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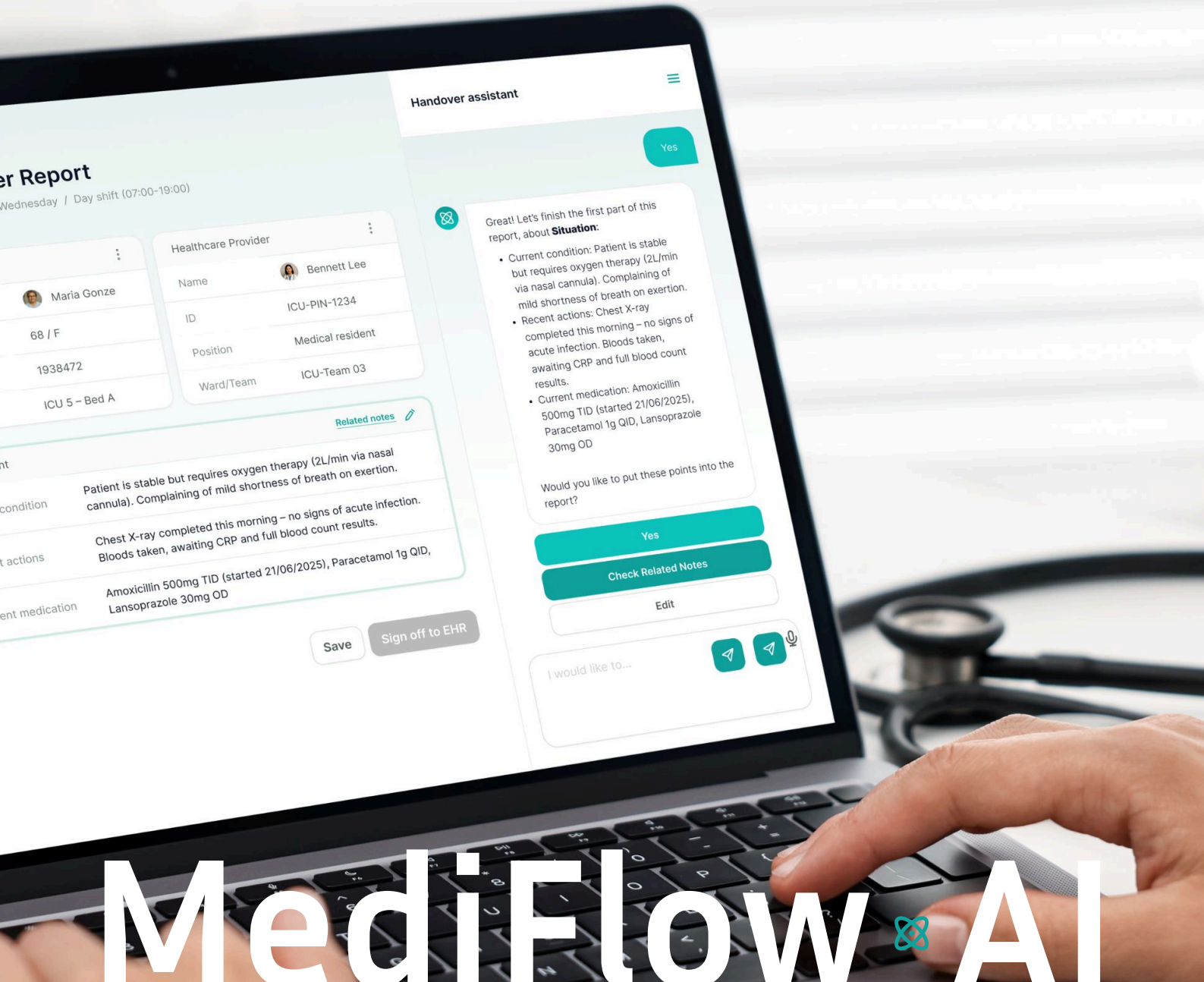

MediFlow AI

Human-Centred System Design for Fragmented Clinical Information Management and Report Generation

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Executive Summary

Project Motivation

As artificial intelligence (AI) rapidly advance, AI-driven design is increasingly reshaping systems and services across diverse domains. Among these, healthcare, a high-priority field characterized by dynamic challenges, presents significant opportunities for design innovation. At the beginning of this project, a brief research question was framed: **how could AI enhance communication processes in healthcare settings.**

Research Activity

To refine the project objective, the research session began with a comprehensive literature review on clinical communication and information management practices. Two critical challenges were revealed:

1. Information Overload and Time Pressure: Large volumes of information are exchanged through fast-paced communication among Healthcare professionals (HCPs) daily, which is a process essential for ensuring timely, high-quality patient care.
2. EHR System Complexity: While Electronic Health Record (EHR) systems are widely adopted for storing detailed medical information, their complex features and user interfaces create cumbersome documentation and administrative processes. These time-intensive tasks reduce the time and energy HCPs can dedicate to patient care, even lead to professional burnout.

The literature review also examined research on AI integration in healthcare, providing both theoretical supports and practical considerations for addressing clinical communication and information management challenges with AI.

Building on these insights, the study conducted a comparative analysis between two contrasting healthcare settings—the Intensive Care Unit (ICU) and nursing homes. Despite their fundamental differences in pace and pressure, both settings revealed shared challenges. These common pain points are believed to extend beyond the studied contexts, leading to design opportunities with potential applicability across a wider range of healthcare scenarios.

Through user interviews, market research, and user journey mapping, the literature-based findings were validated and expanded. A new critical issue emerged:

3. Data Loss and Fragmentation: In healthcare settings, vast amounts of fragmented yet critical details are documented and exchanged through uncoordinated media. Much of this information is inconsistently organized within EHR systems or lost entirely, creating risks for treatment continuity and quality.

Additionally, the insufficient integration of AI medical tools into current workflows, combined with HCPs' perspectives on AI adoption, provided valuable design considerations.

Design Goal

Based on research insights, the design goal was established: **design an AI-driven system that assists in collecting and organizing fragmented medical information, enabling fast and efficient data entry and report generation into EHR systems.** The system aims to reduce documentation and administrative burden on HCPs, minimize information loss, and ultimately improve patient treatment quality.

Human-Centred Design Process

Guided by identified pain points and the defined design goal, design criteria were established to direct the development process. Brainstorming sessions generated multiple concepts, from which three promising directions were refined. Through systematic evaluation, one final concept was selected for further development.

The final design is an AI-driven system for fragmented clinical information management and report generation, including a digital platform and a companion voice-enabled pin, that serves as an innovative bridge between HCPs and EHR systems.

The process was guided by human-centered design principle, placing target users' experiences and feedback at the heart of all design decisions.

Evaluation

Evaluation targets were defined based on the design goal and established criteria. Evaluation session was conducted with both target users and design experts. These combined evaluation methods offered important comprehensive insights for future project discussion and reflection.

Abbreviations

AI - Artificial intelligence
HCPs - healthcare professionals
EHR - Electronic Health Record
ICU - Intensive Care Unit
PtFams - Patients and their families
NLG - Natural Language Generation
LLM - Large Language Models
ASR - Automatic speech recognition
CPOE - Computerized Physician Order Entry
ML - Machine Learning
NLP - Natural Language Processing
OCR - Optical Character Recognition
ICR - Intelligent Character Recognition

01

Introduction

1.1 Project Context
1.2 Project Objective
1.3 Project Background
1.4 Research Overview

Chapter Overview

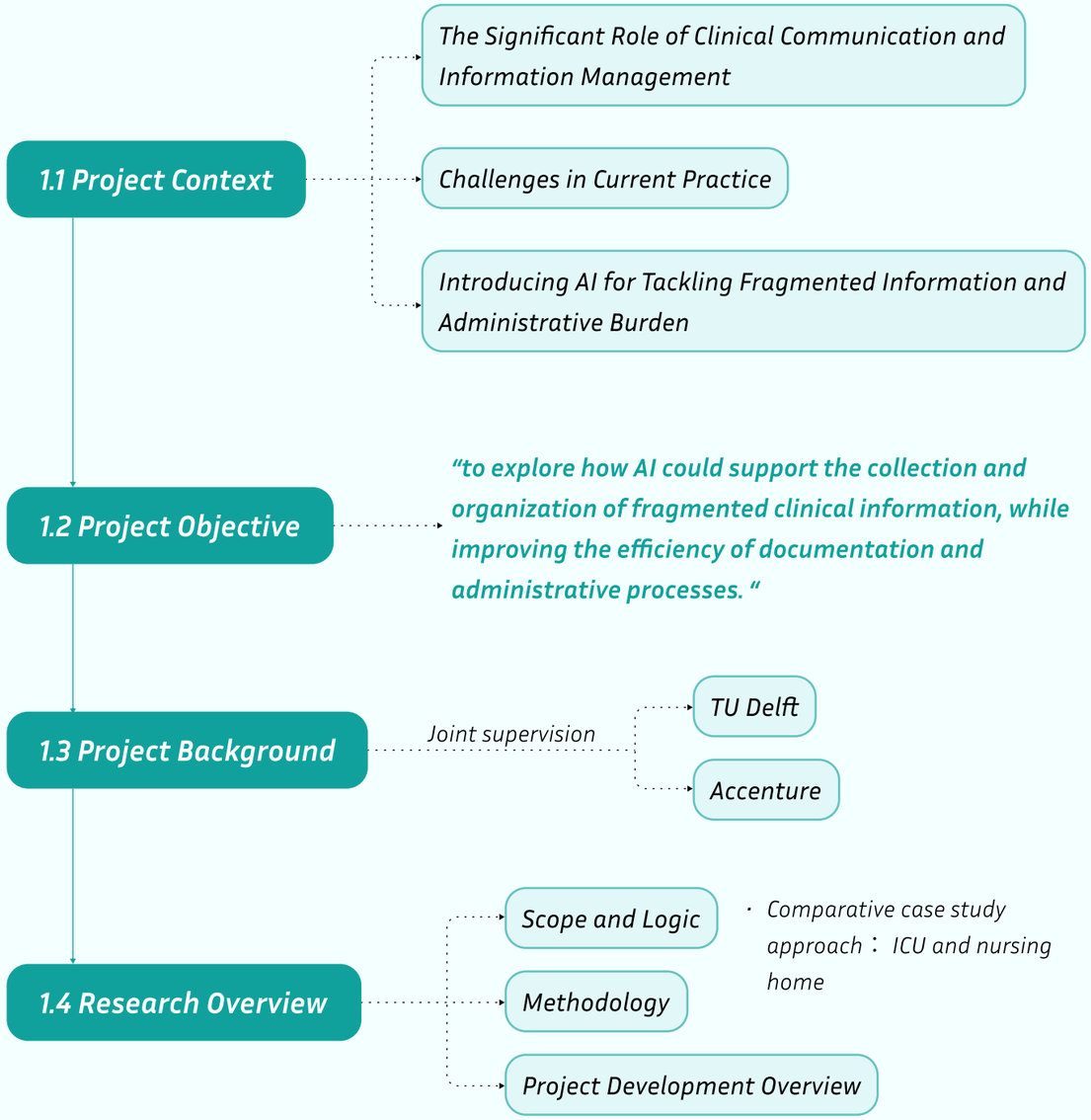


Figure 1. Mind map of Chapter 01



1.1 Project Context

1.1.1 The Significant Role of Clinical Communication and Information Management

Clinical communication between healthcare providers (HCPs), as well as between HCPs and patients and families (PtFams), represents two essential dimensions of medical communication. These conversations occur daily with fast paced and high intensity, involving substantial volumes of complex medical information.

Manser (2009) highlights that team performance in clinical environments is highly dependent on effective and efficient communication, which serves as a critical factor in ensuring high-quality and safe patient care.

In PtFams-HCPs interactions, Kim et al. (2024) provide systematic evidence that empathetic and clear communication by HCPs leads to improved treatment adherence, reduced patient anxiety, and enhanced care satisfaction.

EHR systems represent one of the most significant information management tools in contemporary healthcare settings. These comprehensive platforms encompass key functionalities including clinical decision support systems, computerized physician order entry (CPOE) systems, and health information exchange capabilities. EHRs are designed to systematically record and manage health information generated across diverse care delivery settings, with the primary objectives of reducing medical errors and enhancing overall quality of care (Menachemi & Collum, 2011).

1.1.2 Challenges in Current Practice

However, healthcare communication and information management face several significant challenges. The fast-paced and information-dense nature of medical communication poses considerable pressure on HCPs. Furthermore, the widespread adoption of EHR systems, which are significant for data documentation and information exchange, has introduced new burdens, including excessive documentation requirements, workflow disruptions, and administrative overload.

Shanafelt et al. (2016) demonstrate that HCPs experiencing high clerical demands report decreased job satisfaction, reduced availability for meaningful patient interaction, and heightened risks of professional burnout.

Similarly, Amoah et al. (2019) show that time constraints and workload pressures significantly create negative barriers to therapeutic communication between nurses and patients, resulting in rushed consultations and superficial information exchanges.

The negative impact of communication inefficiencies extends beyond healthcare providers. Meldaikyte et al. (2018) reveal that insufficient communication affects the psychological well being of PtFams, who often rely on it as their primary source of medical information, resulting in feelings of disconnection from care providers and heightened anxiety, confusion, and disorientation.

Beyond insights from the literature, exploratory studies in this project identified fragmented information and data loss as another significant challenges in daily healthcare practice. **"Fragmented information" refers to details that emerge during rapid daily clinical communication and are documented across diverse uncoordinated media, including orally communicated tasks, quick notes on scrap paper, reminders on ward whiteboards, handwritten notebooks, meeting notes in mobile apps, or memory-based details etc..** As these records are often scattered, inconsistently documented, or entirely lost, they frequently fail to be integrated into EHR systems, posing significant risks to treatment quality and continuity.

1.1.3 Introducing AI for Tackling Fragmented Information and Administrative Burden

With the rapid advancement of AI, healthcare has emerged as a particularly promising domain for exploring AI-driven design solutions. AI's capacity to process, interpret, and synthesize vast amounts of clinical information positions it as a potential solution to the clinical communication and information management challenges.

Natural Language Generation (NLG) capabilities show particular promise in addressing documentation challenges. Croxford et al. (2025) provide evidence that large language models (LLMs) can extract and summarize complex medical documentation into coherent, actionable insights while maintaining clinical accuracy.

Similarly, automatic speech recognition (ASR) technologies offer solutions to real-time documentation burdens. Chiu et al. (2018) demonstrate, through their clinical conversation dataset, that specialized medical ASR systems can accurately transcribe doctor-patient spoken interactions into structured clinical documentation, with particular strength in capturing medical terminology, which remarkably align with the conversational nature of healthcare settings.

1.2 Project Objective

Building on these theoretical supports and technological capabilities, this project explores how AI could support the collection and organization of fragmented clinical information while improving the efficiency of documentation and administrative processes. The ultimate goal is to reduce burdens on HCPs, minimize information loss, and ultimately enhance the quality of patient treatment.

1.3 Project Background

This project is conducted under joint supervision by TU Delft and Accenture IXID. TU Delft provides expertise in design methodology and academic research, while Accenture IXID contributes practical insights into product design, digital solutions, and system development. This collaborative partnership establishes a balanced foundation for developing solutions that are both theoretically rigorous and practically applicable.



Figure 2. Accenture office



Figure 3. TU Delft Industrial Design Engineering

1.4 Research Overview

1.4.1 Research Scope and Logic

In light of practical resource limitations and the high sensitivity associated with healthcare environments, this project proceeds without a specific organizational client, enabling an open exploratory research approach that maintains investigative flexibility and objectivity.

Based on discussions with the supervisory team, following literature review session that focuses on general healthcare settings, this project also adopts a comparative case study approach examining two contrasting healthcare environments: the ICU and the nursing home. These contexts represent fundamentally different operational patterns: the ICU characterized by fast pace and high pressure, while nursing homes operate within a relatively stable and slower pace.

This comparative framework facilitates systematic analysis of user journeys and communication patterns across both healthcare environments. By identifying shared challenges that persist despite the significant contextual differences between ICUs and nursing homes, this approach reveals pain points that transcend specific settings. The solutions developed to address these common challenges are therefore likely to demonstrate broad applicability and transferability across diverse healthcare contexts.



ICU

fast pace and high pressure



Nursing Home

a relatively stable and slower pace

Common Underlying Challenges

that transcend setting-specific characteristics

Design Solution

broadly applicable solutions across diverse healthcare contexts

Figure 4. Mind map of project scope and logic with pictures from online

1.4.2 Research Methodology

This project employed a comprehensive set of design research methods to build a thorough understanding of challenges in clinical communication and information management, and opportunities for AI-driven design solution.

1. Literature review was conducted to synthesize existing academic insights on healthcare communication, EHR systems, and the application of AI in healthcare settings.
2. Comparative case study methodology is employed to examine communication practices across two contrasting healthcare environments: ICU and nursing home.
3. Document Analysis complemented the literature review by examining publicly available videos, and articles on healthcare communication workflows and digital documentation practices.
4. Journey mapping helped visualize the workflows of HCPs, PtFams and care givers in ICUs and nursing homes, highlighting information flow and key stages in daily communication.
5. Competitive analysis was performed to investigate existing representative AI medical tools, identifying current market gaps and limitations.
6. User interviews were conducted with target users and design experts to collect first-hand insights into everyday practices, pain points, and expectations for new systems.
7. Thematic analysis (Braun & Clarke, 2006) was used to systematically analyse qualitative data collected from interviews and evaluation session, which enabled the identification of recurring patterns, common pain points, design opportunities and suggestions for further development.

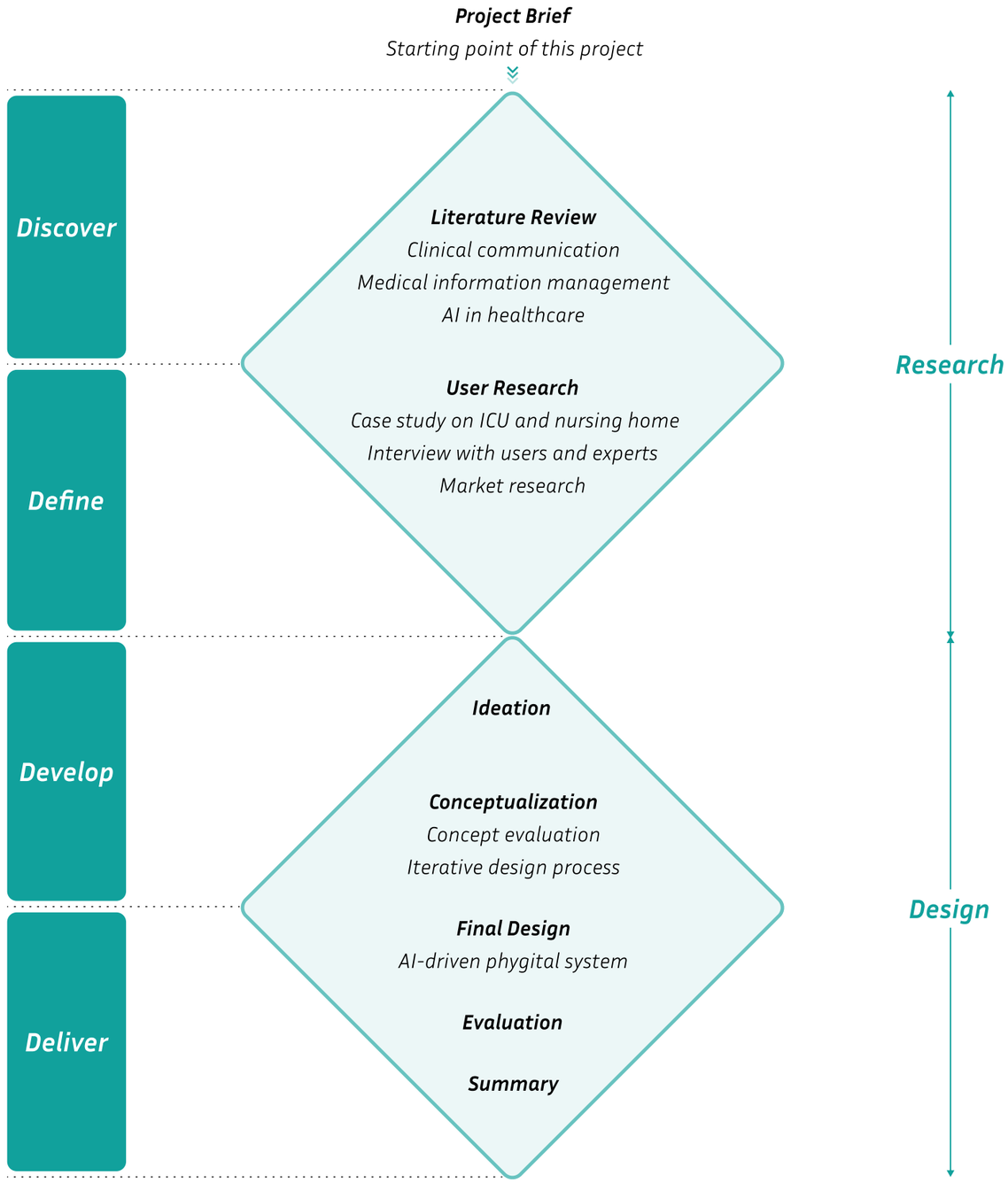


Figure 5. Project development overview

02

Literature Review

2.1 Introduction to Clinical Communication
2.2 EHR Systems and Clinical Information Management
2.3 Challenges in Clinical Communication and Information Management
2.4 AI in Healthcare
2.5 Main Takeaway

Chapter Overview

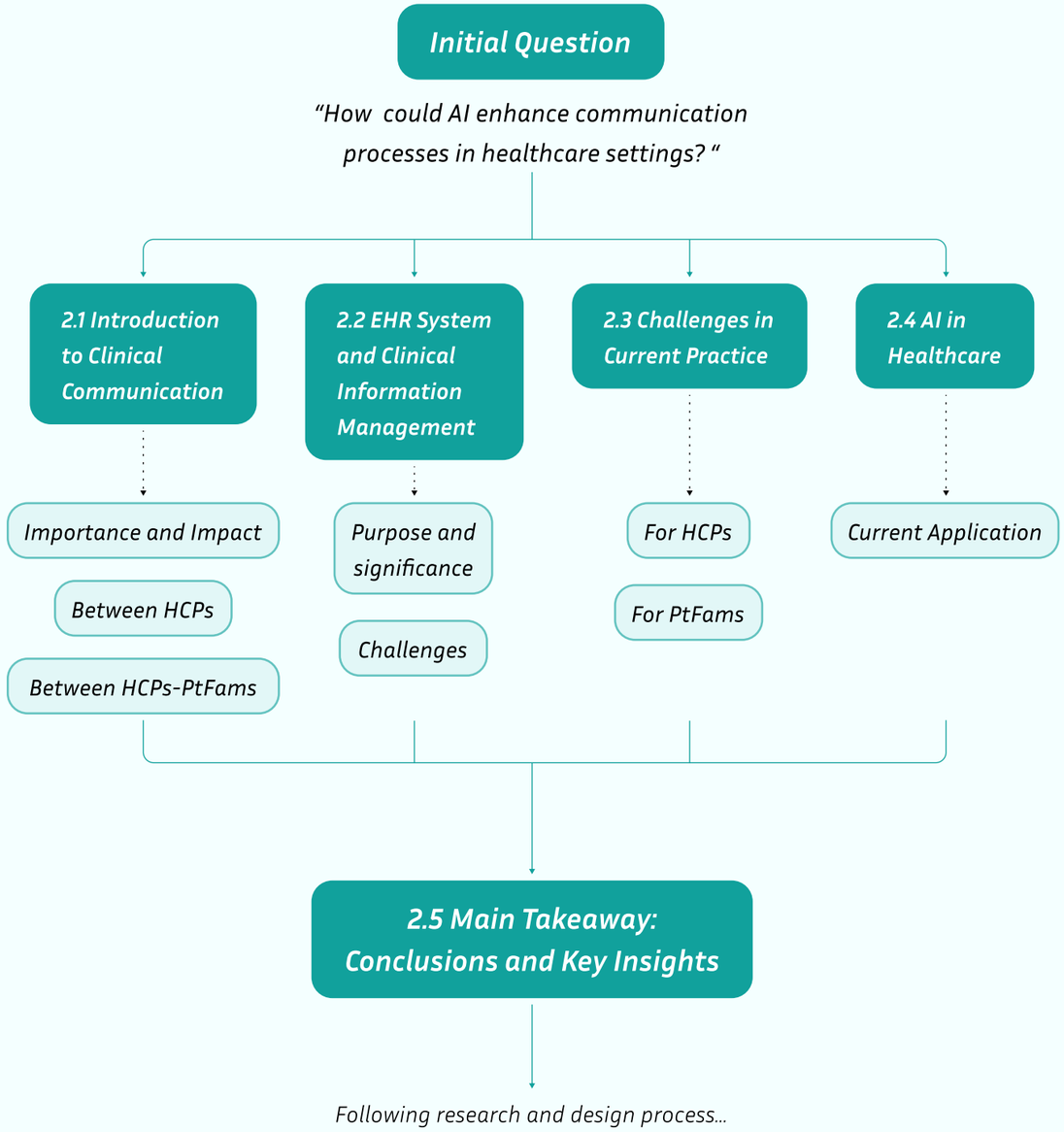


Figure 6. Mind map of Chapter 02

2.1 Introduction to Clinical Communication

2.1.1 Importance and Impact of Communication in Healthcare

Healthcare is a highly dynamic and complex field characterized by the need to process and synthesize massive amounts of data from multiple sources. In this information-rich environment, effective communication among different stakeholders serves as one of the key foundations for successful treatment delivery and optimal patient outcomes. Even small clinical teams generate substantial volumes of information exchange through numerous channels, making communication management a critical operational challenge (Coiera, 2006).

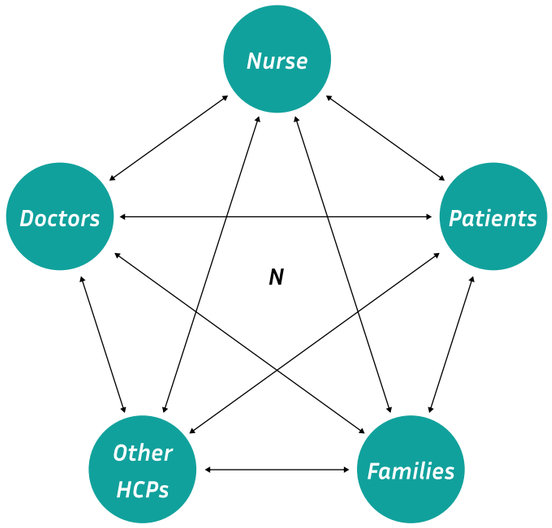


Figure 7. Updated model of communication processes in healthcare settings.
Adapted from Coiera (2006), with modifications based on the author's own research findings and contextual analysis.

Benefits of Effective Communication

The benefits of effective healthcare communication are well-documented across multiple dimensions of care delivery. Good communication practices contribute to building stronger therapeutic relationships between HCPs and PtFams, as well as enhanced interprofessional coordination and teamwork. These improvements significantly reduce the risk of medical errors, ensure better patient outcomes, and foster higher levels of patient satisfaction (Lang, 2012).

Manser (2009) emphasizes that team performance in clinical environments is heavily dependent on effective and efficient communication, which serves as a critical determinant of patient safety and care quality.

Recent evidence further supports this foundation. Kim et al. (2024) provide systematic evidence that empathetic and clear communication by HCPs leads to improved treatment adherence, reduced patient anxiety, and enhanced patient satisfaction. These findings underscore the multifaceted benefits of investing in communication excellence within healthcare settings.

Negative Impact of Communication Failures

Conversely, communication failures might lead to significant negative impacts on both treatment processes and healthcare economics. At the clinical level, communication errors have been identified as the leading cause of medical errors, occurring with twice the frequency of errors attributable to inadequate clinical skills (Coiera, 2006). These communication breakdowns manifest in various forms, including incomplete information transfer, misunderstood instructions, and delayed or missed communications between healthcare providers.

At the administrative and economic level, poor communication generates substantial financial consequences for healthcare systems. These economic impacts include increased hospital readmissions, unnecessary diagnostic testing, inappropriate polypharmacy, and redundant referrals, all contributing to inflated healthcare costs without corresponding improvements in patient outcomes. The magnitude of this economic burden is considerable, with communication inefficiencies among physicians in hospital settings estimated to generate approximately $800 million in annual waste (Vermeir et al., 2015).

The negative consequences extend to PtFams experiences as well. Meldaikyte et al. (2018) reveal that insufficient communication affects PtFams, who often rely on HCPs as their primary source of medical information, resulting in feelings of disconnection from healthcare providers and heightened anxiety, confusion, and disorientation.

Among all significant categories of healthcare communication, this project focuses primarily on communication between HCPs (interprofessional and intraprofessional communications) and communication between HCPs and PtFams.

2.1.2 Between HCPs: Interprofessional and Intraprofessional Communications

Interprofessional and intraprofessional communication represent two significant aspects of clinical communication systems. Interprofessional communication refers to information exchange across different professional disciplines, such as physician-nurse and therapist-pharmacist communications. Intraprofessional communication refers to communication within the same professional group, such as nurse-to-nurse and physician-to-physician communications. These communication patterns can be classified into two dimensions that help understand their complexity and variety within healthcare settings.

Synchronous Communication

Synchronous communication refers to real-time conversations where participants interact simultaneously and receive

immediate feedback. This category includes clinical meetings, ward rounds, handovers, emergency consultations, and teleconferences. The immediacy of synchronous communication enables rapid decision-making and collaborative problem-solving, making it essential for time-sensitive clinical situations.

Asynchronous Communication

Asynchronous communication refers to information exchange that occurs with time delays, allowing for documentation, reflection, and reference. This category includes written documentation, medication orders, whiteboard communications, and EHR system entries. Asynchronous communication provides the advantage of creating permanent records and enabling thoughtful, detailed information transfer.

Communication Touchpoints

The media of clinical communication typically represent a hybrid combination of traditional and digital touchpoints. Traditional touchpoints include face-to-face interactions, paper-based documentation, and telephone calls. Digital touchpoints encompass EHR systems, secure messaging platforms, and mobile applications. This hybrid nature creates both opportunities for enhanced information sharing and challenges related to information fragmentation across multiple media.

It has been well established that ineffective interprofessional and intraprofessional communications negatively impact medical team performance, leading to unsatisfactory and potentially dangerous patient outcomes, including delayed treatment, misdiagnosis, medication errors, patient injury, and even death (Foronda, MacWilliams, & McArthur, 2016).

2.1.3 HCPs-PtFams Communications

Effective HCPs-PtFams communication represents a core clinical function that serves multiple critical purposes. High-quality communication can reduce PtFams' anxiety, facilitate better understanding of their needs and expectations, and even decrease length of hospital stay. These benefits significantly contribute to delivering high-quality, patient-centered treatment outcomes and optimal patient satisfaction (Ha & Longnecker, 2010). Effective HCPs-PtFams communication encompasses several key components:

Information Exchange

- Sharing clinical information such as diagnoses, treatment options, and prognosis in accessible language
- Collecting comprehensive patient information about symptoms, concerns, and medical history
- Providing educational information about medical conditions, procedures, and treatment plans in understandable terms

Trust Building

- Demonstrating empathetic listening and understanding of PtFams' concerns
- Showing respect for PtFams' dignity
- Adapting communication styles to meet diverse PtFams' personal needs

Shared Decision-Making

- Presenting treatment options with clear explanations of benefits, risks, and alternatives
- Integrating patient values and preferences into treatment planning processes
- Ensuring patients are fully informed, understand, and agree to proposed treatments through informed consent processes

2.2 EHR Systems and Clinical Information Management

The landscape of healthcare communication has undergone significant transformation with the widespread adoption of digital tools, particularly Electronic Health Record (EHR) systems. The implementation of EHR systems represents one of the most significant technological shifts in modern healthcare.

HCPs are required to document extensive volumes of data on a daily basis and generate various types of reports, such as handover reports, meeting reports, and case discussion reports, which are all uploaded and stored in EHR systems. Consequently, EHR systems have evolved to incorporate highly sophisticated functionalities and complex user interfaces to accommodate the multifaceted documentation needs *(figure 8)*.

Purpose and Significance of EHR Systems

EHR systems serve as the primary infrastructure for clinical information management in modern healthcare settings. The core significance of EHR systems lies in their capacity to centralize patient information, improve care coordination, reduce medical errors, and enhance overall patient safety and care quality.

The theoretical benefits of EHR systems are extensive and well-documented. Menachemi and Collum (2011) identify several key advantages that EHR systems are designed to provide:

1. Improved access to comprehensive patient data that enables more informed clinical decision-making;
2. Enhanced clinical decision support through integrated alerts, reminders, and evidence-based guidelines;
3. Better care coordination among multiple healthcare providers through shared access to patient information;
4. Reduced duplication of tests and procedures through comprehensive medical history availability.

Additionally, EHR systems facilitate improved documentation quality, enable better population health management through data aggregation and analysis, and support evidence-based medicine through access to clinical research and best practice guidelines.

Implementation Challenges and Negative Impact

Despite these substantial theoretical benefits, the implementation of EHR systems has created new barriers to effective communication and information management, significantly impacting HCPs' professional satisfaction, patient care quality, and overall healthcare delivery efficiency. While designed to streamline clinical workflows, EHR systems have unexpectedly introduced new complexities that affect both the process and outcomes of patient care.

With complex interfaces and features, EHR systems always require multiple clicks and navigation through various screens to access basic patient information, leading to increased time spent on administrative tasks rather than meaningful patient care activities.

Menachemi and Collum (2011) also acknowledge that alongside the benefits, EHR implementation presents significant challenges including workflow disruptions during transition periods, new documentation and administrative burden, and the need for extensive staff training and adaptation. These implementation challenges might result in decreases in productivity and efficiency.

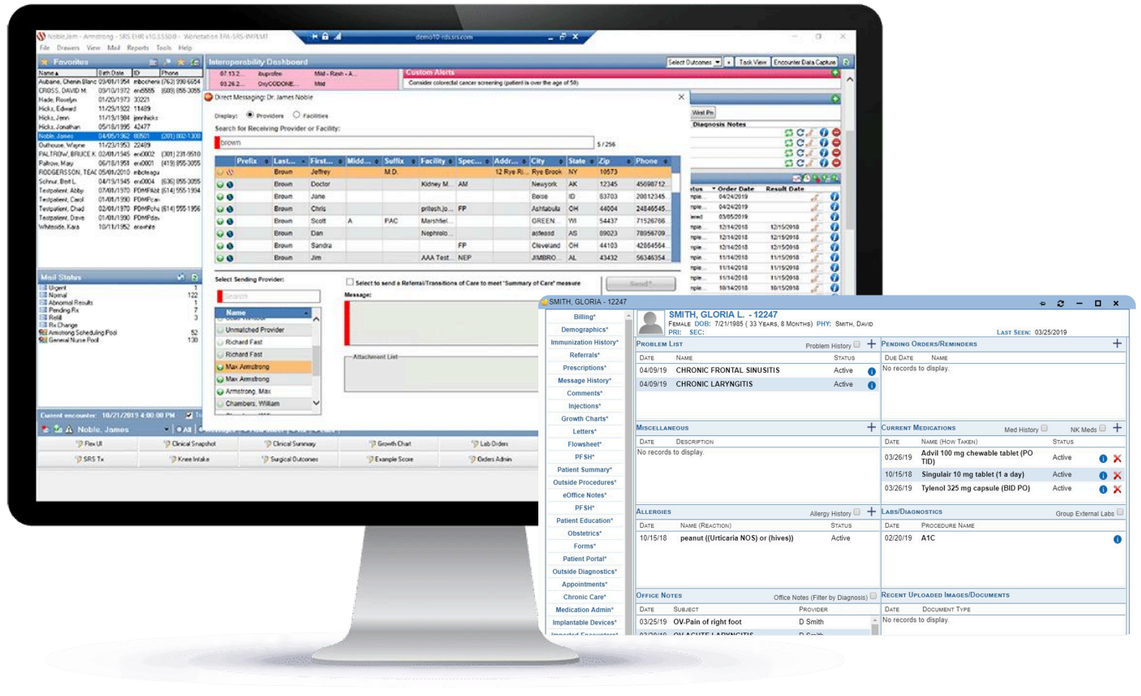


Figure 8. The complex features and user interface of an EHR system
Image source: online.

2.3 Challenges in Clinical Communication and Information Management

2.3.1 Challenges for HCPs

It is reported that more and more HCPs are experiencing decreased job satisfaction, reduced availability for meaningful patient interactions, and elevated rates of professional burnout. This trend has become a critical concern affecting the entire healthcare delivery system (Croxford et al., 2025). Research demonstrates that professional burnout directly correlates with lower quality of care, increased risk of medical errors, and leads physicians to reduce clinical work hours, which are consequences that negatively impact both the process and outcomes of patient treatment.

EHR-Related Documentation Burden

Many HCPs report that the widespread implementation of EHR systems has led to excessive documentation requirements, information overload, frequent workflow interruptions, delayed communication responses, and increased administrative burden (Shanafelt et al., 2016).

The documentation burden has become particularly severe. In many hospitals, EHR systems have implemented self-entry of notes through typing or voice recognition. These changes have paradoxically increased the amount of time HCPs spend on documentation and clerical tasks.

Current research reveals that physicians now spend approximately 6 hours of their 11-hour workdays within EHR systems and approximately 1.5 hours on documentation alone (Croxford et al., 2025).

Recent studies have identified workflow fragmentation as another significant challenge, which leads to cognitive overload and reduces the efficiency of clinical tasks (Amoah et al., 2019). HCPs report that EHR systems often fail to integrate smoothly into clinical workflows, creating multiple interruptions. In addition, navigation through complex EHR interfaces to access necessary information has been consistently identified as a barrier to efficient clinical work. Many systems require multiple clicks and navigation through various screens to access basic patient information, leading to increased time spent on administrative tasks rather than patient care activities.

2.3.2 Challenges for PtFams

The integration of EHR systems has fundamentally altered the nature of clinical encounters by introducing technological support into traditionally direct human interactions. As HCPs experience increased administrative burden and burnout, HCP-PtFam interactions are directly impacted.

Impact on Communication Quality

Research demonstrates that increased time spent on EHR systems correlates with heightened exhaustion among healthcare providers, resulting in fragmented attention, limited availability for meaningful patient interactions such as empathetic communication and eye contact (Asan et al., 2014), and rushed consultations characterized by superficial information exchanges (Amoah et al., 2019). This degradation in communication quality creates an environment where communication errors become more frequent, potentially compromising patient safety and care outcomes.

Under these challenging circumstances, PtFams face increasingly complex barriers that threaten not only their immediate treatment outcomes but may also contribute to longer-term psychological impacts, including post-hospital trauma (Bell et al., 2018).

Barriers to PtFams Engagement

When confronted with communication errors, possible mistakes, mismatched care goals, or confusing and conflicting information, PtFams frequently hesitate to ask clarifying questions or raise concerns. This reluctance stems from multiple psychological and social barriers. PtFams often avoid speaking up because they fear being perceived as "troublemakers" by the healthcare team, perceive that healthcare teams are too busy for their concerns, or feel uncertain about how to appropriately raise questions. The overall communication atmosphere from HCP teams may appear "unsupportive," further discouraging patient and family engagement (Bell et al., 2018).

Despite these barriers, research demonstrates that input from PtFams represents a crucial component of safe, effective healthcare delivery. PtFams often detect errors and changes that may be overlooked by busy healthcare teams and help improve continuity by conveying key information across different HCPs (Bell et al., 2018).

Psychological and Emotional Impact

PtFams traditionally rely on HCPs as their primary sources of medical information and explanation. Zhang et al. (2023) reported that when healthcare providers lack sufficient time or attention to provide comprehensive information and continuous care, PtFams experience increased tension, disappointment, and difficulty establishing trusting integration and connections with their healthcare teams.

The interpretation and explanation of medical information are particularly significant for PtFams. Evidence shows that inappropriate use of medical terminology and inadequate clinical explanations impact communication effectiveness (Amoah et al.,

2019). When HCPs use complex medical language without adequate explanation or fail to ensure patient comprehension, PtFams may feel excluded from their treatment management, leading to confusion, anxiety, and emotional distress.

2.4 AI in Healthcare

2.4.1 Current Applications and Potential

The integration of AI in healthcare began nearly five decades ago, with the first documented application dating back to 1976 (Aung et al., 2021). Since these early implementations, the field has experienced unprecedented growth, evolving from simple rule-based systems to complex, adaptive technologies. Contemporary AI healthcare applications encompass machine learning (ML), deep learning, LLMs, natural language processing (NLP), rule-based expert systems, and robotic process automation (Davenport & Kalakota, 2019). With their rapid development, the integration of AI and healthcare has a promising future.

The contemporary healthcare industry faces unprecedented challenges that threaten care delivery quality. Healthcare systems worldwide struggle with increasingly severe workforce shortages and alarming rates of professional burnout characterized by emotional exhaustion. These systemic pressures have created an environment where traditional approaches to healthcare delivery are insufficient to meet patient needs while maintaining HCPs wellbeing.

In this context, AI has emerged as a potentially transformative solution, offering opportunities to address fundamental challenges through technological innovation and process optimization. Research demonstrates that AI integration into healthcare systems has been proposed as a key strategy for addressing workforce challenges and improving overall care quality. AI systems can effectively relieve workload pressures, enable more efficient responsibility distribution, and in some cases, completely replace manual processes with automated alternatives, ultimately improving patient safety (Aung et al., 2021).

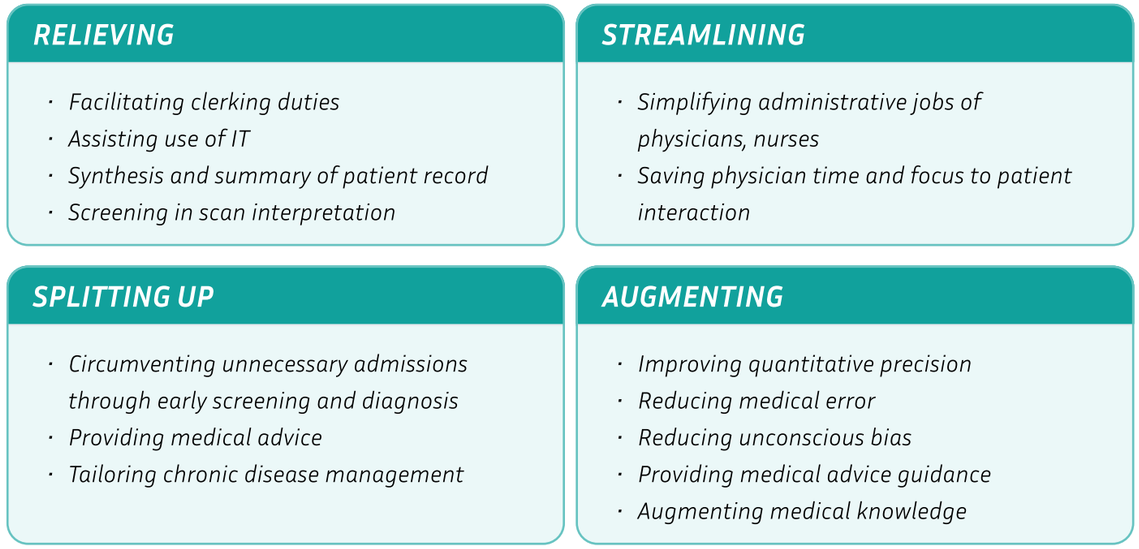


Figure 9. Updated model of benefit of AI in Healthcare.
Adapted from Aung et al.(2021), with modifications based on the author's own research findings and contextual analysis.

2.4.2 Current Challenges of AI Implementation in Healthcare Settings

While the widespread application of AI in healthcare settings appears inevitable, several barriers limit the full utilization of AI's capabilities in clinical environments:

1. Ethical Challenges: The development of robust AI algorithms necessitates access to large volumes of personal and sensitive healthcare data for effective training (Pham, 2025). This requirement creates understandable concerns among PtFams regarding privacy and data security. When patients lack confidence in data access protocols and how their personal health information is collected, used, and protected, they may become reluctant to share data. This hesitancy directly impacts the quality and comprehensiveness of data available for AI training, subsequently affecting the

accuracy and reliability of AI-driven clinical decisions (Ahmed et al., 2023);
2. Technical Challenges: The effectiveness of AI in improving patient outcomes depends fundamentally on the quality, accuracy, and comprehensiveness of training datasets. However, ensuring these critical data characteristics remains challenging. Inconsistent standardization across different experts during data evaluation and entry can introduce bias into AI algorithms (Ahmed et al., 2023);
3. Legal and Regulatory Challenges: When AI systems guide or propose clinical decision-making processes, questions of responsibility for adverse outcomes remain largely unresolved. This uncertainty creates substantial barriers for healthcare providers who must balance potential benefits of AI-assisted care against legal and professional risks associated with AI-guided decisions. The absence of mature regulatory frameworks and comprehensive implementation guidelines (Nair et al., 2024) leads to lack of transparency and accountability, discouraging trust in AI systems (Petersson et al., 2022);
4. Workforce and Implementation Challenges: Successful AI implementation requires comprehensive education and training systems that prepare healthcare professionals to effectively utilize these technologies. However, current inadequate training programs create significant barriers. Also, HCPs' attitudes toward AI significantly influence their willingness to adopt these technologies. Resistance to AI integration, whether due to unfamiliarity, concerns about job displacement, or skepticism about AI capabilities, can result in underutilization of potentially beneficial tools. Additionally, financial implications including costs for training, testing, implementation, and maintenance create hesitation due to budget constraints (Ahmed et al., 2023).

2.4.3 AI as a Solution to Clinical Communication and Information Management Challenges

Despite implementation challenges, AI technologies offer significant potential for addressing clinical communication and information management problems identified in earlier sections. Among various AI applications, AI-powered conversational systems, Automatic Speech Recognition (ASR) technology, and Optical Character Recognition (OCR) systems are particularly promising for transforming healthcare information management and communication.

AI-Powered Conversational Systems

AI-powered conversational systems, supported by advanced NLP and ML algorithms, offer transformative solutions for managing complex digital communication. These systems improve critical aspects of healthcare service delivery, including information exchange and patient engagement.

Recent research demonstrates significant potential for AI conversational systems to enhance patient engagement and emotional support through interactive conversations and interventions. These systems can positively influence patient behavior and treatment outcomes. Applications commonly include offering real-time access to medical information, appointment scheduling and management, and remote monitoring for chronic disease management (Sun et al., 2023).

For clinical documentation, NLG capabilities show particular promise. Croxford et al. (2025) provide evidence that large language models can extract and summarize complex medical documentation into coherent, actionable insights while maintaining clinical accuracy, directly addressing the documentation burden identified as a major challenge for healthcare providers.

Supporting this potential, recent studies demonstrate that AI scribes and LLM can significantly reduce documentation burden while maintaining clinical accuracy. Research indicates that these systems can automatically generate clinical notes, discharge summaries, and treatment plans, allowing healthcare providers to focus more on direct patient care rather than administrative tasks (Mess et al., 2025).

Furthermore, generative large language models have shown remarkable capabilities in medical research and healthcare applications, including automated report generation, clinical decision support, and medical question answering. These models can process vast amounts of medical literature and patient data to generate comprehensive, contextually appropriate medical reports that maintain clinical standards (Peng et al., 2023)

Optical Character Recognition (OCR) and Intelligent Character Recognition (ICR) for Handwritten Medical Notes

A critical gap in current clinical information management systems is the inability to effectively digitize and integrate handwritten clinical notes, which remain prevalent in many healthcare settings. OCR and ICR technologies specifically address this challenge by converting handwritten medical documentation into machine-readable digital formats.

Recent comparative studies demonstrate that modern OCR models, particularly those enhanced with deep learning techniques,

show significant improvements in recognizing both handwritten and printed medical reports. These systems can accurately interpret doctor's handwritten notes, prescription details, and clinical observations, which are often critical components of patient care documentation (Kumar et al., 2023).

Advanced ICR systems, designed specifically for interpreting handwritten text, employ neural networks and feature extraction techniques to decode various forms of medical handwriting, from cursive signatures to complex clinical notes. Unlike static OCR systems, ICR technology continuously improves its accuracy through machine learning from new datasets, making it particularly valuable for handling the diverse handwriting styles found in medical practice (Kumar et al., 2023).

Post-correction approaches using deep learning have further enhanced OCR accuracy in processing medical reports, addressing common recognition errors and improving overall system reliability for clinical documentation (Karthikeyan et al., 2022).

Automatic Speech Recognition (ASR) and Information Capture

Spoken interactions contain vast amounts offragmented but critical information in healthcare settings. As Coiera (2006) notes, "the biggest information repository in healthcare sits in the heads of the people working within it, and the biggest information network is the complex web of conversations that link the actions of these individuals." Research indicates that approximately 60% of clinical time is devoted to verbal communication, with a significant portion occurring through face-to-face interactions (Coiera, 2006). These conversations are critically important for overall information transactions in healthcare settings.

ASR systems have been continuously refined to handle various challenges inherent in conversational healthcare language, including multiple speakers, overlapping dialogue, diverse speech patterns and accents, background noise, and accurate capture of specialized medical terminology. With intensive development in voice recognition technology, these systems are becoming increasingly accurate and reliable.

The growing adoption of voice recorders supported by transcription systems for digital clinical documentation has generated increasing interest in ASR technology's impact on medical practice. Chiu et al. (2018) demonstrate through their clinical conversation dataset that specialized medical ASR systems can accurately transcribe doctor-patient spoken interactions into structured clinical documentation, with particular strength in capturing medical terminology. With ASR and speech-to-text functions serving as foundational technologies, information extraction and summarization technologies can be built on these systems to help relieve documentation and administrative burden faced by HCPs (Karolina et al., 2023).

Addressing Information Fragmentation Through Integrated AI Systems

One of the most significant opportunities for AI in healthcare lies in addressing information fragmentation: the scattering of critical clinical information across multiple media and formats. Current healthcare environments generate vast amounts of fragmented information through various informal media, including orally delegated tasks, quick notes on paper, whiteboard communications, handwritten notebooks, meeting notes in mobile applications, and memory-based details etc.. Much of this information is inconsistently documented or entirely lost, failing to be integrated into EHR systems and posing risks to treatment quality and continuity.

AI technologies, particularly those combining ASR, NLP, OCR/ICR, and machine learning capabilities, offer potential solutions for capturing, organizing, and integrating this fragmented information into coherent, accessible formats. The integration of multiple AI technologies creates a robust system capable of handling diverse information sources: ASR systems capture verbal communications, OCR/ICR systems digitize handwritten notes and paper-based documentation, while NLP systems process and structure this information into standardized formats.

Recent advances in AI-backed OCR in healthcare demonstrate the potential for these integrated systems to automatically extract, digitize, and organize clinical information from multiple sources, significantly reducing the manual effort required for documentation while improving data completeness and accessibility (Daniela Gifu, 2022).

Furthermore, comprehensive reviews of AI applications in healthcare highlight the significant gaps that natural language processing and machine learning can address in electronic medical records and clinical documentation, particularly in integrating diverse data sources and formats into cohesive patient records (Priyanka et al, 2024).

By automating the collection and organization of scattered clinical information across multiple media: spoken, handwritten, and digital, AI systems could substantially reduce documentation burden on healthcare providers while improving the completeness

and accuracy of medical records.

2.5 Main Takeaway

Communication serves as a fundamental pillar of healthcare, as it involves extensive exchange and transmission of information. The effectiveness of communication significantly impacts the performance of medical teams, which in turn affects the overall treatment process and final patient outcomes.

In modern clinical environments, EHR systems have been increasingly adopted as a key clinical information management tool, designed with the goal of enhancing the accuracy and safety of medical care.

The fast-paced and information-dense nature of medical communication poses considerable pressure on HCPs. Furthermore, HCPs face unprecedented burdens from EHR systems. This administrative overload contributes to decreased job satisfaction, reduced patient interaction time, elevated burnout rates, and workflow fragmentation that collectively compromise care quality. PtFams experience deteriorating communication quality as HCPs become overwhelmed with administrative tasks. They often feel disconnected from care teams and excluded from treatment decision-making processes.

AI has evolved from simple rule-based systems to sophisticated technologies. Evidence shows AI's potential to relieve workload pressures and improve patient safety through automated processes.

However, significant barriers limit AI's healthcare implementation. These include concerns over data privacy and security, the lack of comprehensive legal and regulatory frameworks, the generally conservative attitudes of healthcare workers, and the potential economic burden that may hinder administrative support. All of these factors warrant careful consideration in future research and system design.

Despite implementation barriers, AI offer uniquely suited solutions to clinical communication and information management challenges. With technologies such as NLG, NLP, LLM, and ASR, spoken interactions can be transcribed into structured clinical documentation. Complex medical records can also be extracted and summarized into accurate, actionable insights. These are all highly beneficial to reducing the current burden of HCPs and ultimately improving the patient treatment.

These insights establish a clear foundation for exploring AI-driven solutions to clinical communication and information management challenges. The identified problems and AI capabilities will inform subsequent research phases, focusing on designing systems that integrate seamlessly into clinical workflows while addressing the specific needs.

03

User Research

3.1 Online Document Analysis
3.2 User Interview
3.3 Competitive Analysis of AI-Powered Medical Scribe Tools
3.4 Comparative Analysis of ICUs and Nursing Homes as Main Takeaway

Chapter Overview

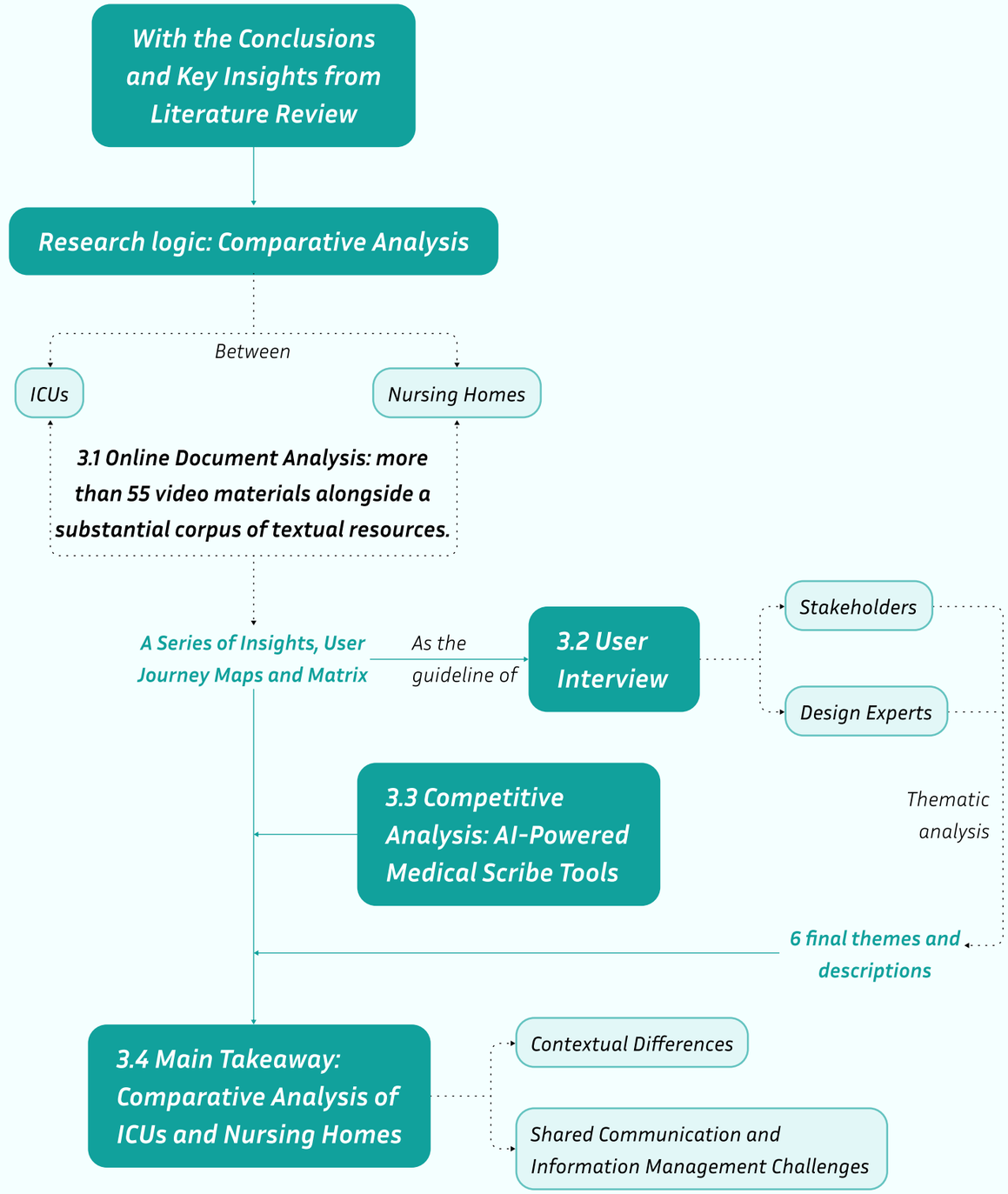


Figure 10. Mind map of Chapter 03

3.1 Online Document Analysis

3.1.1 Overview of Comparative Case Study between ICUs and Nursing Homes

Building on a series of challenges and insights from the literature review identified as critical issues in general healthcare environments, a comprehensive research approach was needed to understand these issues in more detailed healthcare settings.

Given the sensitive and demanding nature of healthcare environments, where hospitals and institutions operate under constant time pressures and critical care requirements, the research methodology required careful consideration. Following extensive discussions with the supervisory team, a comprehensive online document analysis phase was initiated as the foundation of the user research session.

This preliminary investigation was guided by the belief that substantial valuable information could be gathered through digital channels, enabling subsequent interview phases to be more efficient, structured, and better aligned with the operational realities of healthcare settings.

The online documentation analysis strategy focused on two contrasting healthcare environments: ICUs and nursing homes. This comparative approach was deliberately chosen to examine commonalities and differences between two fundamentally different care settings: one characterized by extreme urgency, complexity, and rapid decision-making (ICU), and another defined by relatively stable, long-term care provision (nursing home).

By analyzing these contrasting environments, the research aimed to identify pain points that transcend specific healthcare settings and potentially affect a broad spectrum of healthcare institutions beyond ICUs and nursing homes.

The scope of the online exploration was extensive, **including analysis of more than 55 video materials alongside a substantial corpus of textual resources.** This multi-modal approach provided rich insights into operational dynamics, communication patterns, and information flows within these healthcare environments. The analysis process was systematic and thorough, ultimately resulting in the development of eight comprehensive journey maps, among which six focused on user journeys and two dedicated to information exchange processes.

Throughout the analysis, particular attention was paid to three critical dimensions of information management: the nature of information being carried, the formats in which this information is presented, and the media through which it flows. The research systematically identified and catalogued digital touchpoints, physical touchpoints, potential pain points, as well as the needs and expectations of various stakeholders within these settings.

This comprehensive online exploration phase served multiple strategic purposes:

1. Providing a solid foundation for understanding healthcare information flows and communication challenges;
2. Establishing a knowledge base for developing targeted interview questions, and creating a framework for understanding the broader context in which healthcare providers operate.

This preparatory work was essential for ensuring that subsequent engagement with HCPs would be maximally productive and respectful of their time constraints.

3.1.2 ICU Context

The Intensive Care Unit (ICU) represents a specialized department dedicated to providing comprehensive care to patients with life-threatening conditions requiring continuous monitoring and advanced medical interventions.

Physical Environment

The ICU's physical layout is strategically designed to facilitate rapid response and continuous monitoring.

1. Individual patient rooms equipped with glass walls or large windows enable constant visual monitoring while housing essential life-support equipment.
2. Many ICUs incorporate open bay configurations where multiple beds are arranged in shared spaces separated by curtains or partitions. This enables rapid medical intervention and continuous observation, particularly beneficial for postoperative patients or those requiring frequent medical attention.
3. Central to ICU operations are usually strategically positioned nursing stations that serve as coordination hubs for patient monitoring and staff communication. These stations provide access to EHR systems and centralized patient monitoring networks, enabling nursing staff to oversee multiple patients simultaneously while maintaining detailed care documentation.
4. Specialized rooms within the ICU include procedure rooms and negative pressure isolation rooms equipped for emergency interventions.
5. Supporting infrastructure encompasses medication preparation areas with automated dispensing systems, equipment storage facilities for medical devices, and separate clean and utility rooms, all designed to support the complex logistics of critical care delivery.

Healthcare Team Structure and Roles

ICU operations depend on sophisticated multidisciplinary teams led by intensivists: specialized physicians trained in critical care medicine who are responsible for overall patient management and clinical decision-making. These medical leaders coordinate with residents and fellows who provide continuous medical coverage under supervision, ensuring round-the-clock physician availability for patient care and emergency response.

The integration of nurse practitioners (NPs) and physician assistants (PAs) has become increasingly important in addressing healthcare workforce challenges while maintaining care quality. These professionals perform medical histories, physical examinations, and certain invasive procedures.

Critical care nurses provide specialized bedside care through continuous patient monitoring, medication administration, and implementation of complex treatment protocols. These registered nurses possess advanced training in intensive care management and work closely with respiratory therapists managing mechanical ventilation and respiratory support systems, pharmacists overseeing medication management and dosing protocols, physiotherapists facilitating early mobilization and rehabilitation, and dietitians ensuring appropriate nutritional support for critically ill patients.

Working Shifts

Different hospitals may have varying schedules. Dutch ICUs typically operate under eight-hour shift systems with three daily rotations: day shifts (07:00-15:00) focusing on medical and nursing activities, evening shifts (15:00-23:00) managing continued care and new admissions, and night shifts (23:00-07:00) providing monitoring and emergency response coverage.

ICU Journey maps

Following comprehensive online document analysis encompassing videos, articles, and other digital resources, the key findings have been synthesized and integrated into a comprehensive visualization *(Figure 11)*. This figure presents the journey maps of three critical stakeholder groups: ICU medical residents, nurses, and PtFams mapped onto an authentic ICU floor layout. The visualization captures the complex interplay of movements, interactions, and information flows that characterize daily operations within the ICU environment, providing a spatial understanding of how different stakeholders navigate the physical space while managing clinical responsibilities and communication requirements.

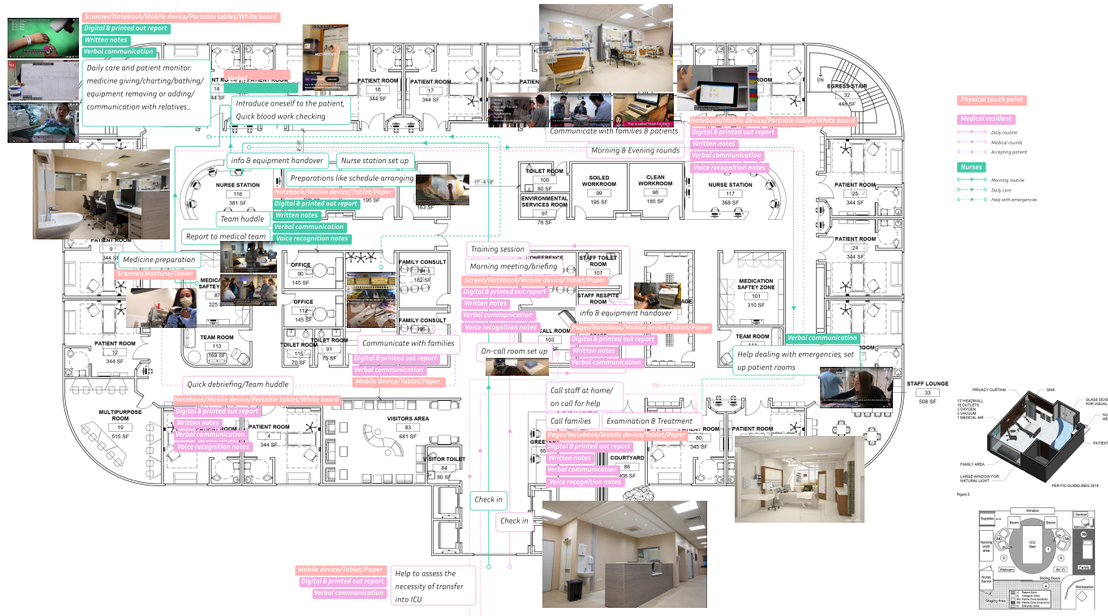


Figure 11. Integrated user journeys of ICU medical residents, nurses, and PtFams in ICU Physical layout.

Source of image used in this figure: online.

3.1.3 ICU Communication-specific User Journey Maps

Through further refinement and filtering of information from the user journeys displayed within the ICU layout *(Figure 11)*, specialized communication journey maps have been developed as shown in the following pages *(figure 12, 13, 14)*. Each step of these communication-focused journey maps is analyzed through four critical dimensions:

1. Physical environment: the spatial context and infrastructure where communication occurs.
2. Touchpoints: the interfaces and media through which information is exchanged.
3. Primary needs: the essential information and communication requirements at each stage.
4. Potential pain points: the barriers, inefficiencies, or challenges that may impede effective communication flow.

This analytical framework enables a systematic examination of how communication patterns unfold across different physical spaces and operational contexts within the ICU environment.

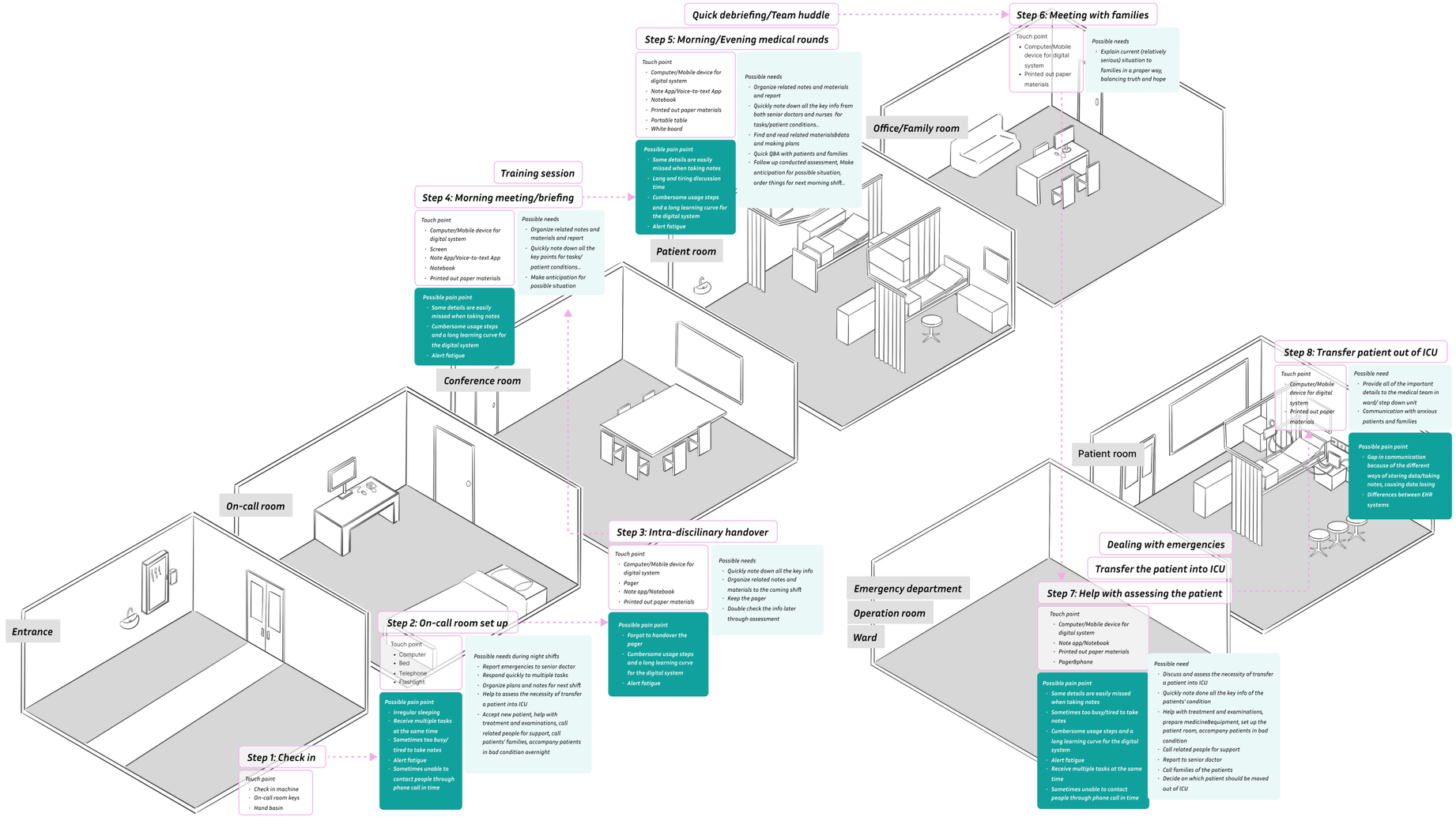


Figure 12. Communication journey map of ICU medical resident

Figure 13. Communication journey map of ICU PtFams

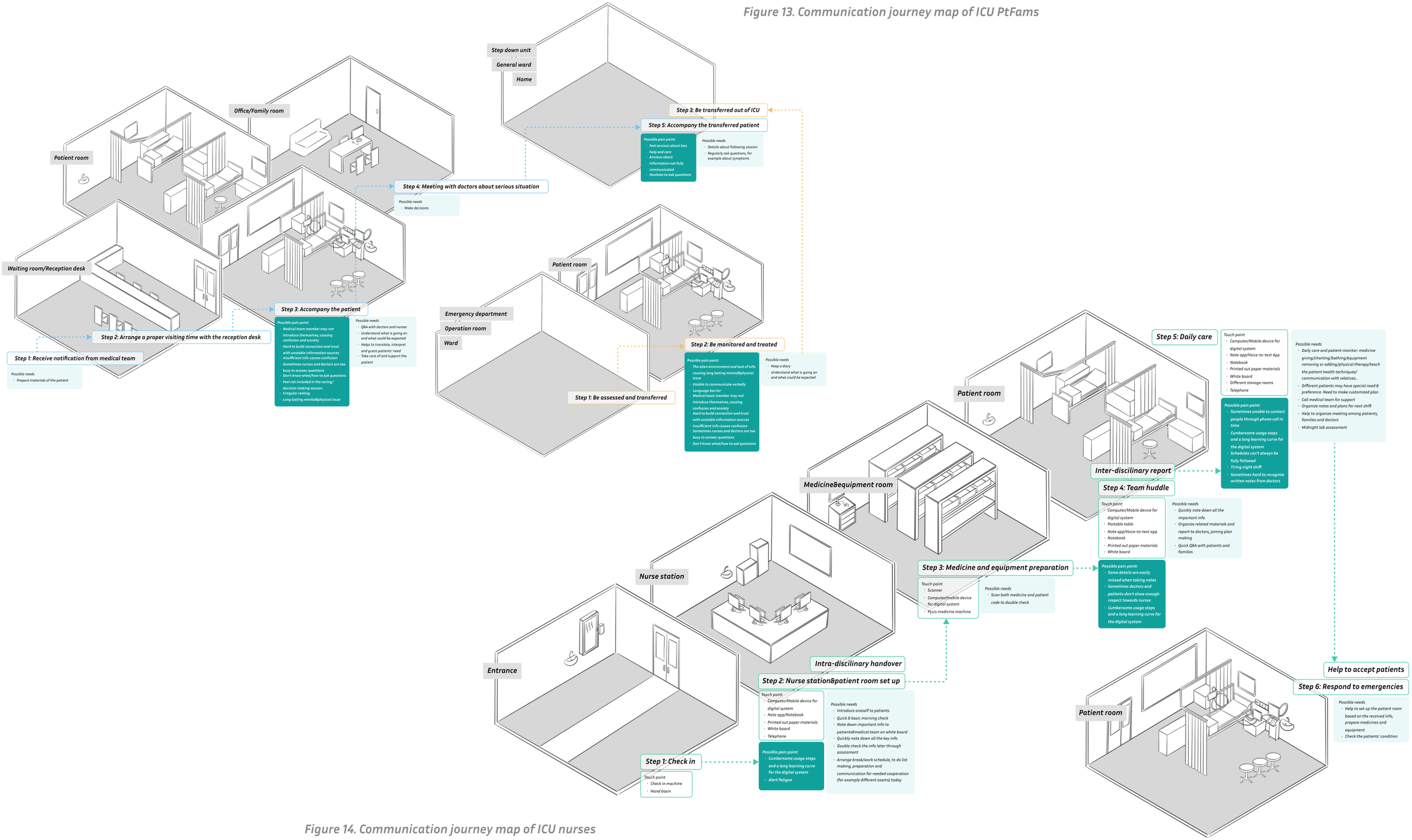


Figure 14. Communication journey map of ICU nurses

3.1.4 ICU Clinical Communication and Information Management Analysis Matrix

Following the visualization of communication journey maps within the physical ICU environment, key stages related to information management and clinical communication were further distilled and synthesized into the table presented below *(Figure 15)*. Each step is analyzed across four critical dimensions:

1. Communication purpose: the intended objective or goal of the information exchange.
2. Information format: the mode and structure through which information is communicated.
3. Touchpoints: the channels, interfaces, or media used for information transfer.
4. Primary stakeholders: the main roles and participants involved in each communication step.

To enhance visual clarity and priority identification, relatively urgent steps are highlighted in red, with the intensity of red coloring corresponding to increasing levels of urgency.

This analytical approach aims to provide an systematic presentation of communication-related information, facilitating subsequent analysis and identification of critical patterns, dependencies, and potential improvement opportunities within the clinical communication and information management workflow.

	Assessing a new patient	Accepting a new patient	Handover & meeting	Medical rounds	Daily care & monitor	Emergency	Transfer out of ICU
Main goal of the communication	· Assess and understand the condition of the patient · Decide on the necessity of transition into ICU	· Settle the patients down in ICU · Further assessment to understand the condition of the patients · Preparation for the following treatment plan · Inform the families about the transition	· Clearly transfer/accept information of the patients · Further discussion on the missions and goals for the team · Understand personal role & tasks · Organize personal/team working schedule of the day	· Stay on track about the condition of the patients · Gather information from all aspects to further discuss the design and adjustment of treatment plan · Provide information to patients & families	· Record the data/daily performance of patients in details · Contact and report to related medical staff for support · Provide information to patients & families · Adjust the caring plan based on patients' preference and condition	· Contact and report to related medical staff for support · Respond & decide quickly for life saving procedure: Organize operations/ Emergency treatment... · Quickly share & catch the current condition of the target patient	· Clearly transfer/accept information of the patients · Organize following treatment plan · Provide information to patients & families
Form of information	· Raw Data from devices · Historical record in the system · Observation · Interpretation & conclusion · Notes/Report from original section	· Raw Data from devices · Historical record in the system · Observation · Interpretation & conclusion · Notes/Report from original section · Suggestions & instructions from medical teammates · Information about medical history from families	· Interpretation & conclusion · Notes/Report from last shift/medical teammates · Schedule/Plan · To do lists	· Raw Data from devices · Historical record in the system · Observation · Interpretation & conclusion · Notes/Report · Schedule/Plan · Quick notifications · Information from patients & families	· Raw Data from devices · Observation · Interpretation & conclusion · Notes/Report · Schedule/Plan · Quick notifications · Information from patients & families	· Interpretation & conclusion · Notes/Report · Schedule/Plan · Quick notifications	· Historical record in the system · Notes/Report · Schedule/Plan · Information from patients & families
Touch points of communication	· Face-to-face teamwork · Phone call · EHR system · Printed out paper · Notes (paper/mobile device)	· Face-to-face teamwork · Phone call · EHR system · Printed out paper · Notes (paper/mobile device)	· Face-to-face teamwork · EHR system · Printed out paper · Notes (paper/mobile device)	· Face-to-face teamwork · White board · EHR system · Printed out paper · Notes (paper/mobile device)	· Face-to-face teamwork · Phone call · White board · EHR system · Printed out paper · Notes (paper/mobile device)	· Face-to-face teamwork · Phone call · White board · Printed out paper · Notes (paper/mobile device) · Labels on the bed	· Face-to-face teamwork · EHR system · Printed out paper · Notes (paper/mobile device)
Main users of communication	· Medical staff from original sections (Emergency department/Operation room/ General ward) · Medical resident from ICU	· On-site Medical resident & nurses · Off-site medical teammates · Families & patients	· Medical team · Nursing team	· Medical team · Nursing team · Families & patients	· Nursing team · Families & patients	· On-site Medical resident & nurses · Off-site medical teammates	· Medical staff from following sections (SDU/General ward) · Patients & families

Figure 15. ICU clinical communication and information management analysis matrix

3.1.5 Nursing Home Context

Nursing homes represent essential components of the healthcare continuum, providing comprehensive residential care for seniors with significant health challenges requiring round-the-clock medical and personal support. These facilities serve diverse populations through varied care models, ranging from general nursing homes offering comprehensive services for elderly residents with multiple health conditions, to specialized facilities focusing on specific medical conditions such as dementia or memory disorders. This specialized approach allows for tailored care environments and treatment protocols that address the unique needs of different patient populations.

Healthcare Professional Roles and Responsibilities

Medical care in nursing homes involves physicians who conduct scheduled visits on weekly or biweekly bases, reviewing resident records, performing medical examinations, adjusting treatment plans, prescribing medications, and updating EHR systems. These physicians coordinate with nursing staff and specialists to ensure comprehensive care while remaining available for emergency consultations.

Nursing staff operate across multiple shifts to provide continuous care coverage. Morning shift responsibilities (07:00-12:00) include receiving handover reports from night staff, assisting residents with hygiene and mobility, administering morning medications, conducting routine health assessments, and supporting physician rounds. Afternoon shifts (12:00-18:00) focus on meal assistance, dietary monitoring, therapy coordination, family meetings, new admission processing, and afternoon medication administration. Evening and night shifts (18:00-07:00) emphasize sleep preparation, wound care, pain management, monitoring residents with dementia or sleep disturbances, and detailed documentation for next-shift handovers.

Caregivers provide essential daily support including feeding assistance, mobility support, toileting help, and companionship while engaging residents in social activities and monitoring for early signs of health decline such as poor appetite or confusion.

3.1.6 Nursing Home Communication-specific User Journey Maps

Same as the analysis of ICU context, specialized communication journey maps *(figure 16, 17, 18)* in nursing home context have been developed as shown in the following pages. Each step of these communication-focused journey maps is analyzed through four same critical dimensions:

1. Physical environment: the spatial context and infrastructure where communication occurs.
2. Touchpoints: the interfaces and media through which information is exchanged.
3. Primary needs: the essential information and communication requirements at each stage.
4. Potential pain points: the barriers, inefficiencies, or challenges that may impede effective communication flow.

This framwork enables a systematic examination of communication across different physical spaces in the nursing home context.

Figure 16. Communication journey map of nursing home physician

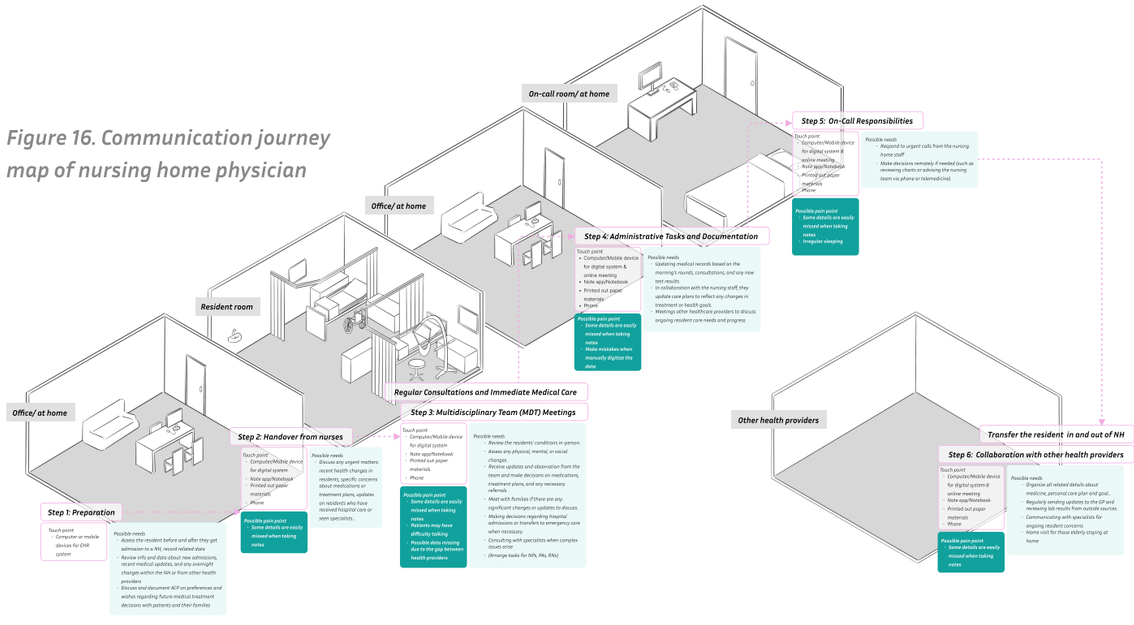


Figure 17. Communication journey map of nursing home nurses (and NPs, PAs, RNs)

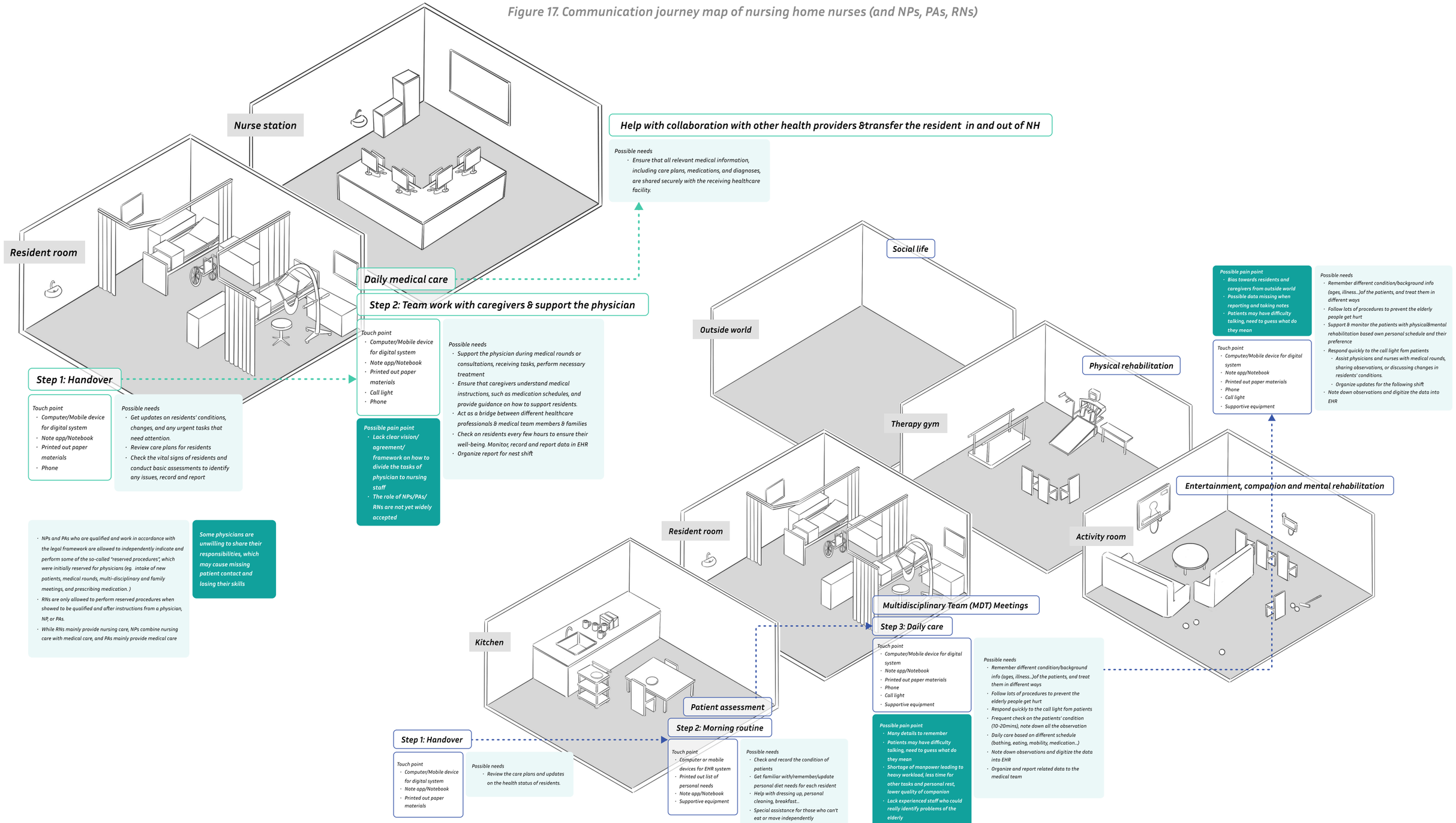


Figure 18. Communication journey map of nursing home caregivers

3.1.7 Nursing Home Clinical Communication and Information Management Analysis Matrix

Same as the analysis of ICU context, key stages related to information management and clinical communication in nursing home context were further distilled and synthesized into the table presented below *(Figure 19)*. Each step is analyzed across the same four critical dimensions:

1. Communication purpose: the intended objective or goal of the information exchange.
2. Information format: the mode and structure through which information is communicated.
3. Touchpoints: the media, interfaces, or media used for information transfer.
4. Primary stakeholders: the main roles and participants involved in each communication step.

To enhance visual clarity and priority identification, relatively urgent steps are highlighted in red, with the intensity of red coloring corresponding to increasing levels of urgency.

This matrix aims to provide an intuitive and systematic presentation of communication-related information, facilitating subsequent analysis and identification of critical patterns, dependencies, and potential improvement opportunities.

	Assessing a new resident	*Accepting a new resident*	*Handover & meeting*	*Consultancy*	*Daily care & monitor*	*Emergency*	*Transfer out of NH*
Main goal of the communication	· *Assess and understand the condition of the resident* · *Decide on the necessity of admission into NH*	· *Settle the resident down in NH* · *Further assessment to understand the condition of the resident* · *Together with residents and families to create the goal and plan for treatment*	· *Clearly transfer/accept information of the residents* · *Gather information and preference from residents to adjust treatment plan* · *Understand personal role & tasks* · *Organize personal/team working schedule of the day*	· *Provide information to patients & families* · *Consult other health providers for support*	· *Record the data/daily performance of patients in details* · *Contact and report to related medical staff for support* · *Provide information to patients & families* · *Adjust the caring plan based on patients' preference and condition*	· *Contact and report to related medical staff for support* · *Respond & decide quickly base on the goal & plan chosen by patients* · *Consult other health providers for support* · *Clearly transfer/accept information of the residents*	· *Clearly transfer/accept information of the residents* · *Regularly receive updates from other health providers* · *Provide information to patients & families*
Form of information	· *Raw Data from devices* · *Historical record in the system* · *Observation* · *Interpretation & conclusion* · *Information from families and resident*	· *Raw Data from devices* · *Historical record in the system* · *Observation* · *Interpretation & conclusion* · *Notes* · *Information from families & residents*	· *Interpretation & conclusion* · *Notes/Report from last shift/medical teammates* · *Schedule/Plan* · *To do lists* · *Information from families & residents*	· *Historical record in the system* · *Interpretation & conclusion* · *Notes/Report* · *Schedule/Plan* · *Information from patients & families* · *Information from other health providers*	· *Raw Data from devices* · *Observation* · *Interpretation & conclusion* · *Notes/Report* · *Schedule/Plan* · *Quick notifications* · *Information from patients & families*	· *Interpretation & conclusion* · *Notes/Report* · *Schedule/Plan* · *Quick notifications* · *Information from other health providers*	· *Historical record in the system* · *Notes/Report* · *Schedule/Plan* · *Information from patients & families*
Touch points of communication	· *Face-to-face communication* · *Phone call* · *EHR system* · *Printed out paper* · *Notes (paper/mobile device)*	· *Face-to-face communication* · *EHR system* · *Printed out paper* · *Notes (paper/mobile device)*	· *Face-to-face teamwork* · *EHR system* · *Printed out paper* · *Notes (paper/mobile device)*	· *Face-to-face communication* · *Phone call/Online meeting* · *EHR system* · *Printed out paper* · *Notes (paper/mobile device)*	· *Face-to-face teamwork* · *Phone call* · *White board* · *EHR system* · *Printed out paper* · *Notes (paper/mobile device)*	· *Face-to-face teamwork* · *Phone call* · *EHR system* · *Printed out paper* · *Notes (paper/mobile device)*	· *Face-to-face teamwork* · *Phone call* · *EHR system* · *Printed out paper* · *Notes (paper/mobile device)*
Main users of communication	· *NH physician* · *Residents & families*	· *NH physician* · *Residents & families*	· *Medical team* · *Nursing team* · *Caregiver*	· *Medical team* · *Nursing team* · *Families & residents* · *Other health providers*	· *Nursing team* · *Caregivers* · *Families & residents*	· *Medical team* · *Nursing team* · *Families & patients* · *Other health providers*	· *Medical team* · *Families & residents* · *Other health providers*

Figure 19. Nursing home clinical communication and information management analysis matrix

3.2 User Interview

3.2.1 Background

Following the comprehensive analysis conducted through literature review and online exploration, a series of preliminary conclusions and assumptions emerged. While these initial findings provided valuable insights into ICUs and nursing home facilities, the need for deeper validation became evident. To address potential gaps in the research framework and uncover additional perspectives, a systematic interview study was designed and implemented.

The Goal of User Interview

The interview phase served multiple critical purposes within the broader research methodology:

1. It provided an opportunity to validate the preliminary findings through direct stakeholder feedback, ensuring that the observed patterns and identified challenges accurately reflected the lived experiences of HCPs and PtFams.
2. The conversational format allowed for the emergence of unexpected insights and previously unconsidered perspectives that could inform the research direction and problem definition.

Through systematic analysis of the interview data, the research team sought to identify and articulate the core problems that would become the primary focus of the project.

3.2.2 Methodology

To ensure comprehensive coverage of relevant perspectives and maximize the validity of findings, the interview targeted two distinct but complementary groups of participants. This dual-group strategy was designed to capture both the direct experiences of healthcare system users and the professional insights of individuals with experience in innovation with healthcare.

Primary Stakeholder Group

The first group consisted of direct stakeholders of healthcare systems. This group included:

- one ICU attending physician
- one senior nurse
- one family member of an 80-year-old inpatient
- two patients with prior hospitalization experience
- two nursing home caregivers.

The structured interview guide is presented in *Appendix 3*. The interview protocol was systematically structured according to the following procedure:

1. Introduction and Informed Consent: The researcher initially presented the project background and explained the interview objectives. Participants were subsequently invited to provide their informed consent through electronic signature on the designated consent form.
2. Demographic Data Collection: Essential demographic information, including working department, country/region, and organizational role etc., was systematically collected from each participant.
3. User Journey Presentation and Validation: Based on participant categorization, the researcher presented corresponding user journeys that had been developed during the previous user research phase. Particular emphasis was placed on explaining each step in terms of the physical environment, primary activities, key interaction touchpoints, and critical stages of information exchange and transfer processes. Participants were then invited to augment or refine these steps based on their personal professional experiences.
4. In-depth Follow-up Inquiry: Supplementary questions were strategically posed to further explore and clarify specific details shared by participants throughout the discussion process.

This semi-structured interview methodology ensured both methodological consistency across diverse participant groups and sufficient flexibility to capture unexpected insights. This approach enabled participants to elaborate freely on their experiences while maintaining alignment with the overarching research objectives and ensuring comprehensive data collection for subsequent analysis.

Expert Group

The second group focused on experts with specialized experience in designing with healthcare, selected for their ability to provide strategic insights and creative perspectives on healthcare system improvement. This group included:

representatives from a consultancy agency specializing in AI applications within healthcare settings

two designers who worked on ICU workflow research and recycling system design in hospitals.

one innovation manager of an Utrecht hospital.

The interviews with expert participants followed a more conversational, semi-structured format designed to encourage creative thinking and the emergence of innovative perspectives.

3.2.3 Data Collection and Analysis

All interviews were conducted with participant consent. Consent forms are shown in *Appendix 4*. The raw data, documented through key quotes, are

presented in *Appendix 5*. The interview data was analyzed using thematic analysis following the framework established by Braun and Clarke (2006).

Thematic Coding and Analysis

As illustrated in *Figure 20*, each key quote was categorized along two analytical dimensions.

1. Four distinct contextual perspectives were represented using different colored post-it notes: experiences from general hospital settings, ICU, nursing homes, and design experts.
2. Each post-it note was annotated with a colored dot indicating the participant's stakeholder role, representing seven different identities.

The analytical process began by distilling each quote into one or more core keywords that captured its essential meaning. These keywords were subsequently clustered based on thematic similarity, leading to the identification of nine preliminary themes:

- Theme 01: Paper and pen remain the primary method for note-taking
- Theme 02: Data distributed across multiple media
- Theme 03: Reliance on mental retention of information
- Theme 04: Risk of data loss
- Theme 05: Attitudes toward artificial intelligence
- Theme 06: Electronic health records present usability challenges
- Theme 07: Patient-family communication difficulties
- Theme 08: Inadequate workflow integration
- Theme 09: Poor data organization

Then as illustrated in *Figure 21*, these nine preliminary themes subsequently underwent iterative refinement. Similar or overlapping themes were merged, and their definitions were refined, ultimately yielding six consolidated themes. Notably, because each refined theme was summarized with quotes from participants across all four contextual perspectives, these six themes were interpreted as shared pain points of ICU and nursing home contexts, even extend to broader, more diverse healthcare environments.

Final Refined Themes

1. Persistent Reliance on Pen and Paper (from Theme 01): HCPs continue to depend heavily on handwritten documentation due to its speed and simplicity. However, during high-intensity or information-dense clinical encounters, critical details are frequently overlooked or incompletely recorded. Additionally, the physical loss of handwritten notes can result in the loss of valuable clinical information.
2. Information Fragmentation and Data Discontinuity (from Themes 02, 03, 04): Clinical information is documented across informal documentation media including personal notebooks, loose papers, whiteboards, memory recall, and mobile devices. This fragmentation substantially increases the risk of missed, forgotten, or misinterpreted data. For novice or rotating staff members, the absence of comprehensive contextual information within EHR systems may contribute to medical errors.
3. Electronic Health Record Documentation Burden (from Themes 06, 09): While EHRs are designed to serve as the primary repository for clinical documentation, their complex interfaces and functions present significant usability challenges. The daily processes of organizing reports and documenting patient encounters are repetitive and cognitively demanding, reducing operational efficiency and imposing substantial mental burden on HCPs.
4. Insufficient Integration of AI Documentation Tools (from Theme 08): Current AI-enabled documentation solutions lack seamless integration into existing clinical workflows. These tools typically require dedicated time allocation outside of routine patient care activities, precluding real-time data capture capabilities. Consequently, substantial volumes of clinically relevant information remain undocumented or are permanently lost.
5. PtFams Communication Barriers (from Theme 07): PtFams frequently experience difficulty processing, retaining, and comprehending information communicated by HCPs, particularly under conditions of psychological distress. Factors such as reluctance to burden busy clinical staff, anxiety regarding potentially negative information, or hesitation to seek clarification often result in difficulties in recording, remembering and understanding important medical information.
6. HCPs' Attitudes Toward AI Adoption (from Theme 05): While healthcare providers increasingly acknowledge the need for technological advancement, they demonstrate preference for maintaining established workflows and working habits. AI is generally preferred as an assistive enhancement to existing practices rather than as a disruptive replacement of familiar systems, recognizing that comprehensive systemic changes require substantial time investment and organizational commitment to implement successfully.

This analytical approach ensured that shared insights across participant groups were systematically identified and categorized to provide comprehensive understanding of the research domain.

Theme 01 Paper and pen remain the primary method for note-taking

From the family member
"In the morning round doctors will ask questions and explain details. They will quickly note down things on paper."
Notes mainly on paper

From the Caregivers
"I We first write things down on paper, or directly in the system, then document them in the system."
Notes on paper/ directly in system

From the ICU physician
"Mostly with paper and pen because it's so far the fastest and easiest way (even faster than with mobile devices when dealing with emergencies), sometimes with phone/pad. "
Mainly note with pen and paper/ sometimes with devices and apps

From the ICU physician
"For now we don't really use word-to-text app because it works not very well in a complicated environment like ICU"
Lack speech to text support

From the senior nurse
"They all have small notebooks and pens in their packet, but they will even just remember everything in their mind because they are familiar with their work, and they are always super busy. They will have a "floor plan" in their mind and remember everything with bed numbers.. "
Have pen and paper, still remember many details in mind

From the designers
"A Use a lot of paper chart because it's fast, also possible for extra notes and explanation. The digital system is not possible for this.. "
Paper charts are convenient and flexible

Theme 02 Data distributed across multiple media

From the ICU physician
"Although note-taking is about personal habit, we mostly note with paper and pen because it's so far the fastest and easiest way (even faster than with mobile devices when dealing with emergencies), sometimes with phone/pad. "
Mainly note with pen and paper/ sometimes with devices and apps

From the ICU physician
"When we are really busy, for example with both hands helping the patient, we can only remember things in mind or write them down on a random paper. Sometimes we might forgot some details, or the paper is missing. "
Too busy to take notes so have to keep details in mind/on random surface, notes missing/forgotten

From the Senior Nurse
"In urgent situations, sometimes we even just grab discarded scraps of paper nearby to take notes. "
Data on random paper

From the designers
"A large number of white boards for quick communication, mostly temporary info, will be wiped later, note sure if they are documented. "
Info on many whiteboards, not sure if they are documented

From the Caregivers
"I We first write things down on paper, or directly in the system, then document them in the system."
Notes on paper/ directly in system

Theme 03 Reliance on mental retention of information

From the family member
"Nurses conduct shift handovers at the patient's bedside, relying primarily on verbal communication. I did not see them taking any notes during our stay in the hospital."
HCPs keep details in mind

From the senior nurse
"They all have small notebooks and pens in their packet, but they will even just remember everything in their mind because they are familiar with their work, and they are always super busy. They will have a "floor plan" in their mind and remember everything with bed numbers. "
Have pen and paper, still remember many details in mind

From the ICU physician
"When we are really busy, for example with both hands helping the patient, we can only remember things in mind or write them down on a random paper. Sometimes we might forgot some details, or the paper is missing. "
Too busy to take notes so have to keep details in mind, notes missing/forgotten

From the Caregivers
"I hope to have a simpler and more efficient way to record information, in order to ensure that the content being documented is sufficiently detailed and comprehensive. For some caregivers who have worked here for a long time, they are very familiar with their work and often keep many details about each resident in their minds. In contrast, for caregivers with less experience, it's difficult to quickly catch up without these detailed pieces of information available in the system. If the way of recording could be more easier, I believe more details could be recorded to improve this situation "
Keep details in mind, info in the system not comprehensive enough to understand the condition of residents, wish to have a easier and faster way to encourage more info into system

Theme 04 Risk of data loss

From the family member
"They (nurses) are not required to have detailed knowledge of each patient's personal information. But I would say it is still possible to forget something."
Worry about forgetting details

From the cured patients
"There might be many details missing or not well documented. some medical staff may forgot what condition the patients are in and need to catch everything up again"
Notes loss/ not well documented, affecting the treatment

From the ICU physician
"From my personal perspective, when having a long discussion, information and instructions from the senior doctors can easily be missed when taking notes "
Hard to note down everything, details are missed

From the ICU physician
"When we are really busy, for example with both hands helping the patient, we can only remember things in mind or write them down on a random paper. Sometimes we might forgot some details, or the paper is missing. "
Too busy to take notes so have to keep details in mind/on random surface, notes missing/forgotten

From the designers
"A large number of white boards for quick communication, mostly temporary info, will be wiped later, note sure if they are documented. "
Info on many whiteboards, not sure if they are documented

From the ICU physician
"During ward rounds, for instance, senior physicians may issue a series of instructions quickly. Even when I am taking notes really fast, it's still possible to miss some critical points since I am partly focused on writing things down. "
Can't write everything down, details missed

From the innovation manager
"Also he believe this can encourage more data documentation, as in his observation, many nurses keep details in mind and don't really document them when they are taking care of the patient/ during medical rounds, maybe because they are busy or the EHRs are complicated to use. "
Keep details in mind because nurses are too busy to take notes/EHRs are hard to use

From the innovation manager
"We are currently experimenting with several AI documentation tools; however, none of them have been fully integrated into the workflow to enable real-time recording. You always still need a specific period of time dealing with all the documentation. As a result, a significant amount of information remains unreported or is lost.. "
Current tools are not naturally integrated into the work flow, still cause data loss

From the Caregivers
"I hope to have a simpler and more efficient way to record information, in order to ensure that the content being documented is sufficiently detailed and comprehensive. For some caregivers who have worked here for a long time, they are very familiar with their work and often keep many details about each resident in their minds. In contrast, for caregivers with less experience, it's difficult to quickly catch up without these detailed pieces of information available in the system. If the way of recording could be more easier, I believe more details could be recorded to improve this situation "
Keep details in mind, causing info in the system not comprehensive enough to understand the condition of residents, wish to have a easier and faster way to encourage more info into system

Theme 05 Attitude towards AI

From the cured patients
"I am kind of open to it if it can really support the communication. But overall, it shouldn't make things more complicated."
Support communication, easy to use

From the family member
"I hold a relatively neutral and complex view on this. It would certainly be ideal if communication could be made clearer and more accurate. However, the warmth and companionship that come from human interaction are always incredibly important."
Neutral and complex. It should support communication, be accurate

From the ICU physician
"The current workflow has been collaboratively established by all healthcare staff in this hospital and is already highly efficient; therefore, any new design can serve to optimize rather than replace existing processes"
AI is not a replacement

From the ICU physician
"I think it is very necessary, but it may only be used to assist diagnosis and treatment, such as helping to find data or improve reports, or solve the information missing issue I mentioned above. At least at this stage, it is difficult for people to mentally accept AI making key decisions. "
Necessary, Serve as an assistant, Improve the data loss

From the Senior Nurse
"The whole workflow so far is built up by the whole team for a long time so they don't want to accept a whole new system (also they are training new interns,it's impossible to train them with a unique system that isn't applied to other healthcare settings). They prefer to have small new designs added up to what they have now in a natural way "
Serve as a natural adding up to the current work flow

From the designers
"Should balance efficiency, empathy and distance between medical team and patients, easy to use & less burden for medical staff always comes first "
Efficient, easy to use

From the Caregivers
"I hope to have a simpler and more efficient way to record information, in order to ensure that the content being documented is sufficiently detailed and comprehensive. For some caregivers who have worked here for a long time, they are very familiar with their work and often keep many details about each resident in their minds. In contrast, for caregivers with less experience, it's difficult to quickly catch up without these detailed pieces of information available in the system. If the way of recording could be more easier, I believe more details could be recorded to improve this situation "
Keep details in mind, info in the system not comprehensive enough to understand the condition of residents, wish to have a easier and faster way to encourage more info into system

Theme 06 EHRs present usability challenges

From the innovation manager
"Also he believe this can encourage more data documentation, as in his observation, many nurses keep details in mind and don't really document them when they are taking care of the patient/ during medical rounds, maybe because they are busy or the EHRs are complicated to use. "
Keep details in mind because nurses are too busy to take notes/EHRs are hard to use

From the ICU physician
" EHR system. It's a system with very complicated functions. Everyday I will really need to sit down and spend some time on organizing different reports and documenting notes into it. It's actually a bit tiring for me, since it's a everyday process."
Complicated system, everyday process, a bit tiring

From the Senior Nurse
"In the EHR system, actually all the info are in a messy order. The nurses should go through all of them by themselves and find out what is significant. "
Data not well organized

Theme 07 PtFams communication difficulties

From the cured patients
"Since I don't have a medical background, I have to find ways to bring along a relative or friend with medical knowledge when seeing the doctor."
Have no medical background

From the cured patient
"But many notes are written in abbreviation so it's hard to read."
No explanation, hard to understand

From the cured patients
"If the patient doesn't have enough medical background information/ under a really stressful mindset, it's hard for them to understand and remember all the information. They may still feel confused/ repeatedly ask same questions/need companion who has medical information "
No explanation, hard to understand

From the family member
"When having medical rounds or meetings with doctors, we will try to note all the details down in our group chat so that everyone can catch up the situation."
PtFams try to understand and document info from HCPs

From the family member
"As we don't have a medical background, we don't usually question the reasons behind their decisions — we mostly just take note of the instructions and follow them as they are."
Have no medical background

Theme 08 Inadequate workflow integration

From the innovation manager
"We are currently experimenting with several AI documentation tools; however, none of them have been fully integrated into the workflow to enable real-time recording. You always still need a specific period of time dealing with all the documentation. As a result, a significant amount of information remains unreported or is lost.. "
Current tools are not naturally integrated into the work flow, still causes data loss

From the Senior Nurse
"As a nurse manager, I do not like seeing nurses constantly using their phones. Regardless of whether it is for work-related tasks or personal entertainment, I consider it a distraction from their duties. "
Data not well organized

Theme 09 Poor data organization

From the Senior Nurse
"In this hospital, nurses sometimes do not have dedicated verbal handovers between shifts. Instead, they rely on the EHR system to review notes left by previous staff. However, the note section is often disorganized, with all the information in no particular order. Nurses must manually scan through all the notes to identify the parts that are relevant to them "
Data not well organized

From the Senior Nurse
"In the EHR system, actually all the info are in a messy order. The nurses should go through all of them by themselves and find out what is significant. "
Data not well organized

- General healthcare related
- ICU related
- Nursing home related
- Expert group related

- From one family member of an 80-year-old inpatient
- From two cured patients
- From one senior nurse
- From one ICU attending physician
- From two caregivers

- From two designers
- From one innovation manager of an Utrecht hospital

Figure 20. Interview Data Coding and Emergent Themes from Initial Analysis

Final refined theme	Synthesized from	Description	Quote
1. Persistent Reliance on Pen and Paper	Theme 01	Many HCPs rely on pen and paper for recording information because of its speed and simplicity. However, during fast-paced or information-dense interactions, important details are often missed. The loss of paper notes also results in the permanent loss of valuable data.	"Although note-taking is about personal habit, most of us still rely on pen and paper, which is generally faster and more convenient than typing on digital devices." -- an ICU attending physician "...senior physicians may issue a series of instructions quickly. Even when I am taking notes really fast, it's still possible to miss some critical points since I am partly focused on writing things down." -- an ICU attending physician "In urgent situations, sometimes we even just grab discarded scraps of paper nearby to take notes." -- a senior nurse
2. Fragmented Information, Data Loss and Discontinuity	Theme 02 Theme 03 Theme 04	Clinical information is often scattered across multiple informal media such as notebooks, random papers, whiteboards, memory, and mobile devices. This fragmentation creates risks of missed, forgotten, or mistaken data. For new or less experienced staff, the lack of comprehensive contextual information in EHR systems hinders situational awareness and may lead to mistakes.	"Nurses conduct shift handovers at the patient's bedside, relying primarily on verbal communication. I did not see them taking any notes during our stay in the hospital." -- a patient family "Some caregivers, having worked in the facility for a long time, are very familiar with each patient's basic condition and personal preferences. However, this information is rarely documented in the system, which creates difficulties for new caregivers like me or other volunteers." -- a nursing home care giver "A large number of white boards for quick communication, mostly temporary info, will be wiped later, note sure if they are documented. "." -- a designer
3. EHR Documentation Burden	Theme 06 Theme 09	Although EHRs serve as the primary channel for clinical documentation, their complex features and UI make them challenging to use. Organizing reports and documenting notes within EHRs is a repetitive and tiring daily process, which reduces HCPs' efficiency and increases cognitive load.	"...Instead, they rely on the EHR system to review notes left by previous staff. However, the note section is often disorganized, with all the information in no particular order. Nurses must manually scan through all the notes to identify the parts that are relevant to them." -- a senior nurse "It's a system with very complicated functions. Everyday I will really need to sit down and spend some time on organizing different reports and documenting notes into it. It's actually a bit tiring for me, since it's a everyday process." -- a ICU attending physician
4. Insufficient Integration of AI Tools	Theme 08	Existing AI documentation tools lack seamless integration into clinical workflows. They often require dedicated time outside of routine activities, preventing real-time data capture. As a result, a significant amount of clinical information remains unreported or lost.	"We are currently experimenting with several AI documentation tools; however, none of them have been fully integrated into the workflow to enable real-time recording. You always still need a specific period of time dealing with all the documentation. As a result, a significant amount of information remains unreported or is lost." -- a innovation manager "As a nurse manager, I do not like seeing nurses constantly using their phones. Regardless of whether it is for work-related tasks or personal entertainment, I consider it a distraction from their duties. " -- a senior nurse
5. PtFams Communication Barriers	Theme 07	PtFams often struggle to process, remember, or understand the information conveyed by HCPs, especially under psychological stress. Hesitation to ask questions—driven by fear, anxiety, or concern about burdening staff—results in repeated inquiries and persistent confusion.	"Since I don't have a medical background, I have to find ways to bring along a relative or friend with medical knowledge when seeing the doctor." -- a cured patient "My father is elderly and was under a lot of stress during his hospital stay, so it was really difficult for him to remember the key points the doctors mentioned. He had to keep asking the same questions." -- a patient family
6. Attitudes Toward AI Adoption	Theme 05	While HCPs acknowledge the need for change, they often prefer maintaining familiar workflows. There is a preference for AI to act as an assistive tool integrated into existing practices rather than replacing established systems, as large-scale changes demand significant effort and adaptation.	"The current workflow has been collaboratively established by all healthcare staff in this hospital and is already highly efficient; therefore, any new design can only serve to optimize rather than replace existing processes.." -- an ICU attending physician

Figure 21. Thematic analysis results: final themes and descriptions

3.3 Competitive Analysis of AI-Powered Medical Scribe Tools

During user interviews, HCPs mentioned the existence of various medical scribe tools in the market designed to enhance the speed and efficiency of documentation and administrative processes. Based on these insights, a comprehensive competitive analysis was conducted to understand the current landscape of AI-driven clinical documentation solutions and their potential to address the communication and information management challenges identified in earlier research phases.

3.3.1 Current State of AI Medical Scribe Technology

Compared with traditional transcription tools that transcribe all captured audio content, contemporary AI-based medical scribe solutions demonstrate advanced capabilities through NLP technology. These tools can identify, extract, and document medically relevant information to create focused clinical documentation. This technological advancement enables clinicians to simply review and sign off on AI-generated documentation without the need to write, dictate, or manually edit notes, potentially saving up to three hours per day (DeepScribe, n.d.).

3.3.2 Methodology and Scope

To identify representative AI-supported medical scribe solutions, this study referenced a recent industry review article titled "10 Best Medical Scribes (June 2025)" published on UNITE.AI. Based on the solutions listed in this comprehensive review, a systematic competitive analysis was conducted focusing on three main analytical dimensions *(Figure 22):*

1. Primary usage scenarios: the clinical contexts and workflows where these tools are used.
2. Platforms and accessibility: the technological infrastructure and user interfaces through which these tools operate.
3. Key features and capabilities: the core functionalities and technological strengths of each solution.

3.3.3 Key Findings and Market Characteristics

The analysis revealed several consistent patterns across existing AI medical scribe solutions. The predominant characteristic of current market offerings is their digital-first approach, with most solutions taking the form of standalone software applications or integrated EHR plugins. While these tools demonstrate impressive technical capabilities in speech recognition and clinical text generation, they exhibit notable limitations in addressing the specific challenges identified in user interviews:

1. Limited Workflow Integration: Most existing solutions operate as separate digital tools that require HCPs to consciously engage with. This approach fails to achieve seamless integration into existing clinical workflows.
2. Lack of Companion-like Qualities: Current AI scribe tools typically function as passive documentation assistants rather than active communication partners.
3. Inadequate Addressing of Information Fragmentation and Data Loss: The digital tool-centric approach of current solutions does not effectively capture the spontaneous, fragmented information exchanges that occur throughout clinical workflows. Consequently, the fundamental problem of information loss and fragmentation remains largely unaddressed, as these tools primarily focus on formal documentation scenarios rather than the comprehensive information capture needed in dynamic healthcare environments.

3.3.4 Implications for Design Direction

This competitive analysis provides valuable insights for informing subsequent design decisions. The identified gaps in current

Name	*Primary usage scenario*	*Platform*	*Key features*
Tool 01	*Patient visit meeting*	· *Mobile phone* · *Computer*	· *Automatically structures the meeting documentation into the right form* · *Write the content in personalized styles*
Tool 02	*EHR documenting process*	· *Computer*	· *Create and edit templates using voice* · *AI-assisted decision support and real-time analytics*
Tool 03	*Patient visit meeting*	· *Computer*	· *Real-time charting that documents patient interactions and assists with post-visit tasks* · *Customizable templates*
Tool 04	*Patient visit meeting*	· *Computer*	· *AI-powered ambient listening technology* · *Generates and categorizes clinical document drafts, capturing order details*

market offerings, particularly the lack of seamless workflow integration, limited companion-like interaction qualities, and inadequate solutions for information fragmentation, representing key opportunities for developing more integrated approaches to clinical information management.

Name	Primary usage scenario	Platform	Key features
Tool 05	*Patient visit meeting*	· *IOS application*	· *Generate medical documentation automatically by ambient AI, ML, and NLP* · *Customizable voice-activated macros*
Tool 06	*Patient encounter*	· *Mobile phone*	· *Offer voice-enabled, ambient clinical intelligence (ACI)* · *AI-generated summary for patient encounter*
Tool 07	*Patient encounter*	· *Mobile phone*	· *Note dictation and conversation transcription* · *Craft customized Pre-Notes reflecting personalized documentation approach*
Tool 08	*Patient visit meeting*	· *Mobile phone*	· *NLP allows users to speak naturally without having to memorize specific commands* · *Ambient documentation* · *Edit notes using voice*
Tool 09	*Patient visit meeting*	· *Mobile phone*	· *Integrate several key features, including AI Scribe, Medical Dictation, and Medical Search, to enhance workflow efficiency.*
Tool 10	*Patient visit meeting*	· *Mobile phone*	· *Real-time medical documentation through ambient AI*

Figure 22. Competitive analysis matrix of 10 best AI-powered medical scribe tools

3.4 Comparative Analysis of ICUs and Nursing Homes as Main Takeaway

3.4.1 Results of Comparative Analysis

The comparative analysis between ICU and nursing home contexts reveals contrasts in operational dynamics alongside shared challenges in clinical communication and information management systems.

Contextual Differences

The ICU environment is characterized by a high-acuity, time-critical care model where life-threatening conditions need rapid decision-making, continuous monitoring, and intensive multidisciplinary collaboration. Communication patterns in ICUs are inherently urgent, typically occurring during structured rounds, emergency situations, or brief handovers, with information exchange being both dense and time-sensitive.

Conversely, nursing homes operate within a person-centered, long-term care paradigm where communication prioritizes care continuity, resident quality of life, and sustained collaboration among caregivers, physicians, and family members. Information exchanges in this context are less time-pressured but equally complex, encompassing multidisciplinary care conferences, comprehensive care documentation, and ongoing family engagement.

Shared Communication and Information Management Challenges

Despite these fundamental contextual differences, our comparative analysis identified six refined themes representing common systemic challenges across both care settings:

1. Persistent Reliance on Manual Documentation: HCPs in both settings continue to depend primarily on handwritten notes due to their perceived immediacy and accessibility. However, this practice introduces significant risks, including incomplete capture of critical information during high-intensity situations and potential data loss when physical documentation is misplaced or destroyed.
2. Information Fragmentation and Discontinuity: Clinical information is documented across multiple informal media, including loose paper notes, personal notebooks, whiteboards, mobile devices, and individual memory etc.. This fragmentation creates substantial gaps in care continuity, particularly challenging for novice staff who struggle to access comprehensive, contextualized patient information.
3. EHRs Documentation Burden: While EHRs represent the primary infrastructure for clinical documentation, their complex functionality and interfaces create substantial usability barriers. Both ICU physicians and nursing home staff report that the repetitive, labor-intensive processes of structuring clinical notes and organizing reports significantly increase cognitive workload while diminishing overall efficiency.
4. Inadequate Integration of AI-Assisted Documentation: Although AI documentation tools are being tested, none achieve seamless integration into existing clinical workflows. These tools typically require dedicated usage periods separate from routine patient care activities, preventing real-time documentation and leaving substantial portions of clinical information undocumented.
5. PtFams Communication Barriers: PtFams frequently experience difficulty comprehending and retaining medical information communicated by HCPs, particularly during periods of heightened psychological stress. This contributes to increased anxiety and disorientation.
6. Attitudes Toward New AI Tools: Healthcare providers across both settings acknowledge the critical need to address current communication inefficiencies while expressing preference for AI solutions that function as assistive technologies embedded within established workflows rather than disruptive replacements.

3.4.2 Implications and Conclusions

This comparative analysis demonstrates that despite fundamental differences in care intensity, temporal frameworks, and patient populations, ICU and nursing home environments share systemic vulnerabilities in information flow management, documentation efficiency, and digital tool integration. These common challenges underscore the necessity for design solutions that can address both the urgent, complex demands of critical care and the longitudinal, relationship-centered requirements of long-term care.

The identification of these shared pain points suggests significant potential for developing scalable interventions with broad applicability across diverse healthcare contexts, creating opportunities for system-wide improvements that transcend care setting boundaries. Future research should focus on developing integrated solutions that can adapt to varying care intensities while maintaining core functionality across different healthcare environments.

04

Design Focus

4.1 Problem Statement
4.2 Design Goal
4.3 Design Criteria

Chapter Overview

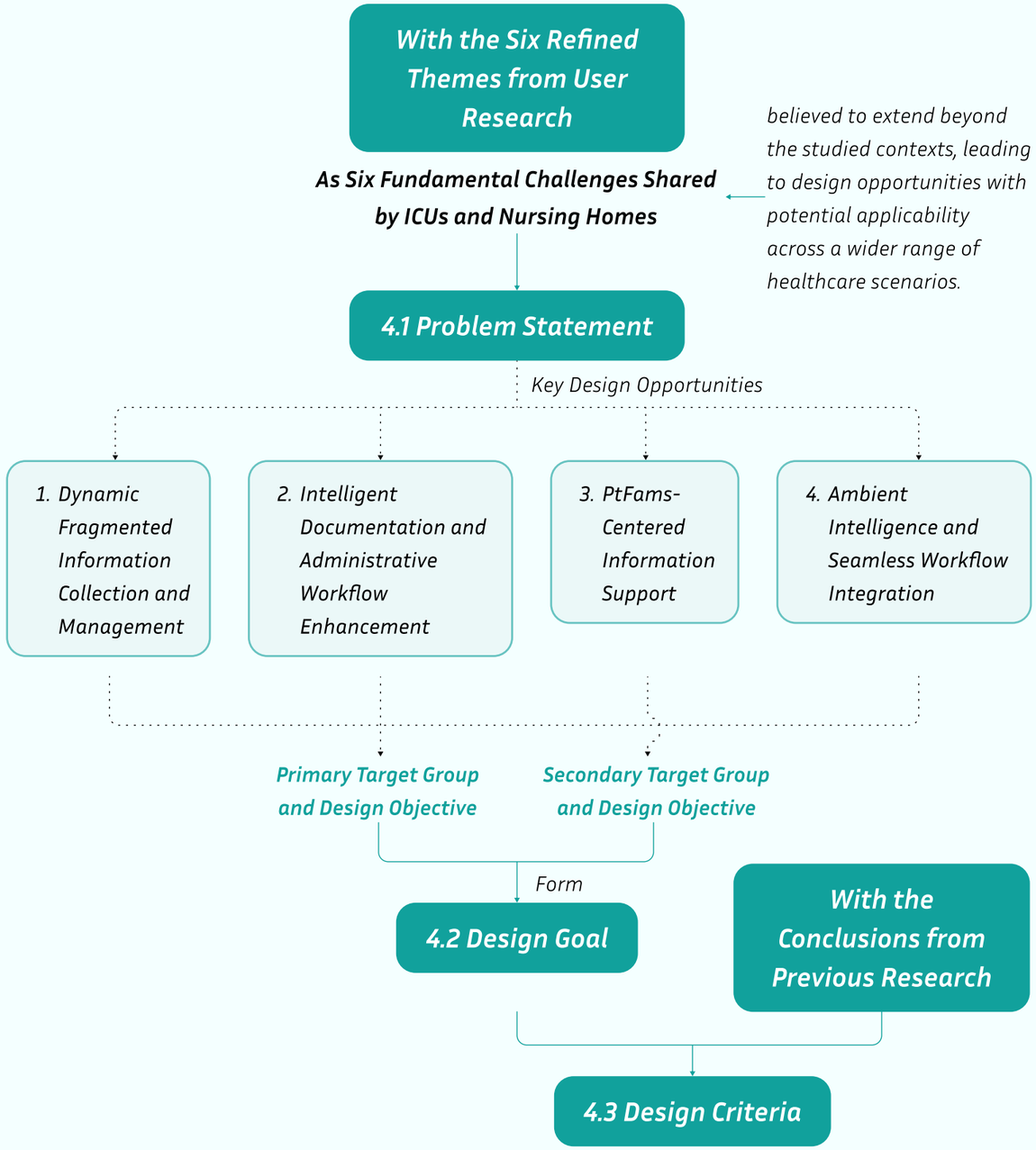


Figure 23. Mind map of Chapter 04

4.1 Problem Statement

Drawing from the comprehensive literature review and comparative analysis of ICU and nursing home contexts, six refined themes emerged as fundamental challenges in clinical communication and information management across diverse healthcare settings. The synthesis of these shared pain points informed the identification of four key design opportunities, forming the foundation of the final design direction *(Figure 24):*

Key Pain Point	*Description*	*Key Design Opportunity*
1. Reliance on Pen and Paper	*Many HCPs rely on pen and paper for recording information because of its speed and simplicity. However, during fast-paced or information-dense interactions, important details are often missed. The loss of paper notes also results in the permanent loss of valuable data.*	***1. Dynamic Fragmented Information Collection and Management***
2. Fragmented Information, Data Loss and Discontinuity	*Clinical information is often scattered across multiple informal media such as notebooks, random papers, whiteboards, memory, and mobile devices. This fragmentation creates risks of missed, forgotten, or mistaken data. For new or less experienced staff, the lack of comprehensive contextual information in EHR systems hinders situational awareness and may lead to mistakes.*	
3. Burden of EHR Documentation	*Although EHRs serve as the primary channel for clinical documentation, their complex features and UI make them challenging to use. Organizing reports and documenting notes within EHRs is a repetitive and tiring daily process, which reduces HCPs' efficiency and increases cognitive load.*	***2. Intelligent Documentation and Administrative Workflow Enhancement***
4. Limited Integration of AI Tools	*Existing AI documentation tools lack seamless integration into clinical workflows. They often require dedicated time outside of routine activities, preventing real-time data capture. As a result, a significant amount of clinical information remains unreported or lost.*	
5. PtFams Communication Barriers	*PtFams often struggle to process, remember, or understand the information conveyed by HCPs, especially under psychological stress. Hesitation to ask questions—driven by fear, anxiety, or concern about burdening staff—results in repeated inquiries and persistent confusion.*	***3. PtFams-Centered Information Support***
6. Attitudes Toward AI Adoption	*While HCPs acknowledge the need for change, they often prefer maintaining familiar workflows. There is a preference for AI to act as an assistive tool integrated into existing practices rather than replacing established systems, as large-scale changes demand significant effort and adaptation.*	***4. Ambient Intelligence and Seamless Workflow Integration***

Figure 24. Extraction of key design opportunities

1. Dynamic Fragmented Information Collection and Management: Develop systems that enable rapid, intuitive capture, documentation, and organization of fragmented clinical information across temporal boundaries and communication media. This capability addresses the critical risk of information omission, loss, or misinterpretation while promoting comprehensive documentation practices among HCPs.
2. Intelligent Documentation and Administrative Workflow Enhancement: Create AI-driven assistance that reduces the administrative burden on healthcare providers while improving documentation quality and efficiency.
3. PtFams-Centered Information Support: Design interventions that empower patients and families to comprehend and retain critical medical information during communication with HCPs, reducing confusion, repetitive inquiries, and heightened anxiety.
4. Ambient Intelligence and Seamless Workflow Integration: Implement AI technologies as augmentative rather than replacement tools, ensuring natural integration within established clinical workflows and care environments, allowing healthcare providers to maintain familiar operational patterns while achieving improved communication efficiency and documentation accuracy. The system should function transparently, requiring minimal learning curves or workflow disruption.

4.2 Design Goal

4.2.1 Target User Prioritization

Analysis of the four identified key design opportunities reveals a strategic focus distribution: three opportunities (1, 2, and 4) primarily address HCPs' needs, while one opportunity (3) centers on PtFams' requirements. Based on this analysis, HCPs are designated as the primary target user group of this project, with the central design objective focused on resolving their challenges in clinical communication and information management. PtFams need constitute secondary design considerations, ensuring a comprehensive and inclusive system architecture that addresses the broader healthcare communication ecosystem.

4.2.2 Primary Design Objective

In summary, the final design goal of this project is to **design a AI-driven system that assists in collecting and organizing fragmented medical information，enabling fast and efficient data entry and report generation into EHR systems.**

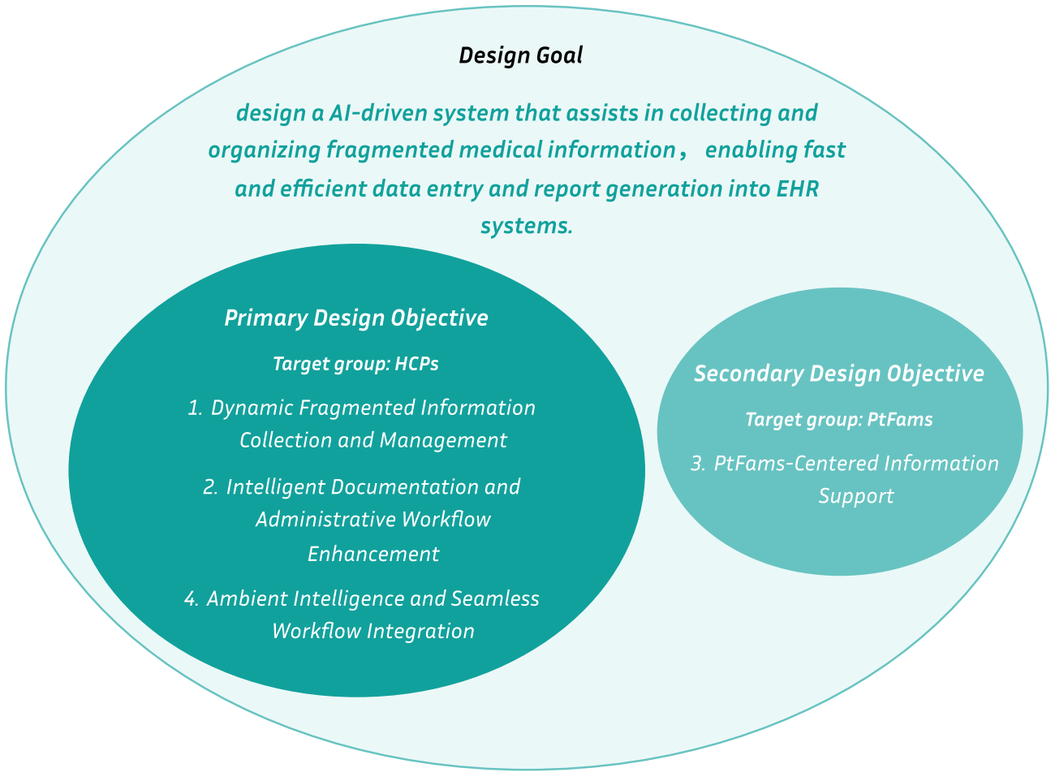


Figure 25. Composition of the design goal

4.3 Design Criteria

Drawing from insights generated through previous research sessions, a comprehensive set of design criteria has been established to guide the design development process. These criteria are organized into two hierarchical categories: Demand representing essential requirements the design must fulfil, and Wish representing desirable qualities that enhance system value when feasible.

4.3.1 Demand

1. Seamless Environmental Integration: The system must achieve intuitive and natural integration within existing physical and digital healthcare environments, supporting both patient care areas and provider workspaces.
2. Workflow Compatibility and Enhancement: The design must complement and augment established clinical workflows rather than create new disruption or replacement. Integration should feel natural, preserving familiar operational patterns while introducing efficiency improvements.
3. Operational Simplicity and Efficiency: The system must demonstrate minimal learning requirements and optimized operational speed, ensuring low cognitive load and reduced friction during routine use.
4. Privacy and Security: The design must follow healthcare privacy standards and data protection regulations. All stakeholders must receive transparent, real-time notification when information capture or processing occurs, ensuring informed consent and maintaining trust.

4.3.2 Wish

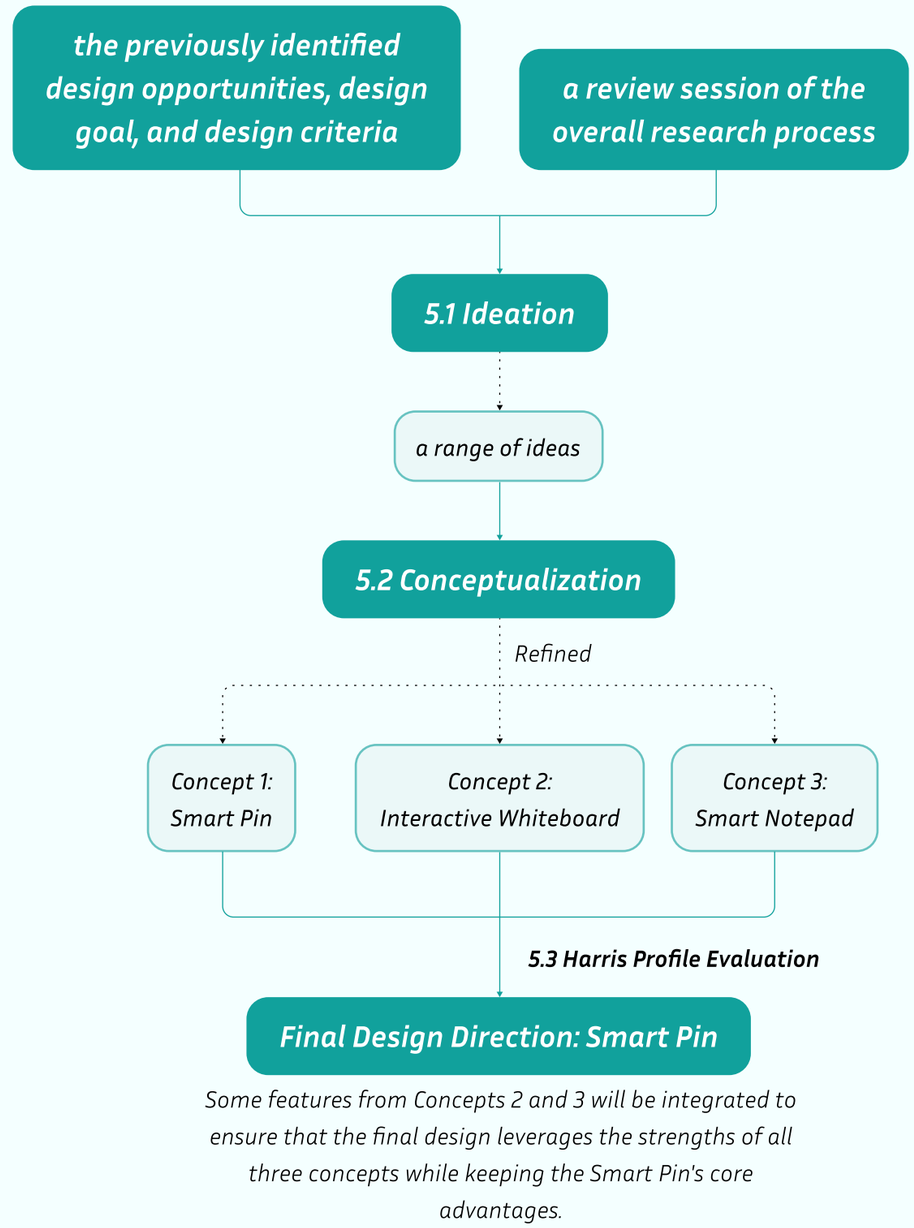
1. Contextual Flexibility and Adaptability: The system should accommodate diverse usage patterns, clinical scenarios, and individual user preferences, demonstrating responsive adaptation to varying healthcare contexts and user needs.
2. Information Preservation and Documentation Enhancement: The design should minimize information loss risks while actively encouraging comprehensive documentation practices.
3. Intelligent Data Organization and Synthesis: Captured information should undergo automated structuring, categorization, and summarization processes that transform raw data into clinically meaningful, easily reviewable formats that support efficient decision-making and care coordination.
4. Patient Empowerment and Support: The system should assist PtFams to document, comprehend, and process critical health information.

05

From Insights to Concepts

5.1 Ideation
5.2 Conceptualization
5.3 Evaluation

Chapter Overview



Some features from Concepts 2 and 3 will be integrated to ensure that the final design leverages the strengths of all three concepts while keeping the Smart Pin's core advantages.

Figure 26. Mind map of Chapter 05

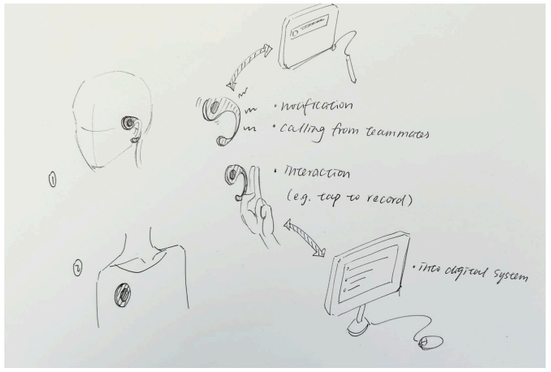
5.1 Ideation

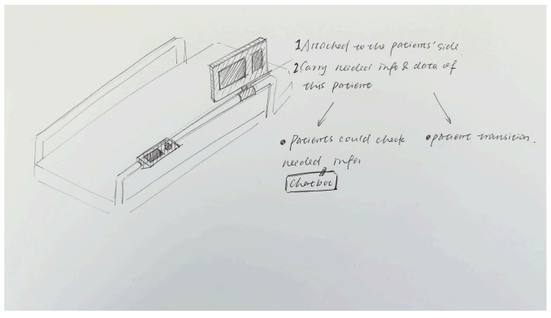
Building on the previously identified design opportunities, the established design goal, and defined design criteria, and following a review session of the overall research process, an ideation session was conducted with support from the supervisory teams at Accenture and TU Delft. The primary objective of this session was to generate and explore a diverse range of potential design directions.

During the ideation process, the focus was concentrated around several key conceptual themes that emerged as critical considerations for effective healthcare communication solutions. These core themes included：

1. Workflow integration: ensuring the solution seamlessly embeds within existing clinical processes rather than disrupting established routines;
2. Continuous accompaniment: providing persistent support throughout the entire patient care journey;
3. Rapid activation and deactivation: enabling healthcare providers to quickly engage or disengage the system as needed during dynamic clinical situations;
4. Efficient information capture and presentation: facilitating swift collection, processing, and display of relevant clinical data;
5. Preservation of existing work practices: maintaining the familiar operational methods that healthcare professionals have developed and refined over time;
6. Structured information transfer to patients: enabling the organized documentation and systematic communication of recorded clinical information to patients in an accessible and comprehensible format.

These thematic directions collectively aimed to address the fundamental challenge of enhancing clinical communication efficiency while respecting the complexity and variability of healthcare delivery environments.





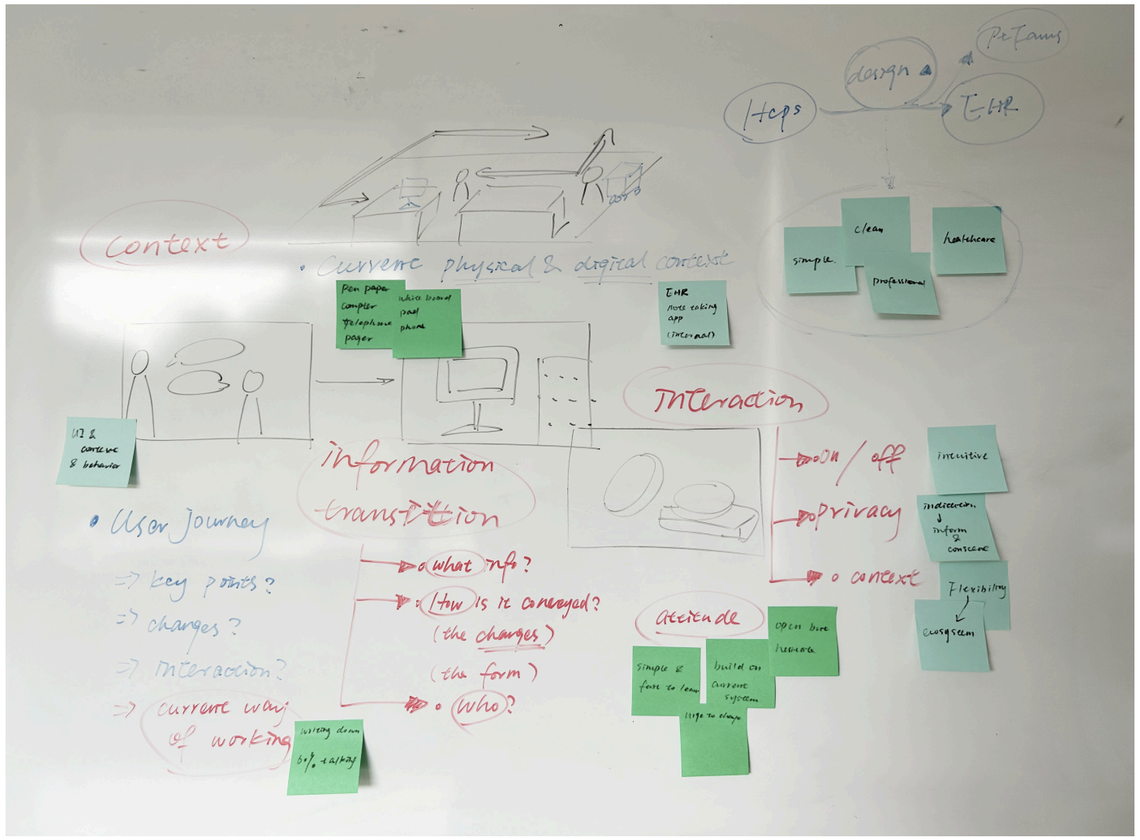
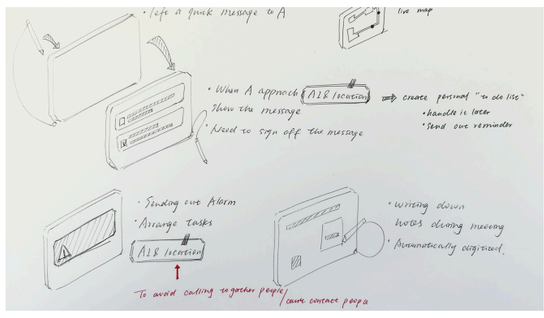


Figure 27. A brief review session of the overall research process, along with identified design opportunities, the established design goal, and defined design criteria



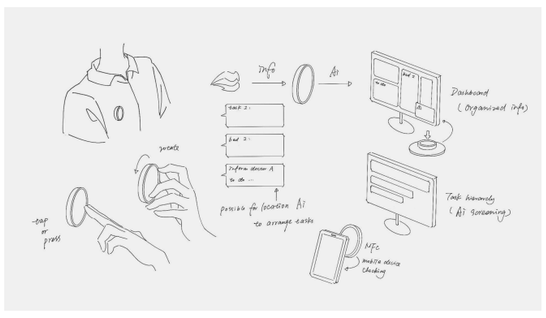


Figure 28. A series of generated concepts

5.2 Conceptualization

Through this collaborative exploration, three concepts emerged with comparatively greater potential for further development. These concepts were subsequently refined, visualized, and presented through detailed storyboards that illustrated their potential applications and usage scenarios.

Importantly, each concept was developed not only for technical feasibility but also with strong emphasis on user-centered design principles, ensuring alignment with the authentic needs and established working practices of HCPs and PtFams.

The storyboards provided a concrete foundation for the subsequent evaluation process, ultimately informing the selection of the final design direction.

5.2.1 Concept 1: Smart Pin

This concept centers on a wearable, voice-enabled pin designed for HCPs and PtFams. The device enables users to record conversations and meetings while issuing voice commands during their clinical workflow. An integrated AI model processes the captured audio data by automatically collecting, classifying, and organizing relevant information according to predefined categories. With the camera on the pin, fragmented written notes could also be scanned and collected. The processed data becomes accessible through a dedicated personal portal, enabling users to efficiently review notes, complete documentation requirements, and generate comprehensive reports with significantly reduced manual effort and time investment.

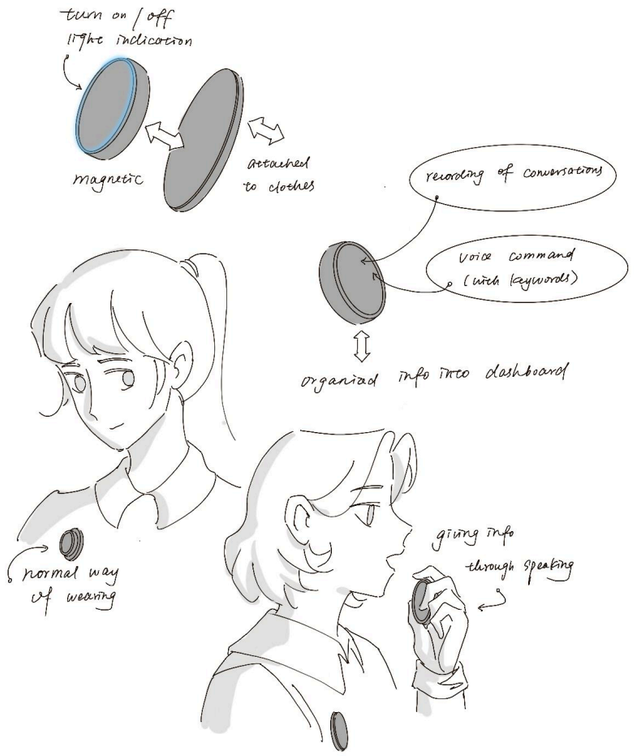


Figure 29. Illustrations of concept 1

Storyboard

The storyboard mainly illustrates how HCPs interact with the Smart Pin across different scenarios, including meetings, medical rounds, routine management of fragmented information, and communication with PtFams. It depicts the use of the pin for voice recording, voice input, photo scanning, and report generation, demonstrating its role in seamlessly supporting daily clinical workflows.

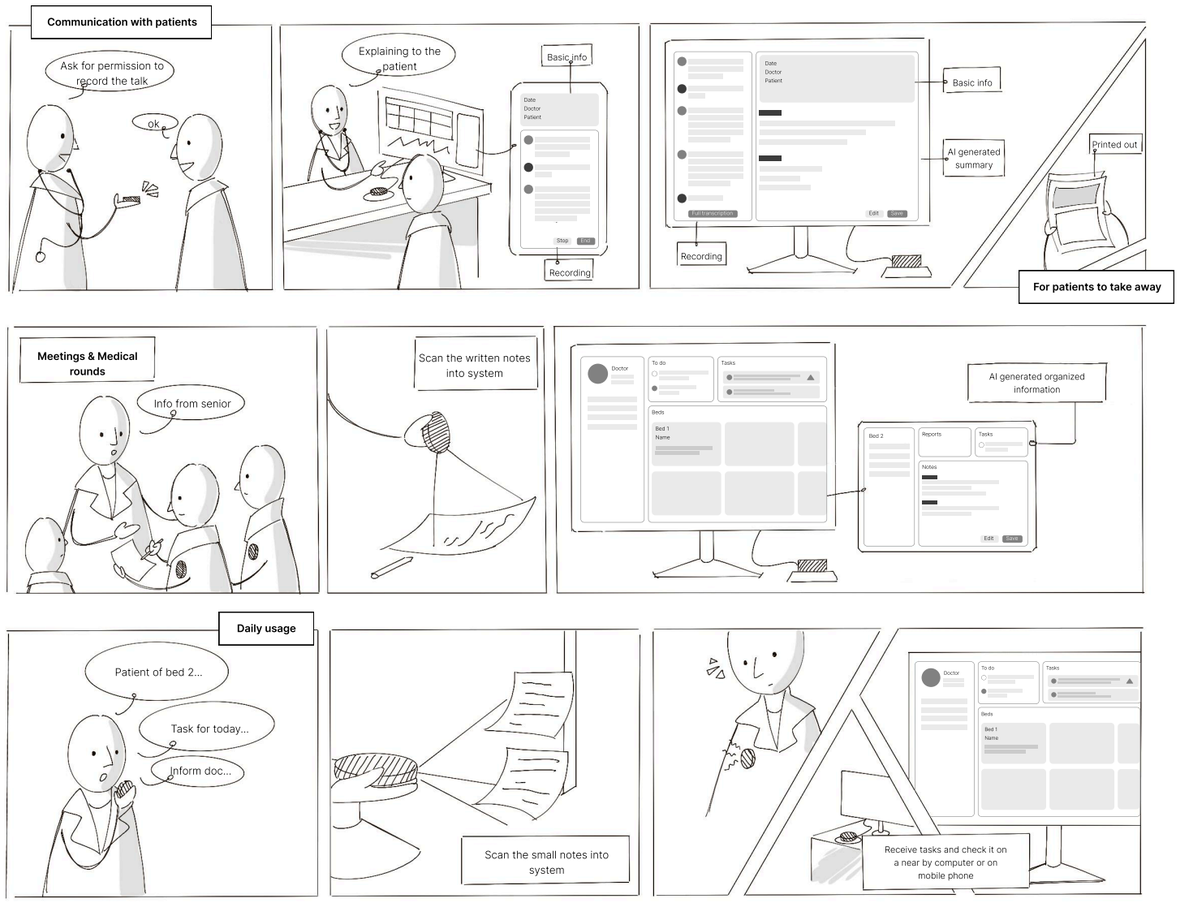


Figure 30. Storyboard of concept 1

5.2.2 Concept 2: Interactive Whiteboard

Whiteboards are commonly used in hospital wards, serving as essential tools for handwritten notes that facilitate information sharing with PtFams and communication among HCPs. Building upon this established practice, this concept reimagines the traditional whiteboard as an interactive digital medium that preserves familiar usage patterns while enhancing functionality.

In its default state, the system operates as a conventional writable surface, maintaining the original interaction healthcare professionals expect. However, during clinical activities such as ward rounds or multidisciplinary team meetings, the whiteboard can be activated as an interactive display. This activation enables users to digitally write, organize, and present information in a more dynamic and structured manner, transforming routine documentation and communication processes while respecting existing workflows.

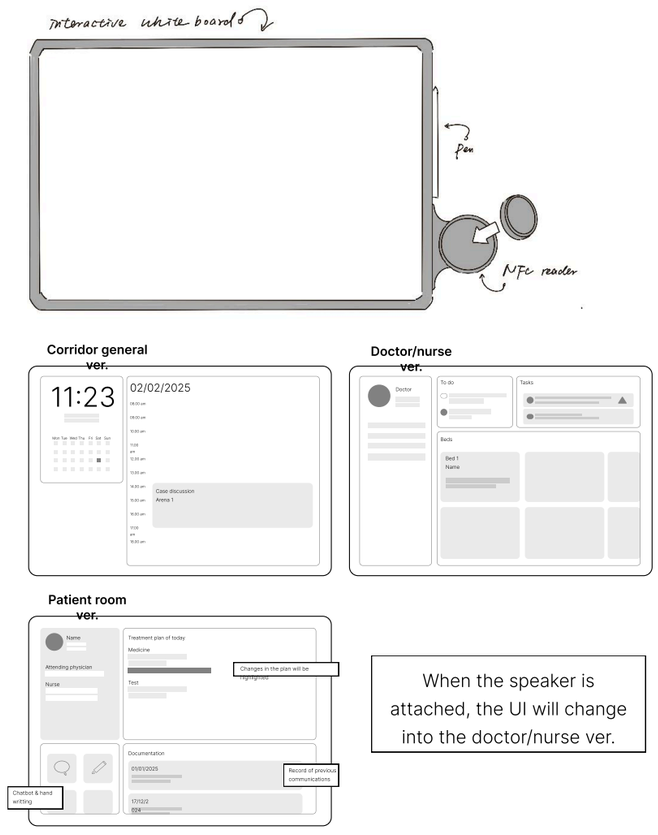


Figure 31. Illustrations of concept 2

Storyboard

The storyboards depict three key usage scenarios:

1. PtFams using the whiteboard for routine needs documentation and information searching;
2. HCPs reviewing patient information collected through the whiteboard system;
3. HCPs interacting with the whiteboard in both its inactive conventional state and its activated interactive mode.

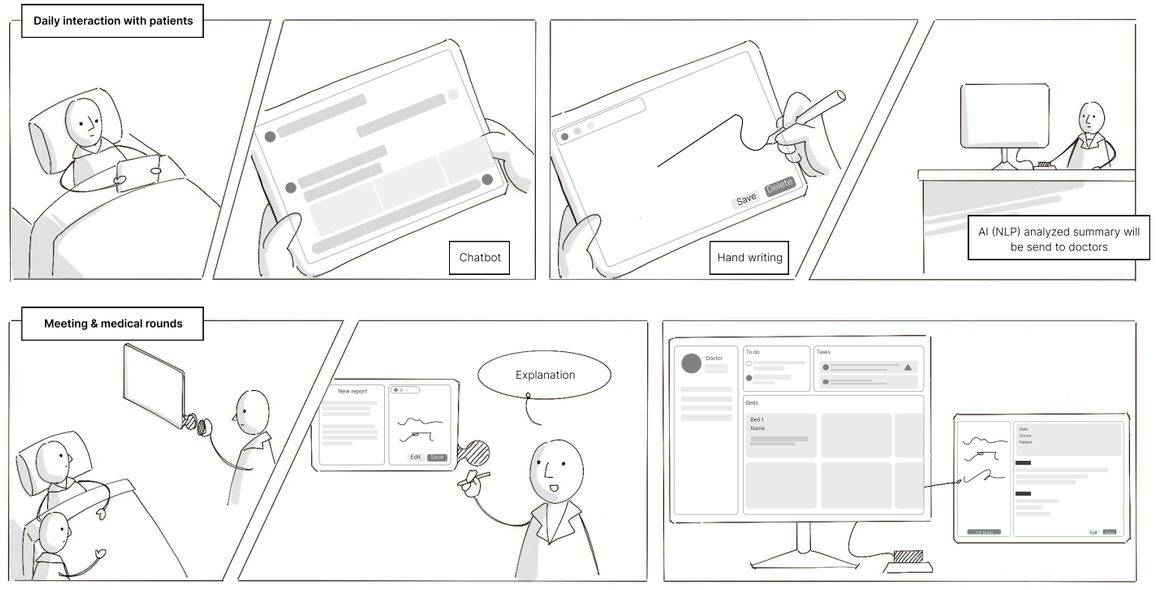


Figure 32. Storyboard of concept 2

5.2.3 Concept 3: Smart Notepad

This concept features a digital notepad that enables handwritten notes to be digitally captured and synchronized with the system in real-time. The design specifically accommodates HCPs' preference for maintaining familiar work practices, particularly the established habit of handwriting, while seamlessly integrating digital capabilities into their existing workflows.

Storyboard

The storyboards primarily illustrate how healthcare professionals interact with the smart notepad across various clinical scenarios, including team meetings, medical rounds, routine management of fragmented information, and communication with patient families. It also demonstrate how PtFams can use the device to document their daily questions and care needs, which will be gathered to HCPs in the system.

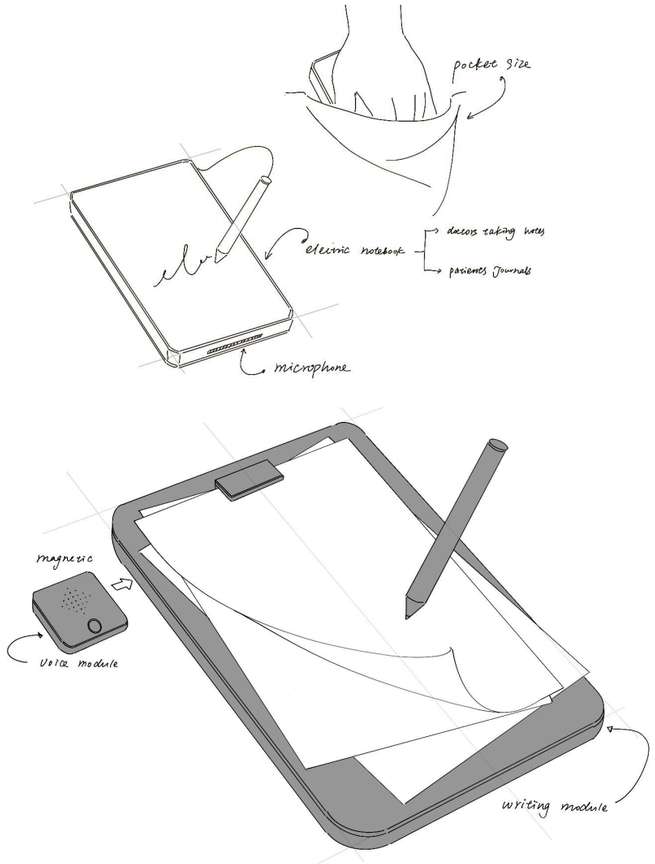


Figure 33. Illustrations of concept 3

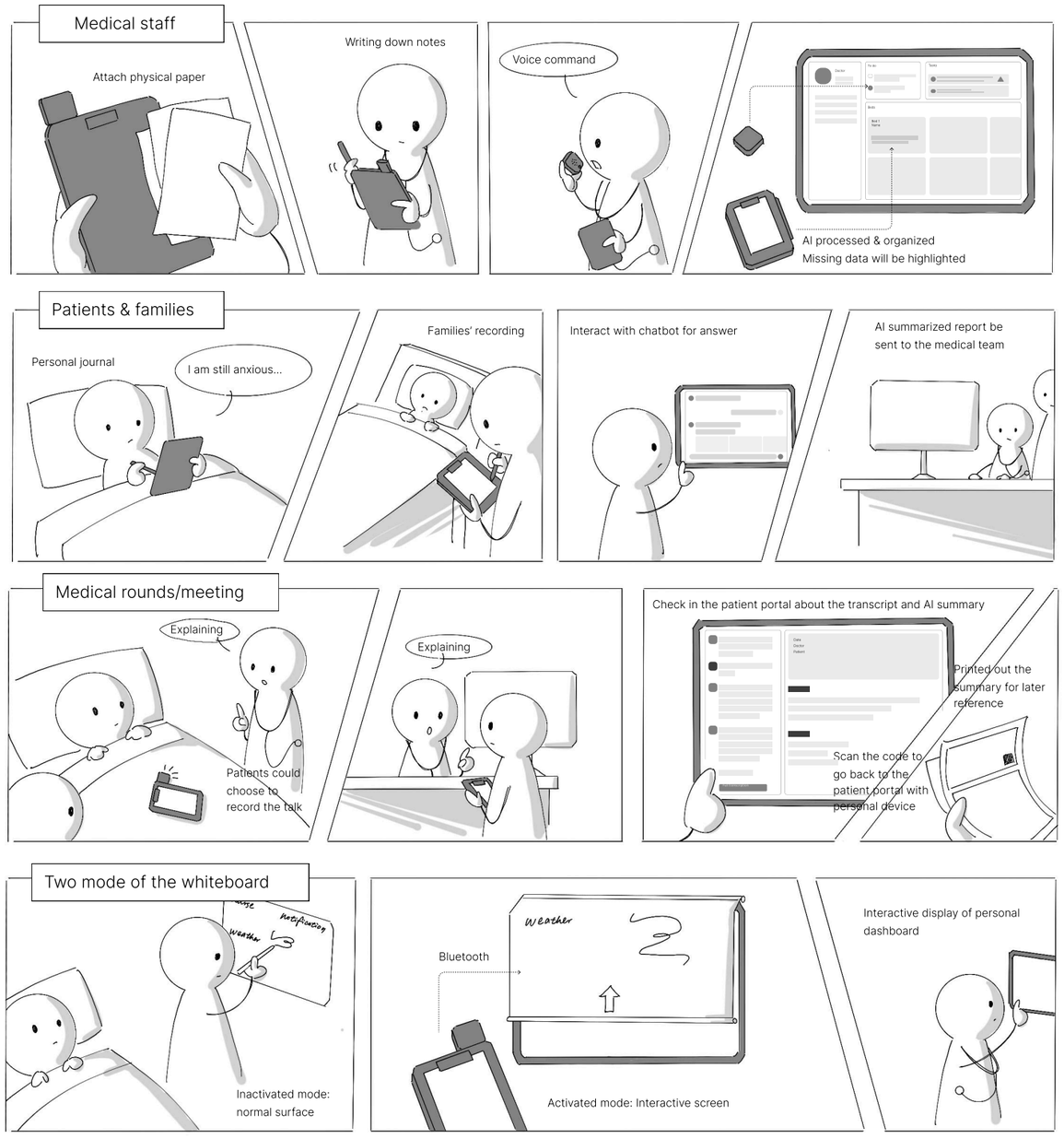


Figure 34. Storyboard of concept 3

5.3 Evaluation

Harris Profile

To converge from three concepts to a single design direction, a Harris Profile evaluation was conducted. Each concept was systematically assessed based on the established design criteria using a four-point scale (-2, -1, +1, +2).

The Harris Profile analysis revealed that Concept 1 (Smart Pin) emerged as the strong winner, demonstrating superior performance across the majority of evaluation criteria. Consequently, the Smart Pin concept was selected to serve as the foundation for the final design direction.

To develop a comprehensive solution that meets the full design criteria, some features from Concepts 2 and 3 will be integrated into the final concept. This hybrid approach ensures that the final design leverages the strengths of all three concepts while keeping the Smart Pin's core advantages.

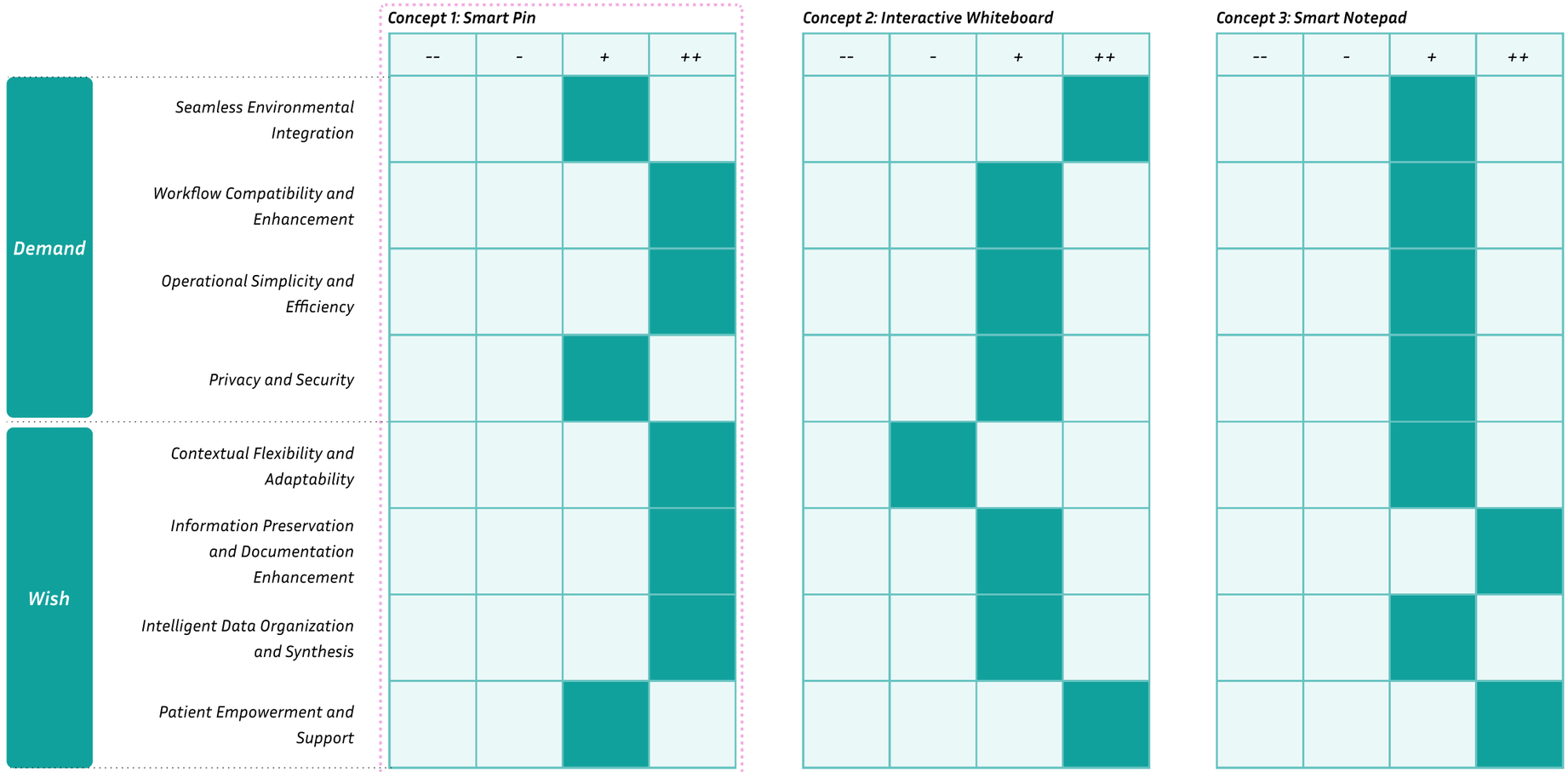


Figure 35. Results of Harris Profile

06

Final Design

6.1 System Build up
6.2 System Components
6.3 Technology Support
6.4 UI Key Pages Walkthrough

Chapter Overview

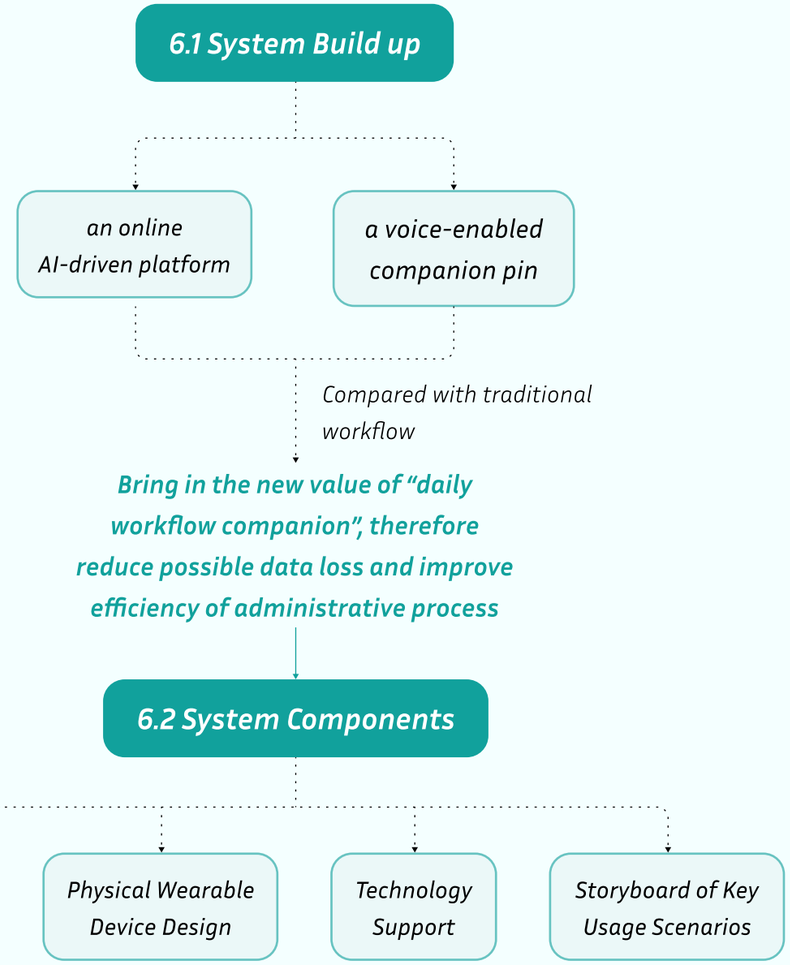


Figure 36. Mind map of Chapter 06

6.1 System Build up

Based on the Harris Profile evaluation of the proposed concepts, the Smart Pin was selected as the foundation for the final design direction. Through iterative refinement and careful alignment with the project's established design goals, this concept finally evolved into a comprehensive AI-driven system that facilitates the collection and organization of fragmented medical information, enabling rapid and efficient data entry and report generation within existing EHR systems.

Figure 37 presents a comparative analysis between traditional clinical workflows and the proposed new AI-assisted workflow.

6.1.1 Traditional workflow

Within conventional healthcare workflows, HCPs interact directly with complex EHR systems through time-intensive manual processes. During clinical shifts, fragmented information is typically documented across disparate media platforms, including paper-based notes, whiteboards, and various digital applications etc.. At the end of a shift, HCPs must collect these scattered records, also generate related standardized formal reports before final submission to the EHR system.

This fragmented approach presents significant challenges, as a big part of the clinical information that is not collected and structured in real-time frequently becomes lost, overlooked, misremembered or remain solely in HCPs' memory without formal documentation, creating potential risks for patient treatment.

6.1.2 AI-Assisted New Workflow

In contrast, the proposed system introduces an innovative companion AI system designed to function as an intuitive bridge between HCPs and existing EHRs.

Throughout clinical shifts, HCPs can capture essential information immediately through multiple ways: voice commands, conversation recordings, or digitized handwritten notes, thereby significantly reducing information loss risk. The collected information will also be well organized by AI in the system.

During the documentation phase, the AI assistant provides substantial support by automatically generating preliminary report drafts based on all the collected information, transforming the traditionally labor-intensive documentation process into a more streamlined, efficient, and accurate workflow. After clinical validation and approval, finalized reports are seamlessly archived within the EHR systems.

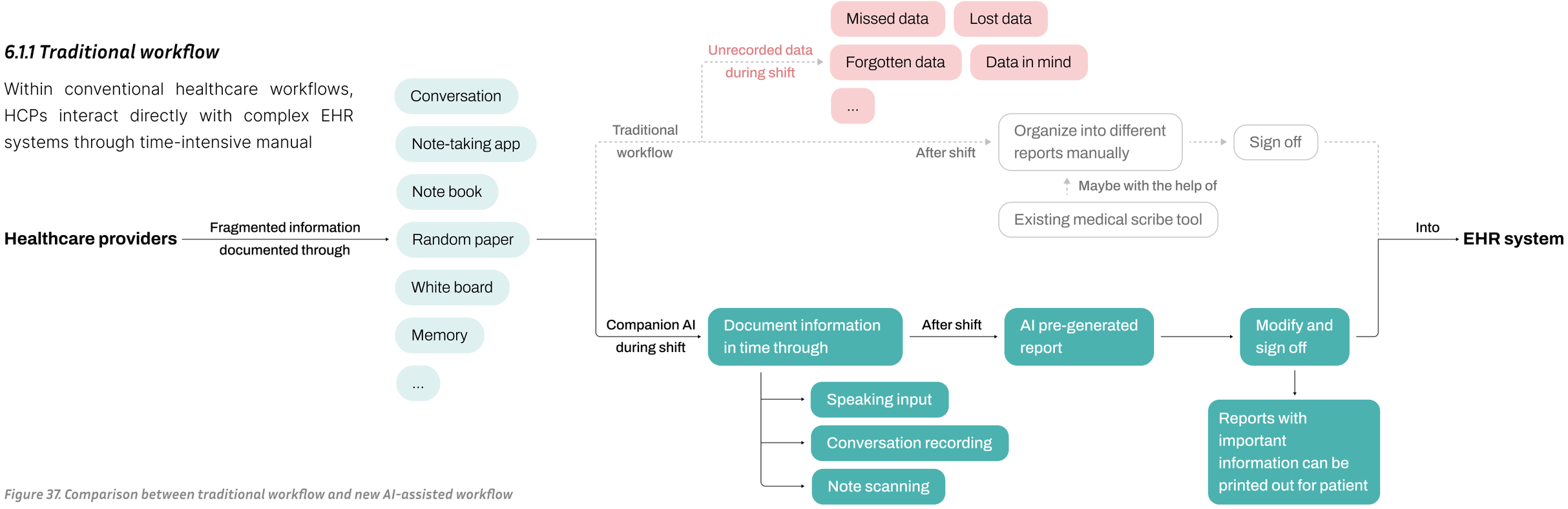
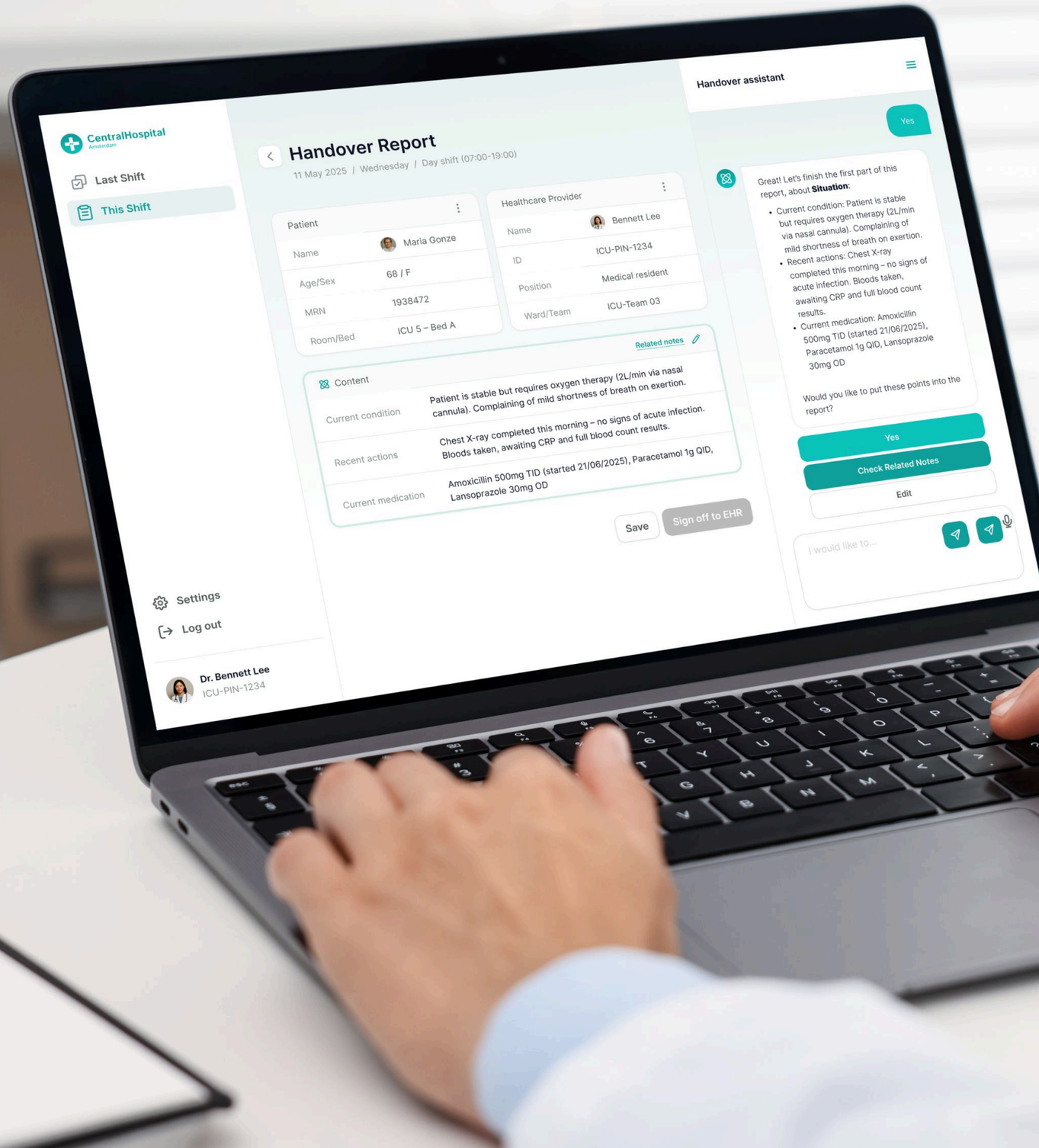


Figure 37. Comparison between traditional workflow and new AI-assisted workflow

6.2 System Components



Building on the overall system rationale and its anticipated value, the following section elaborates on the specific components, core functions, application scenarios and technologies that constitute the final design.

6.2.1 System Touch Points Design

The final system consists of two integrated components: **an online AI-driven platform and a voice-enabled companion pin.** Detailed documentation of the iterative development of UI system and the pin are provided in *Appendix 6* ***and*** *Appendix 7*, respectively.

Online AI Platform

Core Functionalities

The online AI platform serves as the central hub supporting three core functionalities:

1. Real-time capture of fragmented clinical data during shifts through three input modalities, including voice commands, meeting recordings, and digitized handwritten note scanning.
2. AI-powered automatic classification and organization of collected information into structured formats.
3. AI-assisted report generation based on the comprehensive recorded information, with full traceability linking each conclusion to its original source documentation to ensure clinical accuracy and accountability.

Theme Color Consideration

The system adopts green as its primary theme color, grounded in evidence-based color psychology research. Studies have demonstrated that green induces feelings of relaxation, calmness, and comfort due to its strong associations with nature, life, and vegetation (Dijkstra et al., 2008). Furthermore, green has been widely used in healthcare environments for practical reasons: as the complementary color to red, it provides visual relief from prolonged exposure to red stimuli (such as blood), helping to mitigate visual fatigue and maintain color sensitivity among healthcare professionals.

Voice-Enabled Companion Pin

Core Functionalities

The companion pin functions as a wearable device designed for continuous use throughout clinical shifts, enabling precise real-time voice data capture. When it is connected to the paired workstation, the station provides battery charging and rapid user authentication with seamless access to personalized work portals.

Privacy Consideration

To address privacy considerations and maintain user autonomy, the pin incorporates intuitive interaction design: a double-tap gesture enables quick activation or deactivation, while an illuminated status ring provides clear visual feedback regarding recording status, ensuring transparency for all individuals within the recording environment. This design allows for immediate deactivation should any individual express discomfort with being recorded, maintaining ethical data collection practices.



Figure 38. HCPs wear the pin during their daily workflow

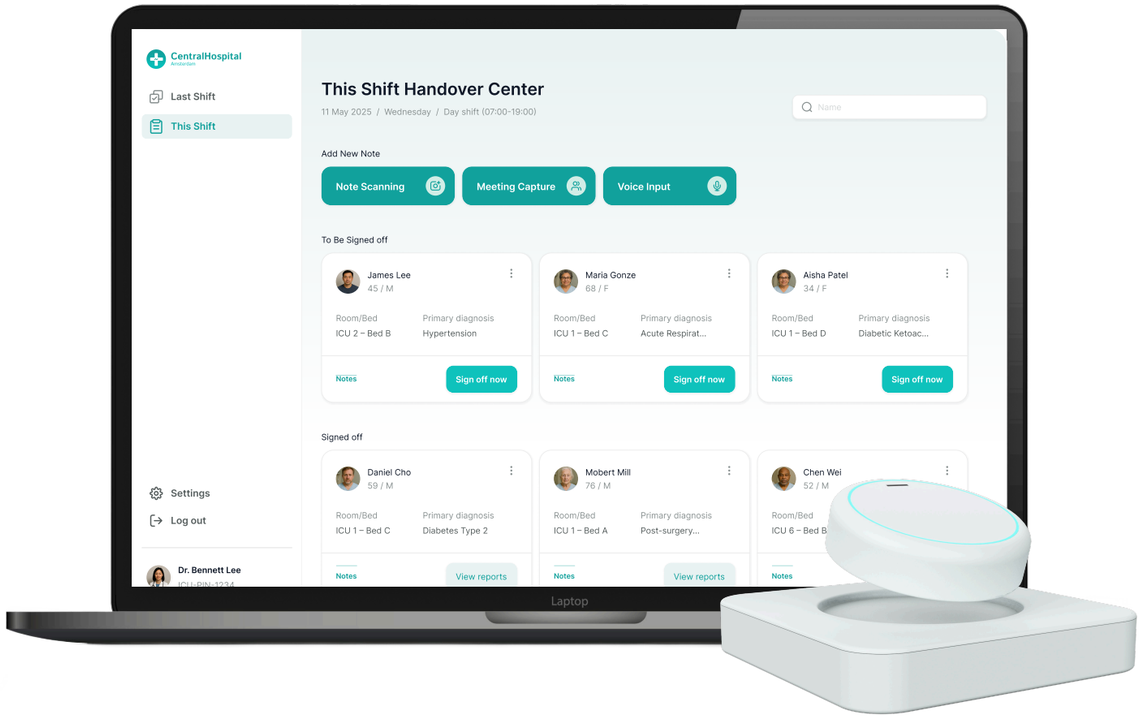
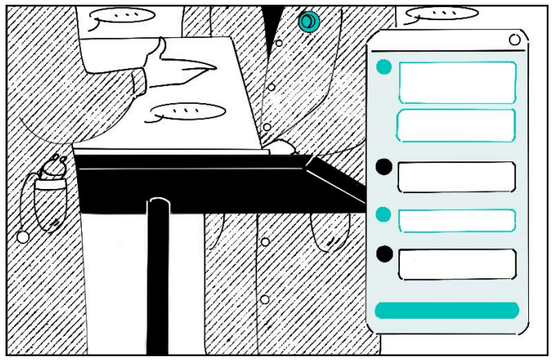


Figure 39. AI-driven system and voice-enabled companion pin

6.2.2 Storyboard of Key Usage Scenario



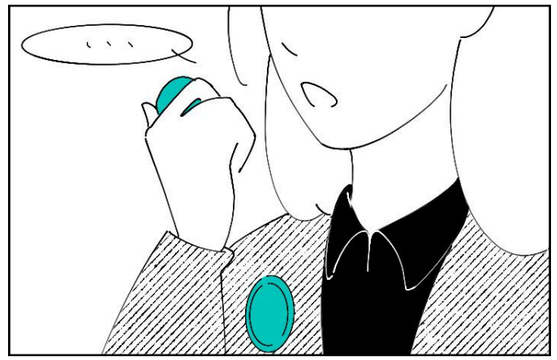
Meeting Recording and PtFams Support

During conversations or meetings, the companion AI Pin can be activated, while ensuring privacy considerations, to record the content. A floating window displays real-time transcription throughout the session. After the meeting, the AI system assists HCPs in rapidly generating an analysis or summary, which could be printed out and given to PtFams with recorded information.



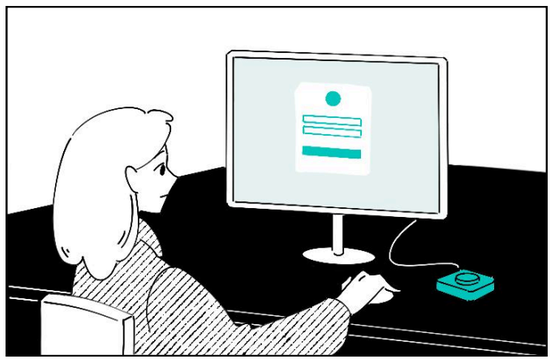
Written Notes Scanning

At the end of a shift or during the shift itself, the system's note scanning function enables HCPs to quickly digitize fragmented handwritten notes. The AI automatically recognizes handwriting from captured images and converts it into editable text, facilitating accurate and organized documentation.



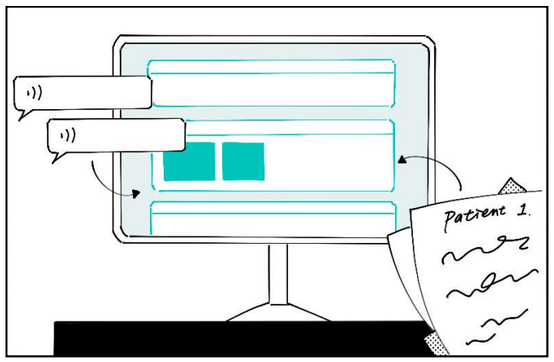
Daily Workflow Companion

During a shift, HCPs wear the pin with them. The pin itself connects magnetically to its base. When a piece of information, such as an observation, needs to be recorded, the pin can be easily detached and used for instant voice input, enabling timely and efficient data capture within the workflow.



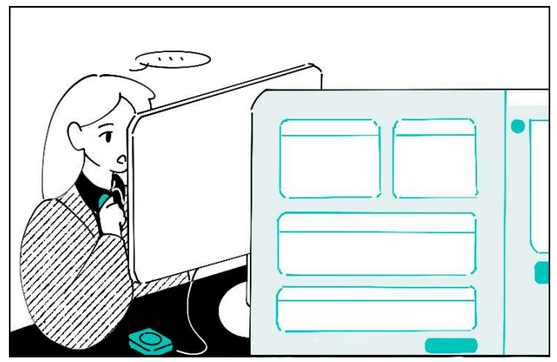
Seamless Portal Log in

When HCPs need to quickly log into their personal work portal, the AI Pin can placed onto its computer-connected docking base. This action simultaneously recharges the pin and enables rapid identity verification, allowing seamless and secure access to the system.



Automatic Information Organization

All information collected throughout the workflow is automatically categorized and organized by the AI into a specific note page, enabling HCPs to conveniently review and edit the content.



Efficient Report Generating

When generating reports, HCPs can use the AI assistant and voice input to improve the overall efficiency, while also reviewing the raw information sources behind AI-generated conclusions to ensure accuracy.

Figure 40. Storyboard of key scenarios

6.3 Technology Support

The proposed system integrates a voice-enabled pin with a online AI-driven platform, supported by a set of emerging AI techniques and hardware components. This integration enables seamless capture, organization, and synthesis of fragmented clinical information within real-world healthcare environments.

6.3.1 Companion Pin

The wearable pin is engineered to accurately capture spoken information in acoustically challenging clinical environments through the following technical capabilities:

1. Speech Enhancement and Noise Reduction: The device employs advanced signal processing algorithms and deep learning-based speech enhancement models, including beamforming, spectral subtraction, and neural noise suppression techniques. These technologies enable the isolation of human speech from ambient noise in dynamic hospital settings, ensuring high-fidelity audio capture during critical clinical interactions.
2. Secure Wireless Data Transmission: Audio data is transmitted to the online platform via encrypted wireless protocols, utilizing Bluetooth Low Energy or Wi-Fi connectivity to ensure both data security and energy efficiency.
3. Touch-Based Activation Interface: A double-tap activation mechanism is implemented through embedded accelerometer or capacitive touch sensors, enabling users to initiate or terminate recording sessions with minimal disruption to clinical workflows.
4. Privacy Transparency Features: An integrated LED indicator ring provides real-time visual feedback regarding device status, ensuring transparency and maintaining stakeholder awareness of recording activities in compliance with privacy protocols.
5. Magnetic Charging and Docking System: The pin utilizes a magnetic charging dock that facilitates rapid power replenishment. The dock connects directly to computers via USB-C or equivalent high-speed data interfaces, enabling seamless data synchronization.
6. Hardware-Based User Authentication: When docked, the system leverages hardware identifiers such as Near Field Communication (NFC) or secure chip authentication to enable rapid user verification and automatic login to personalized work portals, streamlining workflow transitions.

6.3.2 Online AI-Driven Platform

The online platform serves as the central information processing hub and reporting interface, incorporating the following AI technologies:

1. Medical-Domain ASR: Audio streams from the wearable device are processed using specialized ASR models trained on medical terminology and clinical conversation patterns. This domain-specific optimization ensures accurate transcription of complex medical discussions, pharmaceutical names, and technical procedures.
2. Intelligent Information Categorization: NLP algorithms and ML classification models automatically organize fragmented notes into predefined clinical categories, including observations, tasks, patient complaints, and care instructions. This automated categorization significantly reduces the cognitive burden associated with manual information organization.
3. Enhanced OCR: The system digitizes handwritten notes and whiteboard content through photographs using advanced OCR technology augmented by machine learning-based handwriting recognition algorithms. This capability converts analog information sources into searchable, editable digital text entries.
4. AI-Assisted Report Generation: A LLM-powered conversational interface assists healthcare providers in generating structured clinical reports according to institutional formatting requirements. The system synthesizes all collected information: transcribed audio, digitized notes, and categorical data into coherent draft reports while maintaining complete traceability. Each generated conclusion is directly linked to its source material, with relevant supporting content highlighted to ensure accuracy and provide contextual transparency for clinical decision-making.

Through the seamless integration of these advanced technologies, the system provides real-time, accurate, and user-centered documentation support that directly addresses the persistent challenges of information fragmentation, data loss, and administrative burden in contemporary clinical environments.

6.4 UI Key Pages Walkthrough

As the central repository for information management and report generation, the online AI-driven system serves as a critical component of the overall design. To ensure usability and clinical relevance in real-world healthcare environments, the system development followed to user-centered design principles, with particular emphasis on addressing the operational needs and workflow patterns of HCPs identified in previous sessions. Consequently, a series of key interfaces were designed to demonstrate the system's core functionalities and support primary application scenarios, establishing the foundation for seamless integration into daily clinical workflows.

6.4.1 Login Page

HCPs initiate system access by placing the pin onto its docking station, which connects to the computer. This action simultaneously charges the device and enables rapid identity verification. The HCPs need only enter a password to access their personalized work portal seamlessly.

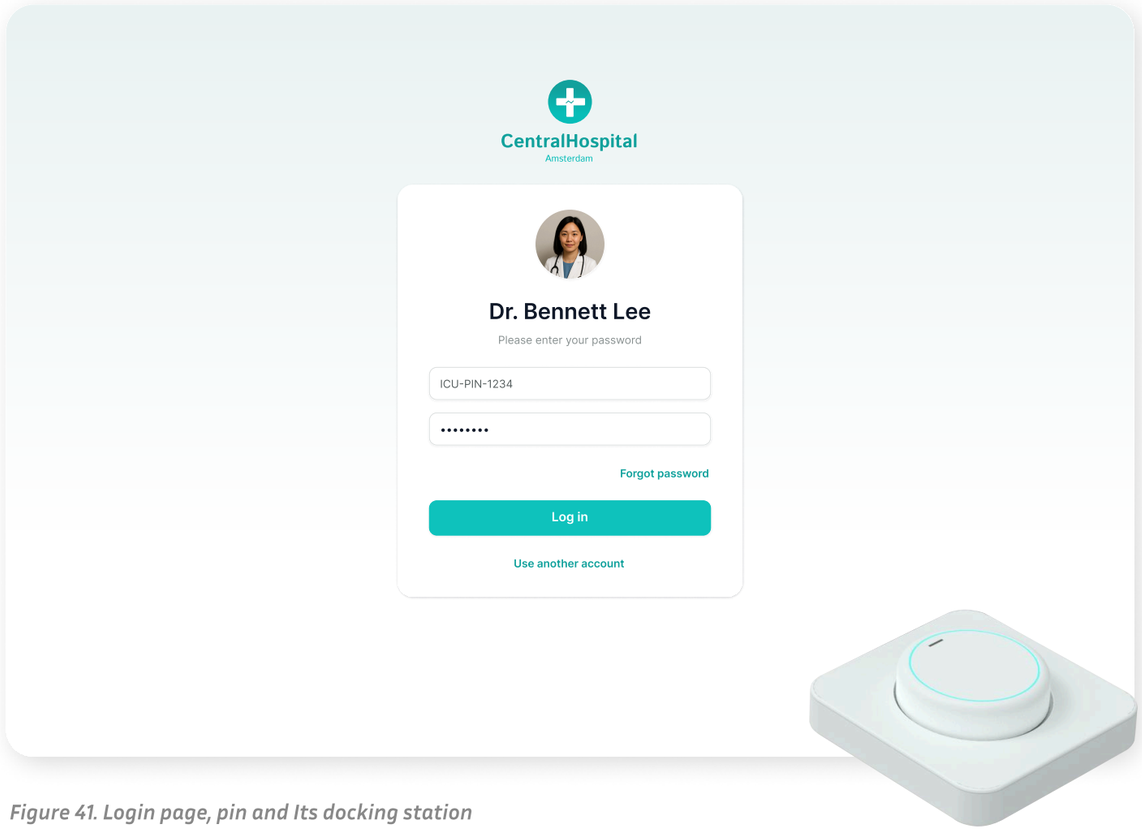


Figure 41. Login page, pin and Its docking station

6.4.2 Shift Handover Center

The shift handover center is organized into two primary sections: "Last Shift" and "This Shift." At the top hierarchical level, three primary information channels enable HCPs to efficiently collect and organize shift data: note scanning, meeting capture, and voice input. Below this interface, patient information cards are displayed, allowing HCPs to monitor handover report sign-off rapidly. Each patient card contains essential demographic and clinical information while providing access to shift-specific notes pages, direct entry points for handover report generation, and options to review previously signed and uploaded reports within the EHR system.

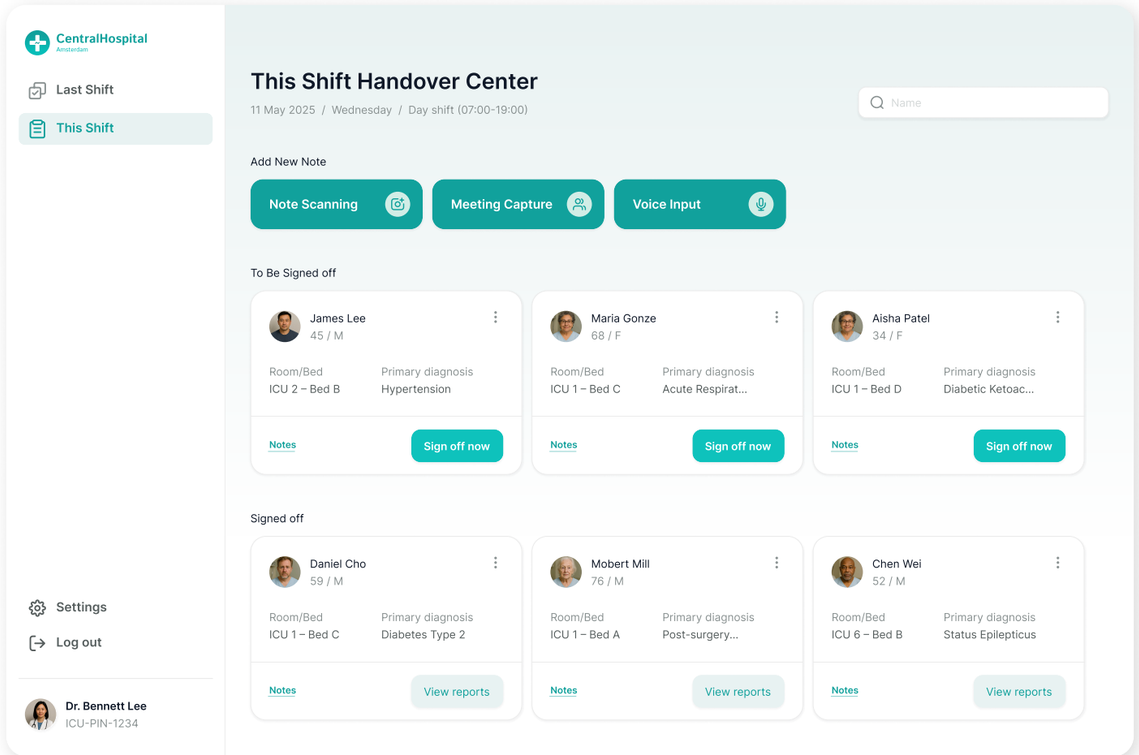


Figure 42 . Handover center of this shift

6.4.3 Meeting Capture

Meeting capture represents one of the primary channels for information collection and organization within the system. HCPs select the appropriate report template based on meeting type and activate the AI pin to record the session. The AI assistant subsequently generates a draft report from the audio recording. For each AI-generated conclusion, professionals retain the ability to modify content or review the original conversation transcript to ensure report accuracy and completeness.

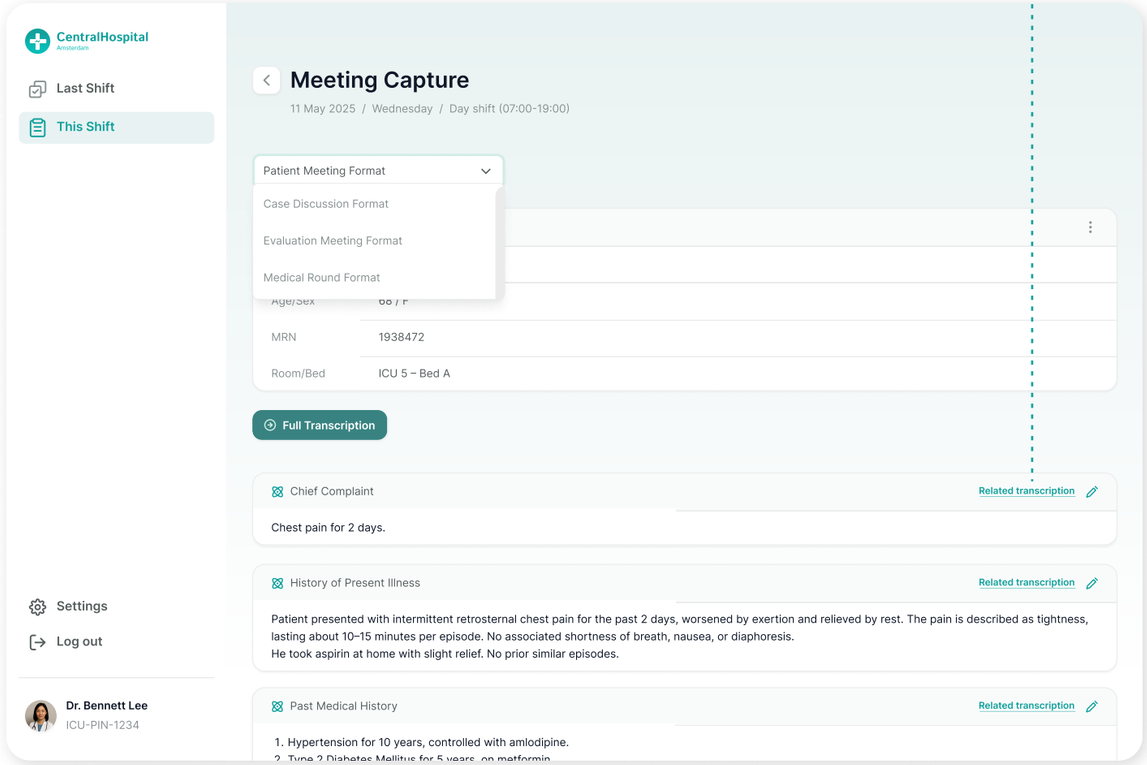


Figure 43. Meeting capture page with report generation

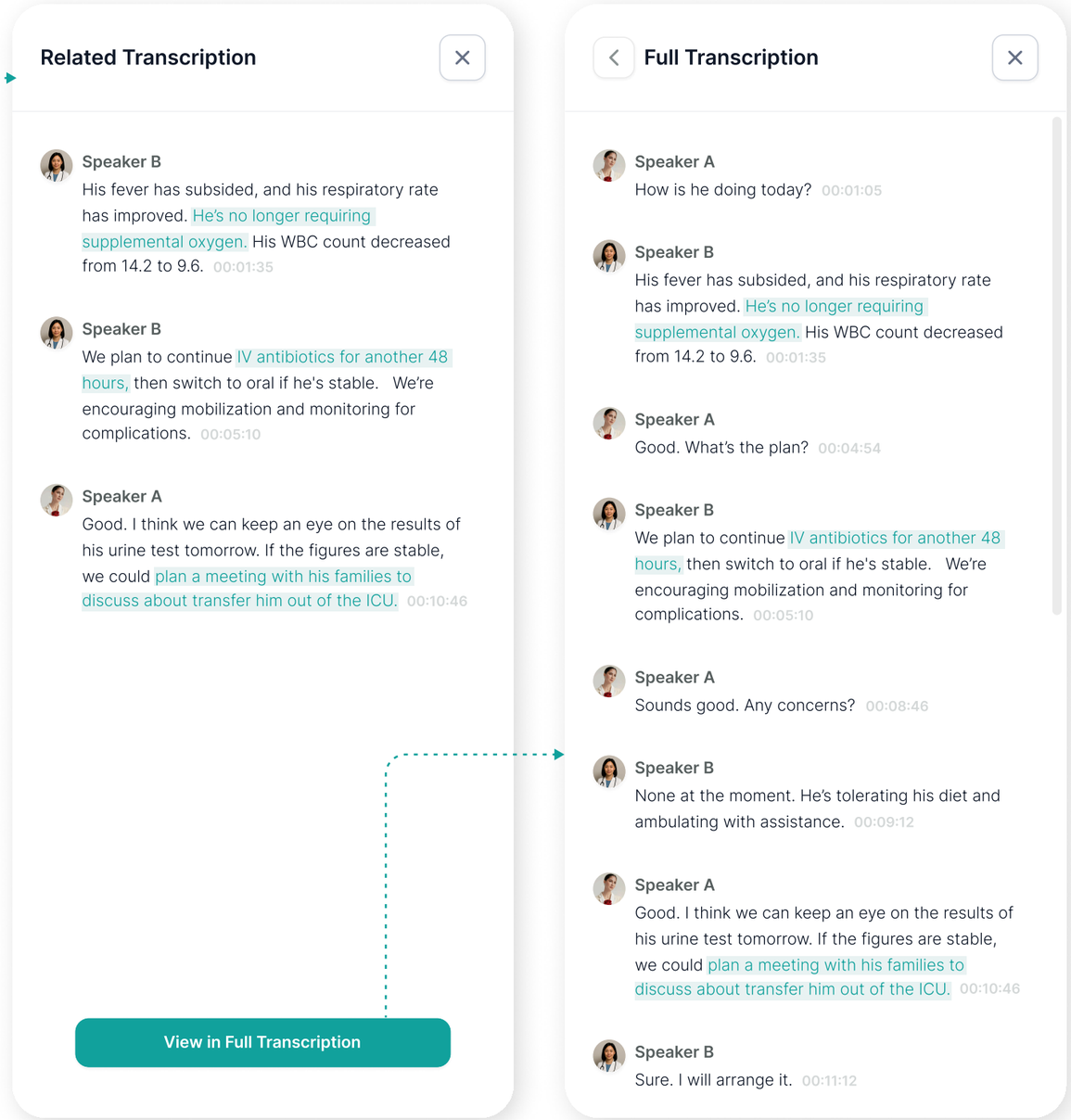


Figure 44. Floating windows with transcription to support conclusions tracing

6.4.4 Handover Report Generation

Upon initiating the handover report generation phase, an AI chatbot assistant guides HCPs through the structured report format section by section. The format template can be customized to accommodate specific departmental or institutional requirements.

Alternatively, HCPs may skip the assistant to directly review AI-generated reports, implement necessary modifications, and authorize submission to the EHR system. Throughout the report generation process, HCPs can access "related notes" to examine the source material underlying each AI-generated conclusion, with associated note information provided directly within the chatbot interface.

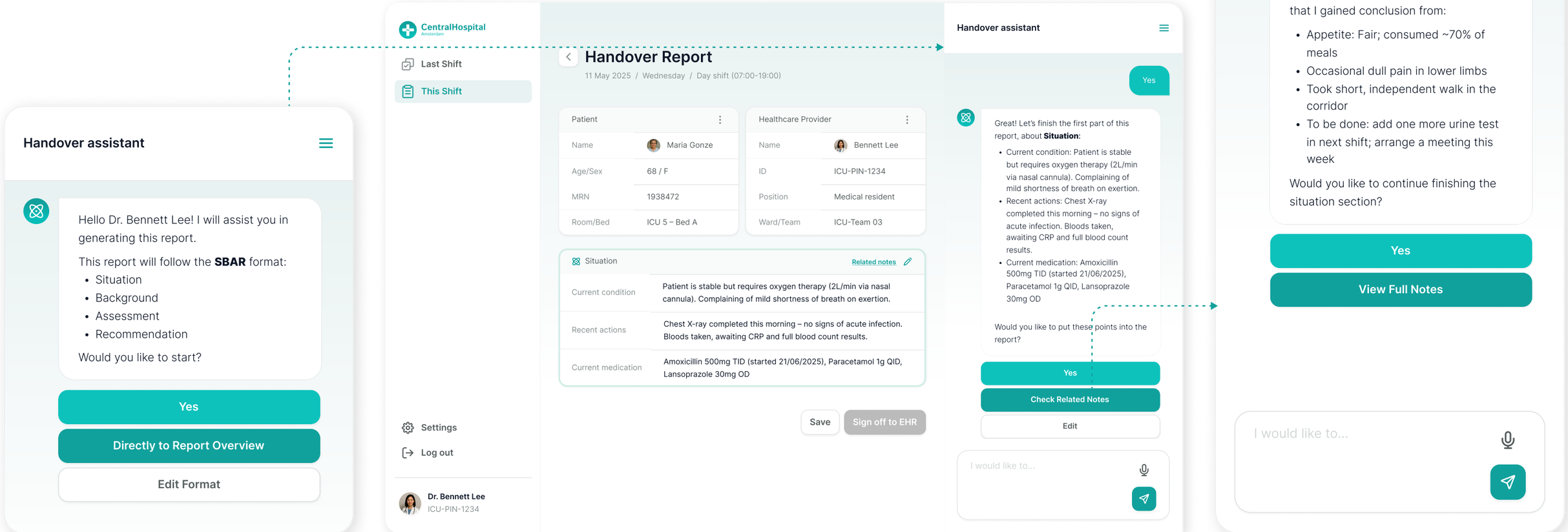


Figure 45. AI chatbot to assist efficient handover report generation

6.4.5 Note Review and Verification

When comprehensive review is required, HCPs can navigate to the dedicated note collection and organization page, where relevant notes are highlighted for easy identification.

This interface provides access to original handwritten note images, source audio recordings, and corresponding transcriptions, ensuring accuracy and maintaining transparency in the documentation process.

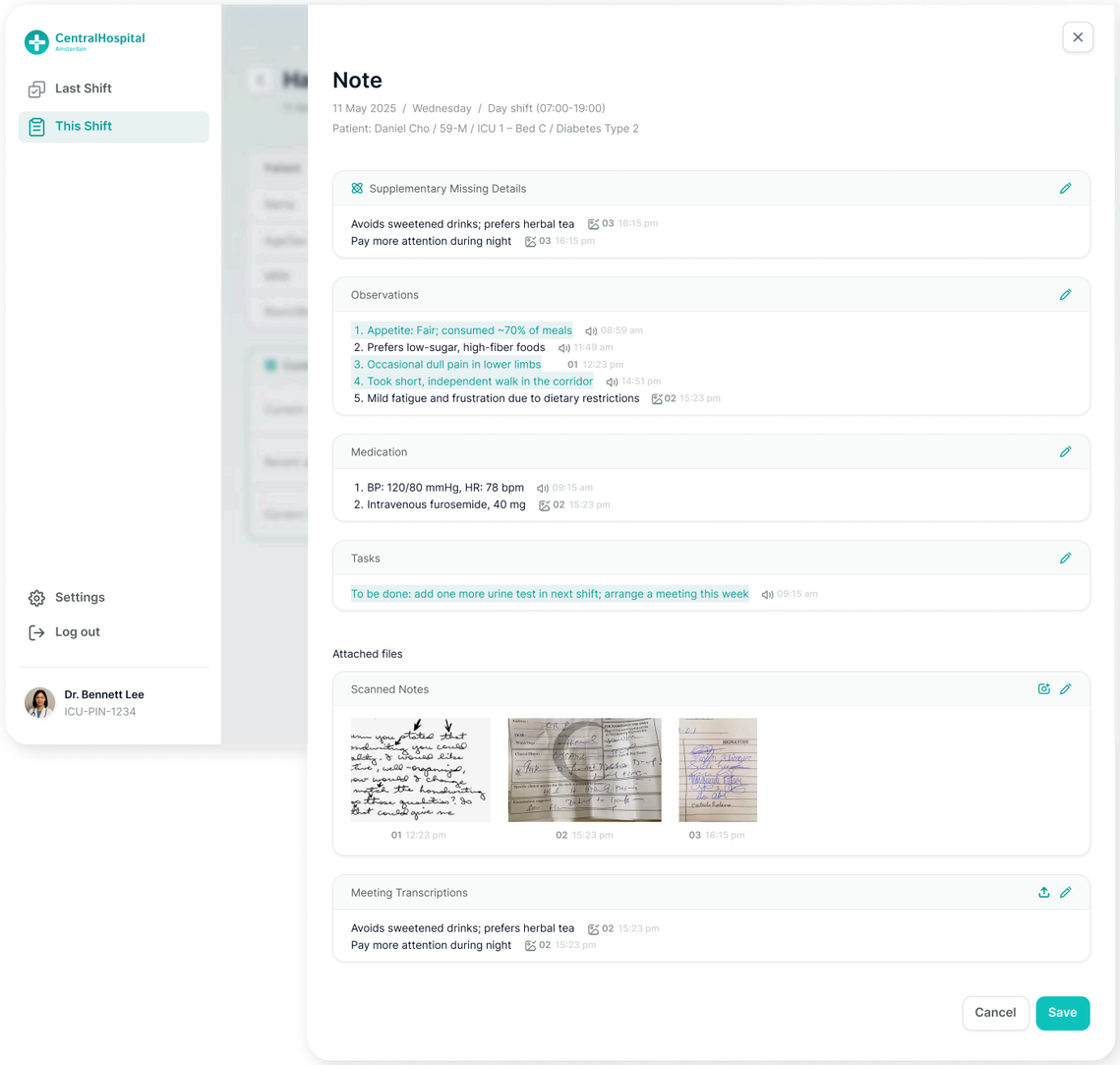


Figure 46. Automatically organized notes of this shift

6.4.6 Note Scanning

Clinicians can rapidly digitize information through handwritten note scanning functionality. The trained AI system automatically recognizes and extracts handwritten content, converts it into editable text format, and systematically organizes the information within the note management system. This allows the HCPs to maintain their traditional working habit, while enabling efficient data documentation.

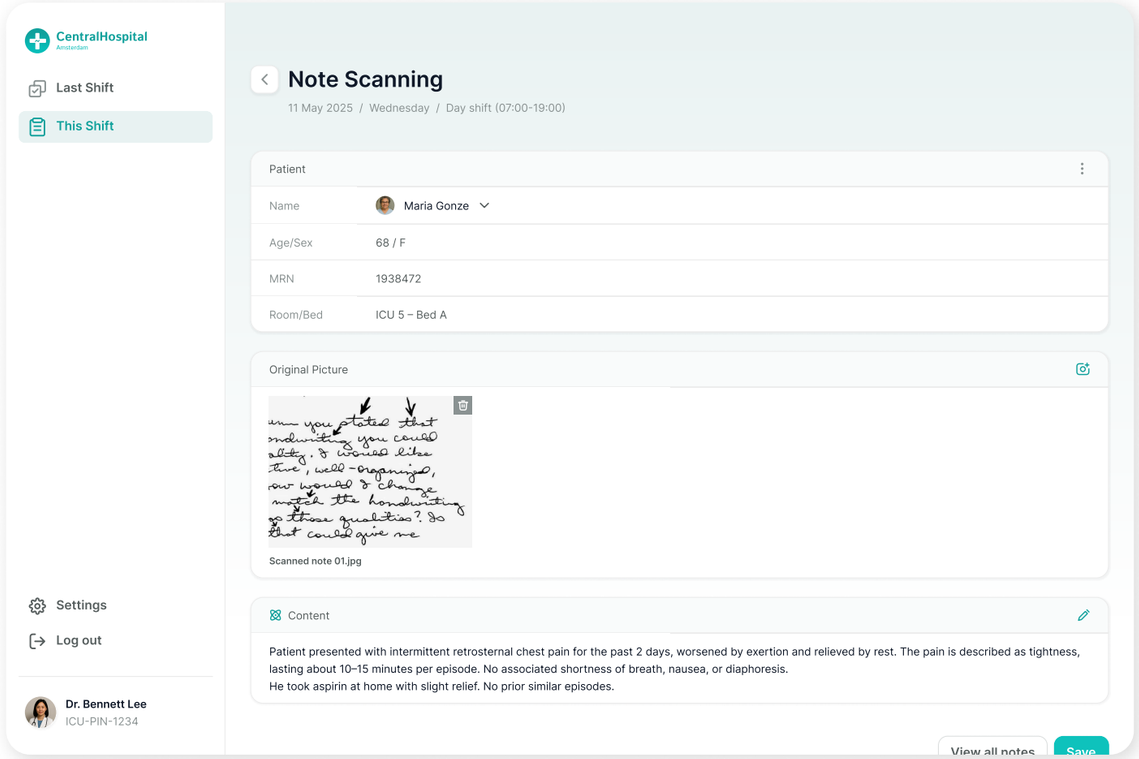


Figure 47. Scanned and recognized handwritten notes

07

Evaluation

7.1 Evaluation Plan
7.2 Prototype
7.3 Evaluation Session

Chapter Overview

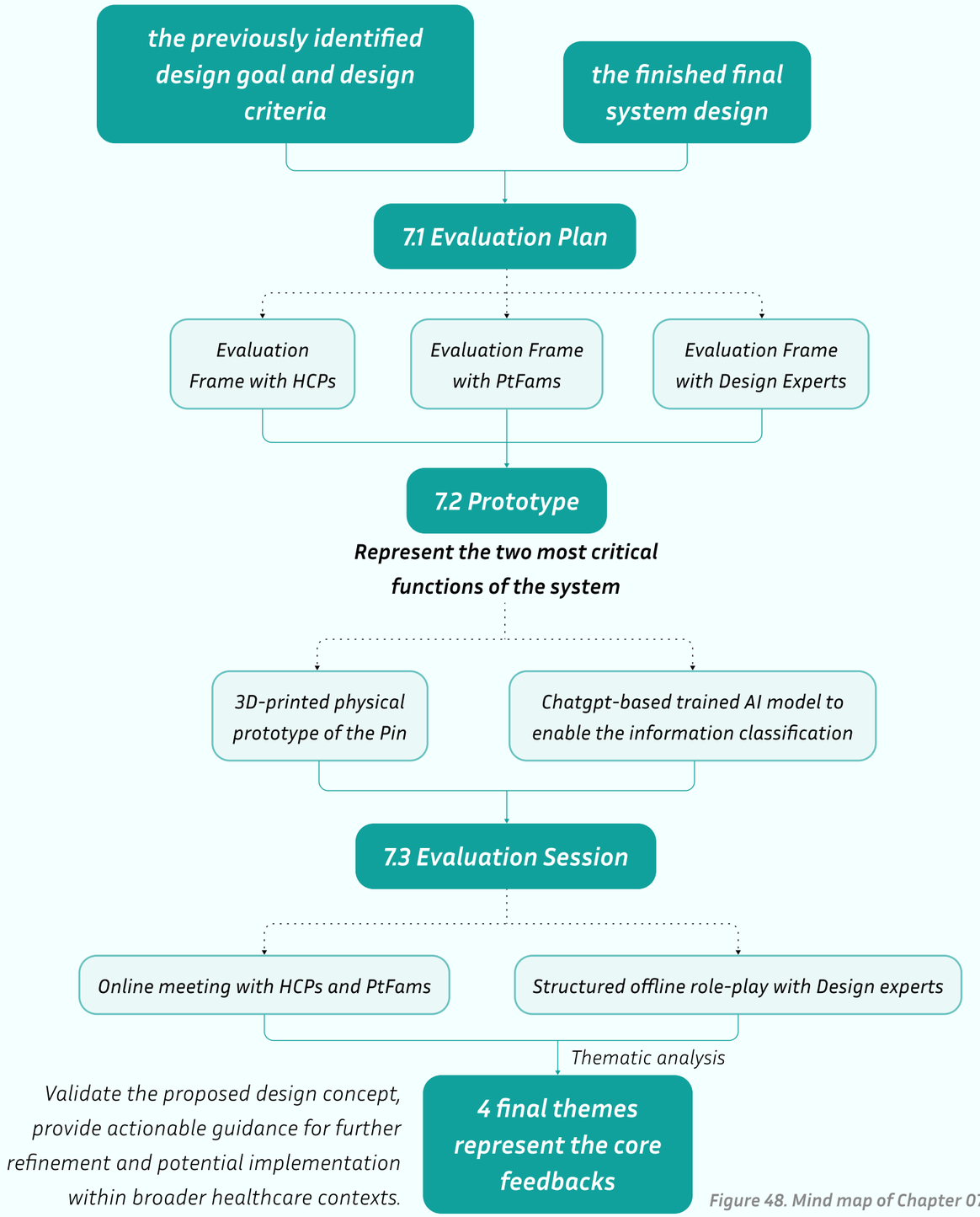


Figure 48. Mind map of Chapter 07

7.1 Evaluation Plan

Following completion of the final design, comprehensive evaluation sessions were conducted to gather comprehensive feedback from both practical implementation and design perspectives. Based on the previously identified design opportunities, project objectives, and established design criteria, the evaluation was structured around three distinct stakeholder groups: HCPs as primary users, PtFams as secondary users, and design experts providing specialized evaluation expertise.

7.1.1 Evaluation Framework by Stakeholder Group

Evaluation with HCPs

The primary evaluation group focused on assessing the design from the HCPs perspective, examining the following critical dimensions:

1. Information Management Efficacy: Assessment of the system's capacity to support collection and organization of fragmented clinical data, thereby reducing the probability of information loss, misremembering, or omission during patient care transitions.
2. Documentation Efficiency: Evaluation of system impact on report generation processes within existing EHR workflows, in order to save time and alleviate administrative documentation burden.
3. Workflow Integration and Usability: Analysis of design simplicity, learning curve requirements, and compatibility with established clinical workflows to minimize operational disruption.
4. User Acceptance and Attitudes: Assessment of healthcare providers' overall receptivity to the proposed solution and willingness to adopt the technology in practice.
5. Additional Insights: Collection of supplementary feedback, implementation suggestions, and identification of potential concerns or barriers to adoption.

Evaluation with PtFams

The secondary user group evaluation concentrated on PtFams perspectives, specifically addressing:

1. Privacy and Autonomy: Assessment of the design's ability to provide users with a sense of control over privacy settings while maintaining comfort and demonstrating respect for personal boundaries.
2. Information Comprehension Support: Evaluation of the system's effectiveness in recording and facilitating better understanding of critical medical information during physician-patient communications.
3. User Experience Feedback: Collection of additional insights, suggestions, and concerns.

Evaluation with Design Experts

The third evaluation group comprised design professionals whose feedback focused on design dimensions, including system architecture, interaction design details, user experience optimization, and adherence to established user-centered design principles.

7.1.2 Participant Recruitment and Methodology

Participant Profile

The evaluation involved six participants representing diverse healthcare and design backgrounds: one ICU attending physician, one family member with direct experience caring for a hospitalized patient, one nursing home caregiver, and three design students from Industrial Design Engineering (IDE). Notably, three participants (the ICU physician, patient family member, and nursing home caregiver) had previously participated in the initial interview phase, providing them with basic understanding of the project context and objectives.

Evaluation Methodologies

Two distinct evaluation approaches were implemented to accommodate participant availability and environmental constraints:

1. Remote Guided Evaluation Sessions: Conducted with the ICU physician, patient family member, and nursing home caregiver, these sessions were held online due to the sensitive nature of hospital environments and participants' limited availability. The researcher systematically introduced the design concept, demonstrated the functional prototype, and facilitated structured discussions addressing the predetermined evaluation dimensions.
2. In-Person Role-Playing Sessions: Design expert participants engaged in structured role-playing exercises where they were assigned specific stakeholder roles and provided with corresponding user journey scenarios. The researcher conducted observational analysis of participant interactions. Following the role-play activities, group discussions were facilitated to gather perspective-specific feedback and leverage participants' expertise on interaction, experience and system design.

7.2 Prototype

Based on the finalized design concept and the established evaluation plan and goals, two prototypes were developed to help participants clearly and intuitively understand and experience the proposed system during the evaluation sessions. These prototypes were designed to represent the two most critical functions of the system.

7.2.1 Prototype 1: Physical Model of the Pin

The first prototype was a physical model of the pin, created through 3D printing following Rhino-based modeling. The purpose of this prototype was to show the ergonomic scale of the device and demonstrate how its three main components interact:

1. Component 1: The Pin, which magnetically attaches to Component 2: A wearable base clipped onto the user's clothing. This allows the pin to be easily detached for voice recording and reattached afterward.
2. When placed on Component 3: A charging dock connected to a computer, the pin can be rapidly recharged while simultaneously enabling user authentication for seamless access to the online AI system.

This physical prototype allowed participants to directly perceive the device's form factor and its basic interaction principles.

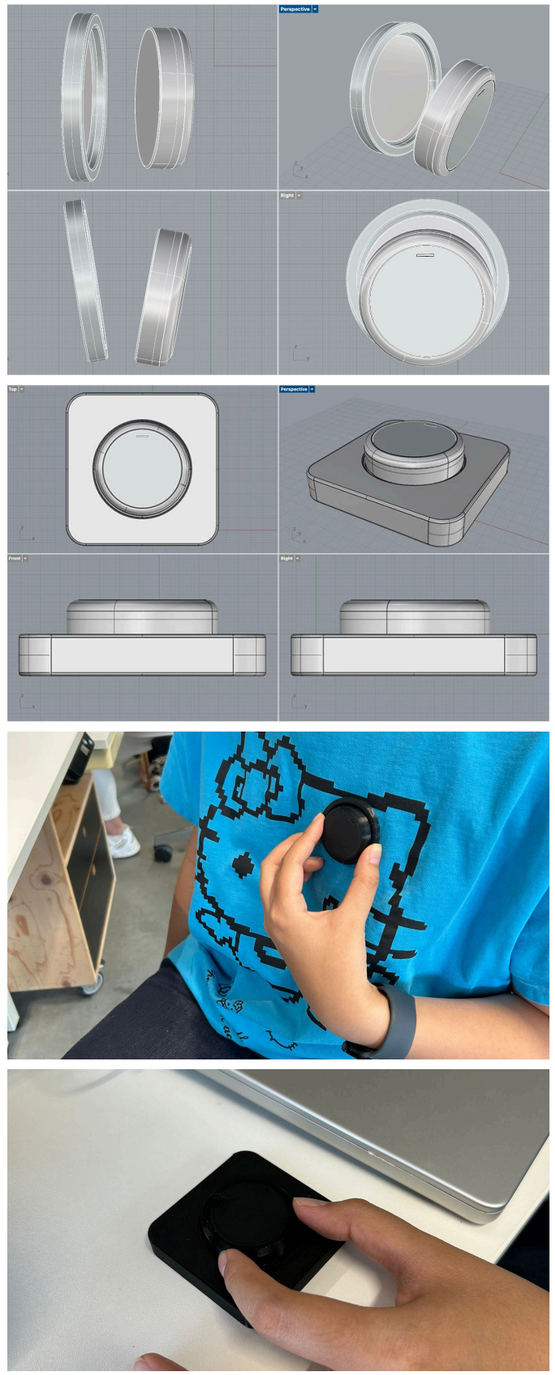


Figure 49. Rhino modelling and 3D printed prototype

7.2.2 Prototype 2: Online AI System for Fragmented Information Classification

The second prototype focused on the system's ability to organize fragmented clinical information. This prototype was implemented using ChatGPT as a functional demonstration. The process involved first asking the model to establish two coordinate axes: one consisting of patient profiles (nine patients, each identified with bed number, name, age, and gender), and the other consisting of predefined categories (e.g., observation, task, patient complaint, medication, etc.). New notes were then to be placed into the correct cell of a two-dimensional table defined by these axes. Importantly, the model was instructed to preserve all previously stored notes while adding new entries, thereby simulating continuous data collection and aggregation. The instruction prompt submitted to ChatGPT was as follows:

You are an AI note organizer for ICU medical staff.
You are managing records for 9 patients:

1. *Bed 01 - James Lee, 45-year-old male*
2. *Bed 02 - Maria Gonze, 68-year-old female*
3. *Bed 03 - Aisha Patel, 34-year-old female*
4. *Bed 04 - Daniel Cho, 59-year-old male*
5. *Bed 05 - Mobert Mill, 76-year-old female*
6. *Bed 06 - Chen Wei, 52-year-old male*
7. *Bed 07 - Bill Wang, 35-year-old male*
8. *Bed 08 - Marko Free, 56-year-old male*
9. *Bed 09 - Annie King, 43-year-old female*

Every note you receive will belong to one patient and one category. The categories are:

1. *Observation – Objective or subjective observations about the patient's condition.*
2. *Patient Complaint – Statements about symptoms or discomfort expressed by the patient.*
3. *Task – Actions that need to be performed in the future.*
4. *Vital Signs – Measured clinical values(temperature, BP, HR, oxygen saturation, etc.).*
5. *Medication – Information about drugs given, dosage changes, or medication plans.*
6. *Medical History – Relevant past medical conditions or treatments.*
7. *Emotional/Social Notes – Observations about the patient's emotional state or family interactions.*
8. *Plan/Recommendation – Professional advice or next steps for treatment.*
9. *Administrative Note – Non-clinical tasks (paperwork, transfer arrangements, etc.).*
10. *Diagnostic/Test Result – Laboratory or imaging findings.*
11. *Other – Any note that does not fit the above. Keep a table for all 9 patients. For each patient, store notes under the correct category.*

When a new note comes in, add it to the correct patient and correct category. Never create a new patient not on the list. Do not move or delete past notes unless I explicitly tell you to.

To ensure classification accuracy, the model was iteratively trained. In each round, 30 randomly generated clinical notes were entered into the model, and the resulting classification output (example shown in *Figure 50*) was manually verified. Misclassified entries were corrected, and feedback was incorporated into the next iteration. This training process was repeated across four rounds. By the fifth and sixth rounds, the model demonstrated consistent accuracy, with no observed classification errors.

7.2.3 Use in Evaluation

During the evaluation sessions, both prototypes were presented to participants. First, the 3D-printed pin and its accessory components allowed participants to experience the device's physical dimensions and interactions. Subsequently, participants were invited to input five random medical notes into the ChatGPT-based prototype and review the resulting classifications. This combination of tangible and digital prototyping proved valuable in helping participants understand the design concept and provide feedback.

Bed & Patient	Observation	Patient Complaint	Task	Vital Signs	Medication	Medical History	Emotional/Social Notes
Bed 01 - James Lee	- Oxygen saturation dropped to 88% early morning. - Appeared anxious and restless during the night. - Coughing improved compared to yesterday.		- Schedule follow-up CT scan for Friday afternoon.	- Blood glucose: 10.4 mmol/L			- Wife requests daily update on progress.
Bed 02 - Maria Gonze	- Nurse observed mild tremors in both hands.	- Patient reports feeling dizzy after standing. - Family says more forgetful over past week. - Feels short of breath after climbing two steps.		- Blood sugar level 12.8 mmol/L at 6:00 AM. - Heart rate increased to 120 bpm during mobilization.	- Administered 1g paracetamol IV at 14:00		
Bed 03 - Aisha Patel	- Patient refused breakfast this morning.		- Schedule chest X-ray for tomorrow morning. - Needs interpreter for tomorrow's consultation. - Needs blood culture results reviewed urgently.	- BP 110/70 mmHg, HR 75 bpm, Temp 37.0°C		- History of hypertension for over 20 years.	- Wife brought patient's personal pillow from home.
Bed 04 - Daniel Cho	- Patient coughed persistently for about 5 minutes after repositioning.	- Reports mild chest pain after physiotherapy.	- Prepare consent form for tracheostomy.		- IV antibiotics started at 10:00 AM. - Administered 500 ml normal saline over 1 hour.		
Bed 05 - Mobert Mill				- Temperature 38.5°C, BP 150/95 mmHg. - Oxygen saturation dropped to 89% during ambulation.	- Continue antibiotics for another 3 days.	- Past history of breast cancer treated 10 years ago. - History of chronic obstructive pulmonary disease.	
Bed 06 - Chen Wei			- Arrange ultrasound of abdomen next week.	- Urine output for last 6 hours: 400 ml	- Started amlodipine 5 mg daily.	- History of chronic kidney disease, stage 3.	- Brother visited and brought home-cooked soup.
Bed 07 - Bill Wang			- Change wound dressing on left leg at 15:30.		- Increased insulin dose to 14 units before dinner.		- Patient cried after hearing test results.
Bed 08 - Marko Free	- Oxygen saturation stable at 96% on room air.		- Needs to fast from midnight for procedure.		- Started on amlodipine 5 mg once daily.		

Figure 50. Part of the table generated inside Chatgpt

7.3 Evaluation Session

Building upon the established evaluation plan and the two developed prototypes, comprehensive evaluation sessions were finally conducted with three distinct participant groups: HCPs, PtFams, and design experts. Each session was structured to align with the predefined evaluation objectives and criteria, ensuring the collection of both practical and design-oriented insights.

7.3.1 Final Evaluation with HCPs

This evaluation session finally included two participants: an ICU attending physician and a nursing home caregiver. Both participants had previously participated in earlier interview sessions, providing them with comprehensive familiarity regarding the project's background and direction. Due to the sensitive nature of hospital environments and participants busy schedules, the evaluation was conducted via online meeting.

1. Step 1: The researcher presented the design outcomes through user journeys and storyboards developed during the previous research and design phases. The 3D-printed prototype of the pin and its accompanying accessories was demonstrated to effectively convey realistic ergonomic dimensions and interaction patterns. Subsequently, participants were invited to generate five randomized medical notes and input them into the trained GPT-based AI model, enabling real-time review of the model's classification results.
2. Step 2: A structured discussion were organized around five key questions:

- Do you think this design could help you collect and organize information and notes more efficiently? For example, could it reduce information loss or misrecord, and encourage you to document more information details?
- Do you think this design could help you generate different reports more efficiently, and thus reduce your paperwork burden?
- Do you think the learning curve of this system is simple, and it won't significantly disrupt your workflow?
- What's your overall attitude and acceptance toward this design?
- Do you have any additional suggestions or concerns?

7.3.2 Final Evaluation with PtFams

This group consisted of one participant: a family member with experience caring for an 80-year-old patient with cardiac complications, alongside two other siblings. The participant had also engaged in earlier interview sessions, ensuring familiarity with the project context. The session was also conducted online.

1. Step 1: The researcher introduced the design outcomes using user journeys and storyboards, demonstrating the pin and its accessories, including ergonomic dimensions and interactions. The participant was subsequently invited to create five randomized medical notes and input them into the trained GPT-based AI model, followed by a review of the classification results.
2. Step 2: A discussion was conducted regarding three primary questions:

- Please imagine this situation: when you are in the hospital taking care of your family, the doctor talking to you is wearing this pin. The doctor explains its purpose and tells you that you have the right to refuse to turn it on. In that case, do you feel that your privacy is respected? Would you feel comfortable with the presence of this pin?
- In current design, the system mainly helps patients and their families by quickly generating a conversation report, which can then be printed and shared to you. This way, important information won't be missed, and you can review it later. Do you think this feature would be helpful for your communication with healthcare providers?
- Do you have any other suggestions or concerns?

7.3.3 Final Evaluation with Design Experts

This session included three design students from the Faculty of Industrial Design Engineering (IDE): one from Strategic Product Design (SPD) and two from Design for Interaction (DFI). The evaluation was conducted in-person through a structured role-play methodology. The objective was to immerse participants in authentic user perspectives while collecting feedback focused on interaction design, user experience, and system integration.

1. Step 1: The researcher presented the project background alongside key findings and insights from earlier research phases to provide participants with appropriate contextual understanding.
2. Step 2: Participants were assigned three key roles: physician, nurse, and patient's family member. Each role was comprehensively explained, including associated responsibilities, core requirements, and pain points identified during the research phase.
3. Step 3: Participants enacted the traditional user journey under researcher guidance.
4. Step 4: Participants performed the redesigned user journey, supported by the proposed design solution. During this process, those role-playing physician and nurse interacted with the pin prototype and were invited to create five randomized medical notes, which were subsequently input into the trained GPT-based AI model for result review.

5. Step 5: Following the role-play exercise, participants engaged in an open group discussion to reflect on their experiences and provide design-oriented feedback.

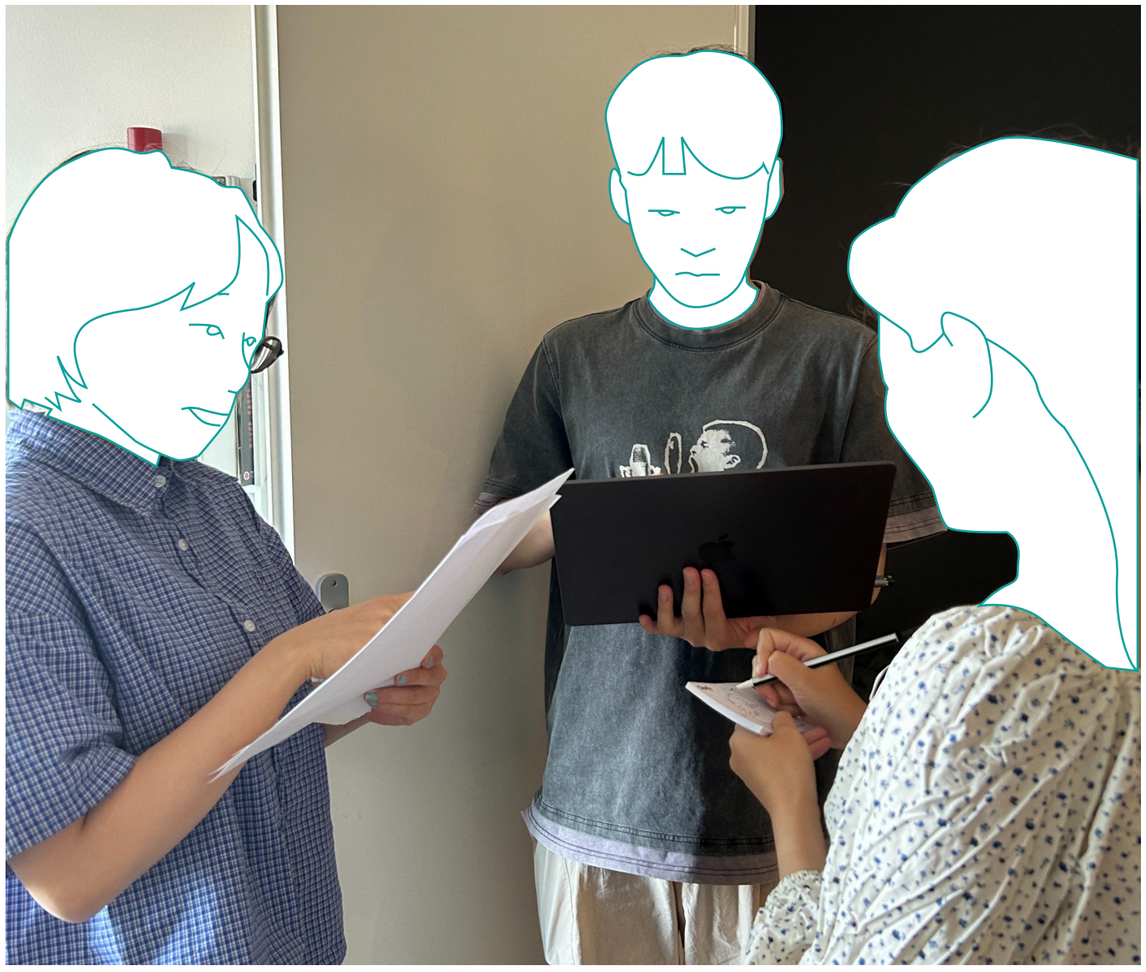


Figure 51. Evaluation session with design experts

7.3.4 Data Collection and Documentation

Comprehensive evaluation protocols and detailed session outlines are documented in *Appendix 8.* All participant responses and discussions were noted down as key words and representative quotes. The data was analyzed using thematic analysis following the framework established by Braun and Clarke (2006).

Thematic Coding and Analysis

As illustrated in *Figure 52*, each quote was coded using a four-color system, representing distinct perspectives from four participant groups: an ICU attending physician, a nursing home caregiver, a patient family member, and a design expert group including three designers.

The analytical process began with summarizing each quote into one or more core keywords, which were subsequently clustered based on thematic similarity. This iterative process generated four preliminary themes:

- Theme 01: Attitude toward the design
- Theme 02: Potential improvement possibilities
- Theme 03: Key considerations
- Theme 04: A clear explanation is always essential

Theme Refinement

As depicted in ***Figure 53***, these 4 themes underwent iterative refinement, resulting in the following final thematic framework:

1. Positive Recognition and Acceptance (from theme 01) : All participants demonstrated a supportive attitude toward the design outcomes, characterizing the system as "interesting, useful, straightforward, and easy to understand." The design was recognized as effectively fulfilling its design goal : "assisting in collecting and organizing fragmented medical information, enabling fast and efficient data entry and report generation into EHR systems", while providing tangible benefits for both HCPs and PtFams. Participants also appreciated the high value of the overall exploration direction as "alleviating the workload of healthcare professionals."
2. The Importance of Clear Communication (from theme 04): Participants emphasized the critical need for clear and compelling narratives to facilitate rapid user comprehension and system adoption. Well-structured storytelling can significantly reduce the learning curve while more effectively demonstrating the system's added value within healthcare environments and existing workflows.
3. Opportunities for Further Development (from theme 02): Participants identified several directions for system refinement:

- Further improve PtFams support: Empower patients and families with greater autonomy in accessing and

processing information, transcending passive report reception.

- AI capability validation: Conduct further exploration and validation of AI capacity for recognizing and processing different voice data.
- Automated identification: Investigate the necessity and feasibility of enabling the wearable pin to automatically identify patient information (e.g., bed numbers) to enhance system simplicity and seamlessness.
- Intelligent highlighting: Amplify the functionality that AI identifies and emphasizes potentially overlooked clinical details.
- Real-world usability testing: Conduct further testing and refinement of the physical pin's practical usability within authentic healthcare contexts.
- Interaction design optimization: Refine interaction design details, such as providing micro-feedback to confirm successful note recording, to enhance system intuitiveness.

4. Critical Implementation Principles (from theme 03)

- Liability considerations: When AI integration occurs within medical workflows, PtFams will inevitably express concerns regarding accountability in cases of mistakes.
- Regulatory compliance: Future implementation should carefully consider the legal and regulatory variations across different countries and regions.

Analytical Outcomes

This structured analytical methodology ensured systematic identification and categorization of shared insights across all participant groups. The findings not only validate the proposed design concept but also provide actionable guidance for further refinement and potential implementation within broader healthcare contexts. The thematic analysis revealed strong stakeholder support while identifying concrete pathways for system enhancement and implementation considerations.

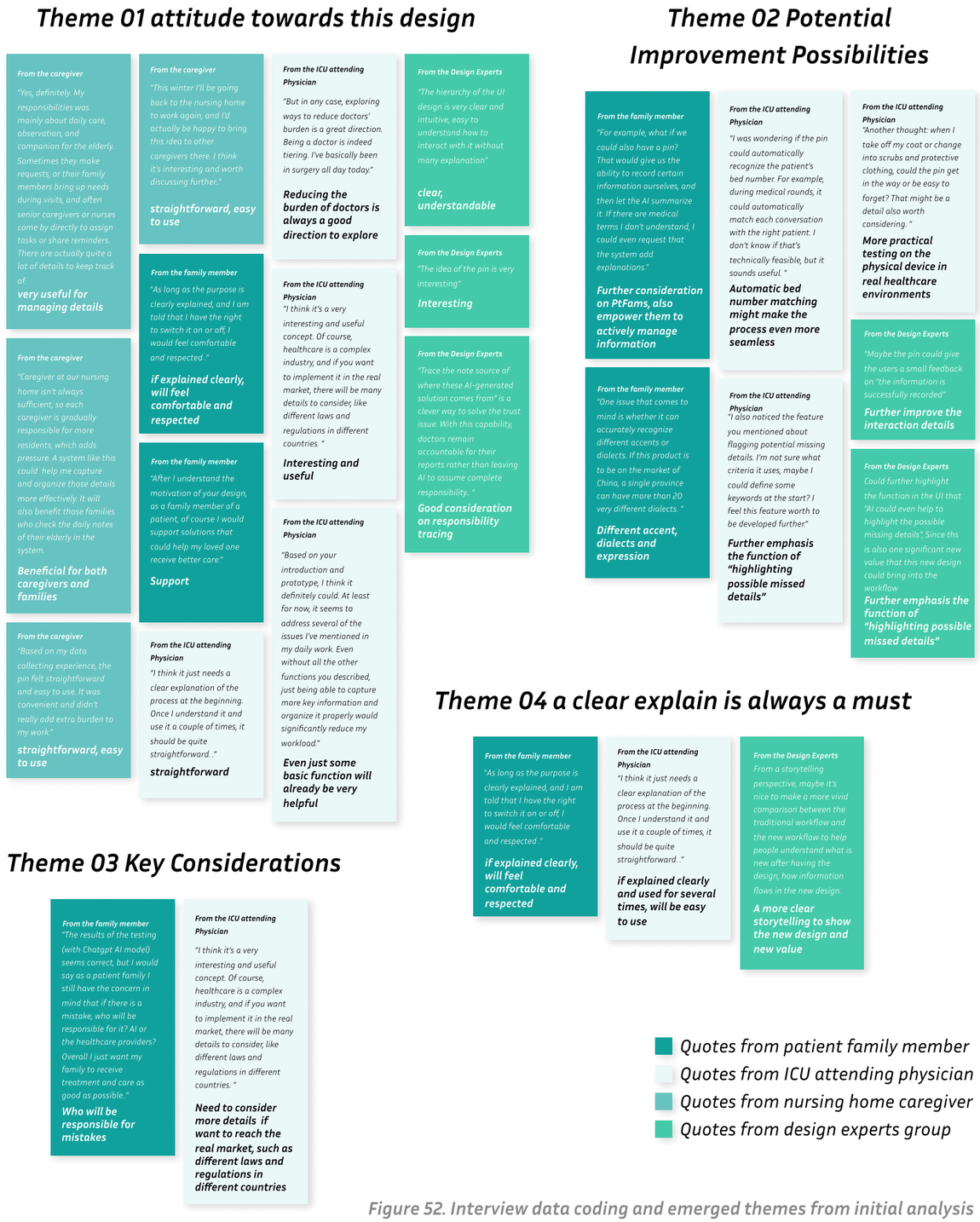


Figure 52. Interview data coding and emerged themes from initial analysis

Final refined theme	*Synthesized from*	*Description*	*Quote*
1. *Positive Recognition and Acceptance*	*Theme 01: Attitude toward the design*	*All participants demonstrated a supportive attitude toward the design outcomes, characterizing the system as "interesting, useful, straightforward, and easy to understand." The design was recognized as effectively fulfilling its design goal : "assisting in collecting and organizing fragmented medical information, enabling fast and efficient data entry and report generation into EHR systems", while providing tangible benefits for both HCPs and patient families PtFams. Participants also appreciated the high value of the overall exploration direction as "alleviating the workload of healthcare professionals."*	*"Caregiver at our nursing home isn't always sufficient, so each caregiver is gradually responsible for more residents, which adds pressure. A system like this could help me capture and organize those details more effectively. It will also benefit those families who check the daily notes of their elderly in the system.." -- an nursing home caregiver* *"Based on your introduction and prototype, I think it definitely could. At least for now, it seems to address several of the issues I've mentioned in my daily work. Even without all the other functions you described, just being able to capture more key information and organize it properly would significantly reduce my workload." -- an ICU attending physician*
2. *The Importance of Clear Communication*	*Theme 04: A clear explanation is always essential*	*Participants emphasized the critical need for clear and compelling narratives to facilitate rapid user comprehension and system adoption. Well-structured storytelling can significantly reduce the learning curve while more effectively demonstrating the system's added value within healthcare environments and existing workflows.*	*"As long as the purpose is clearly explained, and I am told that I have the right to switch it on or off, I would feel comfortable and respected. " -- an patient family member* *"I think it just needs a clear explanation of the process at the beginning. Once I understand it and use it a couple of times, it should be quite straightforward. " -- an ICU attending physician*
3. *Opportunities for Further Development*	*Theme 02: Potential improvement possibilities*	· *Further improve PtFams support: Empower patients and families with greater autonomy in accessing and processing information, transcending passive report reception.* · *AI capability validation: Conduct further exploration and validation of AI capacity for recognizing and processing different voice data.* · *Automated identification: Investigate the necessity and feasibility of enabling the wearable pin to automatically identify patient information (e.g., bed numbers) to enhance system simplicity and seamlessness.* · *Intelligent highlighting: Amplify the functionality whereby AI identifies and emphasizes potentially overlooked clinical details.* · *Real-world usability testing: Conduct further testing and refinement of the physical wearable device's practical usability within authentic healthcare contexts.* · *Interaction design optimization: Refine interaction design elements, such as providing micro-feedback to confirm successful note recording, to enhance system intuitiveness.*	*"what if we could also have a pin? That would give us the ability to record certain information ourselves, and then let the AI summarize it. If there are medical terms I don't understand, I could even request that the system add explanations." -- an patient family member* *"One issue that comes to mind is whether it can accurately recognize different accents or dialects. If this product is to be on the market of China, a single province can have more than 20 very different dialects." -- an patient family member* *"I was wondering if the pin could automatically recognize the patient's bed number. For example, during medical rounds, it could automatically match each conversation with the right patient. I don't know if that's technically feasible, but it sounds useful. " -- an ICU attending physician* *"Another thought: when I take off my coat or change into scrubs and protective clothing, could the pin get in the way or be easy to forget? That might be a detail also worth considering." --an ICU attending physician* *"Could further highlight the function in the UI that "AI could even help to highlight the possible missing details", Since ths is also one significant new value that this new design could bring into the workflow " -- the design experts group* *"Maybe the pin could give the users a small feedback on "the information is successfully recorded" -- the design experts group*
4. *Critical Implementation Principles*	*Theme 03: Key considerations*	· *Liability considerations: When AI integration occurs within medical workflows, PtFams will inevitably express concerns regarding accountability in cases of mistakes.* · *Regulatory compliance: Future implementation should carefully consider the legal and regulatory variations across different countries and regions.*	*"The results of the testing (with Chatgpt AI model) seems correct, but I would say as a patient family I still have the concern in mind that if there is a mistake, who will be responsible for it? AI or the healthcare providers? Overall I just want my family to receive treatment and care as good as possible." -- the design experts group* *"and if you want to implement it in the real market, there will be many details to consider, like different laws and regulations in different countries. " -- the design experts group*

Figure 53. Thematic analysis results: final themes and descriptions

08

Summary

8.1 Conclusion
8.2 Discussion
8.3 Reflection

8.1 Conclusion

8.1.1 Overall Answer to Research Question

The initial research question is: How could AI enhance communication processes in healthcare settings?

This project answered by developing an AI-driven system that integrates hardware and digital platforms to address this challenge. The solution introduces a voice-enabled companion pin seamlessly integrated into HCPs' workflows, connected to an AI-powered online platform.

Serving as a bridge between HCPs and EHR systems, the solution supports the collection and organization of fragmented medical information, enabling rapid and efficient data entry and report generation.

The system also has good flexibility, allowing HCPs to integrate it within existing working patterns across diverse healthcare contexts.

Evaluation sessions confirmed the system's value and future potential, with all participant groups providing positive feedback and attitude.

8.1.2 Research Methodology

The research process began with a comprehensive literature review to identify theoretical challenges in clinical communication and information management, alongside examining AI's potential to address these issues. Subsequent user research and market analysis activities validated and extended these initial findings. A comparative analysis of two representative healthcare contexts, ICUs and nursing homes, facilitated the identification of six shared core pain points that transcend both environments and likely persist across broader healthcare settings. These insights informed the iterative development and evaluation of the final design solution.

8.1.3 Solution to Fragmented Information Management

Within daily workflows, HCPs wear the companion pin and activate recording through a double-tap mechanism, ensuring privacy protection. With appropriate permissions, the device records conversations or accepts direct voice input. Speech data is transcript via ASR, enhanced by noise reduction and speech enhancement algorithms to ensure reliable performance in acoustically challenging environments. Data transmission occurs securely through Bluetooth Low Energy protocols to the online AI system.

Additionally, handwritten notes can be digitized through photographic upload, with enhanced OCR converting handwriting into

searchable, editable digital text. Utilizing NLP and ML algorithms, all fragmented data is automatically classified into predefined note categories.

8.1.4 Solution to documentation and administrative burden

The online platform integrates a LLM-powered chatbot that assists HCPs in generating structured reports based on collected data and predetermined templates efficiently. Each report section includes traceable references to original transcripts or notes, ensuring transparency and trust. While AI enhances efficiency and comprehensiveness through draft content generation, HCPs retain ultimate authority and responsibility as clinical decision-makers.

8.2 Discussion

Research Contributions

The literature review identified two primary research focus in existing papers:

1. Communication and information management challenges arising from EHR systems' complexity and their adverse impacts on patient care and provider well-being;
2. The theoretical and practical potential of AI technologies to address these challenges.

This project contributes to the field by extending existing knowledge through novel practical insights:

1. Fragmented Information is also a critical healthcare challenge. Substantial volumes of clinical data remain dispersed across different media (paper documentation, whiteboards, memory etc.), with their omission, displacement, or misinterpretation, posing significant risks to patient safety.
2. AI tools' Integration into clinical workflow is insufficient. Current AI documentation tools fail to achieve seamless workflow integration, often requiring additional time investment rather than enabling real-time data capture. This research explores natural AI embedding within daily practices without disrupting established routines.
3. Providing human-centered practical details about HCPs. Research findings confirmed that HCPs rely on traditional pen-and-paper methods and prefer AI to function as a supportive bridge rather than complete replacement technology, reflecting cautious yet receptive adoption attitudes.
4. AI-assisted clinical practice always has to consider about trust and accountability issue. This project proposes a practical solution, which is ensuring traceability of AI-generated content by directly linking conclusions to original transcripts and notes. This transparency mechanism strengthens trust, clarifies responsibility allocation, and reinforces the HCP's role as the ultimate decision-maker.

Evaluation Validation

Findings from evaluation sessions reinforced insights identified during the research process. HCPs, PtFams, and design experts collectively validated the AI-driven companion system's value in reducing information loss, streamlining documentation processes, and supporting report generation. Feedback highlighted three critical discussion areas:

1. Both HCPs and PtFams emphasized that the proposed system is useful and intuitive for addressing fragmented information burdens and complex EHR documentation challenges.
2. Participants proposed practical enhancements, including improving AI accuracy in acoustically challenging conditions, and designing micro-feedback interactions to enhance data capture transparency, etc..
3. Concerns regarding privacy protection, error accountability, and regulatory compliance underscore the necessity for further refinement on details.

This research not only supports theories regarding AI's healthcare potential but also contributes practice-based insights into designing AI systems that seamlessly embed within healthcare workflows, while respecting ethical and human-centered design principles.

8.3 Reflection

8.3.1 Study Limitations

Due to healthcare's sensitive nature and restricted access to authentic hospital environments, participants were recruited primarily through the researcher's personal network. Although diverse roles were represented, total participant numbers remained limited, therefore some perspectives may reflect individual rather than collective viewpoints. Consequently, this research emphasizes conceptual exploration grounded in theoretical frameworks and supplemented by diverse stakeholder perspectives.

Technical feasibility verification occurred primarily through literature review and core function prototyping. Testing within authentic hospital contexts were not feasible due to resource limitations.

8.3.2 Future Research and Development Recommendations

Research Directions

- Expand participant sample sizes in future interviews and evaluations to balance individual perspectives and enhance findings generalizability;
- Extend comparative studies to additional healthcare settings beyond ICUs and nursing homes to further validate the insights and solution.

Practice Directions

- Conduct comprehensive AI performance testing in environments filled with very different voice data;
- Enhance AI capabilities for highlighting overlooked clinical details;
- Expand functionality supporting PtFams, including improved comprehension tools and emotional support features;
- Refine interaction design elements, such as intuitive micro-feedback confirming successful data capture.

8.3.3 Personal Reflection

From a project management perspective, the research timeline aligned effectively with initial planning.

Early motivation of this project “exploring AI's potential in healthcare communication and gaining deeper domain insights” was successfully achieved. The project helped me to collect both theoretical knowledge and practical experience at AI-healthcare intersection.

“Explore the balance of physical and digital elements in system design” was also achieved. Through many rounds of iterative development, I explored the balance between tangible wearable devices and digital AI-driven systems.

While the research successfully engaged real stakeholders, my connections to actual healthcare environments remain limited.

Last but not least, I sincerely hope this project could inspire both academic research at TU Delft and Accenture's ongoing Generative AI exploration by offering novel perspectives on how AI can support healthcare communication and information management.

09

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to the Supervisor Team
to Accenture IXID
to the Participants
to My Parents and Friends

to the Supervisor Team

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to Accenture IXID

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to the Participants

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to My Parents and Friends

Finally, I want to express my heartfelt gratitude to my family and friends. To those in the United States, Switzerland, and China: thank you for always listening patiently, embracing my emotions, and helping me navigate forward whenever I faced challenges. To those here in the Netherlands: my physical and mental well-being throughout this journey has been inseparable from your constant companionship. From writing our theses together at IDE, to calling each other for inspiration and encouragement on projects, to traveling, watching races together on weekends, and sharing countless precious moments. You have made this journey truly unforgettable.

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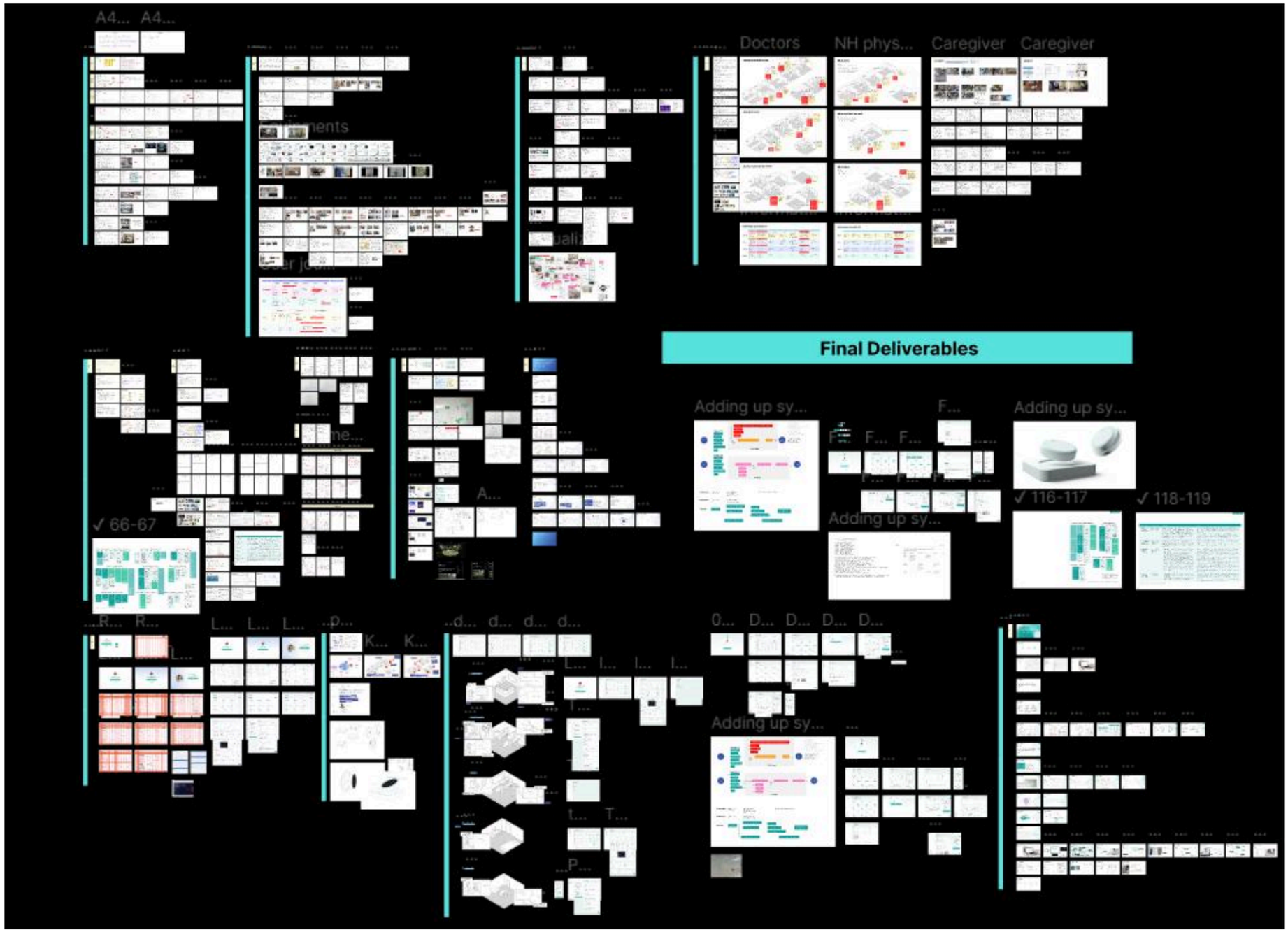
Appendix

01. Project Overview
02. Project Brief
03. Online User Interview Guideline
04. Consent Form
05. Online User Interview Raw Data
06. UI Design Process
07. Wearable Pin Design Process
08. Evaluation Session Raw Data

01 ***Appendix 1. Project Overview***



Appendix 2. Project Brief

DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

Name student _____ **Student number** _____

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT
Complete all fields, keep information clear, specific and concise

Project title Designing a Hybrid Communication System for Coordinated Care in Healthcare Settings

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

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

This graduation project is set within the complex environment of healthcare, such as ICUs, general wards, and nursing homes. The primary stakeholders are medical staff—including doctors, nurses, and caregivers—while patients and their families are also key users whose needs and experiences are taken into account.

Today's healthcare systems are facing many challenges, such as staff shortages, heavy workloads and limited communication. These issues can lead to mistakes in workflow, increased stress among professionals, and tension between patients and medical teams. Additionally, healthcare settings generate and rely on vast amounts of information and data that must be communicated quickly, clearly, and accurately to support effective decision-making and patient care. Within this context, there is a growing opportunity for designs that enhance communication, streamline workflows, and support collaboration across all aspects of care.

However, designing for such environments comes with specific challenges. Medical professionals often have limited time and availability, making it difficult to involve them in user research, testing, or changes to established routines. Despite these constraints, this project aims to develop a system that integrates smoothly into existing practices while delivering meaningful improvements.

➔ *space available for images / figures on next page*

DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

In healthcare settings, effective communication is essential. From the perspective of medical staff, communication is typically a mix of fast, traditional methods—such as phone calls and handwritten notes—and complex, digital systems. While both have their advantages, their coexistence can lead to gaps in information flow and, at times, the loss of critical data. On the other hand, communication between medical teams, patients, and their families often lacks clarity and accessibility. There is always no sufficient information given in an easy-to-understand way of communication, leaving patients and families confused and anxious.

These challenges highlight the need for a more integrated and human-centered approach for communication in healthcare. There is an opportunity to design a hybrid system that streamlines the collection and sharing of clinical information, and improves understanding across all stakeholders. Such a system should support the daily workflows of medical teams while also helping patients and families feel informed, heard, and reassured. By addressing both functional efficiency and emotional clarity, this project aims to bring greater connection and coordination to healthcare environments.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence)
As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Design a hybrid communication system for coordinated care in healthcare settings

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

This project will follow a human-centered and iterative design approach, beginning with a literature review to build a foundational understanding of user journeys in healthcare. Field observations in various healthcare settings, along with a quick survey, will provide initial insights into current practices. These will be followed by structured interviews with medical staff to gain deeper understanding of their needs, pain points, and workflow. The design phase will include ideation sessions informed by research findings, leading to the development of prototypes that combine physical and digital elements. These prototypes will be tested with stakeholders—including medical staff, patients or families—followed by evaluations. Feedback will inform iterative refinements and final design decisions.

Stakeholders will be mainly involved in interviews, prototype testing, and evaluations to ensure the solution aligns with real-world healthcare needs and constraints.

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting**, **mid-term evaluation meeting**, **green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting 16.04.2025

Mid-term evaluation June 2025

Green light meeting Aug 2025

Graduation ceremony Sep 2025

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

1. I am highly interested in the potential of AI to improve healthcare systems. I see this project as a valuable opportunity to explore how intelligent technologies can support communication, decision-making, and care delivery in meaningful ways.
2.This project allows me to step into real healthcare environments and directly engage with stakeholders. I believe hands-on experience and genuine human interaction are essential for design solutions.
3.Through this project, I aim to gain a clearer understanding of the healthcare field. The insights I gather will help me decide whether this is a direction I would like to pursue further in my future career.
4. Blending physical and digital elements has always been central to my design practice. This project offers the perfect opportunity to push that exploration further and find the right balance for a real-world context.

Appendix 3. User Interview Guideline

Interview -physician

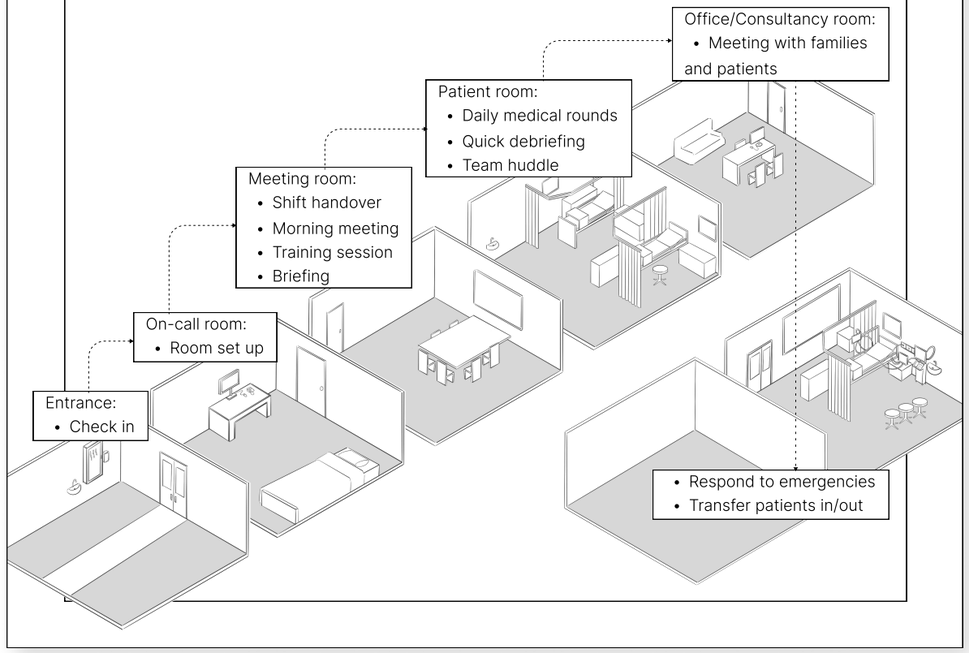
Thank you for taking the time to speak with me today! The main goal of this interview is to better understand the daily communication flow in your role, looking to identify areas where things are working well and where there might be opportunities for improvement. No sensitive or confidential information will be asked for.

Basic info

Name:
Position:
Contact info:
Description of the role:

Daily routine overview

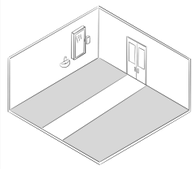
This is a brief overview of the daily routine of an ICU medical resident. What is the difference compared your routine?



Interview -physician

Daily routine details

Entrance

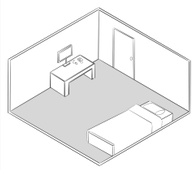


Main duty
- Check in
- Preparation (e.g. hand cleaning)
- ...

Main touch points
- Check in machine
- ...

Information & Communication
- Face-to-face communication
【greeting with colleague...】
- ...

On-call room

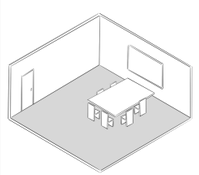


Main duty
- On-call room set up
- Over night duty
- Organize notes and report for next shift
- ...

Main touch points
- Computer
- Telephone/Mobile phone
- Notebook
- Pager
- ...

Information & Communication
- Face-to-face communication
【discussion on the condition of patients...】
- EHR system
【patient record/report...】
- Printed out material
【patient data/report...】
- Phone/pager call from/to medical staff
【call for help/report emergencies...】
- Written down notes on paper/in App
【key info for oneself/for next shift...】
- ...

Meeting room



Main duty
- Shift handover
- Morning meeting
- Briefing
- Training session
- ...

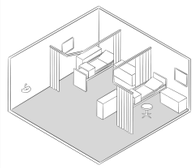
Main touch points
- Computer
- Screen
- Notebook
- Printed out material
- Mobile device
- ...

Information & Communication
- Face-to-face communication
【discussion on the condition of patients/mission of the team...】
- EHR system
【patient record/report...】
- Printed out material
【patient data/report...】
- Written down notes on paper/in App
【key info for oneself/for next shift...】
- Word-to-text app
【Transcription of the meeting】
- ...

Interview -physician

Daily routine details

Patient room

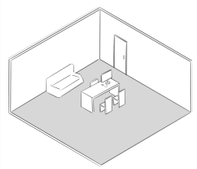


Main duty
- Morning/evening round
- Quick team huddle/debriefing
- ...

Main touch points
- Computer/Mobile device
- Notebook
- Printed out material
- Portable table
- White board
- ...

Information & Communication
- Face-to-face communication
【discussion on the condition of patients/adjustment of caring plan...】
- EHR system
【patient record/report...】
- Printed out material
【patient data/report...】
- Written down notes on paper/in App
【key info for oneself...】
- Information on whiteboard
【reminder from nurses...】
- Quick Q&A with patients & families
【ask questions to check their conditions/answer some questions...】
- ...

Office/ Consultancy room

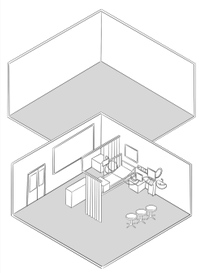


Main duty
- Communication with patients and families
- Digitize necessary data/info into EHR system...

Main touch points
- Computer
- Printed out material
- paper
- ...

Information & Communication
- Face-to-face communication
【explanation the condition of patients/discussion on serious issue...】
- EHR system
【patient record/report...】
- Printed out material
【patient data/report...】
- Written down notes on paper
【tips/key info for patients to take away...】
- ...

Transition between sections



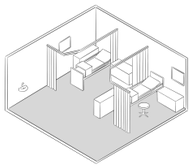
Main duty
- Assess the patients' condition
- Decide on the transition
- Decide on following treatment process
- ...

Main touch points
- Computer/Mobile device
- Printed out material
- Notebook
- ...

Information & Communication
- Face-to-face communication
【understand the condition of patients...】
- EHR system
【patient record/report...】
- Printed out material
【patient data/report...】
- Written down notes on paper
【tips/key info from verbal communication...】
- ...

Interview -physician

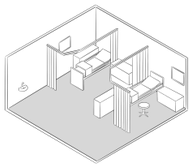
Other notes



Main duty
- ...

Communication
- ...

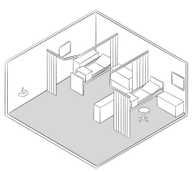
Main touch points
- ...



Main duty
- ...

Communication
- ...

Main touch points
- ...



Main duty
- ...

Communication
- ...

Main touch points
- ...

Interview -physician

Follow up questions

【How do you deal with fragmented information? Notes on paper or in mobile device/ post it notes/data written in paper forms...do you need to digitize them or left them behind?】

【How do medical teammates contact each other?】

【When will you usually communicate with patients and families?】

【How do you organize reports in different scenarios?】

【Apart from direct communication with doctors, are there any other ways for patients in your hospital to express their thoughts or concerns—for example, through writing journals or using other tools?】

【When assessing a patient's overall performance or progress, what aspects do you usually take into consideration? Do emotional factors — such as the feelings or reactions of the patient and their family — play a role in your evaluation?】

Are there any parts of your communication experience that you find challenging or think could be improved?

Are there already AI-driven tools be applied in your hospital?

What is your attitude towards AI?

Appendix 4. Consent Form

You are being invited to participate in a research study titled ***A Hybrid Communication System Design for Coordinated Care in Healthcare Settings***. This study is being done by ***Yijia Tang, prof. Tilman Dingler and prof. Nazli Cila*** from the ***TU Delft*** and ***Erik Vlemmix*** from ***Accenture.***

The purpose of this research study is to ***better understand the information communication flow in your healthcare experience, looking to identify areas where things are working well and where there might be opportunities for improvement driven by AI***, and will take you approximately ***30*** minutes to complete. The data will be used for ***design concept generation, graduation paper submission and publication.*** We will be asking you ***the journey of your healthcare related experience, types of information is communicated in each step, the way and touch points of communication, as well as your attitude towards applying AI into healthcare setting.***

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by ***collecting no sensitive personal, hospital or patient data. The data we collected will mainly be about general types of data, interaction, behavior and opinions.***

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions.

Contact information:
Yijia Tang: priiimetang@tudelft.nl

PLEASE TICK THE APPROPRIATE BOXES	**Yes**	**No**
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [DD/MM/YYYY], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves collecting data about the journey of my healthcare related experience, types of information is communicated in each step, the way and touch points of communication, as well as my attitude towards applying AI into healthcare setting.	☐	☐
4. I understand that the study will last for around 30 minutes.	☐	☐

PLEASE TICK THE APPROPRIATE BOXES	**Yes**	**No**
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
5. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach: The interview questions will not collect sensitive personal, hospital or patient data. The data will mainly be about general types of data, interaction, behavior and opinions.	☐	☐

PLEASE TICK THE APPROPRIATE BOXES	**Yes**	**No**
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
6. I understand that after the research study the de-identified information I provide will be used for design concept generation, graduation paper submission and publication on TU Delft Repository.	☐	☐
7. I agree that my responses, views or other input can be quoted anonymously in research outputs		

PLEASE TICK THE APPROPRIATE BOXES	**Yes**	**No**
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
8. I give permission for the de-identified data that I provide to be archived in TU Delft repository so it can be used for future research and learning.	☐	☐
9. I understand that access to this repository is open.		

Signature

Name of participant [printed]	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Name of researcher [printed]	Signature	Date
Yijia Tang		

Study contact details for further information: priiimetang@tudelft.nl

Appendix 5. Online User Interview Raw Data

Interview -Patient&families

Thank you for taking the time to speak with me today! The main goal of this interview is to better understand the daily communication flow in your role, looking to identify areas where things are working well and where there might be opportunities for improvement. No sensitive or confidential information will be asked for.

Basic info

Name: S
Section: General ward
Region: China
Role: Taking care of a 80-year-old patient with heart problems, together with 2 other sisters

Daily routine overview

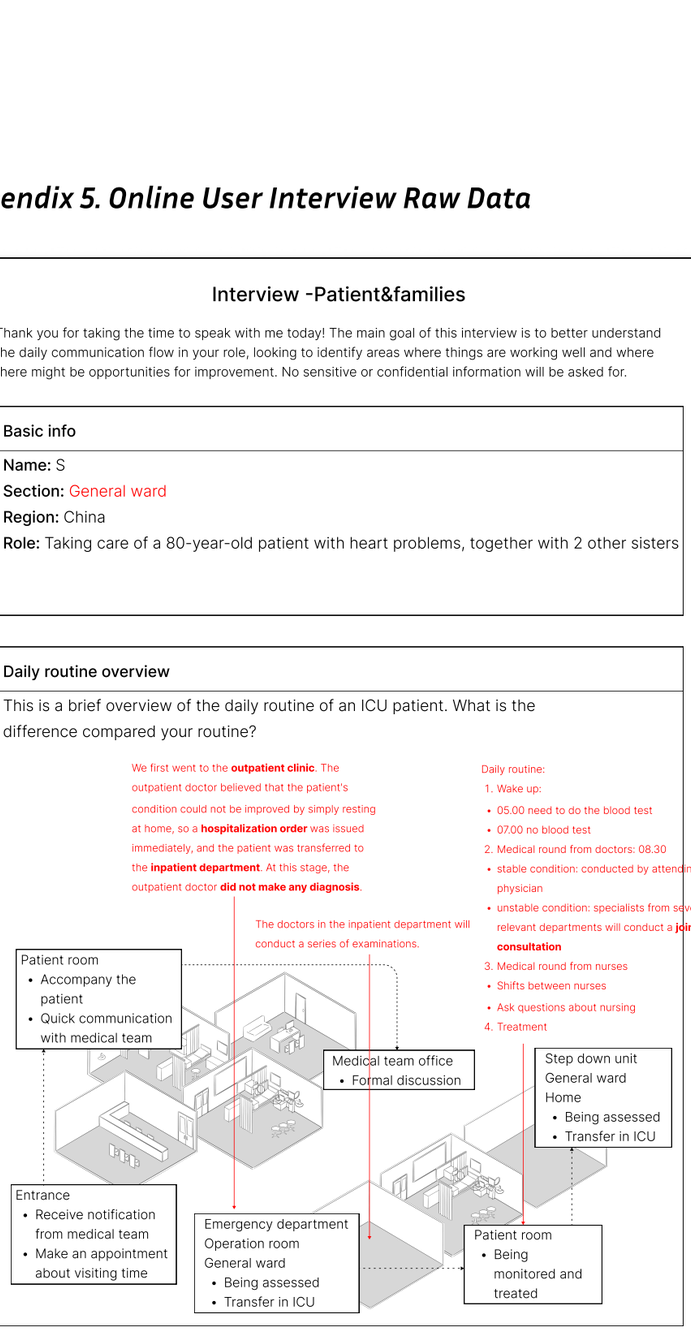
This is a brief overview of the daily routine of an ICU patient. What is the difference compared your routine?

We first went to the **outpatient clinic**. The outpatient doctor believed that the patient's condition could not be improved by simply resting at home, so a **hospitalization order** was issued immediately, and the patient was transferred to the **inpatient department**. At this stage, the outpatient doctor **did not make any diagnosis**.

The doctors in the inpatient department will conduct a series of examinations.

Daily routine:

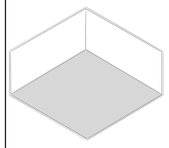
1. Wake up:
   - 05.00 need to do the blood test
   - 07.00 no blood test
2. Medical round from doctors: 08.30
   - stable condition: conducted by attending physician
   - unstable condition: specialists from several relevant departments will conduct a **joint consultation**
3. Medical round from nurses
   - Shifts between nurses
   - Ask questions about nursing
4. Treatment



Interview -Patient&families

Daily routine details

Outpatient Clinic



Main activity
- Communication with doctor

Information & Communication
- Describe the symptoms to doctors

Main touch points
- Hospitalization order
- Digital system

"When having medical rounds or meetings with doctors, we will try to note all the details down in our group chat so that everyone can catch up the situation."

Medical round



Main activity
- (Doc) Adjust the treatment plan anytime based on the answers from the patient, examination report from yesterday, and their own observation of the patients' condition
- (Doc&Nurses) Answering questions, explaining details...
- Nurses shift at the bedside

Information & Communication
- Face-to-face communication
【answers to questions/explanation of new medicines/ changes to treatment plan/nurse shifts: mainly on the condition of patients requiring special care】
- Notes on paper
【Doctors quickly note down key info from patients & their observation】 Mostly note down on paper
- Digital system
【Doctors make adjustments to the prescription in the system based on their notes, and the changes are conducted by the nurses】
- Printed out material
【Examination report from yesterday】
- Written down notes in the phone
【Families will record all new information in time and update each other in the group chat】

Main touch points
- Mobile phone
- paper & pen
- Printed out report
- Digital system

don't really take notes

Patient room



Main activity
- Daily treatment
- Ask medical team members for help

Information & Communication
- Face-to-face communication
【ring the bell to inform the nurses that one process is done】
【directly go to the doctors' office/ nurse station to ask questions】
- Phone call
【inform the attending physician about severe issues】

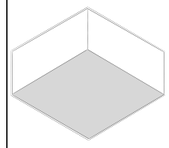
Main touch points
- Bell near the bed

Each attending physician and nurse is responsible for managing a limited number of patients. Doctors typically work only half-day shifts, but they take turns being on 24-hour duty. During their duty shift, they can assist with minor issues even if the patient is not under their direct care. **For more serious issues, the patient's primary attending physician will be notified**

Interview -Patient&families

Daily routine details

Transfer out



Main activity
- Communication with doctor

Information & Communication
- Doctors will printed out some materials to the patients
【doctor's diagnostic notes/ medication records/follow-up instructions】

Main touch points
- Printed out report

Following a standard outpatient consultation, two printouts are typically provided — one summarizing the patient's reported symptoms and the physician's diagnosis, and another listing the prescribed medications.

Interview -physician

Follow up questions

You mentioned about the shifts between nurses are mainly through verbal communication and they don't really take notes. Will you feel worried that some details are missing?

Not very sure. Maybe it's because In China, the care of hospitalized patients **mainly relies on family members.** Nurses are responsible for **general tasks** such as administering injections, changing dressings, distributing medication, taking temperature and blood pressure, collecting blood samples for lab tests, and monitoring the use of medical equipment. **They are not required to have detailed knowledge of each patient's personal information. But I would say it is still possible to forget something.**

How is your overall communication experience with communication inside the ward?

Overall we are satisfied. Since we're not in an especially critical ward (I believe communication would be quite different in an ICU, where the information often involves **life-and-death decisions**), the overall atmosphere is **relatively relaxed**. The doctors and nurses are generally patient and approachable. As we don't have a medical background, we **don't usually question the reasons behind their decisions** — we mostly just take note of the instructions and follow them as they are.

Do you think there are any other challenges in the communication process?

One challenge I've noticed is during the doctor's inquiry into the patient's condition—especially when caring for **elderly patients**. The patient **may have difficulty describing their symptoms clearly, or may not know how to express them**. As family members, we can only **try to guess and help communicate on their behalf**. In such cases, the doctor also has to **rely on their own experience and judgment** to interpret the situation.

What is your attitude towards applying AI into the communication process?

I hold a relatively **neutral and complex** view on this. It would certainly be ideal if communication could be made **clearer and more accurate**. However, the **warmth and companionship** that come from human interaction are always incredibly important.

Interview -Patient&families

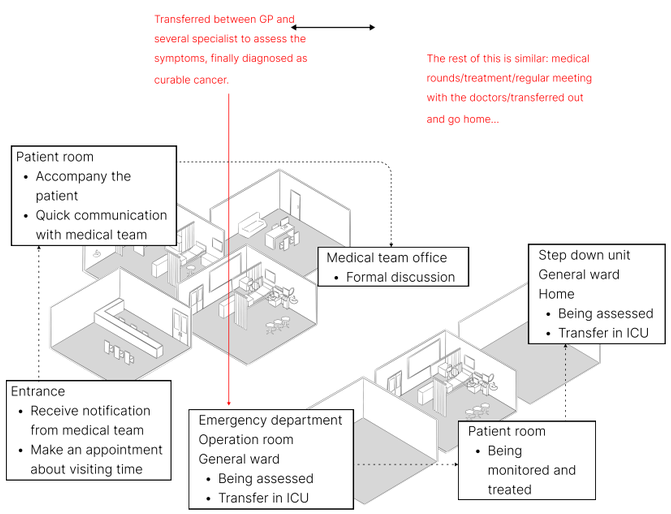
Thank you for taking the time to speak with me today! The main goal of this interview is to better understand the daily communication flow in your role, looking to identify areas where things are working well and where there might be opportunities for improvement. No sensitive or confidential information will be asked for.

Basic info

Name: D
Section: Cancer department
Region: Netherlands
Role: He himself has experienced through the assessment and treatment session of cancer. His father was also once a cancer patient.

Daily routine overview

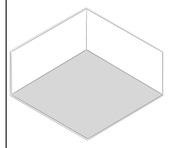
This is a brief overview of the daily routine of an ICU patient. What is the difference compared your routine?



Interview -Patient&families

Daily routine details

At the GP



Main activity
- Communication with GP
- Transferred to specialists

Information & Communication
- Describe the symptoms to doctors
- Give permission to the systems

【Medical members will be able to check all the historical data】

Main touch points
- Digital system

But sometimes maybe the record is not properly interpreted/notes are not properly taken/many details missing and not well documented, some medical staff may forgot what condition the patients are in and need to catch everything up again

Medical round



Main activity
- Happens every several days
- (Doc) quickly ask questions about the patients' feeling
- (Temporary physician) help to record all the performance when the attending physician is not available

Information & Communication
- Face-to-face communication

【Patients passively answer all the questions from doctors】
- Digital system

【Doctors will show patients the screen while taking notes. If there are mistakes, patients could point them out】

But many notes are written in abbreviation so it's hard to read.

Main touch points
- EHR system

Daily communication



Main activity
- Ask medical team members for help

Information & Communication
- Sending messages in the system

【The information will be handled by nurses/secretary team first】
- Phone call

【If they are not confident to solve the issue, the info will be transferred to doctors. 】

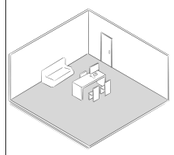
Main touch points
- A message system
- Phone

The attitude of medical team really matters at this stage. If the doctors could keep the vibe relaxing and supportive, it will feel much easier for the patients to ask questions

Interview -Patient&families

Daily routine details

Appointed meeting



Main activity

- 20-30mins/ppl, usually happens as a evaluation session after a period of treatment.

Main touch points

- EHR system
- Paper notes

Information & Communication

- The doctor will show some highlighted data on the screen

【Explanation about the data, trend and symptom】

- Written down notes on paper

【Some notes that could be taken away by families】

If the patient doesn't have enough medical background information/under a really stressful mindset, it's hard for them to understand and remember all the information. They may still feel confused/repeatedly ask same questions/need companion who has medical information

Post treatment



Main activity

- Much less communication
- Ask medical team members for help

Main touch points

- A message system
- Phone

Information & Communication

- Sending messages in the system

【The information will be handled by nurses/secretary team first】

- Phone call

【If they are not confident to solve the issue, the info will be transferred to doctors. 】

But patients will sometimes hesitate to ask questions because they don't want to "go back"/ don't want to know things might get worse. A easy and supportive communication vibe is key to solve this.

Interview -physician

Follow up questions

Do you think there are any other challenges in the communication process?

All in all, If the patient doesn't have enough medical background information/under a really stressful mindset, especially for old people, it's hard for them to understand and remember all the information. They may still feel confused/repeatedly ask same questions/need companion who has medical information

What is your attitude towards applying AI into the communication process?

I am kind of **open to it if it can really support the communication**. But overall, it **shouldn't make things more complicated.**

Interview -physician

Thank you for taking the time to speak with me today! The main goal of this interview is to better understand the daily communication flow in your role, looking to identify areas where things are working well and where there might be opportunities for improvement. No sensitive or confidential information will be asked for.

Basic info

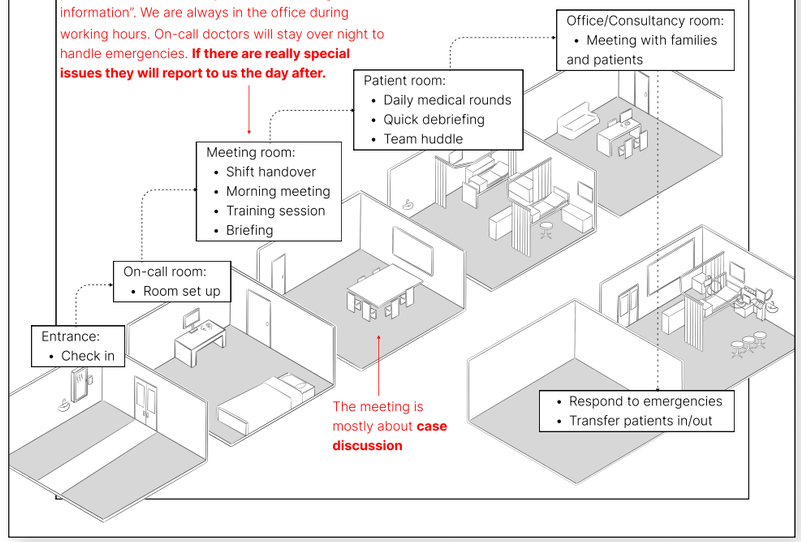
Name: Y
Position: ICU attending physician
Region: China
Role: Responsible for a limited number of beds

Daily routine overview

This is a brief overview of the daily routine of an ICU medical resident. What is the difference compared your routine?

For attending physician we **don't really have "classic shift handover".** In our hospital each of us is responsible for managing a limited number of patients so we don't really need to "exchange information". We are always in the office during working hours. On-call doctors will stay over night to handle emergencies. **If there are really special issues they will report to us the day after.**

the content will mostly be about serious situation & decision

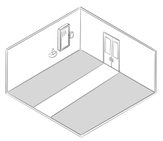


The meeting is mostly about **case discussion**

Interview -physician

Daily routine details

Entrance



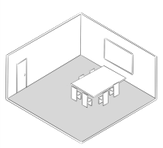
Main duty
- Check in
- Preparation (e.g. hand cleaning)

Information & Communication
- Face-to-face communication
【greeting with colleague...】

Main touch points
- Check in machine

During ward rounds, senior physicians may issue a series of instructions quickly. Even when I am taking notes really fast, it's still possible to miss some critical points since I am partly focused on writing things down.

Meeting room



Main duty
- Shift handover
- Case discussion

Information & Communication
- Face-to-face communication
【Special issues happened last night/ discussion on the target case/ instruction from senior doctor】
- Digital system
【patient record/report】
- Printed out material
【patient data/report】
- Written down notes on paper/in App
【key info for oneself/for next shift...】

Main touch points
- Computer
- Screen
- Notebook
- Printed out material
- Mobile device

We don't really use word-to-text app because it works not very well in a complicated environment like ICU

Patient room



Main duty
- Medical rounds
- Quick Q&A with patients&families
- Quick debriefing/team huddle

Main touch points
- Computer
- Notebook
- Printed out material
- Mobile device
- White board
- Phone

Information & Communication
- Face-to-face communication
【Condition of the patients/changes of the treatment plan/help the whole surgery team to understand the condition of this patient...】
- Digital system
【patient record/report】
- Printed out material
【patient data/report】
- Written down info on white board
【Basic info of the nurses/simple info for patients/reminding to doctors...】
- Written down notes on paper/in App
【Instruction from senior physician】
- Phone call
【Call teammates/senior doctors for help/to report】

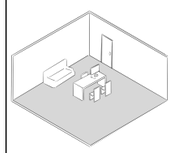
We don't have other notification systems or devices. When there is an emergency we will use broadcast to notify everyone, but this situation is relatively rare to see.

Although note-taking is about personal habit, Mostly with paper and pen because it's the ~~**fastest and easiest way** (even faster than with mobile devices when dealing with emergencies)~~, sometimes with phone/pad.

Interview -physician

Daily routine details

Office



Main duty
- Discuss about relatively serious situation with families

Information & Communication
- Face-to-face communication
【Discussion/decision】
- EHR system
【patient record/report...】
- Printed out material
【patient data/report...】
- Written down notes on paper
【Some notes that could be taken away by families】

Main touch points
- Computer
- Printed out material
- Paper

Interview -physician

Follow up questions

Are there already AI-driven tools be applied in your hospital?

No.

Do you think there are any other challenges in the communication process?

From my personal perspective, when having a long discussion, **information and instructions from the senior doctors can easily be missed when taking notes**

What is your attitude towards applying AI into ICU?

I think it is very necessary, but it may only be used to **assist diagnosis and treatment, such as helping to find data or improve reports, or solve the information missing issue I mentioned above. At least at this stage, it is difficult for people to mentally accept AI making key decisions.**

The current workflow has been collaboratively established by all healthcare staff in this hospital and is already highly efficient; therefore, any new design can serve to optimize rather than replace existing processes

Interview -nurses

- They all have small notebooks and pens in their pocket, but they **will even just remember everything in their mind** because they are familiar with their work, and they are always super busy. They will have a "floor plan" in their mind and remember everything with bed numbers.
- In this hospital, nurses sometimes do not have dedicated verbal handovers between shifts. Instead, they rely on the EHR system to review notes left by previous staff. However, the note section is often disorganized, with all the information in no particular order. Nurses must manually scan through all the notes to identify the parts that are relevant to them.
- **In the EHR system, actually all the info are in a messy order. The nurses should go through all of them by themselves and find out what is significant.**
- The whole workflow so far is built up by the whole team for a long time so **they don't want to accept a whole new system** (also they are training new interns,it's impossible to train them with a unique system that isn't applied to other healthcare settings). They prefer to have small new designs **added up to what they have now in a natural way**
- They have a nurse station with several computers. They will regularly comeback to check information
- Data could already be automatically downloaded into EHR system and calculated
- In urgent situations, sometimes we even just grab discarded scraps of paper nearby to take notes.
- For the communication between people on the same floor: They directly go to each other and speak. **No extra devices needed** because they know quite well where all of their colleagues are. It's often simply a long hallway which you have as one team of medical staff. So the ward gets divided in zones, like east/west or north/south. So, you have a team of maybe 4-5 that are on one zone and **everyone is very aware of where the others are**
- As a nurse manager, she does not like seeing nurses constantly using their phones. Regardless of whether it is for work-related tasks or personal entertainment, she considers it a distraction from their duties.

Interview -caregiver

Thank you for taking the time to speak with me today! The main goal of this interview is to better understand the daily communication flow in your role, looking to identify areas where things are working well and where there might be opportunities for improvement. No sensitive or confidential information will be asked for.

Basic info

Name: W & kim
Position: Nursing home caregivers (last summer) for elderly people in early dementia stage
Region: Netherlands
Role: Day care to keep an eye on/document the performance of the residents, offer assistance, take care of some medication, accompany the elderly

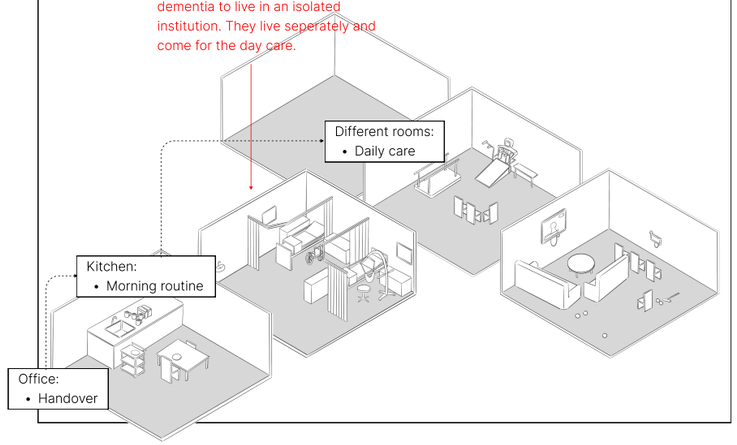
Daily routine overview

This is a brief overview of the daily routine of an ICU medical resident. What is the difference compared your routine?

We use an **internal EHR system** to document all the information such as performance. We first write things down on paper, or directly in the system, then document them in the system. We are able to edit it, and families can log in it to see what's going on.

Most caregivers are **without medical background**

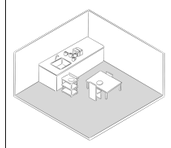
We don't really have this step because they are too early in the stage of dementia to live in an isolated institution. They live seperately and come for the day care.



Interview -caregiver

Daily routine details

Morning routing



Main duty
- Prepare food for residents
- offer help for those who can't easily eat on ones own

Information & Communication
- Printed out diet list

【the detailed diet requirements for each resident】

Main touch points
- Paper material

Daily companion



Main duty
- Accompany the elderly, keep an eye on/document the performance
- Offer assistance
- Take care of some medication
- Update in the system at the end of a day

Information & Communication
- Face-to-face communication

【Report to the nurses in the office about really urgent situation/sometimes nurses will directly coming in and arrange some tasks】
- Phone call

【Report to the nurses in the office about really urgent situation】

Main touch points
- Internal system
- Sometimes paper
- Phone
- Digital system

【abnormal performance/complaints...】
- Written down notes on paper

【key info】

Overall the caregivers don't really deal with that much info. We mainly document abnormal data into the system: uncomfortable/pain/stop eating/complaints...

Interview -caregiver

Follow up questions
Does the nursing home you was working already have some AI-driven tool? No. Do you think there are any other challenges in the communication process worth being improved? I hope to have **a simpler and more efficient way to record information**, in order to ensure that the content being documented is **sufficiently detailed and comprehensive**. For some caregivers who have worked here for a long time, they are very familiar with their work and often keep many details about each resident **in their minds**. In contrast, for caregivers with less experience, it's **difficult to quickly catch up** without these detailed pieces of information available in the system. If the way of recording could be more easier, I believe more details could be recorded to improve this situation

06

Background: ICU Junior Doctor, male, 24 years old

1. **How to take notes?**
   Taking notes is a very important activity in the daily routine of ICU. Verbal communication is very common. **Mostly with paper and pen because it's the most fast and easiest way (even faster than with mobile devices when dealing with emergencies)**, sometimes with phone/pad. They **don't really use voice recognition since it's not always accurate.**

1. **What is the content of the notes?**
   Mainly instructions from senior doctors, for example, what kind of medicines should be used, what procedure should be conducted...

1. **Current digital systems?**
   EHR system. It's a system with very complicated functions. Everyday I will really need to sit down and spend some time on organizing different reports and documenting notes into it. It's actually a little bit tiring for me, since it's a everyday process.
1. **How will you deal with the paper notes?**
   We always just use some abandoned paper to quickly note down everything. After finishing the tasks on it we will just throw the paper away. Since each doctor takes care of his/her patients individually (different from my research) , I **don't really need to notify others what are in my notes and what has been done. Only when some significant tasks are finished, I will report them to the senior doctors.**
   But overall, we are still a team. We may not know all the details of other patients, but we sometimes will still have simple discussions. And we will conduct operations together.

1. **Apart from notes, are there any other touch points for information communication?**
   White boards in the patient rooms will be used for some small details/ notifications, for example the plan of operation, or reminders of the infectious diseases of the patients

1. **Are there any AI tools already in used?**
   We **came across lots of concepts, but actually few are used clinically**. What we are using now is only a small supplementary function for the medical records system, which will help to analyse and remind me where needs to be improved in the report.

1. **What is the most obvious pain point for you in the information/data communication?**
   From my personal perspective, when having a long discussion, **information and instructions from the senior doctors can easily be missed when taking notes**

1. **How do teammates contact each other?**
   Mostly through phone calls. We don't have other notification systems or devices. When there is an emergency we will use broadcast to notify everyone, but this situation is relatively rare to see.

1. **When you need some medical information to support your key decisions, what will you do?**
   I will directly call the senior doctor for help.

1. **When will you usually communicate with patients and families?**
   Mostly simple Q&A during medical rounds. For serious situations we will invite the families to our office for a formal talk, such as before the operation.

1. **Main way of communication?**
   Face-to-face verbal communication

1. **Sequence of dealing tasks?**
   Senior doctor will already decide on the hierarchy when arranging tasks. We could also tell the hierarchy by ourselves when receiving calls. Emergencies go first. For those tasks that are too complicated I will report it to the senior doctor.

1. **What is your opinion towards applying AI into ICU?**
   I think it is very necessary, but it may only be used to **assist diagnosis and treatment, such as helping to find data or improve reports. At least at this stage, it is difficult for people to mentally accept AI making key decisions.**

07

Background: have been to ICU to visit his father

Pain points from the perspective of patients and families:

- There are always different nurses coming in and out (maybe per 30min) without saying anything. **From my side looks like they are working in a really low efficiency way, and hard to ask questions and build connections with them.**
- When you are waiting for all the procedures to be done, there is no medical staff around you, so you **have no idea what to do and what will happen**

08

Background: have collaborated with ICU several years ago

- Use a lot of paper chart because it's fast, also **possible for extra notes and explanation.** The digital system is not possible for this.
- A large number of **white boards for quick communication**, mostly temporary info, will be wiped later, note sure if they are documented
- A lot of **labels on the bed** to help communicate and locate the movement of patients
- Should follow many protocols for safety reason, sometimes makes the process very slow and inefficient
- **The environment might be too noisy for voice recognition**
- Should have the possibility of working off line/no internet
- **Acceptance for changes are low** (busy, learning and training are time consuming and complicated)

09

Background: design agency focusing on ai in healthcare

- promising topic, heard about many companies are also looking into this direction
- Talked to innovation managers of several hospitals, the identified pain points are solid
- Consider about the data standardization while training models

10

- communication with medical staff before entering into hospitals: all related data will be in **a digital system**, medical staff should be able to view all related data after the patient give permission. **But sometimes maybe the record is not properly interpreted/notes are not properly taken, some medical staff may forgot what condition the patients are in and need to catch everything up again**
- During treatment process inside the hospital: 1. during rounds: **really quick, passively being asked** questions to check how the patients are feeling. Sometimes the doctors that is taking charge is **not available, the patients will need to help the "temporary physician" to understand and record their health condition. They will show the screen to the patients. Patients could pointing out possible mistakes. But many notes are written in abbreviation so it's hard to read.** 2. Daily communication: through a **digital message system/make phone calls**. The information will be handled **by nurses/secretary team first**. If they are not confident to solve the issue, the info **will be transferred to doctors.** 3. Appointed discussion: 20-30mins/ppl, usually happens as a evaluation session after a period of treatment. The doctor **will show some highlighted data on the screen and explain them.**
- Post treatment: less communication, **still through phone call & message system. But patients will sometimes hesitate to ask questions because they don't want to "go back"/ don't want to know things might get worse. A easy and supportive communication vibe is key to solve this.**
- **The communication with doctors should be more easy to understand.** For patients under pressure (especially elderly people), **it's hard for them to process all the information at once. So they will feel anxious and might repeatedly ask questions.**

11

Background: graduation with hospital

- Could make **a journey especially about data & info**, how they changed, what characteristics they have, why this way/this software is chosen, the different points in the process (urgent/ normal), for different people what are the different data they need
- The channel between medical team and patients, data is there, how to communicate (they have the app from hospitals but never sending messages, makes the patients anxious), **different people need different data**
- In her observation session in a hospital, they always have to come to a specific computer to record something, so they actually feel easier to just use a post it or tell the nurse to transfer the message
- Should balance efficiency, empathy and distance between medical team and patients, **easy to use & less burden for medical staff always comes first**
- **Alert fatigue and hierarchy of info**

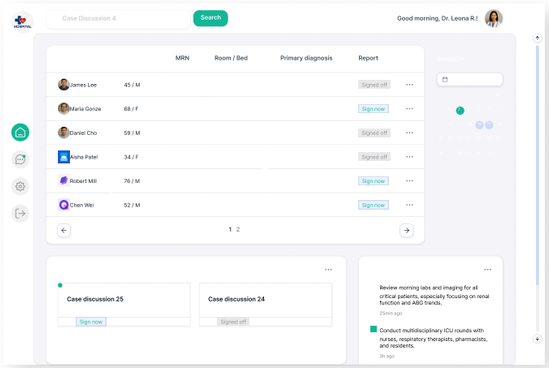
12

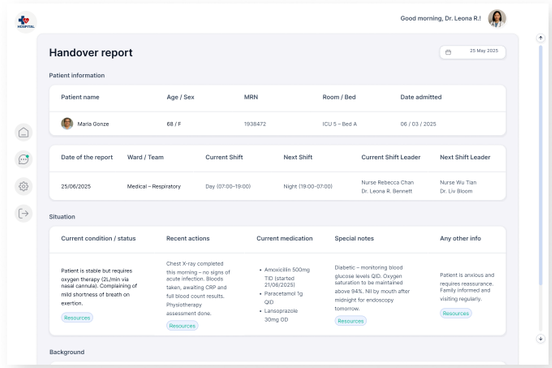
Background: Innovation manager of a Utrecht hospital

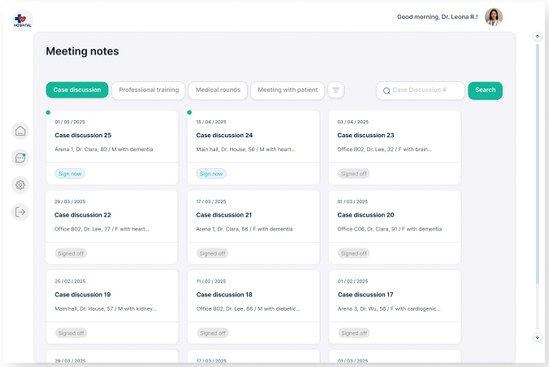
- Valuable topic, the change (application of AI) is a must, since we are facing many problems in current systems, such as lack of manpower and professional burn out. Also he believe this can encourage more data documentation, as in his observation, many nurses keep details in mind and don't really document them when they are taking care of the patient/during medical rounds, maybe because they are busy or the EHRs are complicated to use.
- We are currently experimenting with several AI documentation tools; however, none of them have been fully integrated into the workflow to enable real-time recording. You always still need a specific period of time dealing with all the documentation. As a result, a significant amount of information remains unreported or is lost.

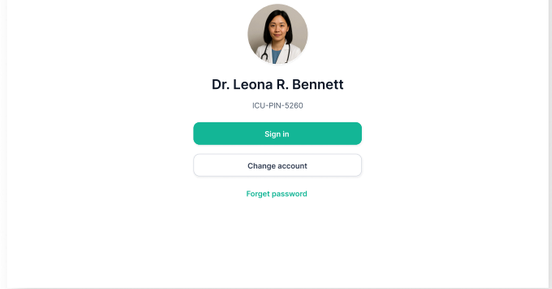
Appendix 6. UI Design Process

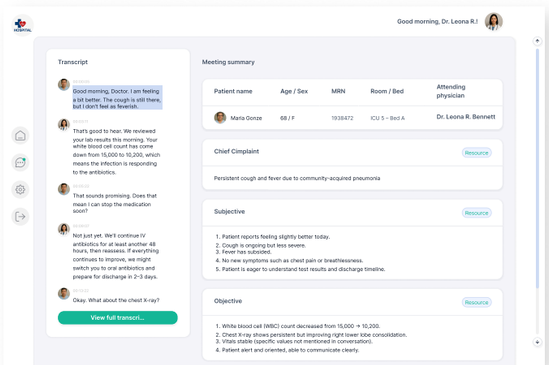
Version 01











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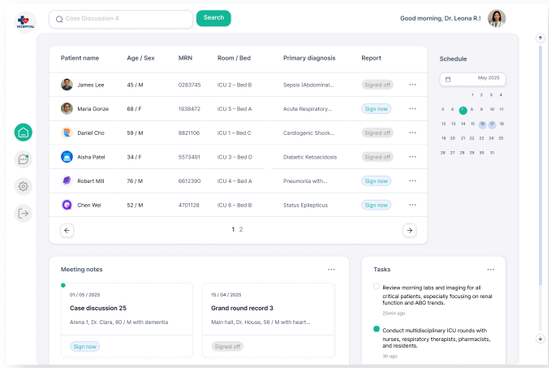

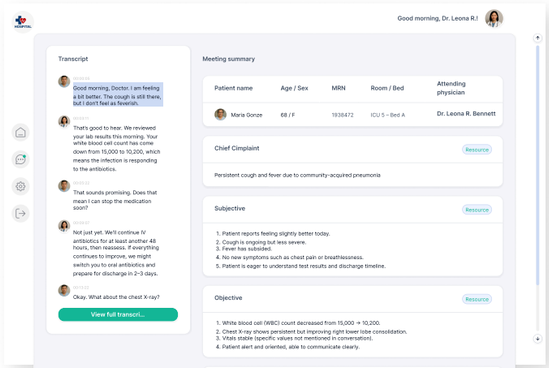

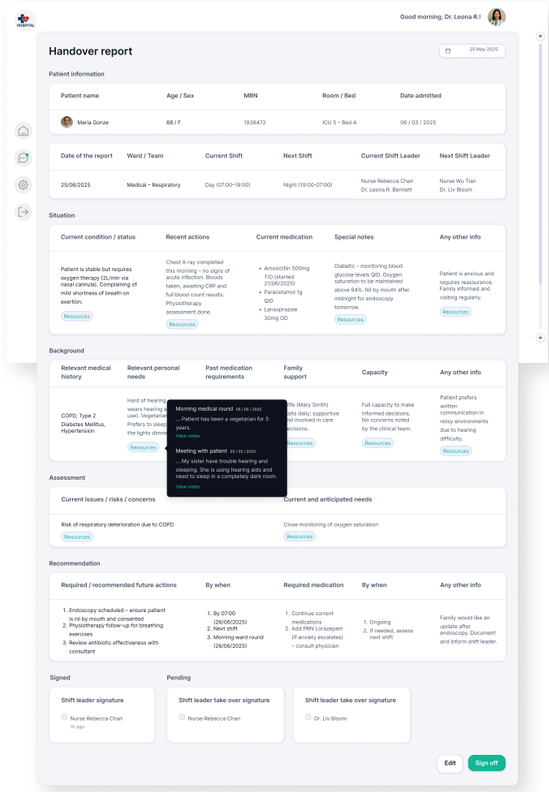

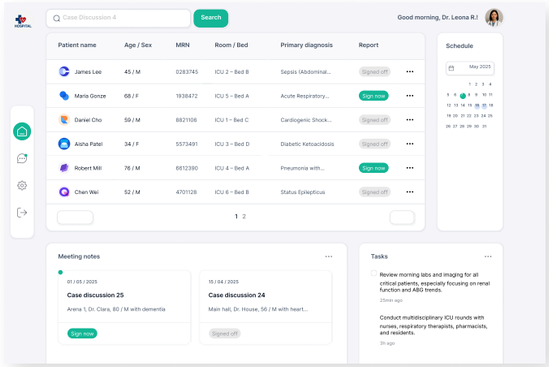

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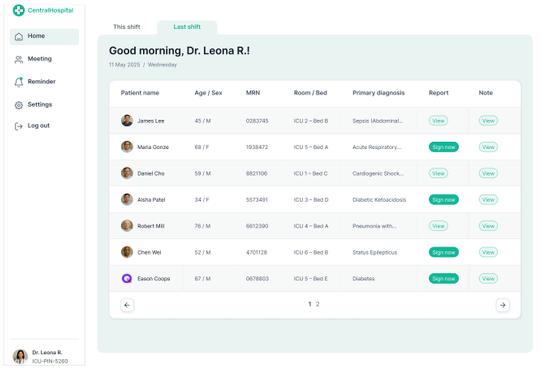

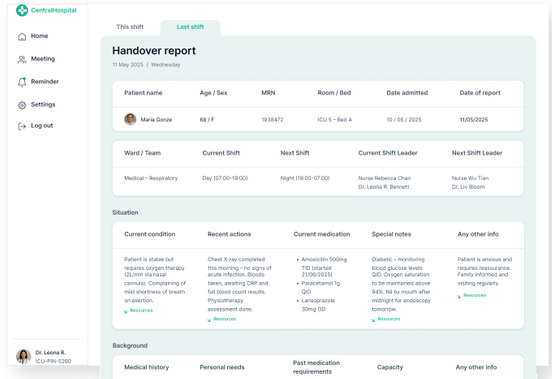

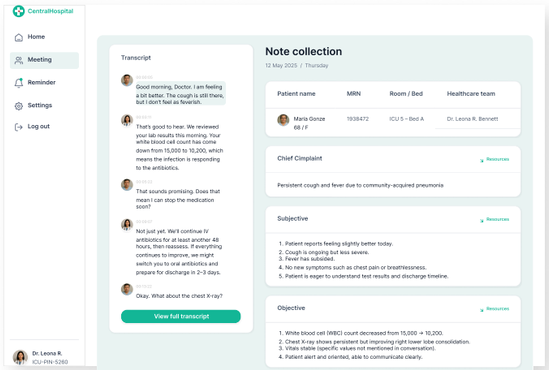

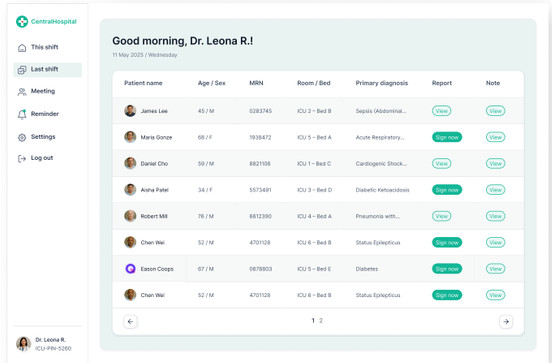

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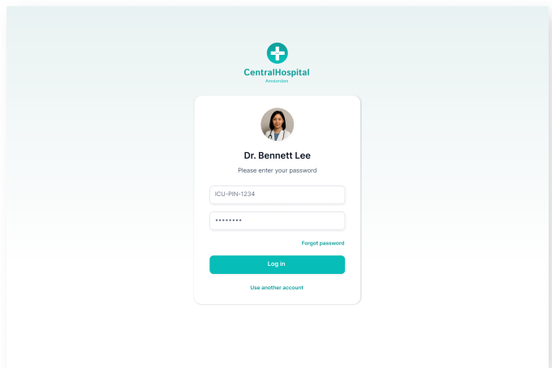
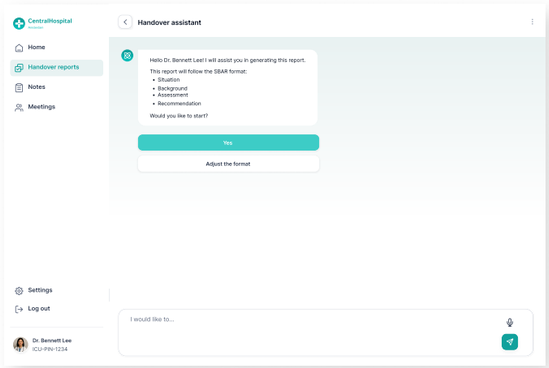
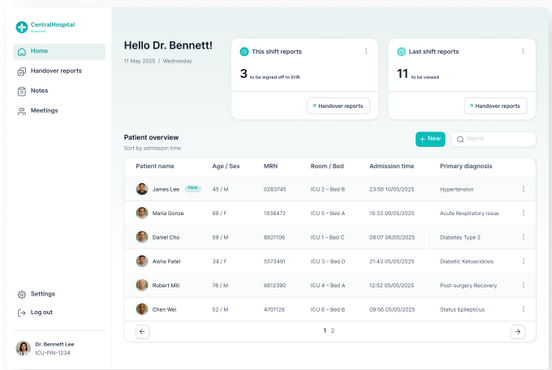
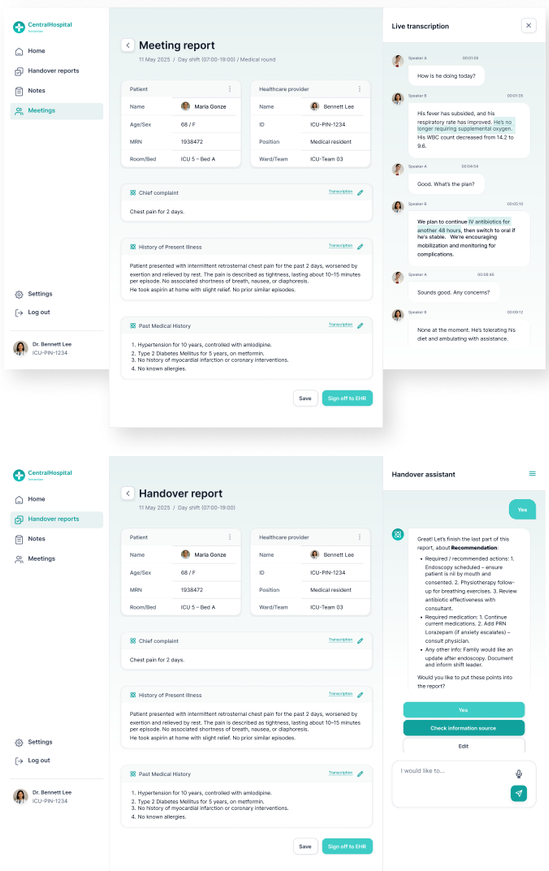
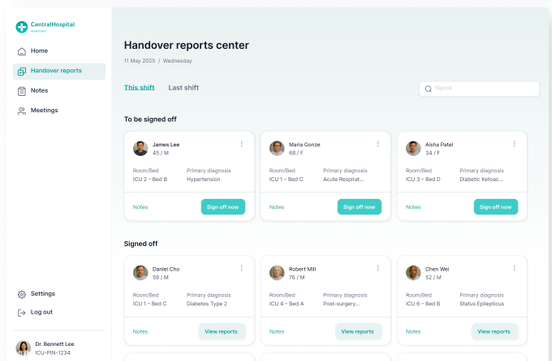


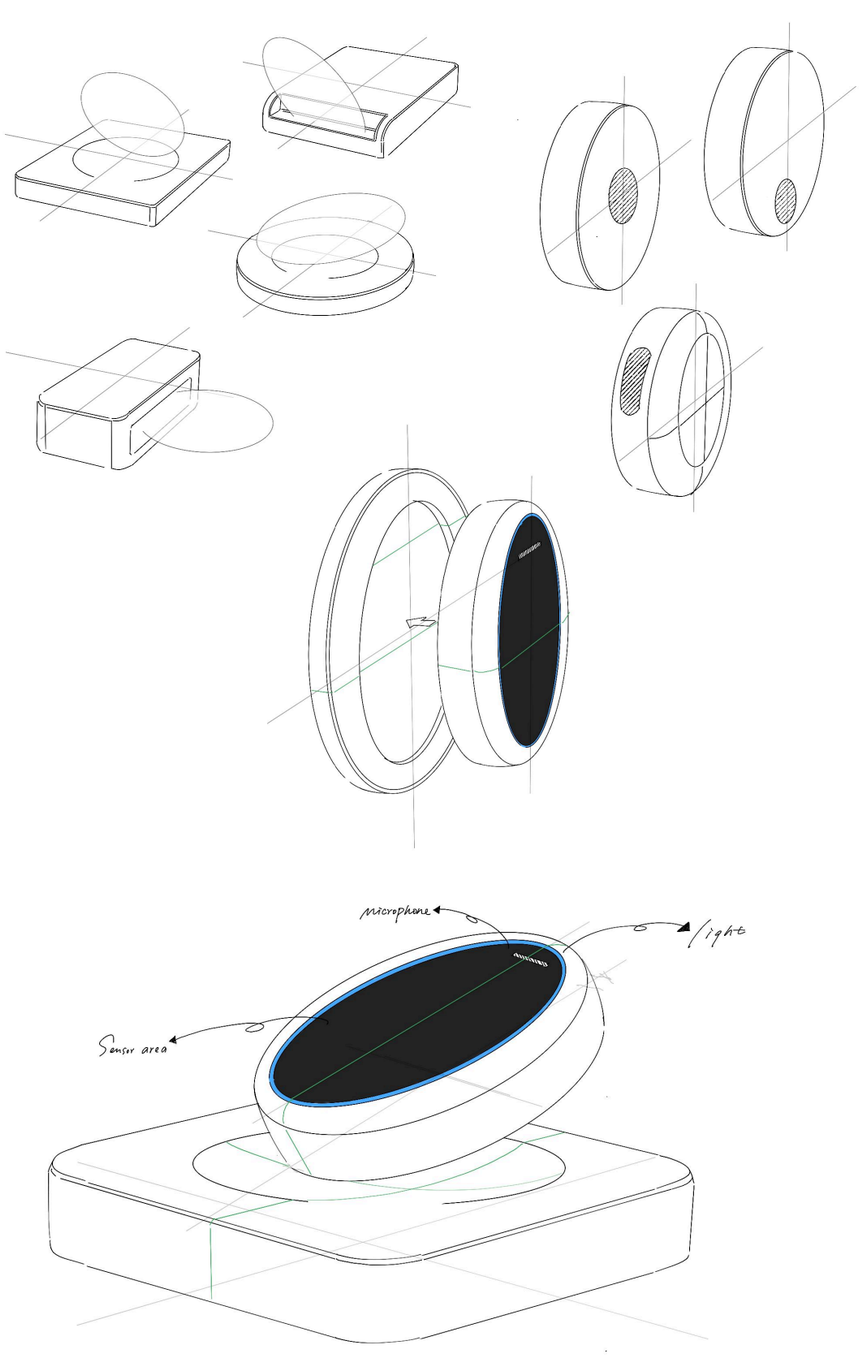


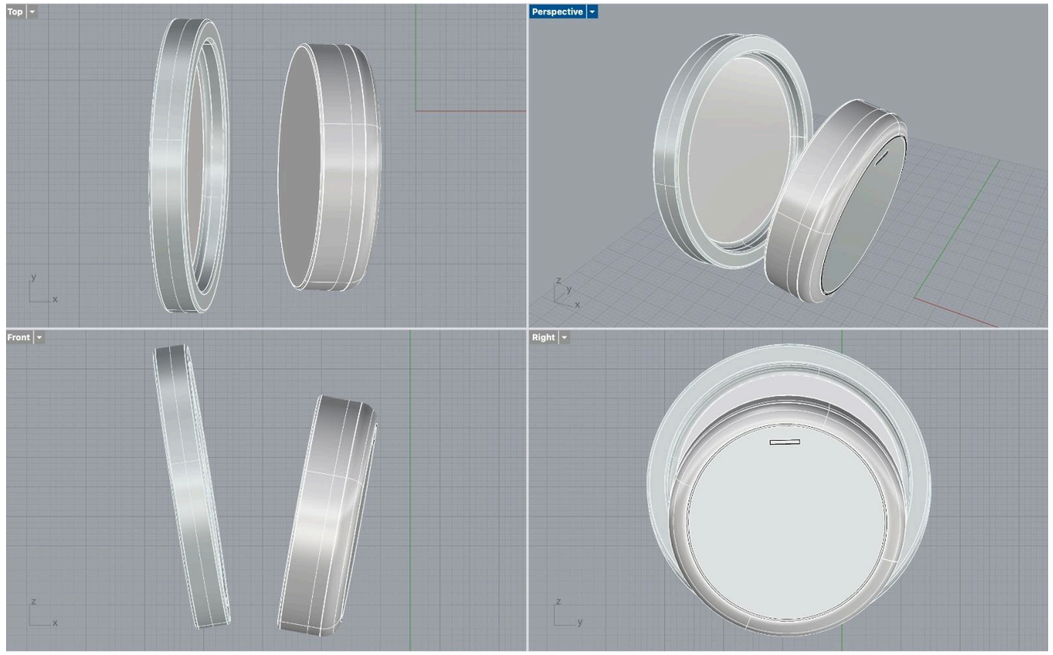




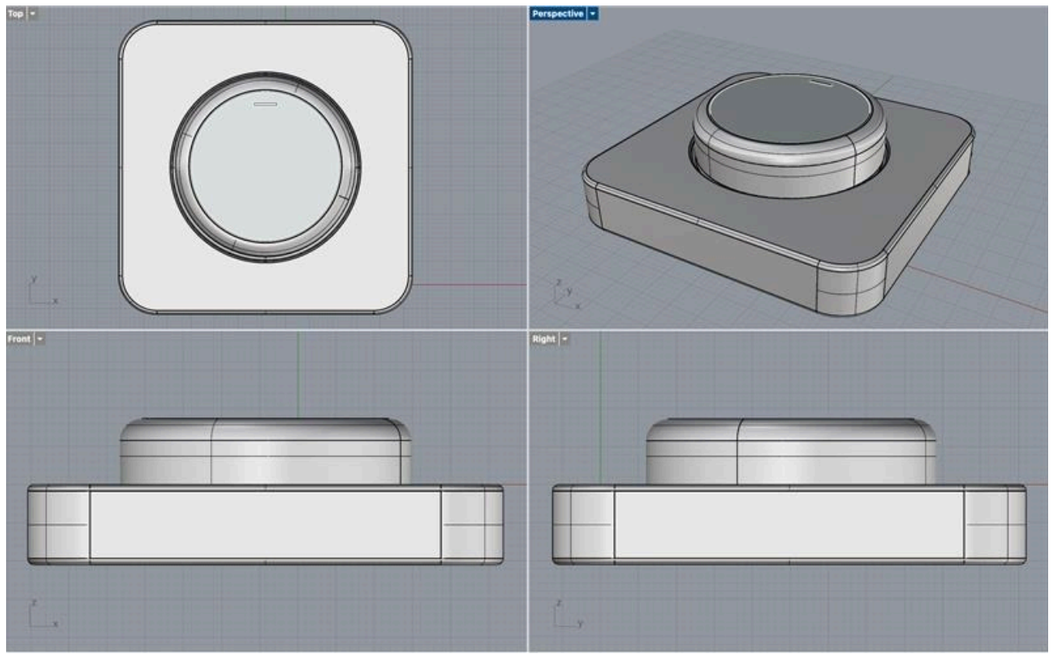


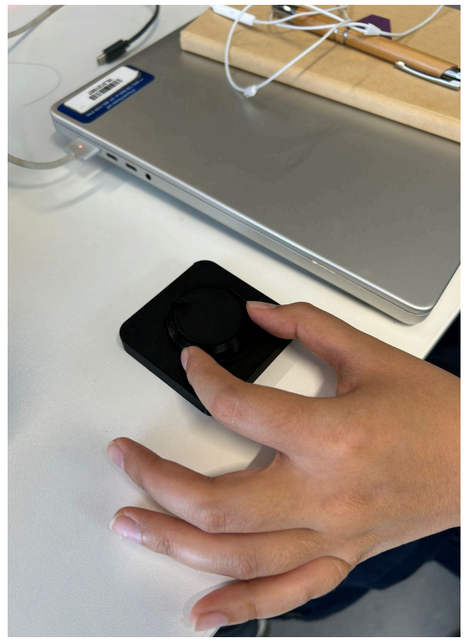
Appendix 7. Wearable Pin Design Process











Appendix 8. Evaluation Session Raw Data

Evaluation -Patient and Familiy

Thank you for taking the time to speak with me today! The main goal of this evaluation is collect attitude, feedback and suggestions from several key dimensions of the final design, looking to identify areas where things are working well and where there might be opportunities for improvement. No sensitive or confidential information will be asked for.

Step 1. Basic info

Name: S
Section: General ward
Region: China
Form of evaluation: Online meeting
Role: Taking care of a 80-year-old patient with heart problems, together with 2 other sisters
Participated in previous interview? Yes

Step 2. Researcher explains the final system design, show the physical prototype, also invite the participant to think about 5 random medical notes, and test within the Chatgpt-based AI model.

Questions

1. Please imagine this situation: when you are in the hospital taking care of your family, the doctor talking to you is wearing this pin. The doctor explains its purpose and tells you that you have the right to refuse to turn it on. In that case, do you feel that your privacy is respected? Would you feel comfortable with the presence of this pin?

   As long as the purpose is **clearly explained**, and I am told that I **have the right to** switch it on or off, I **would feel comfortable and respected.**

   After I understand the motivation of your design, as a family member of a patient, of course I would **support** solutions that could help my loved one receive better care.

2. In current design, the system mainly helps patients and their families by quickly generating a conversation report, which can then be printed and shared to you. This way, important information won't be missed, and you can review it later. Do you think this feature would be helpful for your communication with healthcare providers?

   It would definitely be helpful to some extent, but I think it could **go a step further**.

   For example, what if we could **also have a pin?** That would give us the ability to record certain information ourselves, and then let the AI summarize it. If there are medical terms I don't understand, I could even **request that the system add explanations.**

Questions

3. Do you have any other suggestions or concerns?

   The results of the testing (with Chatgpt AI model) seems correct, but I would say as a patient family I still have the concern in mind that **if there is a mistake, who will be responsible for it?** AI or the healthcare providers? Overall I just want my family to receive treatment and care as good as possible.

   I'm not very familiar with the current level of AI technology, but one issue that comes to mind is **whether it can accurately recognize different accents or dialects.** If this product is to be on the market of China, a **single province can have more than 20 very different dialects.** I think that's a pretty important challenge to address.

Evaluation - Healthcare Providers

Thank you for taking the time to speak with me today! The main goal of this evaluation is collect attitude, feedback and suggestions from several key dimensions of the final design, looking to identify areas where things are working well and where there might be opportunities for improvement. No sensitive or confidential information will be asked for.

Step 1. Basic info

Name: Y
Section: ICU
Region: China
Form of evaluation: Online meeting
Role: ICU attending physician
Participated in previous interview? Yes

Step 2. Researcher explains the final system design, show the physical prototype, also invite the participant to think about 5 random medical notes, and test within the Chatgpt-based AI model.

Questions

1. Do you think this design could help you collect and organize information and notes more efficiently? For example, could it reduce information loss or misrecord, and encourage you to document more information details?

   Based on your introduction and prototype, I think it **definitely could.**

   At least for now, it seems to address several of the issues I've mentioned in my daily work. **Even without all the other functions you described, just being able to capture more key information and organize it properly would significantly reduce my workload.**

2. Do you think this design could help you generate different reports more efficiently, and thus reduce your paperwork burden?

   I imagine if I really started using it at work, there would first be **a bit of an adjustment period** with the AI, mainly around **trust building and accuracy**. But once I get used to it, I believe it could greatly improve efficiency.

   Especially if it **captures details I might have missed**, the resulting reports could add real value to my work.

   I also noticed the feature you mentioned about **flagging potential missing details.** I'm not sure what criteria it uses, maybe I could **define some keywords at the start?** I feel this feature worth to be developed further.

Questions

3. Do you think the learning curve of this system is simple, and it won't significantly disrupt your workflow?

I think it just needs **a clear explanation of the process at the beginning**. Once I understand it and use it a couple of times, it should be quite **straightforward**.

4. What's your overall attitude and acceptance toward this design?

I think it's a **very interesting and useful** concept. Of course, healthcare is a complex industry, and if you want to implement it **in the real market,** there will be **many details to consider,** like **different laws and regulations in different countries**.

But in any case, exploring ways to reduce doctors' burden is **a great direction**. Being a doctor is **indeed tiering.** I've basically been in surgery all day today.

5. Do you have any additional suggestions or concerns?

I was wondering if the pin could **automatically recognize the patient's bed number.** For example, during medical rounds, it could automatically match each conversation with the right patient. I don't know if that's technically feasible, but it sounds useful.

Another thought: when I take off my coat or change into scrubs and protective clothing, could the pin **get in the way or be easy to forget?** That might be a detail also worth considering.

Evaluation - Healthcare Providers

Thank you for taking the time to speak with me today! The main goal of this evaluation is collect attitude, feedback and suggestions from several key dimensions of the final design, looking to identify areas where things are working well and where there might be opportunities for improvement. No sensitive or confidential information will be asked for.

Step 1. Basic info

Name: W
Section: Nursing home caregivers (last summer) for elderly people in early dementia stage
Region: Netherlands
Form of evaluation: Online meeting
Role: Day care to keep an eye on/document the performance of the residents, offer assistance, take care of some medication, accompany the elderly
Participated in previous interview? Yes

Step 2. Researcher explains the final system design, show the physical prototype, also invite the participant to think about 5 random medical notes, and test within the Chatgpt-based AI model.

Questions

1. Do you think this design could help you collect and organize information and notes more efficiently? For example, could it reduce information loss or misrecord, and encourage you to document more information details?

Yes, definitely. My responsibilities was mainly about daily care, observation, and companion for the elderly. Sometimes they make requests, or their family members bring up needs during visits, and often senior caregivers or nurses come by directly to assign tasks or share reminders. **There are actually quite a lot of details to keep track of.**

Caregiver at our nursing home isn't always sufficient, so each caregiver is **gradually responsible for more residents, which adds pressure**. A system like this could help me capture and organize those details more effectively. It will **also benefit those families** who check the daily notes of their elderly in the system.

2. Do you think this design could help you generate different reports more efficiently, and thus reduce your paperwork burden?

Last summer I was still new, so I **didn't handle much formal reporting.** My work focused more on recording daily information. But I can see this system could be useful for those who do need to write reports.

Questions

3. Do you think the learning curve of this system is simple, and it won't significantly disrupt your workflow?

Based on my data collecting experience, **the pin felt straightforward and easy to use.** It was **convenient** and didn't really add extra burden to my work.

4. What's your overall attitude and acceptance toward this design?

This winter I'll be going back to the nursing home to work again, and I'd actually be happy to bring this idea to other caregivers there. I think it's **interesting and worth discussing further.**

5. Do you have any additional suggestions or concerns?

Not at the moment.

Evaluation - Design Experts

Thank you for taking the time to speak with me today! The main goal of this evaluation is collect attitude, feedback and suggestions from several key dimensions of the final design, looking to identify areas where things are working well and where there might be opportunities for improvement. No sensitive or confidential information will be asked for.

Step 1. Basic info

Name: X
Form of evaluation: Role play
Assigned role in the evaluation: Doctor
Role: IDE DFI student
Participated in previous interview? No

Name: M
Form of evaluation: Role play
Assigned role in the evaluation: Nurse
Role: IDE DFI student
Participated in previous interview? No

Name: Z
Form of evaluation: Role play
Assigned role in the evaluation: Patient family
Role: IDE SPD student
Participated in previous interview? No

Step 2: Researcher explains the overall background of this project, go through the key findings and insights from research sessions, to help participants understand and be familiar with the project context.

Step 3: Researcher explains and assigns the three roles: doctor, nurse and family

Step 4: Researcher explains and leads the 3 designers through the traditional workflow

Step 5: Researcher explains and lead the 3 designers through the AI-assisted new workflow, shows the physical prototype, also invite the dwsigners to think about 5 random medical notes, and test within the Chatgpt-based AI model.

Step 6. Group Discussion

Good points:

- The hierarchy of the UI design is very clear and intuitive, easy to understand how to interact with it without many explanation
- The idea of the pin is very interesting
- "Trace the note source of where these AI-generated solution comes from" is a clever way to solve the trust issue. With this capability, doctors remain accountable for their reports rather than leaving AI to assume complete responsibility.

Further discussion:

- Maybe the pin could give the users a small feedback on "the information is successfully recorded"
- Could further highlight the function in the UI that "AI could even help to highlight the possible missing details", Since ths is also one significant new value that this new design could bring into the workflow
- From a storytelling perspective, maybe it's nice to make a more vivid comparison between the traditional workflow and the new workflow to help people understand what is new after having the design, how information flows in the new design.