**.

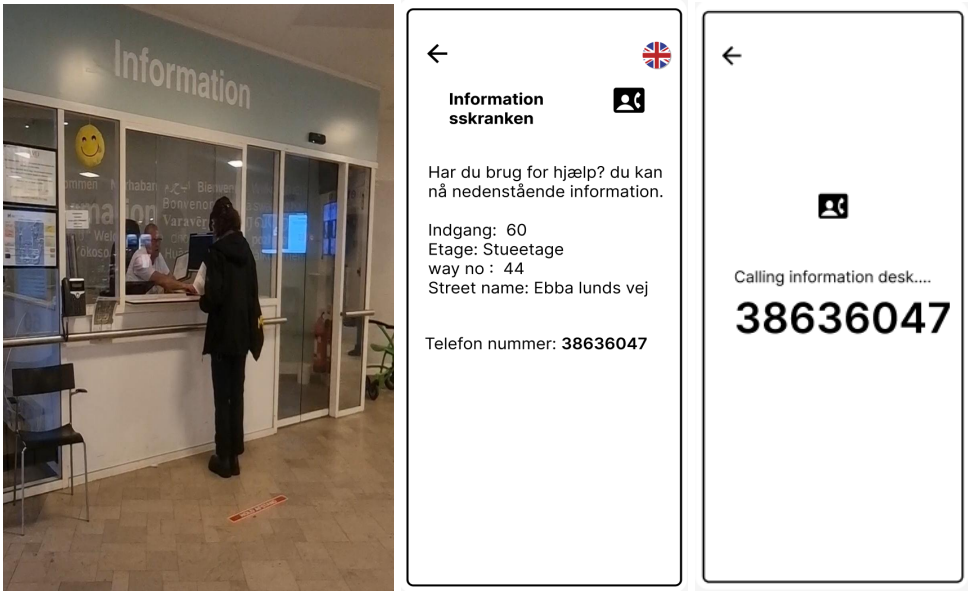


Figure 15: Information desk at the Bispebjerg Hospital and our digital system of the information desk screen (*source*: *Entrance 60, Bispebjerg Hospital, and our prototype*)

6.1.4 Map icon for detailed information

According to our interview takeaways, when users encounter the map at the beginning, they may expect the same interactive functions from their previous experience with other navigation applications like Google Maps. Many participants replied that Google Maps is the most commonly used for finding a way because it is easy to use and offers reliable information with an intuitive interface. When people use similar functions, they get used to how things work and expect other products to work the same way. If a product works differently, it can make it harder for people to use it because they have to learn new things (Nielsen, 2020). For this reason, we chose an interface similar to that of Google Maps.

We implemented clickable icons in the interactive map that represent different locations at the hospital. Once the user clicks on the icon, the address of the location will be displayed along with the list of departments available in the building (see **Figure 16**).

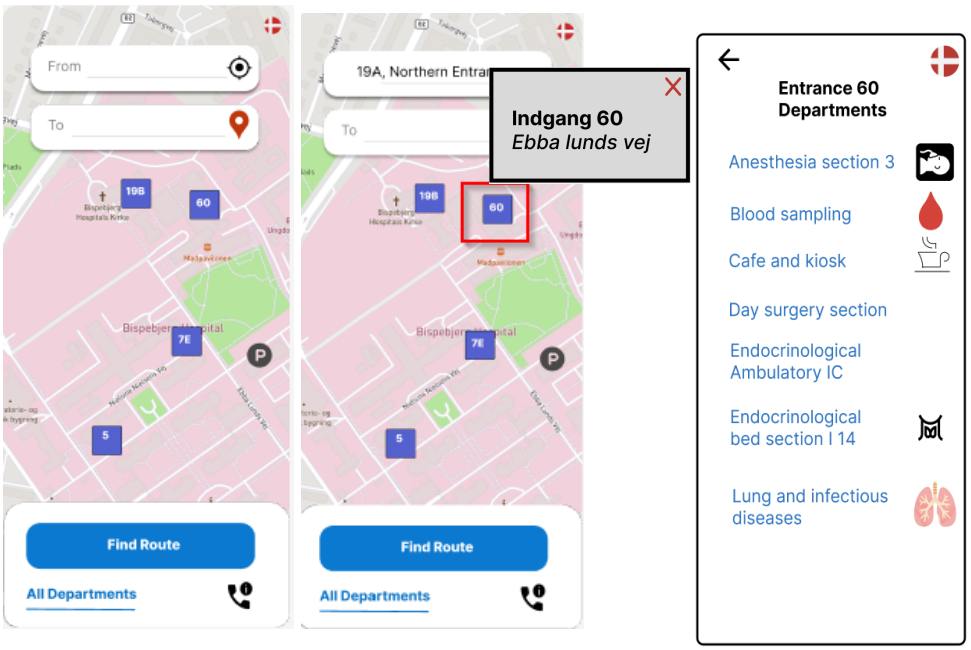


Figure 16: Map icon for detailed information on our digital system (*source*: *own*)

6.2 Navigation function

The navigation function is typically the main feature of digital wayfinding solutions and is depicted in our prototype with the following two screens - first one when the user completes the *From-To* fields prior to clicking on the *Start* button **(**see **Figure 17)**, and the second when the *Start* button is clicked and directions from the starting location to the destination location appear **(**see **Figure 20)**.

6.2.1 Screen before clicking the start button

Once the user completes the *From-To* location fields, the shortest route to its destination will appear in blue color along with a blue-white cyclic icon representing the current location and the red pin icon showing the target location (see **Figure 18)**. In addition, at the bottom of the screen, the distance from the destination, as well as the ETA are shown (see **Figure 19**).

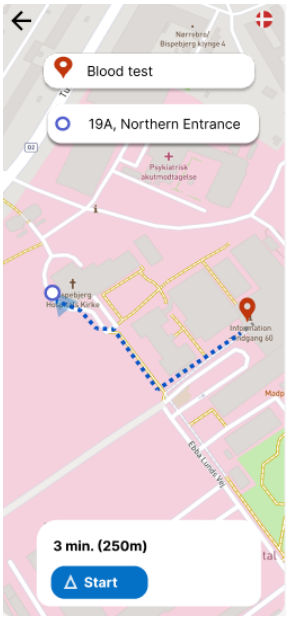


Figure 17: User has completed the *From-To* location before pressing the *Start* button (*source*: *own*)

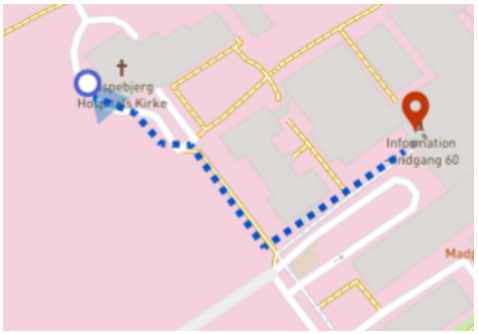


Figure 18: The shortest route between *From* to *To* location (*source*: *own*)

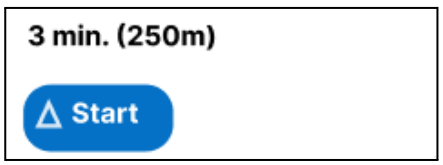


Figure 19: ETA and distance from the destination location (*source*: *own*)

6.2.2 Directions screen after pressing the Start button

Once the user completes the *From-To* location fields and clicks on the *Start* button to initiate the navigation, the screen is updated, and directions with arrows and text are given in the upper part of the screen **(**see **Figure 21)**. Furthermore, real-time navigation takes place on the map **(**see **Figure 22)**, and the *ETA* feature with distance from the final destination is presented at the bottom of the screen. The red icon on the right is helpful to show users their current location on the map **(**see **Figure 23).**

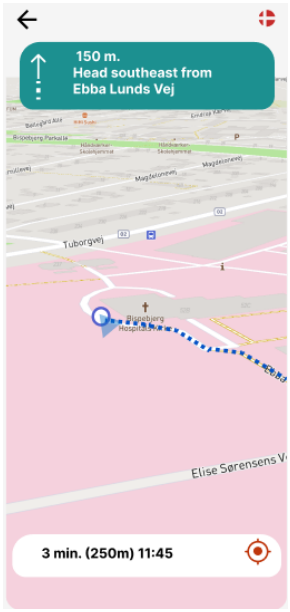


Figure 20: Screen when the user has pressed the *Start* button (*source*: *own*)

Figure 21: Direction with arrows and text (*source*: *own*)

Figure 22: Real-time navigation (*source*: *own*)

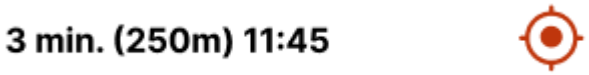


Figure 23: ETA feature (*source*: *own*)

In the next section, we discuss the heuristic principles we applied to our prototype and how we conducted usability testing to ensure usability for our prototype.

7 Ensure Usability

The current section evaluates and improves the quality of our prototype by applying Nielsen's usability principles and conducting usability testing to ensure usability (Nielsen, 2020). It discusses our design choices based on Nielsen heuristics and the changes we made after the usability testing.

7.1 J. Nielsen Heuristics

Nielsen's 10 general principles for interaction design serve as a guide for the creation of interfaces and interactions that cater to the requirements of end-users (Nielsen & Mack, 1994). Following these principles enabled us to create the first prototype of our navigation system, which aims to be intuitive and user friendly while reducing the likelihood of errors and frustration for the users. Additionally, these principles promote consistency and coherence across the different elements of our prototype, resulting in enhanced user navigation and comprehension.

1. *Visibility of system status*

   Users rely on the current system status to understand the consequences of their previous actions and decide on the next steps. By ensuring predictable interactions, users can develop trust in both the product and the brand (Nielsen, 2020).

   On the screen before clicking the "Search" button **(**see **Figure 24)**, the user can be provided with clear information about their current location and destination through the map interface. In addition, the blue dotted line represents the direction and distance between "From" and "To" locations with estimated time information. This function can communicate with users, and it would be useful information for them before they take the next step.

   Applying this principle, users can have a clear idea about their current position and it can help them make decisions on where to go next.

2. *Match between the system and the real world*

   To enhance the user experience, the design should utilize language that users are familiar with, avoiding technical jargon and using words, phrases, and concepts that are familiar to them (Nielsen, 2020).

   In this perspective, we have inspiration from Google Maps, as our majority of participants are used to this application for navigating on a daily basis. To enhance usability, we prioritized a simple navigation feature (see **Figure 24**) and home screen (see **Figure 25**) that resemble the user-friendly interface of Google Maps.

3. *Consistency and Standards*

According to this principle, people tend to use a variety of digital products besides the one we offer, and the users' past experiences with other products set their expectations for how your product should work (Nielsen, 2020). Therefore, it may increase the user's cognitive burden to learn new instructions for use. That means the inconsistencies between our navigation system and others' may affect their overall experience (Nielsen, 2020). To avoid the risk, we followed common interface design elements such as universal icons from established industry conventions on our navigation screen (see **Figure 24**) and home page (see **Figure 25**).

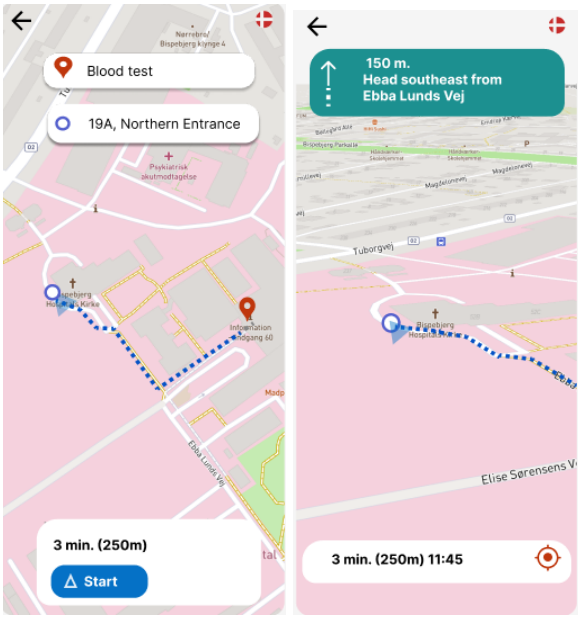


Figure 24: Navigation screen (*source*: *own*)

Figure 25: Home screen (*source*: *own*)

4. *Error Prevention*

The best designs carefully prevent problems from occurring in the first place by either eliminating error-prone conditions or presenting users with a confirmation option before they commit to the action (Nielsen, 2020). We prevented unconscious errors caused by users' attentional mistakes, such as wrong spelling or memory burden. By applying this principle, we included an autocomplete function in our prototype to support users who have problems with language barriers, difficult medical terms, and missing information on the map. Additionally, a general explanation of each department (see **Figure 26**) is provided for the user's understanding.

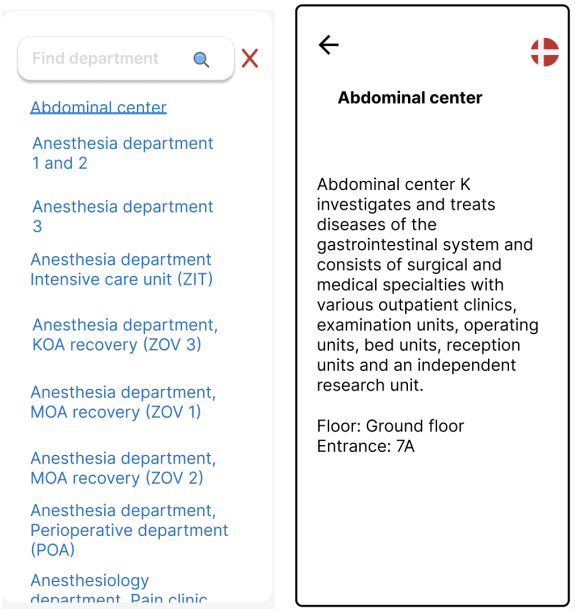


Figure 26: Department information (*source*: *own*)

5. *Recognition rather than recall*

   The interface design should ensure that users don't have to remember information across different parts of the interface. Since humans have limited short-term memories, all the necessary information should be readily available and visible when required (Nielsen, 2020). The hospital wayfinding system contains numerous medical terms and complex information related to each department's location.

   Therefore, we need to solve the difficulties to minimize user frustration and avoid cluttering the department information with unnecessary elements or information, as this can confuse and overwhelm users. The "*department information*" provides the department list at first, and then clickable links to detailed information pages by each department in case the user needs more explanation and address. As a result, the user does not need to remember every department's details.

6. *Flexibility and efficiency of use*

   Lastly, regarding the "*information desk*" **(**see **Figure 27)**, we applied "*Flexibility and efficiency of use*" design principle. This principle is related to flexible processes that can be carried out in different ways so that users can select whichever method works for them. The principle is explained with the example; New users often require guidance when using a system and need clear and obvious options because they have not yet developed a mental model of how the system works (Nielsen, 2020). We made an information desk option available for technologically challenged users to get help from staff by calling.

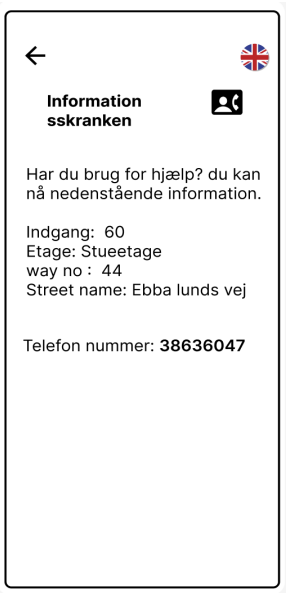


Figure 27: Information desk (*source*: *own*)

7. *User Control and Freedom*

Since users often make mistakes or encounter problems while interacting with systems, the system should enable users to easily exit an undesirable state without the need for prolonged dialogues (Nielsen, 2020). We apply the concept to multiple screens where we give the chance to the user to cancel their actions or go back to the previous screen (see **Figure 28**).

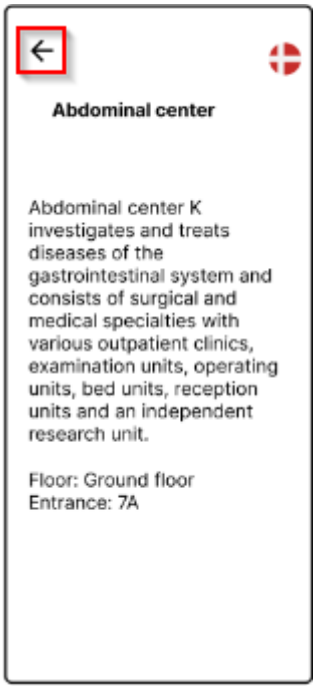


Figure 28: Arrow to go back to the previous screen (*source*: *own*)

Once we completed the prototype, we proceeded with testing to collect feedback from our participants and improve usability. The next section presents the process we followed to conduct the usability testing and the changes we applied after completing it.

7.2 Usability Testing

Usability testing allows us to determine whether users understand how to use a product (Rubin & Chisnell, 2008). The think-aloud protocol method is frequently employed while users participate in usability testing, enabling us to access people's thoughts as they interact with the product. It also encourages participants to verbalize their thoughts and feelings while performing a task (Rubin & Chisnell, 2008).

In the following sections, we describe how we designed and conducted the usability testing and which insights we gathered from our participants.

7.2.1 Usability testing process

Following the approach introduced by Tomitsch (Tomitsch et al., 2021, p. 161), we defined the tasks to be performed by our participants and the pre-test and post-test questions following the below steps:

1. We **identified the tasks** that are relevant to the features we want to test and created four different tasks (see **Appendix 10**) to cover all functionalities offered by our solution.
2. We prepared **pre-test** interview questions **(**see **Appendix 11)** to know whether our participants have previous experience using similar wayfinding solutions and to what extent (e.g., Google Maps).
3. We prepared **post-test** interview questions **(**see **Appendix 11)** to capture participants' experience with our solution and possible recommendations.

The usability testing was conducted on two different days with *six* participants in total. We conducted the usability testing in a quiet room at ITU to make our participants feel comfortable and stay focused on the tasks and the process without distractions (Rubin & Chisnell, 2008). Information about the participants is given in **Table 10**.

Table 10: Details about participants

ID	Name	Age	Gender	Nationality	Personal Qualification	Experience with digital navigation solutions
1	Bae Suzy	31	Female	Korean	Student at ITU	multiple digital navigation solutions
2	Maria	27	Female	Mexico	Student at ITU	only Google Maps
3	kate	26	Female	Danish	Student at ITU	mainly Google maps

4	Julia	27	Female	Danish	Student at ITU	mainly Google maps
5	Dravid	30	Male	Danish	Student at DTU	only Google Maps
6	Nolan	30	Male	Danish	Student at DTU	multiple digital navigation solutions

The testing session included the below steps to ensure a smooth and logical flow of the process:

1. We explained to each of the participants the purpose of our prototype to be tested and the procedure to be followed. We also requested permission from our participants to video-record the session.
2. We asked the pre-test questions about the previous experience of our participants using digital wayfinding solutions
3. We gave the tasks to the participants and following the think-aloud protocol (Rooden, 1998), we observed and recorded their reactions while performing the tasks. We also tracked the time to perform each task. We provided help only if the participants could not complete the task alone.
4. We asked post-interview questions to gain insights and recommendations about the usability of our solution.

The next section is dedicated to the feedback we received from our participants and explains our findings regarding the usability of our design and recommendations from our participants on how to improve it.

7.2.2 Usability testing feedback

Once we completed the usability testing, we reported the findings from our six participants in a table **(**see **Appendix 12)**. Each record in the table contains information about *the participant id*, *the task to be performed*, whether it is *completed or not*, the *time of completion, the number of errors,* and *the given feedback.* After reporting their feedback and the information related to specific tasks, we identified what needs to be improved in our prototype, taking into consideration the tasks that our participants struggled the most to perform as well as the time and number of errors they made.

7.2.3 Improvements

The decisions we took after conducting the usability testing were implied directly to our prototype and are presented in *Table 11* below. The table includes a column for the *ID* of the improvement*,* the *description* of the improvement*,* the related *feedback* to our decision, and the respective *transcription* from our participants*.*

Table 11: Improvements to the prototype

ID	Improvement	Feedback	Participant transcription
1	Change the existing **information desk icon** on the home screen.	The information desk icon in the '*Home screen'* used to find specific information and contact details is not intuitive and even though five out of six participants performed the first task easily, most of them mentioned that is not intuitive and a more universal icon should be used instead.	• *Participant id.6* "*This is not intuitive. I didn't know I could click on that to find the number of the information desk.*" • *Participant id.2 "This icon should be more intuitive I think..."* • *Participant id.3 "I would change the icon to something more intuitive…"*
2	The **information desk phone number** has been **underlined** to seem more clickable by the user.	Task 1 was easily performed by almost all of our participants. Two participants mentioned that they didn't realize that the contact number of the information desk was clickable.	• *Participant id.2 "Nothing indicates that the phone number is clickable… I would make it bold or underline it to seem more clickable."* • *Participant id.6 "I was not sure if the number was clickable… It doesn't seem very…"*
3	***From*** and ***To*** destination search fields are changed to be in the **same section**, one on top of the other. *From* field is placed **above** the *To* field.	The majority of our participants reported confusion using From and To destination fields because unlikely to Google Maps, From field appears below To and they are not used to that. In addition, based on participant id.4, they are in separate sections of the screen and it creates some more confusion.	• *Participant id.1 "I think the From field should be above To…"* • *Participant id.2 "I expected the From field to appear first…I suggest changing the order of the fields…"* • *Participant id.4 "I recommend changing the order of From and To fields…"* • *Participant id.3 "...They are in separate sections and they have the same functionality. This is confusing…I think they should be merged in the same section…"*
4	Interactive map icons are changed to appear **bigger** and in a **different color** to look more clickable.	Most of our participants found it hard to perform task 3 and made at least one mistake. All of the participants mentioned that the clickable icons related to the entrance number in the interactive map were too small and hard to	• *Participant id.2 "...The icons on the map are very tiny. I didn't know I could click on them… I would make them bigger and maybe change their color."* • *Participant id.3 "...These icons are very hard to identify…They are quite small and that color does not make me think I can click on*

		realize that they are clickable.	*that…"* ● *<u>Participant id.4</u> "...The icon of building 60 in the interactive map is a bit small…They need to be bigger…"* ● *<u>Participant id.5</u> "...The entrance number icons on the map are small…"*

8. Discussion

Our analysis indicates that the mobile-based web application can significantly enhance navigation efficiency for hospital visitors compared to the existing systems. These results are in line with previous research that highlights the importance of user-centered design in developing effective digital wayfinding systems (Harper et al., 2019). However, our study focuses on first-time or non-regular visitors in different situations, and a mobile interface is considered a solution to cover users' needs and address pain points. As a result, our empirical investigation revealed a correlation between visitors' anxiety levels and the amount of pre-information they received. Moreover, the participants reported experiencing challenges in understanding and distinguishing different kinds of information on signage and outdoor maps. This idea is consistent with the previous studies, and Harper pointed out that basic heuristics such as cognitive load and universal search are often overlooked, such as properly classifying information, minimizing unnecessary contents, presenting visual aids effectively, and supporting the platform standards in wayfinding systems (Harper et al., 2020). Hence, we have focused on improving these basic usability heuristics for infrequent visitors, thereby reducing the anxiety and frustration that often accompany navigating unfamiliar environments.

One of the main strengths of our research is the combination of several qualitative research techniques to investigate problems and emphasize our users. We started by analyzing previous studies regarding hospital wayfinding systems and observing the current wayfinding systems at the hospital. In addition, we designed eight vignettes, then recruited participants to observe while performing the vignettes, and conducted in-depth interviews to generate our empirical data. Throughout this process, we were able to gain important insights for our digital navigation system. However, we also discovered that the majority of participants encountered similar difficulties regardless of the given situations. Therefore, we identify three interesting findings related to our solutions that have important implications for the design and development of future navigation systems at the hospital.

1. **Informative solution, may not be essential for scheduled visitors**

   The visitors who are scheduled at the hospital already have enough information to find their destination; therefore, they might not need to use an interactive map. Based on our empirical data, the scheduled visitors with an exact address were generally able to find the location using third-party mobile applications, even though the application does not completely provide all locations. Therefore, our digital solution would not be beneficial for patients who have received pre-information from the hospital. However, we have identified ongoing issues that are currently under investigation by a limited number of participants who possess pre-information. According to Sadek, "Navigation is also influenced by other factors such as cognition levels, spatial perception, spatial strategies, and individual differences" (Sadek, 2015, p. 7). We will be aware that different personal cognitive abilities can

have a great impact on the general impression of the system; therefore, our solution should be beneficial for everyone.

2. **Design solution to combine with current wayfinding systems**

   Our participants experienced some difficulties and frustrations with certain aspects of the on-site visual elements. Although the static system provides useful signs or maps for guiding people to their desired destinations, visitors do not use them because they are struggling to recognize the meaning of the signage or visual elements on the map. This issue stems from a lack of explanation regarding visual elements and the complicated layout of current wayfinding systems. Thus, we expect the combination of static signage and our digital solution to provide users with personalized information regardless of space limitations. This integration of design elements aims to enhance the user experience and make wayfinding processes more efficient.

   As we explore the implications further, we strongly agree with the perspective of Sadek that he considers smartphones and their applications have added a new dimension to traditional wayfinding systems (Sadek, 2015). Furthermore, the consistent visual elements in both static and digital systems can strategically improve the navigation experience.

3. **Technological solution for geological features**

   We detect the fact that wayfinding systems are not useful at night or during the dark winter season. According to "Sunset Times in Denmark" (Worlddata.info, n.d.), the sunset time in Denmark varies throughout the year. However, due to its northern location, Denmark has a short daytime during the winter season from December to March, with an average of 7 hours of daylight. Therefore, the current wayfinding system is hardly visible depending on the time, season, or weather conditions.

   Our digital solution will be essential for Bispebjerg Hospital since it is a stable and effective way for visitors to find directions in any environmental condition. Therefore, we recommend not only the digital system but also improving static signage with lighting.

9. Conclusion

Our thesis aims to explore the challenges faced by first-time or non-regular visitors when navigating complex hospital environments and how digital technology can enhance visitors' experience. To address this research objective, we conducted a literature review to examine findings from previous studies. Additionally, qualitative research was carried out to generate data through observations and subsequent interviews with recruited participants. Drawing from the insights gained through qualitative research, we developed a prototype for a mobile-based web application intended to improve navigation at Bispebjerg Hospital. To ensure usability, we applied Nielsen's design principles and conducted usability testing.

The results of our findings indicate that navigating in unfamiliar places with only static signs and maps is considerably challenging for first-time or non-regular visitors who are not familiar with the environment. In addition, people are already familiar with using mobile applications for real-time navigation on a daily basis (Morag & Pintelon, 2021). For these reasons, we consider the interactive navigation system through the user's mobile device to be essential to our target user groups, which are the most vulnerable visitors in a large and complex hospital environment. Since our solution has the ability to provide a clear guideline to direct visitors to their destination, it can be a valuable tool for visitors without requiring the assistance of hospital staff. Furthermore, our participants consistently highlighted difficulties regarding ambiguous, overloaded information on the current hospital map. As a result, we developed design, informative, and technical themes to overcome current difficulties in accommodating important features such as real-time location and estimated arrival time to enhance the overall hospital experience.

Limitations and Future Studies

Although our study clarified the current problems and ways to improve the wayfinding system, it was conducted solely at Bispebjerg Hospital and over a short period of time. Moreover, our findings highlight the importance of considering users' cognitive and perceptual abilities for outdoor wayfinding. Therefore, the generalizability of the results to other hospitals or public spaces may be limited.

Future studies can be extended to target user groups such as individuals with disabilities or the elderly to examine the applicability of these findings to diverse populations. Given that hospitals serve as public spaces catering to individuals from various backgrounds, it becomes imperative to investigate the usability and effectiveness of wayfinding systems across a wider spectrum of users. In addition, the implementation of the digital wayfinding system requires careful consideration of various factors, including the three themes; design, information, technicality, and the involvement of stakeholders.

Overall, our thesis provides a comprehensive perspective on the potential benefits of digital wayfinding for improving the current systems at Bispebjerg Hospital. The proposed

mobile systems require consideration for integration with the current system in order to coexist.

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Appendices

Appendix 1: Descriptive Literature Review

Paper 1:

Author	**Title**	**Year**	**Abstract**			
Ido Morag, Liliane Pintelon	Digital wayfinding systems in hospitals: A qualitative evaluation based on managerial perceptions and considerations before and after implementation	2021	The purpose of this paper is to explore the challenges and benefits of digital systems used in indoor digital wayfinding. The researchers divided the participants who took part in the study into two groups, namely **pre-managers** who were asked prior to the implementation of the system about their expectations, thoughts, advantages, and disadvantages such a system would have, and **post-managers** who described their experiences and opinions after using the system.			
Source	**Author keywords**	**Reference**				
Google Scholar		Morag, I., & Pintelon, L. (2021). Digital wayfinding systems in hospitals: A qualitative evaluation based on managerial perceptions and considerations before and after implementation. Applied ergonomics, 90, 103260.				
Found in Step						
keyword-" Digital Indoor wayfinding "						
Method	**Data Collected**	**Object of Analysis**	**Level of Analysis**	**Theory & models**	**Findings & recommendations**	**Further work**
Qualitative	Semi-structured interviews (n= 20 - hospital	3 different digital systems were utilized	User perspective		**Personal Mobile device** 1) users get real-time direction updates using	Even though this paper reduced the gap of

	managers)	in study Fixed computerized terminals Portable devices Personal mobile device	System design Operational		navigation maps 2) user-friendly & interactive 3) ***Trust in technology***- older people were more under stress when information is processed slowly 4) Most people found difficulties with delays in information and communication interruption due to multiple users accessing servers at the same time - ***Availability*** **Fixed computerized terminals** 1) older people find challenges to perceive the information on screens due to font size **Portable device** 1) These devices are offered with loaded images of public places, hallways, etc 2) Device lacks images in real-time & user's difficulty with which orientation to gaze the loaded image. The difference in the user group's perceptions, "newcomers vs. those experienced with the hospital setting,"(Morag & Pintelon, 2021, p. 3) varied.	accommodating different users groups using systems in terms of user perspective, design and how it operates partially, there is room for improvement to design digital systems in more complex environments.

Paper 2:

Author	Title	Year	Abstract
Christy Harper, Tyler Duke, Angie Avera, Spencer Jefferies	Designing Hospital Wayfinding Systems, Touchscreen Kiosks, Environmental Cues, and Mobile	2020	This paper explores the design of wayfinding systems in large and complex medical-care environments and aims to provide recommendations to enhance usability and effectiveness of wayfinding applications. Firstly, the authors present the findings of research examining the usability of interactive, touchscreen, and wayfinding kiosks in chosen hospitals. Participants were recruited to complete several tasks using wayfinding devices with navigation functions. The results of this research showed that basic heuristics such as cognitive load and universal search were often overlooked.

	Apps: An Evaluation of a Mobile Wayfinding Application		Second, the authors investigate and evaluate mobile applications designed for large multi-building hospital environments. A heuristic analysis was conducted by four researchers, composed of twenty dimensions and six categories, including language, the effectiveness of wayfinding instructions, consistency between the environment and application, interface interaction, accessibility, and cognitive workload (Harper et al., 2020). The authors recommend a universal search function, the ability to find a help desk, and a map with appropriate orientation as features to enhance the navigation experience and usability.				
Source	**Author keywords**	**Reference**				
Google Scholar **Found in Step** keyword-" Designing wayfinding systems"	Wayfinding, Healthcare, Usability Design, Heuristic evaluation, Human factors, Mobile application	Harper, C., Duke, T., Crosser, A., Avera, A., Jefferies, S. (2020). Designing Hospital Wayfinding Systems, Touchscreen Kiosks, Environmental Cues and Mobile Apps: An Evaluation of a Mobile Wayfinding Application. In: Lightner, N., Kalra, J. (eds) Advances in Human Factors and Ergonomics in Healthcare and Medical Devices. AHFE 2019. Advances in Intelligent Systems and Computing, vol 957. Springer, Cham. https://doi.org/10.1007/978-3-030-20451-8_9				
Method	**Data Collected**	**Object of Analysis**	**Level of Analysis**	**Theory & models**	**Findings & recommendations**	**Further work**
Heuristic analysis Qualitative research Usability testing	Primary It is not mentioned if it is interviews or surveys Observations Researchers involvement Hospital visits	Usability and effectiveness of hospital wayfinding systems Touchscreen kiosks, environmental cues, and mobile apps	Three large hospitals User perspective System design	Own developed heuristics to evaluate usability intended for mobile applications User-centered design	The authors recommend adding the following **features** in wayfinding mobile apps: 1) Universal **search option** 2) Option to locate a **Help Desk** or **customer support** center 3) **Map** with	The evaluated mobile application **does not provide real-time orientation or mapping**. As further work, the authors suggest the **development** and **usability testing** of a modern application that incorporates real-time location

					appropriate orientation to assist users with visual navigation 4) Essential information should be contained in **color-coded indicators**, **signage**, **and landmarks**, followed by a list of instructions from the selected "From" to "To" location. The system should **match the environment** since recognizing surrounding cues makes the navigation experience better.	and direction using a map.

Paper 3:

Author	**Title**	**Year**	**Abstract**
Nancy Hughes, Michael Brown	Navigating To and through large hospitals	2015	This paper examines users' experiences and highlights the challenges of navigating through large hospitals in the United Kingdom. Identifying the challenges researchers suggest new navigational techniques and technological improvements that reduce navigational inefficiencies and improve the overall user experience. With the aid of the "Critical Incident Technique", the researcher examines the participants' most recent and first-hand encounters (Hughes et al., 2015, p.4). Color-coded signage, wall-mounted maps, numbering systems, and human support were used in indoor navigation.
Source	**Author keywords**	**Reference**	
Google Scholar **Found in Step** keywords-" Wayfinding in hospitals"	navigating, hospital environment, user-centered design, Critical Incident Technique	Hughes, N., Pinchin, J., Brown, M., & Shaw, D. (2015, October). Navigating in large hospitals. In *2015 International Conference on Indoor*	

		Positioning and Indoor Navigation (IPIN) (pp. 1-9). IEEE.				
Method	**Data Collected**	**Object of Analysis**	**Level of Analysis**	**Theory & models**	**Findings & recommendations**	**Further work**
Qualitative	Critical Incident Technique (n=11 participants)	User's first time and most recent experience This paper examines users' most recent or first-time experiences navigating through large hospitals using different indoor systems and highlights the challenges faced.	User-driven Evidence-based United Kingdom		Participants were influenced on how they navigate indoors by Measurable quantities such as time, availability, and cost. It is observed that a large amount of time is needed to find the exits. **Challenges:** 1) Inconsistent signage & redundant directional system 2) Difficult to read the signage in linking corridors for hints 3) Lack of awareness & information recognition of route with color-coded Finally, the researchers recommend that a mobile app for indoor wayfinding would be the best fit to reduce the user's travel time and improve efficiency. Some of the recommendations for the app are up-to-date level maps, walk time estimates, and interface design to reduce information recognition issues.	

Paper 4:

Author	**Title**	**Year**	**Abstract**
Catia Prandi Barbara Rita Barricelli	Accessible wayfinding and navigation: a	2021	This paper offers a systematic mapping of the literature to identify pain points and proposes devices and software applications that enhance accessible wayfinding and navigation in indoor and outdoor environments.

Silvia Mirri Daniela Fogli	systematic mapping study		The authors examine various aspects of the literature, such as the circumstances under which it was used, the intended audience, the technological tools used, the types of information sources, and the role of the user in designing and assessing the system. The authors categorized the current academic papers by type to identify gaps in previous studies and provide directions for future studies. The selected papers were then analyzed based on the context of use, target users, technologies, data sources, and user roles. The devices and software were classified into mobile applications, web applications, wearable devices, and smart devices. Most papers in the literature suggest the development of a mobile app, while a smaller number recommend creating a web application. The study found that a significant number of papers explored cutting-edge solutions for wearable devices, smart gadgets, and touch-enabled and public systems.			
Source	**Author keywords**	**Reference**				
www.researchgate.net **Found in Step** keyword search: "Digital wayfinding", "Hospital wayfinding", "wayfinding system"	Architectural barrier, Indoor navigation, Outdoor navigation, Universal design, Urban accessibility, Wayfinding system	Prandi, C., Barricelli, B.R., Mirri, S., *et al.* Accessible wayfinding and navigation: a systematic mapping study. *Univ Access Inf Soc* (2021). https://doi.org/10.1007/s10209-021-00843-x				
Method	**Data Collected**	**Object of Analysis**	**Level of Analysis**	**Theory & models**	**Findings & recommendations**	**Further work**
Qualitative Document Analysis	Database from previous studies(n=111) Selected papers published in the period 2009–2020,	To identify pain points and propose devices and software applications to assess	5 dimensions such as the context of use, target users, technologies, data sources, and user roles.	Distribution of the analyzed papers along the user role dimensions and devices.	Based on the paper, mobile applications for the wayfinding system are considered beneficial for diverse users, especially the handicapped. For example, mobile wayfinding system used various techniques to ensure e-accessibility. These include speech-to-text	Advanced technologies, such as AR, can be applied to present virtual directional arrows on the smartphone display to aid navigation

					and text-to-speech technologies, verbal prompts, and simplified touch interfaces.	

Paper 5:

Author	**Title**	**Year**	**Abstract**			
Lujie Deng, Nurul Hanim Romainoor	Bibliometric analysis of literature on healthcare facilities' wayfinding research from 1974 to 2020	2022	The purpose of this paper is to cover the evolution of **wayfinding within healthcare institutions** from 1974 to 2020 and to provide some ideas for future research. The authors discuss a number of earlier studies that were primarily concerned with environmental variables, such as environmental design, environmental psychology, and environmental management, as well as wayfinding from a cognitive psychological perspective. The authors give essential information on digital technologies used in wayfinding, describing the characteristics of the systems within different age groups and their issues using them.			
Source	**Author keywords**	**Reference**				
Google Scholar **Found in Step** keyword-" "Hospital wayfinding literature review"	Healthcare facilities Wayfinding VOSviewer Knowledge structures Bibliometric analysis	Deng, L., & Romainoor, N. H. (2022). A bibliometric analysis of published literature on healthcare facilities' wayfinding research from 1974 to 2020. Heliyon, 8(9), e10723. https://doi.org/10.1016/j.heliyon.2022.e10723				
Method	**Data Collected**	**Object of Analysis**	**Level of Analysis**	**Theory & models**	**Findings & recommendations**	**Further work**
Bibliometric analysis Co-citation analysis using VOSviewer software and SPS for statistical	Scopus database (2359 articles between 1974 and 2020)	The purpose of this paper is to cover the evolution of wayfinding within healthcare institutions from 1974 to 2020	Worldwide literature on wayfinding in healthcare Author co-citation analysis		There are differences in **knowledge acquisition, information perception**, and **logical thought** between different **age groups, genders**, and **cultural groupings**	A **Systematic literature review** of wayfinding is needed to provide an in-depth level of understanding

analysis.		and provide some ideas for future research.	Country co-citation analysis		(Jamshidi et al, 2020). Younger people performed better at wayfinding than older people did. Both men's and women's **educational backgrounds** had an effect on problem-solving and decision-making. The **success** of wayfinding was greatly influenced by environmental elements, including the destination's name practices, the quantity of signage, visibility, and position. The authors recommend future research focus on investigating wayfinding solutions that can address difficulties people with **special needs** (disabled people, people with Alzheimer's, etc) typically encounter.	of particular topics and fields rather than the high level that the current bibliometric analysis gives.

Paper 6:

Author	**Title**	**Year**	**Abstract**
Ahmed Hassem Sadek	A comprehensive approach to facilitate wayfinding in healthcare facilities	2015	This paper proposes a comprehensive methodology to investigate the environmental factors that facilitate navigation in hospital environments. By employing space syntax as an analytical tool, the study reveals a connection between the spatial configuration of the facility and the cognitive strategies and route preferences of individuals. These results are expected to lead to the development of innovative technology-driven wayfinding aids that improve visitors' experiences and assist them in reaching their intended destinations. Furthermore, this paper focuses on analytical techniques to enhance the design and evaluation of wayfinding systems, resulting in a conceptual model. This model can serve as a framework to guide future research and design in digital wayfinding systems.
Source	**Author keywords**	**Reference**	

Google Scholar **Found in Step** keyword search: “Designing digital wayfinding systems”, “Digital wayfinding in hospitals”, “wayfinding”	Wayfinding, spatial characteristics, space syntax	Sadek, A. H. (2015, July). A comprehensive approach to facilitate wayfinding in healthcare facilities. In 3rd European Conference on Design4Health (Vol. 3, pp. 13-16). Sheffield: Sheffield Hallam University.				
Method	**Data Collected**	**Object of Analysis**	**Level of Analysis**	**Theory & models**	**Findings & recommendations**	**Further work**
Qualitative	A review of the published literature	For understanding the connection between spatial configuration and people’s cognitive strategies and path choice preferences using space syntax	Investigate the existing knowledge and discuss the analytical methods to assess environmental features.	Own created a conceptual model	The evaluation of proposals for wayfinding should involve an examination of several elements, including spatial configuration, visual features, environmental information, and technological solutions implemented.	The conceptual model could be used to design a better wayfinding system.

Appendix 2: Vignettes

Vignette 1:

One week ago, Bispebjerg Hospital sent you a note via e-boks requesting additional testing for your health. This note includes the following details (see Table 4) and a contact phone number in case you need to change your appointment. Before visiting the hospital, you look up the route on Google Maps and use the hospital website to find the department's address and position information. It is now 10:00, and you should **hurry** to navigate inside the hospital and reach your **single destination**.

Table 4: Details of **Scheduled appointment**

Date	*22 March 2023*
Time	*kl 10:30*
Location	*Tværsektoriel Udredningsenhed*
Address	*Bispebjerg Hospital* *Indgang 60* *Ebba Lunds Vej 44* *2400 København NV*

Vignette 2:

You are Robert, your friend had successful appendix surgery and is hospitalized at Bispebjerg Hospital. You want to make it a surprise and visit him before going to work. You are in a **hurry** (15 minutes) to navigate Bispebjerg Hospital and you decide to find an information desk first to ask in which building your friend is in **(two destinations)**.

Vignette 3:

Two days ago, Bispebjerg Hospital sent Federer a **scheduled message** requesting blood work. The message included the information below as well as a phone number you can call in case your meeting needs to be changed. Being a busy university student, you only recall the time and place, and when you got to one of the hospital's major entrances, you started to wonder where you were exactly. There are only 10 minutes left to get there, and it is already 10:00. You need to be in a **hurry** now to find your **single destination**.
kl 10:10, Blodprøvetagning, Bispebjerg Hospital, Indgang 60, stuen, Ebba Lunds Vej, 2400 København NV

Vignette 4:

You share an apartment in Amager with Mr. Tomas. On your way home today at 18:30 p.m., you get a call from someone posing as an information help desk employee at Bispebjerg Hospital, telling you that Tomas broke his leg while bicycling. However, he doesn't have any serious fractures, and, he must spend the next few days in the infirmary. Unfortunately, Tomas forgot to bring his wallet with him and needs your assistance this evening, though there is **no hurry**. In this **unscheduled** situation, you are on your way to assisting Tomas, who is fortunate to have a friend like you. Additionally, the caller advises contacting the information site once you arrive to assist in locating your buddy as it's a bit complicated **(two destinations)**.

Vignette 5:

You're Dr.Andres, one of the researchers working at Dianox Co. PDE-4 inhibitor clinical trials were being developed by the Bispebjerg Pathology Research Unit to treat different dermatological conditions. They rely on your business in a complicated situation for two days because of a lack of staff. Unfortunately, because of the **unscheduled and hurry** situation and the short amount of time, you began traveling right away from Fruebjergvej to the Bispebjerg pathology department **(single destination)**.

Vignette 6:

You scheduled a visit at Bispebjerg Hospital and you received information (see Table 5) about it in your e-boks given below. When you realized **you are not in a hurry** at 10:00, you decided to visit first your friend who is manning the kiosk next to the information desk in building 60 and then go to your appointment **(two destinations)**.

Table 5: **Scheduled appointment** details

Date	*22 March 2023*
Time	*kl 10:30*
Location	*Abdominalcenter K*
Address	*Bispebjerg Hospital* *Indgang 7A* *Nielsine Nielsens Vej 41A* *2400 København NV*

Vignette 7:

You booked an appointment at Bispebjerg Hospital, and you received information about it in your e-boks given below. It is 18:15 now, and even if you are in a **hurry**, you decide to give your friend who works in the kiosk next to the information desk in building 60 the mobile phone that he forgot yesterday in your apartment **(two destinations)**.

Table 6: **Scheduled appointment** details

Date	*22 March 2023*
Time	*kl 18:30*
Location	*Abdominalcenter K*
Address	*Bispebjerg Hospital* *Indgang 7A* *Nielsine Nielsens Vej 41A* *2400 København NV*

Vignette 8:

You have arrived at Bispebjerg Hospital and trying to find your friend, who has an appointment at the *Lunge og infectionssygdomme ambulatorium* department for some health examinations in 40 minutes. She does not have a battery on her phone, hence, calling her for more information is not possible. You are **not in a hurry** and trying to find your **single destination**

Appendix 3: Semi-structured interview guide

Research Questions	Interview Question
Introduction	● What is your name & age? ● Could you tell us where are you from? ● Are you visiting Bispebjerg Hospital for the first time or a frequent visitor? ● If it's your first time, could you please tell us the reason why you arrived at Bispebjerg?
Personal Experience	● Could you explain your overall experience in terms of navigation at Bispebjerg Hospital? ● Were there any particular challenges you faced when finding your way around the hospital? ● Do you think the current wayfinding systems are effective in helping you get to your destination in the hospital?
Different systems	● What systems did you notice? ● What various types of systems have you used in the process of navigating? ● How accurate, and efficient are those? ● Did you find the hospital signage easy to read the understand? ● Why did you choose these systems among other systems that are available? ● What challenges have you come across using such a system? (e.g screen) ● What could be improved about the current hospital navigation experience?
User Interface	● Would you prefer to use digital wayfinding tools, such as interactive maps or mobile apps, to help you navigate the hospital? ● What attributes would be important to you using a wayfinding application(for example colors, signs, numbers, landmarks, etc)? ● What do you think of a universal search function in a wayfinding system?
Outdoor wayfinding	● Was it easy to find a specific building, could you elaborate? The reason why easy or difficult.
Room for improvement	● What could be improved about the current hospital navigation experience?

Appendix 4: Takeaways (from Data collection)

Participant ID1 (Vignette 1):

- She got an email from the hospital regarding detailed information about the destination. (department address and the entrance number)
- Overall, she felt a bit confused about navigating the destination even though she had an exact address. Because she tried to use google Maps with the address, as the street name to find the direction but she also had to use the map at the hospital to find the exact entrance number for entering the specific department section where she had to go.
- She didn't find the department name in the outdoor sign when she arrived at the entrance, so it was challenging to be sure the place is correct.
- She thinks that it might be better to provide specific information about the department on the sign. "*I was able to see only the blood and information desk symbols at the entrance sign, not the specific information that can reach departments through the entrance*."
- She noticed that there were outdoor maps and direction signs, and the arrows in the signs were helpful to be sure of her destination. ("*It was kind of confirmation that I go in the right direction. I think the arrow signs are very good, actually, it pointed to me the actual direction*")
- She said the current wayfinding system was not extremely bad but could have been improved.
- In the beginning, she used Google Maps to search for the address of the destination, but she needed to look at the on-site map at the hospital to get the current position and the department name for matching Google Maps.
- At first, she was confused to find her destination on the map because it shows all the entrances, buildings and streets of the entire hospital. "*It was really huge, and that was extremely confusing to look at to find. Because it has two numbers on it. I believe that it was the street number and entrance number and it was confusing and had too much information. It was overloading information.*"
- After starting the journey, she could remember the street name and the direction of her destination from the map. Therefore, she didn't have to see her phone many times to check the stored map picture.
- Since the department location was not complex, she feels that it was quite easy to find. "*I knew that I can go straight until I meet the Ebba rund vej then turn left. Otherwise, if the way was located to several turns, I would be lost.*"
- She thinks that it is important to know her current position to indicate a place on the map while she is moving with a red dot.
- She mentioned that the physical map was hard to read, but still, it was useful for on-site wayfinding because Google Maps can show the information of the street name from the address and it is not always consistent with the specific information of the department/floor/room which she needs to know eventually.
- She considers if Google Maps can indicate not only directions but also actual destinations would be nice. Because when she searches for the address on Google Maps, she would not be completely comfortable because there are so many buildings at the address and still not 100% sure of getting to the actual place.

"*I would rather navigate by the actual department name than the street name. Maybe it is fine to navigate outside, but I feel way more comfortable navigating the actual place of the department which I have to go*"

- She thinks that the ideal way is searching the department name (the place of her appointment with a doctor) and get a live guide from a map like Google Maps.
- She didn't expect to find the way difficult at first, however, the given address has several parts of buildings and the scale was huge. For this reason, she only trusted the information from the hospital such as signs, maps and indoor kiosks and not anymore Google Maps at the last minute.
- She comments on the importance of 'trust information' from the hospital.
  "*The context of navigating the hospital department and navigating the hospital address are two completely different things. So, I trust the information from the hospital more than the address from Google Maps*."
- She prefers the type of mobile phone for digital wayfinding, but would not download any extra applications because she doesn't use it every day.
- She wishes for more accessible wayfinding functions such as an instant digital map similar to Google Maps without downloading to create a new account for using it.
- She liked to use a physical map but she might need to get the current location all the time in case her destination is complicated. The digital map would be good because she doesn't have to remember the direction for ensuring her way while she is navigating.
- If she searches some keyword to find a place indoors, she prefers to use the final destination name, not the address or street name of the building.
- She explains that the digital screen of floor maps in the big shopping mall would be effective to find the indoor location by having arrow functions to get indications about the specific part of the building.
- She disagreed with the function of virtual arrow signs on the digital map.
  "The reason why I use the arrow sign is that I don't look at my phone all the time to check the direction.", "If I can use the map on my phone, I can track my way to the destination, so I probably just see the movement of the red dot. I don't think I need to see arrows on the map. It is too much! I can see the direction on the map without arrows."
- She didn't really care about the color code on indoor signs because it was not related to her destination.
- She suggested improving the signs in front of the entrance number to have more detailed information because it is important to get the actual department's information within the building.

Participant ID2 (Vignette 4):

Observation:

- She noticed the map and spotted the red dot indicating her current position on the map.
- She found the info desk but the wrong icon. She could not recognize the icon for the information desk.
- She tried to translate the signage into English to find where is the information desk.
- She found an irrelevant to the information desk department.
- She is very lost and frustrated.

- She asked the receptionist in a random building. She is informed that the information desk is at building 60.
- She noticed the map but could not find where she was.
- She took a picture of the map.
- Finally found building 60.
- She looks very frustrated that she has to go to a different building. She cannot find her way and takes the wrong direction.
- She cannot find a map to spot her current location.
- Everything is in Danish which makes it hard for her to understand where she needs to go.
- She mentioned that on a rainy day, the paper map is destroyed.
- She arrived at building 7A and tried to find the destination department.
- She checks the indoor signage and takes the elevator to go to the 3rd floor.
- Initially, she didn't check the signage and mentioned that if she was in a hurry she would ask someone where is the department where she has to go.

Interview:

- She thinks that the navigation experience in the hospital was frustrating. "*It was a bit frustrating because it was a very big place with a lot of buildings and it was hard to navigate. I was confused about the map and took longer than I expected.* ".
- She was not sure if she read the map correctly and therefore it was hard for her to find the information desk.
- She confused the icon of the information desk with the icons of the info spots.
- She could not be helped by arrows showing street names and destinations because she doesn't know at that time where was her location." *It was hard for me to recognize my current spot*".
- She checked the numbers in the buildings and it was very useful.
- She used the maps and tried to find her way by memorizing the map.
- Finding her current location was a big challenge for her."*Definitely, the hardest part was finding my current location on the map*."
- She tried to memorize her way from one building to another.
- She followed and memorized building numbers rather than street names because she does not speak Danish.
- She found the outdoor and indoor signage useful even though the arrows are super small.
- She claims that a digital solution would help make the navigation experience better. A mobile app showing the current location and direction would be helpful. It should also be in English.
- She believes that a search function selecting your current location and the department you want to go to would be useful.
- She thinks that live time location and arrow indicating your way would be ideal.
- She didn't notice indoor color coding "*I remember some colors in the start but I didn't spend time using them*".
- She found it hard to read the indoor signage and she would ask someone to find it sooner.
- She mentioned feeling frustrated and lost.

Participant ID3 (Vignette 7):

Observation:

- He got an email from the hospital regarding detailed information about the destination. (department address and the entrance number)
- Overall, it was fine for him to find his initial destination (building 60) and final destination (7A building, Abdominal department).
- It took him 12 minutes to complete it, even though he had more time (15 minutes).
- Initially, he got a bit confused looking where he needed to go when looking at the map. He took a picture of the map.
- He used the picture of the map throughout the whole outdoor navigation.
- When asked why he uses the picture of the map, he replied that he is a visual person, and looking at the map helps him find his way.
- Along with picture of the map, he used signage as well.
- Regarding his indoor navigation, he found on the indoor signage that the department he is looking for is on the 3rd floor.
- He was confused with the signage found in the elevator. The elevator was going up to the 2nd floor and he decided to take the stairs.
- He didn't pay attention to the color-coded lines inside the building.
- He arrived at the 3rd floor and found his final destination using the signage.

Interview:

- He thinks it was not very hard to find his way. "*It wasn't difficult to find the places. Mainly I looked at the map and already saw the two places. It helped me also that the main spot I had to go to, I had to go through there to find my first spot* ".
- The number of the entrance (7A) helped him remember the second spot he had to go to. In addition, the size number was big and helped him see it from afar.
- He thinks that the entrance of the buildings is not well signalized. Should be more identifiable. "*The entrance number should be like in the rest of the surroundings. There are several entrances and the main entrance is not signalized*"
- He claims that the red dot on the onsite maps is very useful. "*Red dots on the maps really help me see where I am on the map and that creates a point to start looking where I have to go.*"
- He took a picture of the map that was constantly checking because it helps him remember where are the places located and where he has to go. "*I could see everything on the map. It was everything on the map. It all fit in the map and make me remember*".
- He noticed the onsite maps and the outdoor signage in terms of navigation wayfinding systems.
- He thinks that arrows are quite helpful in showing where he had to go.
- He got confused with indoor navigation. The signage in the elevator didn't include the 3rd floor (where his destination was and had to take the stairs. "*When we went into the elevator I saw that there was no way to go to the 3rd floor and I took the stairs. The indications in the elevator were not very good*"
- He didn't pay attention to the color coding inside the building. " *I didn't notice that*"
- He thinks that the onsite map was very descriptive and therefore didn't need Google Maps.
- He believes that inside navigation was harder than outside navigation because of signalization. "*It should be clear signs indoors*".
- When we asked him what could be improved and whether a digital wayfinding system would be helpful, he said he prefers static signs over digital systems. "*Static signs that it is*

easier to see would be helpful and faster". On the other hand, he believes that a digital system is covering a very important need which is the live-time location and arrows indications of where he needs to go." *It is important to know your location live-time and arrows indicating where you have to go*".

- When asked about the application features, he mentioned that it is important for an application to include only the necessary information and not redundant. In addition, it would be helpful to have a search function that shows the current location and destination location. " *The system should be simple. I want it to show only the information I am interested to learn*".
- Google Maps show too much information and he didn't use it because it shows more information than he needed.
- A system that could visualize the main tasks/destinations would be ideal. It was not very clear what he meant by that.
- He never used the address names to search for his destination.
  "*I didn't look at the address names even if I knew them. I only looked at the building numbers*"

Participant ID4 (Vignette 8):

Observation:

- Overall duration is around 13 mins
- He utilized the on-site map at the nordvestlig entrance. He found the description board confusing, weird, and overloaded as he couldn't find the exact direct name "*Lunge og infectionssygdomme ambulatorium*"
- He recognized his current position by identifying the red spot on the map
- He felt a bit frustrated with too many entrance numbers on the map and trying to read "*What the fuck is going on. Too many numbers and many buildings. It is difficult to understand. There is no intuitive system where we go from this red spot towards…* "
- **He also feels annoyed seeing the colurs of the buildings on map**
  "*Why so many buildings colors are similar. I dont understand and why some are green here…Also why do we have both entrance number and vej no again, it's a bit confusing again…* "
- It took him almost 5 minutes just to understand the map to figure out which direction he needs to go exactly
- He decides to go to "Lungmedicine Ambulatorium" as he believes it's a closer name to the given department name and wanted to ask people over there
  "*What I'm gonna do is, I'm gonna go to Lungmedicine Ambulatorium because the whole string to that is similar to that. Otherwise if I just miss it I'm gonna ask somebody"*
- He noticed Building no 60 and vej no 44 from the department information board and searches on the map. It took him a while to notice where 44 is located in map because of the colour of the building and number are same.
- He used google maps searching with entrance number and started moving
  " *I Just throwed the entrance number on google maps and following directions. Basically I can have address and hope it's correct…I'm not good at looking at map and decide i had to go that way. Without this i can't really find a way… "*

- He noticed a street board with arrows and building numbers near the "AKUTMODTAGELSE" and decided to move towards arrow pointed to 60 (Information desk)
- **He's not interested seeing the another map again on the way because he tells that it makes even more confusing for him**
  "I don't want to get even more confused seeing the map again, because I know i need entrance 60…"
- He expects having a street name near the buildings area on the street board
  "I expect a street name with the entrance number here. Otherwise why would we have street names…"
- He went inside entrance 60 and asked the helpdesk for the department name

Interview:

- Overall his experience was confusing because the department name not present in map system
  "*I have to use my logic to find. Say if this is related to lungs then I had lungs given in task and decided i had to go there and get assistance from someone…*"
- He couldn't understand the entrances and street names looking them at first glance
  "It's a bit hard to understand the system itself with the street name and entrances. At first glance I coulnt understand very well. But when I started walking I could understand. Its better I remebered entrance 60 hahaha…"
- He conveys his time was wasted looking at many different symbols, signs on the map and figuring
  "*Shh I was completely blown off. I was like what do I do now.. I wasted a lot of time looking at map for approx 5 minutes…* "
- **He tells he didn't even looked at the building color on the map to find vej 44. But we observed that he felt annoyed figuring where it is located on map**
  "*For me the street name, entrance numbers, vej no was similar to me and my brain was overloaded with it to be honest…I didnt even looked at the color of vej44… "*
- Searched with street name and vejno using googlemaps
- He was thinking to ask hospital staff if department related to lungs is located in multiple buildings
- He thinks he used the street signs only to confirm his way but he is more confident on the map he is using
  "*I used street direction only to confirm but i was depending on my phone and i kind use it as an assurance whether I'm going in correct way…*"
- He used his mobile because it makes him faster to search rather than looking at map and wasting time again
- He describes he remembered the indgang number in the map and he believes if he gets lost in the middle he can again look at the entrance numbers on the map.
  "*It's good that I remember that I need to go entrance 60 because if i have forgotten there is no indication on where to go on the street name…In that case, i would have to look at map again to move to 60…*"

Participant ID5 (Vignette 6):

Observation:

- He got an email from the hospital regarding detailed information about the destination. (department address and the entrance number)
- Overall, it was easy for him to find his initial destination (building 60) and final destination (7A building, Abdominal department) using Google Maps.
- Initially, he searched for Building 60 on Google Maps and he went there easily.
- He did not use the onsite maps at all.
- He used the signage mainly to verify that he was in the correct way.
- He was very calm and not stressed throughout the whole navigation.
- He used the signage to navigate indoors.
- He did not pay attention to the color coding on the stairs
- He found his destination using the signage on the 3rd floor and following the arrow showing where the department is.
- It was very easy for him to navigate indoors.

Interview:

- He mentioned that his navigation experience was good. It was easy for him to find his way using Google Maps and signage.
- He thinks that arrows indicate the way in signage is very useful. "*Arrows are always helpful*"
- He mentioned he noticed indoor and outdoor dashboards (signage).
- He noticed onsite maps but didn't use them.
- He didn't notice color coding inside the hospital.
- He searched with building 60 for the first destination and with the given address for the final destination.*" I used the name of the hospital to arrive and then for my first destination, I used building 60. For the second destination, I searched using the address I had from eboks".*
- He believes that building number is very important. *"Outside of the building, you can see the building number very clearly".*
- He didn't pay attention to address names.*"I ignored street names while walking".*
- He claims that sometimes cannot rely completely on google maps. Both onsite systems should be there along with google maps. *"If the direction of google maps is different than the direction showing in the dashboards I would follow the dashboards".*
- Google Maps vs Onsite Systems. *"Google Maps is easier because you can see your position and destination and estimate the time to get there".* He also mentioned that he is a bit shy about asking people.*" First online and then ask someone. It is an additional task for both of us".*
- He mentioned that onsite maps are very complicated and hard to read because of too much information.
- Downloading another application is an additional task for him. if google maps are fine, he won't use another application provided by the hospital.
- Information should be mentioned in English.
- According to him, indoor navigation needs some improvement.
- It is better for him to stick to one interface(Google Maps) and not use another application because it is an additional task to become familiar with a new application.
- In a case where a department can be found in multiple buildings, he thinks that searching in the hospital app by department name will be better.

- It would be useful to have the QR code in advance when receiving the email with the appointment in eboks.
- Important features for an application would be the search by department and estimated time to your destination.

Participant ID6 (Vignette 2):

- He came here to visit his friend who got appendix surgery at the hospital, and he had to hurry.
- He didn't ask where his friend is because it was a surprise visit. Therefore he needed to find the location himself and he had only 15 min to find his friend.
- He said that he is a non-regular visitor. Since he had visited the hospital before, but it was a year ago and one month ago.
- Overall, the task was not easy because it is a big place and a number of small roads, also there are lots of buildings that look similar.
- It took some time to be easier to navigate at the hospital.
  "First time, when I was here, I was completely lost. I feel it is still not entirely easy."
- He thinks if someone doesn't know well about medical terms in this situation, he would be probably struggling a lot because the map indicates only the department name and entrance number. (absent information of the location by a procedure of the patient)
  "...I was thinking of different cases where it end and stuff.If you dont know sort of medical terms or what kind of procedure is for way or have any clue about that. You will struggle a lot because the map is just with departments and entrances. So if u dont know what procedure is done at what department then your'e sort of screwed if you dont figure out that you can just go the information desk and get help… "
- He recommended that going to the information desk to get help would be nice in the case without detailed information.
- He was surprised that all signs and descriptions in the hospitals are only in the Danish language. He suggested adding the English language for non-danish people living in Denmark.
- He expects it would be easier to find the location if he got an address and department name to which he had to go.
- He noticed some arrow signs and an overall map and a department description board and outdoors and it was helpful to navigate.
- He also used Google Maps, but it was only shown the destination partially.
- He thinks that the current wayfinding system at the hospital could be better by providing more description of the department's information in both Danish and English as a simple improvement and a bigger size of signs to contain more information.
- He didn't look at the map while he was on his way because he used his mobile phone for Google Maps and checked the department located on the map before he departs.
- Firstly, he was aware of his final destination name and remember the entrance number and direction from the map of the hospital and then only depended on Google Maps with the information and checked the path from the arrow signs on the way.
- During his journey, he found the correct medical department of the building, however, the reception desk was closed. Therefore, he had to be back to the information desk to get the current location of his friend after the surgery.

- He noticed that the indoor signs which contain floor information were helpful to find the direction of his destination.
  “When I entered the building through the entrance, I found the list of information on the board, and I noticed immediately where I should go.”
- Regarding the indoor wayfinding system, he found a floor easily but when he arrived at the floor, there were a bunch of doors which are not well indicated the details.
- When he arrived at the third floor, he saw small signs on the wall which is indicated what is behind the doors. He is able to read the danish language, so he read the text for finding the place more than other indicators.
- He felt a bit scared to open one of the bunch of doors because he was not sure the room is the right place.
- He relied on Google Maps with his mobile phone when he navigated outdoors at the hospital, but once he arrived at the building, he used the physical indoor signs or tried to ask for help from the hospital staff.
- He expects that he would like to use a mobile application to navigate certain places because he used to follow Google Maps to find some places all the time and he believes that the information from the app is reliable.
  “Before you even go there, you can prepare the place and know how to get there, even some department names can be seen.”
- He recommended an interactive map feature with more information for the future improvement of the wayfinding application.
  “You know, click the kinds of stuff on the map to search information about what is there, also the other way that the list of entrances and buildings and it will be able to click them for showing the location on the map, I would say something like a Google Maps”
- About the search function on the map, he considered that it makes it easier to navigate with any condition facing users such as an address, entrance numbers or department numbers.
  “The search function can definitely be a plus!”
- Instead of downloading the app, he prefers to get the information through QR-code from the hospital on-site or website.
- Additionally, he considers other visual functions would be a good idea. For example, image views of the buildings, color codes are helpful for users to distinguish the different information.
- About the color code system outdoor signs(background color in entrance numbers), he replied that it was not really visible.
- He prefers to use Google Maps because it shows the actual direction to the destination's entrance while he is moving.
  “I can see, I am walking in the right direction, and I can follow while I am walking.”
- He trusts the information from Google Maps, also he would like to use the information from Bispibjerg Hospital at the end.
  “Oh yeah, I trust the hospital because Google shows me the actual entrance, but if I don’t know the address, then it is not useful enough.”
- He recommended that more on-site information needed kind as maps and signs and a mobile map will be good.
- He suggests if each department's information on the hospital website can provide the links to Google Maps, it would be nice to use the information for each user(because the hospital website provides only pdf maps on the website).

Participant ID7 (Vignette 5):

Observation:

- Overall, it took almost 40-45 minutes to find the pathology department.
- At first glance, he got curious and excited to find the directions using signs or maps but missed noticing the map at the nordvestlig indkørsel entrance due to his time limit hurry situation.
- He was staring at each building while passing to notice info regarding the department, and building number, and a bit confused about which way to go.

  "There is zero info nothing at the building...shhh"

- He used Google Translate at the first street board he came across to find the pathology department.

  "I can use a mobile device to translate Danish...because I don't know Danish a lot so this is my go-to...I need to look for a big board so to find out where pathology department is there…"

- He suggested he wanted to search with the department name directly, then with building number, way number, and street name.
- He was annoyed to use google translate every time at each street map and street sign he came across his way.
- He looked at the map for almost 3 minutes to read and understand what is written on it. he insists the map is outdated and not precise to understand.
- He is searching for the alphabet "P" on the map department description board and was reading every department name within the "P" alphabet but couldn't find the pathology department written in it.

  "*There is a pharmaceutical department, physio, psychiatry, and skin research department. But there is no pathology here…*"

- Since he couldn't find the pathology department on board, he wanted to go to the dermatology department.

  "Pathology department is not described in map board. here I could see dermatology in task, so I think I need to go to dermatology department for skin conditions…"

- He got confused with vej no color and entrance number color on the map and information board.

  "I was matching the Vejno color (black) with the entrance number color as it's written big here which is blue in color. That's what I figured with color similarity…"

- He took a picture of the map on his mobile.
  "*Ahh. It's hard to remember the map…wait first I will take a picture in my phone…*"

- He used a paper map as well and finds it better to read.

"*I was confused with sign notation. Here in paper map they showed vejno bigger and in static map it was very smaller. The paper map was way clearer to me…***"**

- He mentioned speaking symbol at entrance 20F on the map is vague as he didn't find a description of what this symbol means.

  "*Right now, I think this symbol is for speaking to people….like in our country we have a support team for help… as there is no description explicitly mentioned regarding the symbol. It is vague…see here there are many symbols for bus, parking and other symbols, I don't know what are those for…*"

- He really liked the feature of having helpdesk number at bottom of the map, he feels it would be easy to call someone if they get lost and want to know the destination.
- He tries to check the Bispebjeg hospital website to check the pathology department. However, he was in a hurry and couldn't stick with searching for it.
- He was confused about finding the information desk, as the symbol "i" was black in color where it overlapped with the building color on the map and he found it hard to recognize. He also got a bit confused with multiple symbols with "i" where most of them are light grey and one is black.
- He notices that all the entrance buildings with green color are not specified which departments it consists of except a few.
  " Wait…there are entrance numbers which are green but they are not mentioned in description except few like psychiatry department…then what is entrance 39? I think this board is outdated or something…."

- At the southern entrance, we noticed he lacked enthusiasm because he invested approx 25 minutes of time already before even reaching the information desk to ask staff regarding department.

Interview:

- Overall, three systems were noticed by him.
  "*I noticed three systems. One is I could communicate with phone number. Secondly, there were maps and boards which is pointed to specific direction. Third one is the information desk or reception desk… "*

- He feels map information is vague and not updated.
  "It was a bit hard to find pathology department here. I think pathology department is set up newly I think so…not sure, and the information was not so well mentioned in the maps and in the campus. I mean it took me a long time to actually find…"

- His overall experience was a bit tiring.
  "*It was very tiring…I actually spent 45 minutes finding a place and I also have suggestions for it where it needed improvement I guess so*"

- He explains reaching to the information desk after working hours is not possible.
- He suggests hospital information be provided in both languages English and Danish.

"*Since hospital is a public place, A well detailed information may be provided in both danish and english*"

- He finds it harder to navigate using the website once he reached the hospital.
  "*It was harder navigating with website once I reach the campus. It's more time-saving if I look around the campus and find the things much more easily…*"

- He prefers having a map dedicated to this hospital specifically which updates from time to time even though there are google maps.
  "*We have google maps and other maps but if there is something dedicated to this hospital campus and well updated time to time is better…I mean time to time here changes made within campus, just something like new building or section information*"

- He thinks the arrow signs and information on street boards are fine
- He suggests symbol descriptions and also colors could be improved on-site map and well explained.
- He suggested on-site map near the 31A entrance could be placed a bit higher because it was out of his side and couldn't notice.
- He thinks he will use the google maps to find the location if he knows the address in advance with building number or vej no.
  "*If you are good enough with maps and have coordinates regarding building number or vej no in advance. I don't think it will be much difficult for me because I can actually see the map and go to that place…*"

- He feels google maps provides directions for outside but not inside and suggests if they have a map on the hospital website which is digitally interactive would be better.
  "*If I have an interactive map, search and find would be much useful… First thing, I would search with department then I look for departments with building numbers or vej numbers…It will also be better if it has smart suggestions…Also, I believe it's more trustworthy…*"

- In Digital systems, he suggests having an audio feature alongside the interactive map with a search function
  "*Alongside search feature, it would be better if you have audio guide…when you search your department ID then audio guide can suggest you go to that location. To make it more accessible this would also help blind or deaf people…*"

- He thinks pictures of buildings are not necessary when he had the coordinates of the building. "...*I mean say like we had this coordinate of 60 & 44 (entrance & vej no). I don't think pictures are not necessary…* "

- In a new digital system in the future, he suggests clicking the building number coordinates could display all the departments in that building
  "...*If you're making maps or some digital systems, you click on the coordinates then you get 4 or 5 departments that are situated here…That would be much helpful on maps…*"

- He suggests flexibility of the system to show the shortest routes
  "*Google Maps doesn't have short routes like off the road… I used a map for hiking and tracking in Spain. I believe a map that shows the shortest path will be helpful*"

- He is experienced with VR using it and he insists not using for hospital environment.
  "*I have not experienced AR but with VR…But I think you could put information with VR but it's not first priority of a person coming hospital…*"

- He **recommends** and **believes** displaying departments on each building would make people easily recognize the place.
- He also suggests no need to maintain authenticity for a digital system
  "I don't think users need to share their third-party credentials in the system because hospital is a public place…"

Participant ID9 (Vignette 3):

- She came to get blood testing for the first time at the hospital.
- She thinks that the given task regarding navigating was fairly easy except for the construction area.
  " That was a bit challenging. I tried to use Google Maps from the parking place, but Google Maps said that I had to go left, going through to block the road, but there was a construction area."
- She found the outdoor map and got the direction to her destination.
- The map showed the two numbers together at the same location as the entrance number and street number, it was confusing.
- She had experienced navigating other hospitals previously, and it didn't give her clear ideas to find a way with the wayfinding systems.
- She shares her experiences with other hospitals(Gentoft, Hviore, Helev hospital), which were also struggling to find the right place in the building because of complicated entrances.
- She mentioned that it was easy to find the place because there were enough amount of maps and outdoor signs along her way at Bispebjerg hospital.
- When she looked at the overview of the map to get a general idea, she was not sure where the place is.
- After she started to walk following the direction, she was able to see the outdoor signs. Therefore, she was confident about the direction towards entrance 60(her destination).
- She was sure about the direction of her journey most of the time.
- One time, she was confused about the way, so she used both Google Maps and the outdoor map to get the direction and it was helpful.
- Because she got the current direction on Google Maps lively, she was able to match the location with the physical map.
- She saw other buildings and other entrances while she passed the way, but she didn't remember the details(entrance numbers on the buildings, or other facilities).
- She likes Google Maps because it provides her current location, however, she thinks that it couldn't give her detailed information compared to the hospital's on-site map.
  "The main reason why I use Google Maps is… I got to know where am I."

- Some main entrances can be seen on Google Maps, but not all entrances or departments.
- She prefers to use digital systems regarding hospital appointments, however, there were already too many healthcare applications in Denmark. The notifications from different applications made her annoyed sometimes.
- She wishes to use one hospital application which is covering all appointments and stores her health records with each location's information as well.
- She expects that the email from eboks can contain links which are connected to the hospital map. It would be easier to access the digital interactive map from the hospital.
- If the new application has to be downloaded, she would use only one platform for getting all information under the Danish central healthcare system. Because there are already several applications regarding health care and hospital systems.
- She thinks that physical maps are not portable(not last a long time and are hard to keep it). Therefore, she wants to access the digital map through her mobile phone.
- When she begins to navigate a place, she needs to see an overview of the area, after that she wants to check the distance between from and to location.
- She would like to use search terms related to her appointments at the hospital such as department name or entrance number from eboks.
- In case, she didn't have detailed information, she would like to search with keywords looking for relevant locations.
  "If I don't know the exact department name, then probably I would like to type some keywords, anything related to 'allergy', something like that, instead of specific actual names."
  "I expect to see the list of related all departments in all of the allergies"
- About the visual guide functions, she said that the red dots from the current position and destination are helpful and the line between the gaps as well.
- Overall, she is familiar with using Google Maps and doesn't need extra features to navigate such as AR or VR.
  "These can be more confusing to find the way."
- Additionally, she agreed that the function which shows the estimated time to the destination would be nice.
- She doesn't want to download the hospital app to use a map because making a new account and login are annoying.
  "If I have to download and log in only to navigate the hospital location, I would not want to download an application."
  "Perhaps I would use mainly Google Maps together with a virtual map from the hospital website to get detailed locations if it is possible."
  "I expect when I google it, some department at the hospital, there will be a link to access the hospital map."
  "There is an overview map to get an overview, and then a QR code for the further interactive map. It will be good."

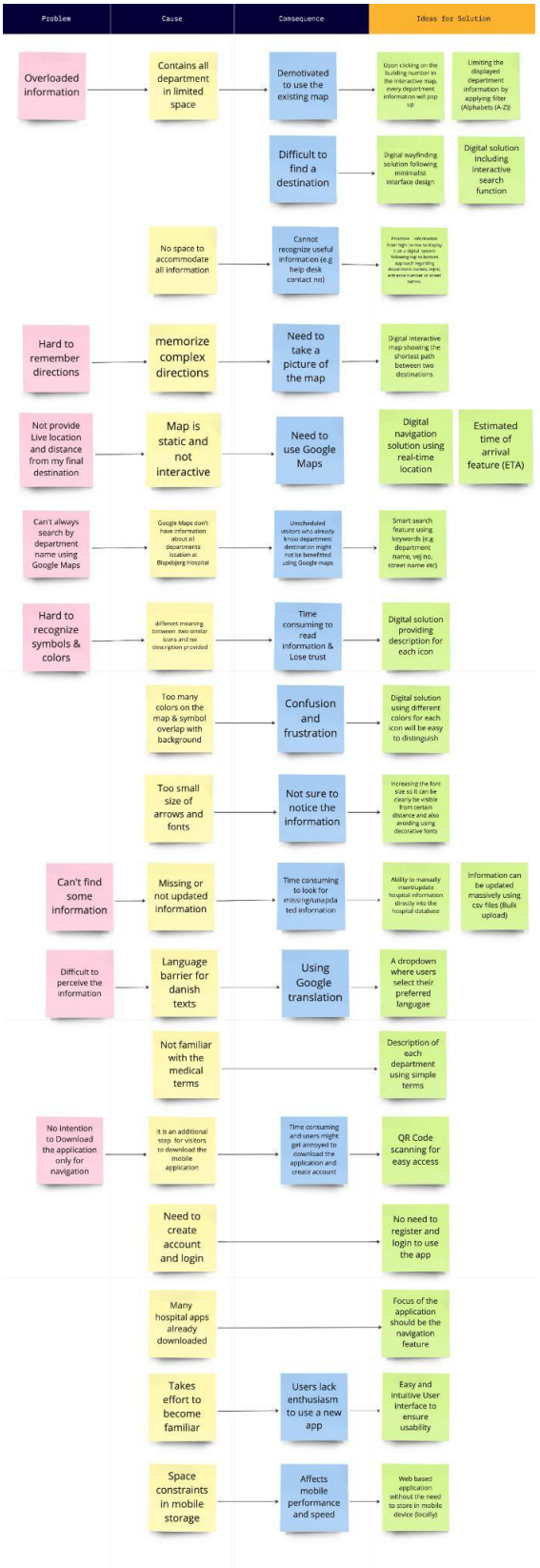
Appendix 5: Affinity Diagram

Key-words	**Findings**
Google Map	**Drawbacks** ● Didn't cover all the hospital information (eg; construction area, shortest path, outdoor) ● Didn't provide Indoor information **Benefits** ● Easy to access ● Familiar to use ● Gets Live location ● Trustworthy
On-site Maps	**Drawbacks**: ● Information is overloaded ● Two numbers on the map (entrance no & street no) ● Information icon confusion ● Color confusion ○ Different colors for an identical icon. (eg: "i" icon) ○ Visibility of overlapped icon "i" with the building color ● Missing information on department names ● Low information readability (Contact number, font size) ● Doesn't provide LIve location ● Hard to read for non-danish speakers ● Hard to remember. Visitors have to take a picture **Benefits**: ● Helpful for unscheduled visitors ● Trust information provided by the hospital
Outdoor Signage	**Drawbacks**: ● Hard for non-Danish speakers to read ● Display limited information due to signage size (e.g all departments included in a building are not displayed) **Benefits**: ● Helpful to confirm that the chosen way is correct ● The Arrow icon is very helpful in showing the direction ● Trustworthy information
Indoor Signage	**Drawbacks**: ● Indoor signage can be confusing ● The indoor arrow size is small ● Hard for non-Danish speakers to read

	Benefits: ● Helpful to show the department located on a floor using different color ● Trustworthy information
Information desk	**Drawbacks**: ● Limited working hours ● The location is not directly accessible and distance depends on hospital entrances **Benefits**: ● Can help visitors without detailed information of the destination ● Provide free maps for visitors ● Can connect with visitors on the phone ● Can be searched by Google Maps (e.g,. Indgang 60) ● Trustworthy information
Hospital staff	**Drawbacks**: ● Staff is not always available or spotted ● Can disturb to busy staff (Some people are not comfortable to ask help) **Benefits**: ● Visitors can find them at the building and get help ● Useful to get directions for both scheduled and unscheduled visitors
Indoor Color -coded	**Drawbacks:** ● Not noticeable for people indoors ● Not always useful since it is applicable for only a few departments **Benefits:** ● Shows the way from start to end following color lines ● Makes differentiation between different destinations
Entrance number	**Drawbacks**: ● Can be confused to the building number or street number ● No guarantee to find the destination department in the same entrance ● Non-scheduled visitors need to search at first the entrance number from the information board to get direction on the map **Benefits**: ● Useful keyword to find location of buildings ● Primary information in outdoor wayfinding at the hospital ● Easier to remember than text or symbols for most visitors and especially foreigners ● The font size is enough big to be recognized
Hospital Mobile application	**Drawbacks**:

	● If people have to download it they will not use it (Accessibility) ● Takes effort to become familiar with a new interface (Familiarity) ● Space constraints is one reason to avoid external app ● Can be annoying to create account and login ● Scheduled visitors would prefer to use Google Maps **Benefits**: ● Most preferred digital navigation system ○ Portability ○ Accessibility through their mobile app ● Digital map ensures memorability of the route ● English language option ● Real-time location ● Universal search function using department and various keywords when exact location is not known ○ Smart search is suggested ● Estimated travel time to destination ● Arrows are helpful to indicate the way ● Easy accessibility if a QR code is scanned ● Audio feature alongside the interactive map with a search function ● Department information on clicking building number in the application map ● Hospital updated information showing the shortest path (e.g construction area alternative shortest path) ● No need for authenticating user's credentials (As the hospital is a public place) ● Add English language for diverse users ● Reliable information provided by the hospital

Appendix 6: Diagnostic Map



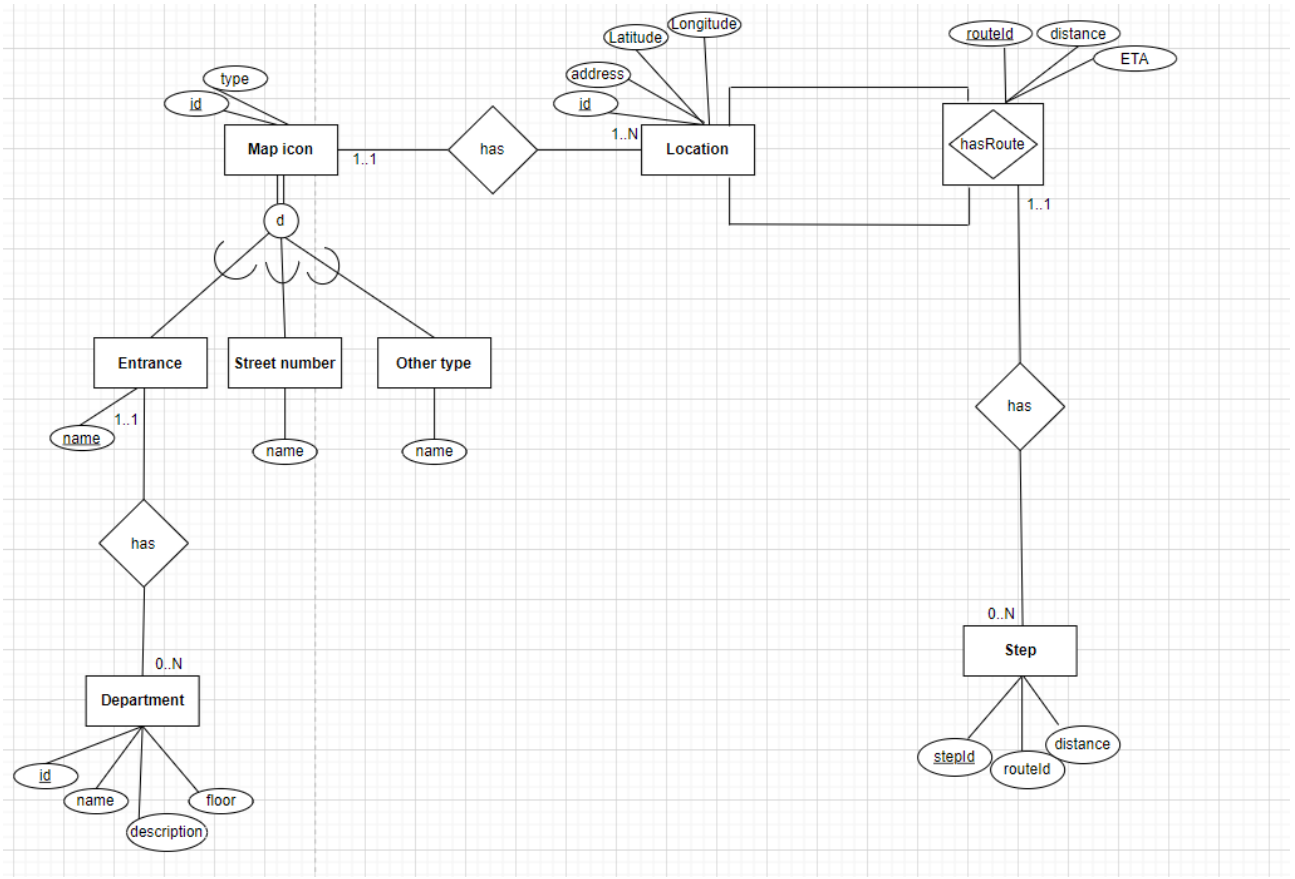
https://miro.com/app/board/uXjVPUnQ7Qc=/?moveToWidget=3458764551094899028&cot=14

Appendix 7:Virtual Map

Ideas for solutions	Actions	Consequences	Evaluation
A simple minimalistic digital user interface that only displays precise department information required for the visitor.	▪ Develop a user interface that is most preferred, intuitive, and easy to use. ▪ Explore Bispebjerg Hospital's existing sources (eg: database, website) about department names to show in the interface. ▪ Features implementation (eg: filter, **search**, **smart suggestions**, **hotline assistance**) to minimize the user's memory load. ▪ Test the usability of the developed interface to ensure ongoing improvement. Design aspects: ▪ Use **noticeable symbols, variation in colours** consistently & present **detailed descriptions**. ▪ Fancy or decorative fonts should be **avoided**. Typography could be inspired from material design guidelines (eg: 16sp font size for small screen interfaces) *Hospital organization needs to:* ▪ Gather newly established department's information and update their database frequently in order to synchronize with the user's interface	▪ Visitors don't have to spend time looking at the department information board on the hospital premises. ▪ Visitors find it easy if they have a variety of colors and can distinguish between them. ▪ Visitors are less likely to become perplexed if they see symbols combined with clear descriptions. ▪ Maintaining a consistent font size helps make text readable for a larger range of visitors (such as those with vision impairments). ▪ A smart search feature will help visitors recognize their address instead of recalling it (can be helpful if department names are long enough and hard to remember) ▪ By offering a chat service, and hotline, visitors can reach the hospital staff for assistance.	▪ Could save a lot of time for visitors. ▪ Could aid in the quick identification of design components and prevent confusion. ▪ Given that it involves IT personnel, implementation can take some time and work. ▪ IT workforce can make use of existing hospital servers to perform database operations or they can create a new server(can be a bit costly) ▪ Does not require user authentication for the future implemented system ▪ Usability testing conducted during the design phase ensures that the needs and requirements of the user are addressed. It directly impacts lowering the budget for implementation and saves time for IT staff and production bugs following the deployment phase.

Navigation improvements	▪ Implement a **real-time location** functionality that also calculates **ETA** (estimated time of arrival) ▪ Include an **interactive map** of the Bispebjerg Hospital in the digital solution. ▪ Incorporate a **smart search function** allowing visitors to search by keywords (e.g department name, street name, etc) *Hospital organization needs to*: ▪ Increase **font size** and use **larger arrows** in the physical indoor signage system	▪ Visitors will be informed in real-time about their **current location** knowing **how far** they are from the final destination. ▪ **No need** to take a picture of the on-site map. ▪ Unscheduled visitors will be able to use the search function **without knowing** the exact address (search by department) ▪ Hospital visitors will notice the indoor signage information	▪ Navigation experience at Bispebjerg Hospital will be **better**. ▪ Developing a digital solution can be **costly**. ▪ Might **not be very useful** for visitors with an appointment because they can use Google Maps (search destination by address)
An idea to reduce time consumption for the visitors gazing the information on existing systems (eg: on street board)	▪ Providing a feature for **translating the information** where visitors can select their preferred language alongside native language and English. ▪ A small **popup** showing **detailed information** about the department names, vej number, entrance number, street names, and etage.	▪ No need for depending on third-party services for translating the information ▪ Visitors don't get confused with hospital terms and can be confident in the information provided	▪ Time is saved and it's low cost to implement. ▪ Can sometimes reduce visitor personal feelings such as frustration, and confusion in hurry situations
Address visitors' concerns about using the digital navigation app	▪ Access the navigation application by scanning a **QR code**. ▪ **No need** to register and login the application to use it ▪ **Web-based application** without the need to store it locally (device) *Hospital organization needs to:* ▪ **Place** a QR code at every hospital entrance and other spots	▪ **No need** to download the application to use it ▪ Visitors will be able to **directly** use the application without the need to register and log in. ▪ Visitors don't need to be concerned about mobile **memory space limitation**	▪ There are still visitors that might consider using a new application requires **effort**. ▪ By scanning the QR code visitors can **directly** start using the app without any other mandatory step

Appendix 8:ER Diagram



Appendix 9:Figma

Link:
https://www.figma.com/file/ptldDZgD5qHF1RE1IlaS2l/Thesis-navigation?type=design&node-id=0-1&t=JS1B5KmxnE2A5KIW-0

Appendix 10: Usability testing tasks

1. You would like to find the **information desk phone number** in order to give them a call. Please find the respective information in the system (**hint**: once you find the number click on it to make the fake call).
2. Go back to the home screen. You want to find the entrance number of the **Abdominal center.** Try to find this information from the list of all **hospital departments** in the system.
3. Go back to the home screen. Using the interactive map, try to find the departments that are located in building 60 (**hint**: use the respective icon in the interactive map). Click on the **Endocrinological bed section | 14.** Translate the page into the **Danish language.**
4. Go back to the home screen. You would like to go to the **Blood test.** Your current location is **19A, Northern Entrance**. Use the system to find your way by completing first the destination field. Click on the **Start** button to start your journey.

Appendix 11: Pre-test and Post-test interview questions

Pre-test interview questions

1. What is your experience with digital navigation tools?
2. Do you use Google Maps frequently?
3. Have you ever used another application besides Google maps for navigation?

Post-test interview questions:

1. What was your experience using the digital system?
2. How did you find the tasks?
3. Did you like something particular in the system?
4. What do you think could be improved?

Appendix 12: Usability testing feedback

Participant id	Task (1-4 based on Appendix 10)	Success (0= not completed 1= completed with difficulty or help 2= easily completed)	Time to complete	Number of errors	Feedback /comments
1	1	2	0:20 min	0	• She finds the task very easy to complete and the system quite straightforward.
1	2	2	0:35 min	0	• She finds the task very easy to complete and the system quite straightforward.
1	3	2	1:02 mins	0	• She finds the task very easy to complete and the system quite straightforward.
1	4	2	1:10 mins	0	• She mentions that the navigation is quite straightforward and similar to other applications she has used. • She claims that *From search field* should be above the *To field* because it is a bit confusing.
2	1	2	0:55 min	0	• She thinks that nothing indicates that the information desk phone number is clickable. She suggests underlining it. • She thinks that the icon for the information desk contact details should be more intuitive.
2	2	2	1:25 mins	0	• She thinks that the search bar should be fixed at the top to appear while scrolling.
2	3	1	2:00 mins	3	• She believes that the map icon does not seem clickable and it is very small. She suggests making it bigger and changing the color.

					• She could not identify the map icon and completed the task only with our help.
2	4	2	2:10 mins	1	• She expects that *From* search field will appear first. She suggests changing the order so that it appears above *To* field. • She suggests renaming the "*Search*" button to "***Find route***".
3	1	2	0:15 min	0	• She thinks that the icon for the information desk could be more intuitive.
3	2	2	1:01 mins	0	• She finds the department list a very useful feature.
3	3	1	1:45 mins	1	• She finds it hard to identify the icon in the map • She suggests making the icon bigger and making it look clickable
3	4	2	1:30 mins	0	• She finds the search fields a bit confusing because they are found in a separate section and suggests to put them together. • She considers the search-by-keyword feature very useful.
4	1	2	0:30 min	0	• It was quite easy to find the information desk contact number.
4	2	2	1:05 mins	0	• She mentioned that system makes sense • She likes the feature to search for different departments and the provided information about entrance and floor.
4	3	2	1:25 mins	1	• The icon of building 60 in the interactive map is a bit small. She recommended making them bigger and easily identified.
4	4	2	2:05 mins	1	• She mentioned that it works similarly to other digital navigation systems. • She recommended

					changing the order of *From* and *To* search fields so that From appears on top of To similarly to other digital solutions.
5	1	2	0:32	0	• Completed the task very easily.
5	2	2	0:45	0	• He likes the feature a lot
5	3	2	1:10	1	• Map icons are not recognizable because they are small • Should be bigger and different color
5	4	2	1:05	0	• He liked the navigation feature and thinks it is intuitive • He suggests to make the *From* and *To* search fields appear in the same area.
6	1	1	1:10 mins	1	• He thinks that the information desk icon was not intuitive and the typical “i” icon could be used.
6	2	2	0:30 min	0	• He considers that search functionality is very useful to find the department the user search.
6	3	2	0:40 min	0	• He mentioned that the map icons for entrance numbers are very small.
6	4	2	1:00 mins		• He suggested changing the label of the search button to “Find route”. • He thinks that the system is very intuitive.