Care Transition Records and Their Transmission Process in Germany: Detailed Analysis and a Proposal for a Digital Solution

Elisabeth Veronica Mess, Matthias Regner, Sabahudin Balic, Lukas Kleybolte, Lisa Daufratshofer, Andreas Mahler, Sabrina Tilmes, Viktor Werlitz, Claudia Reuter, Alexandra Teynor

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Abstract

Background: In Germany, healthcare digitalization is critical for enhancing patient care and system efficiency, yet it faces challenges in innovation, regulatory compliance, data security, and equitable access. German legislation, influenced by EU regulations, mandates strict data handling, impacting the adoption of digital solutions. Internationally, a number of countries have developed digital healthcare projects, but Germany lags behind, partly due to its stringent data protection laws. Additionally, medical and nursing facilities are under considerable pressure because patient numbers are increasing and nursing staff is scarce. Digitalizing administrative care processes could help to save time that could be used for individual care and improve the overall satisfaction of care staff. One example is the digitalization of Care Transition Records (CTRs) and their transmission process. Currently, there are many problems associated with this process: the time-consuming nature of creating CTRs, lack of standard formats, legal regulations, and data protection concerns.

Objective: This paper analyses the Care Transition Record (CTR) and CTR transmission process in Germany as part of transition management and suggests improvements towards a seamless digital solution.

Methods: Several methods were used to assess the satisfaction of nursing staff in the context of patient data transfer in care facilities in Germany. These include the creation of an online questionnaire, conducting field observations and contextual inquiries, BPMN modeling, semantic and frequency analysis of existing CTRs, and a user story mapping.

Results: An online questionnaire involving German nursing professionals (n=33) revealed significant delays in patient care due to manual, patient-transferred Care Transition Records (CTRs), with 70% of respondents advocating for digital transmission to improve efficiency. Observations (n=11) confirmed the high administrative burden, averaging 34 minutes per CTR within a hospital and 47 minutes in care facilities. A semantic analysis of CTRs (n=4) proved the need for standardization and attempted to manually map existing CTRs to the new CTR standard (CTR-MIO). This showed the overall complexity of the new standard.
A frequency analysis showed which information in the CTRs is the most important.
Based on the key findings, a new digital approach, encompassing a "CTR translator" and "CTR-MIO viewer/editor", was conceptualized to streamline the transfer process, offering solutions for both standardized and non-standardized CTRs.

Conclusions: The findings of this paper conclude that a future solution should simplify the overall CTR transmission process by minimizing manual transfers into in-house systems, standardizing the CTR, and providing a secure digital transfer. Doing so could positively impact the overall care process and patient experience. With our solutions, we attempt to support care staff in their daily activities and processes until nationwide state regulations are implemented successfully, but it is uncertain how long this will take.

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Conclusions: The findings of this paper conclude that a future solution should simplify the overall CTR transmission process by minimizing manual transfers into in-house systems, standardizing the CTR, and providing a secure digital transfer. Doing so could positively impact the overall care process and patient experience. With our solutions, we attempt to support care staff in their daily activities and processes until nationwide state regulations are implemented successfully, but it is

uncertain how long this will take.

Keywords: Care Transition Record; Transmission Management; Observations; Process Modeling; Telematics Infrastructure; TI; FHIR; HL7; MIO

Introduction

Digitalization in healthcare in Germany

In recent years, digitalization has emerged as a transformative force across various sectors, profoundly impacting how organizations operate and services are delivered. One such sector undergoing substantial changes is healthcare, where digitalization holds the potential to support patient care, resource management, and overall efficiency.

The progress of the digital transformation shows potential for solving patient problems, optimizing clinical processes, and tackling the significant challenges of demographic change. Around the world, policymakers, researchers, and healthcare practitioners share the goal of expanding healthcare infrastructure and increasing interoperability. While the benefits of digitalization in the healthcare sector are widely recognized, implementing digital solutions in the German healthcare system faces numerous challenges [1].

The complexity of these challenges comes from the need to balance innovation with regulatory compliance, ensure data security and patient privacy, and bridge the digital divide to guarantee equal access to healthcare services.

The Patient Data Protection Act in Germany is derived from the EU Regulation 2016/679 of the European Parliament [2]. This clarifies boundaries for processing personal data and shows the possibilities for overcoming obstacles in digital patient transition. Many EU countries have initiated digitalization projects or aimed to implement them since the EU Regulation, such as Switzerland with the Electronic Patient Dossier (EPD)[3], Austria with the Electronic Health Record (ELGA)[4], France with Mon Espace Santé [5], Finland with My Kanta [6], [7], Sweden with National Patient Summary (NPÖ) [8], Norway with Norsk helsenett [9] and Estonia with an e-health record solution (old name: ENHIS) [10], [11]. Patient data is made available through the Electronic Health Record System in the United States, based partly on the HIPAA Act of 1996 and the HITECH Act of 2009. In Canada, the Canada Health Infoway [12] project was launched in 2001 to digitalize healthcare and enhance interoperability.

Compared to this, Germany started to experience significant delays in implementing electronic health records and the digital transfer of data via a secure “data highway” – the Telematics Infrastructure (TI).

This is due, in part, to the fact that even after implementing the EU Regulation, individual EU countries can expand the proposed law with additional aspects. This results in stricter handling of patient data in Germany as compared to other countries within the EU, which hinders the implementation of innovative new ideas. That is not all.

In a study by the Bertelsmann Foundation evaluating the digital healthcare system [13], countries within the EU and beyond were examined and compared based on the following criteria: the national healthcare system, the development of digital health, policy activity and strategy, technical implementation and readiness, and actual data usage and digitalization profile. In international comparison, Estonia ranks first, Canada second, Denmark third, Israel fourth, and Spain fifth, while Germany is positioned towards the lower end. In terms of the Digital Health Index, policy activity, Digital Health readiness, and actual usage, Germany scores 30.0%, 44.2%, 30.1%, and 15.8% of the maximum achievable score, while Estonia leads with 81.9%, 88.1%, 86.1%, and 71.7% respectively.

These devastating results indicate Germany's need to push forward its digitalization in the healthcare sector.

Given the prevailing shortage of qualified nursing personnel in Germany and the escalating numbers of individuals necessitating care [14], there is a need to enhance the efficiency and overall quality of care procedures. Digitalization of processes or services is one possible way to do so.

However, successful digitalization is not easy and is made even more complex by the interplay between stakeholders, including healthcare providers, technology developers, authorities, and

patients [1].
The authors of this paper attempt to tackle this complex challenge by focusing on one crucial aspect – the seamless transition of patients' information across different healthcare institutions.
Integrating digital solutions into these processes holds considerable promise, especially given the prevalence of paper-based workflows in healthcare, which often leads to delays caused by the need for data format conversions and on-time transfer.
As a direct response to this challenge, the sub-project "Digitization of the Care Transition Record (CTR)" was initiated under the Bavarian project CARE REGIO initiative. This collaborative effort involves the University Hospital Augsburg (UHA) and the Technical University of Applied Sciences Augsburg (TUA), working to digitalize CTRs and refine the entire CTR transition process. The CTR transition process encompasses transferring patient data and its care journey between diverse healthcare facilities. It encompasses the entire spectrum of activities required for the inception, transfer, and manual integration (involving the transcription of information from printouts into in-house systems) of CTR data. Several process-centric challenges were found through literature research: (1) *Creating CTRs is time-consuming***,** (2) *lack of a standard format for CTRs*, and (3) *lack of successfully implemented standards for communication* with nursing facilities in Germany. Additionally, (4) the usage of different *proprietary software solutions and formats to create CTRs*, and, lastly, (5) the *late timing of CTR transmission***.**
To better understand the problems at hand, the authors went through a first problem analysis, which resulted in a digital expert workshop, field observations (UHA: n=6, care facility: n=3), BPMN modeling (n=2) of the observed processes and a rough solution sketch. The sketch offered an initial idea of how to solve the problems at hand with a CTR translation service (transfer of CTRs into a standard) and a CTR viewer (visualization of data for filtering and searching). These findings were published as intermediate results in 2021 [15]. Even though these findings were still unrepresentative up to this point, they pointed to a confirmation of the problems found during literature research. The data suggested that nurses are still frequently interrupted when manually transferring CTR data into their in-house system. The observations also showed that the CTRs do not arrive at the facility before the patient, so the nurses cannot prepare for the patient in advance. In this paper, the authors expand upon these findings and provide more research results.

State of the art

In this paragraph, the authors will revisit aspects of previously published research [15] and give more details on five relevant projects. Two new projects were added as compared to the previous publication (2, 3).
Looking at the previously named challenges in the context of the CTR transition process and how international and nationwide research dealt with these, several projects [16] – [27] were identified. Within these projects, the late transmission of CTRs or reports was generally addressed with a secure infrastructure or health information exchange platform. Furthermore, all projects attempted to devise a solution for the many proprietary software programs and formats that hinder sustainable interoperability. Unfortunately, the international projects' ideas or concepts cannot be directly transferred to German projects due to the mentioned stricter regulations.
That means only the results of five nationwide projects can be considered further: three for the secure infrastructure area and two for the standardization of CTRs area. These are presented below:

Secure infrastructure:
1. Research carried out by the German Society for Medical Informatics, Biometry, and Epidemiology (GMDS) in collaboration with the University of Applied Sciences Osnabrueck aimed to evaluate the technical and organizational feasibility, user-friendliness, practicality, and comprehensiveness of an electronically supported and standardized process for patient care transition. This process involved testing a prototype Telematics Infrastructure (TI) within the German healthcare network, primarily

used to exchange patient data securely.
The infrastructure included terminals with certified card readers, an assertion key as an alternative to an electronic health professional card, a server system for managing electronic patient records, and a secure communication channel between the server and the terminals. The nursing staff at healthcare facilities were authenticated through a software key, while patients were authorized using a test electronic health card with a PIN function.
To initiate a care transfer, a healthcare facility must utilize this test electronic health card and its associated PIN. The process involved storing the care transfer data on a central server by the issuing facility and retrieving it at the receiving facility. The system was generally considered suitable for users, although some challenges were identified. For example, accessing the test Telematics Infrastructure was a significant obstacle, and concerns about losing the electronic health card impeded a seamless transfer [18].
2. “PflegeDigital@BW”, located in Baden-Württemberg, is a project which
over 50 care associations have joined to clarify the path to digital and interoperable exchange for care facilities and interested parties. The regularly updated report focuses on the TI as an exchange platform. With the title "The TI guide" and over 34 pages, it also addresses the problem of insufficient explanation of the connection to the TI on the part of the center operators [26].

Standardization of CTRs:
3. The "ePflegebericht" was created by the University of Applied Sciences in Osnabrueck as a data exchange format for sharing information between care facilities and hospitals. It is based on the HL7 standard described in [20]. This concept was developed after analyzing 114 structurally diverse CTRs (Care Transition Records) and consolidating them into a comprehensive template, as outlined in [22]. The introduction of the "ePflegebericht" represents a significant advancement in the standardization of CTRs and is described in their report as the "appropriate tool for transmitting nursing information within integrated healthcare networks". The "ePflegebericht" template categorizes patient information into sections covering care processes, social details, sociolegal information, home care status, and medical data.
4. The proposed data exchange format of the ePflegebericht report has served as a foundational model for developing a new standard format known as “CTR-MIO”. The German government commissioned this initiative, and the GKV Organization (see No. 5), mio42 GmbH, and Nursing Advisory Board worked on the development.
CTR-MIOs use FHIR datasets, as indicated in [28]. FHIR stands for Fast Healthcare Interoperability Resources. The CTR-MIO, designed to represent a Care Transition Record, was completed by the end of 2022. Nevertheless, uncertainty remains about the swift implementation of this new standard, primarily due to healthcare software manufacturers' financial and human resource challenges. They must adapt their existing products to align with the current specification, which comprises approximately 2000 pages, as shown in [29].

Secure infrastructure and Standardization of CTRs:
5. The GKV organization (National Association of Statutory Health Insurance Funds) represents the interests of Germany's statutory health and long-term care insurance funds. It shapes the framework conditions for intensive competition for quality and efficiency in healthcare and nursing care.
One of its projects includes a piloting project [27] which focuses on TI, digital innovation tools, and structured exchange standards. It started in 2020 and is currently in its final evaluation phase. In the first part of the project, 88 outpatient and inpatient care facilities throughout Germany were connected to the TI to investigate cross-sectoral exchange of information using the TI applications available for care. In the second part of the project, applications that are not part of the TI service but have innovation potential for nursing care are tested. In addition, the development of standards for a structured exchange of information between different service providers within the TI was focused on.

One of these standards is the CTR-MIO (see No.4).
Early evaluations in spring 2023 showed that many caregivers view the TI solution skeptically, and only 36 facilities hope for faster and more complete data availability. 34 facilities expect time savings, less bureaucracy, and data security.
Overall, the findings showed many challenges while using the data transfer service (KIM Mail Client) of the TI, e.g., a lack of facilities who use the service, compatibility with the practice process, technical problems on the part of the TI, and the time required to train nursing staff.
Also, less than half of the facilities surveyed said they had used KIM.
Overall, the assessment of the technical connection process is rather negative.

In conclusion, four of the five projects described above only tackled one of the problems mentioned in the introduction. Only one project (see No. 5) tries to tackle two problems: the lack of a standard format for CTRs and the late timing of CTR transmission. Despite this, neither the TI service KIM nor the new standard (CTR-MIO) has been implemented successfully, which means a seamless transfer of CTRs across facilities has still not been reached.
Therefore, an integral and user-centered approach could help bring together the existing knowledge and best practices to propose a new system that addresses the above-mentioned problems.

Methods

Several methods were used to assess the satisfaction of nursing staff in the context of patient data transfer in care facilities in Germany. These include the creation of an online questionnaire, conducting field observations and contextual inquiries, BPMN modeling, semantic and frequency analysis of existing CTRs, and user story mapping. The findings will be presented in this paper.

Online questionnaire

A quantitative online survey aimed to identify challenges and desires associated with the CTR transmission process. Nurses, nursing assistants, and trainees working in ambulatory, acute inpatient (e.g., hospitals), or long-term care settings (e.g., nursing facilities) were surveyed.
We formulated inclusion criteria: nurses over 18 years of age and familiar with the CTR transmission process were included in the survey. The quantitative survey was conducted online from February 11 to April 30, 2022, using the open-source software LimeSurvey. A data collection and storage server was hosted at ATUAS. The collected data was anonymized. The questionnaire was constructed partly based on literature knowledge and in iterative loops by the project team, consisting of developers, care managers, and Ethical Legal Social Issues (ELSI) experts. In addition, some questions could be taken from the validated survey tool COPSOQ, as provided in [30]. A pre-test was also conducted to evaluate the developed instrument before final use and to match the selected sample comprehensibly, as described in [31]. Invitations to participate were e-mailed to the project team's professional and institutional mailing lists within Germany. An ethics application was submitted to the Joint Ethics Committee of the Universities of Bavaria (GEHBa), and a positive vote was obtained (GEHBa-202107-V-028). The analysis of the collected data was carried out by the statistical analysis program IBM Statistical Package for Social Sciences in version 28.0.0.0. Since the questionnaire contained closed and open-ended questions, the answers from the free text fields had to be categorized using Microsoft Excel. Identical or similar responses from study participants were grouped into categories for clarity. In addition, the collected data material was initially checked for erroneous entries and, if necessary, cleaned up as provided in [32]. That was followed by the data analysis, focusing on vital descriptive figures.

Field observations and contextual inquiries

Field observations and contextual inquiries were conducted to better understand the CTR

transmission process. As the process of a care facility was expected to be less formalized/standardized than within a hospital, contextual inquiries seemed more appropriate in these cases.
Field observations and contextual inquiries are both methods that allow observation of a person's or group's everyday activities within a natural environment (e.g., workplace). In a field observation, the data is collected without intervention or manipulation. In a contextual inquiry, asking questions during a visit is possible, referring to [33], which should not occur during field observation. The possibility to ask questions is beneficial to understand the users' interaction with, for example, complex systems and in-depth processes, according to [34].
In this project, we understand the CTR transmission process to mean all activities (usage of computer equipment, work tools, usage of other supplies, telephone call) necessary to create a CTR at the sending facility as well as the transfer into the in-house system of the receiving facility, including confounding factors. The reason for this is that, in the beginning, it was unclear if the staff entered all the data from the CTR at once or switched between different tasks.
The observation concept with a protocol was prepared and focused on nursing staff in the natural application context. The concept did not include patients or external staff (e.g., patient transport) and was not constrained by, for example, specific individuals, groups, or objects. All observations took place on-site in 2020, 2021, and 2022 without temporal or spatial limitations in the facility. An ethics application was submitted and positively evaluated (GEHBa-202107-V-028).

BPMN modeling of CTR transmission process

The business process model and notation (BPMN) method was chosen to visualize the observed processes of the care facilities. BPMN is an established and widely used BPM graphical representation and ISO standard developed by the Object Management Group (OMG).
In BPMN, a process is a free sequence of activities or events ordered in a sequence flow and connected through split or merge gateways that redirect the flow into one or multiple paths. Due to its simplicity, business process managers have widely used this standard in many application domains. Despite not being explicitly designed for clinical processes, BPMN has proven its value in the healthcare domain, allowing an easy-to-understand representation of clinical processes, for example [35] – [38].

Analysis of existing CTRs

Existing CTRs were provided by three cooperating institutions (hospital: n=1, care facilities: n=2). The hospital provided approximately 200 datasets as an anonymized and randomized data table. The two care facilities provided datasets as anonymized PDFs. These datasets were used for semantic and frequency analysis.

Semantic analysis of CTRs

A semantic analysis was conducted to better understand the structure and content of CTRs. Semantic analysis is used to extract and interpret the meaning of terms and sentences. In the discipline of computer science, it is a fundamental component of natural language processing (NLP) [39], [40].

Frequency analysis of CTR entities

A frequency analysis describes how often the same elements occur within a more significant total quantity. The elements to be analyzed are filtered out and counted. The numerical value determined in this way is understood as the absolute frequency. In addition, the relative proportion of the total quantity can be determined, referred to as relative frequency.
In the context of this paper, frequency analysis is applied to read the relative frequencies of individual CTR entities from a large dataset to determine the relevance of the entities to the care

transfer process.

User story mapping

User story mapping [41] is a user-centric bottom-up technique to outline a product or product feature. The output of this method is called a story map, which builds a global view of a product while providing all the necessary details. A story map can help prioritize tasks, detect dependencies between user stories, and adapt when changes occur. It comprises a release dimension (vertical axis), a backbone (horizontal axis), and user stories. The backbone describes how a user would use the product. The release dimension covers the whole scope of the product usage. The backbone illustrates the user's activities per usage step and the type of user involved. User stories represent a refined version of an activity. User stories follow the pattern “As <user> I want to < feature > so that < value>” [42].

A story backlog is a list of user stories. Those user stories are focused on building small features in agile development. However, they cannot provide the big picture of the whole application. No global view shows user stories in the context of the whole product. That can be achieved with a story map.
In summary, a user story mapping can be seen as a method to organize user stories into a structured global view, leading to a common understanding of the application for developers and stakeholders. Further, it encourages communication between all parties to eliminate misunderstandings early in the development cycle. A user story map enables the team working on an understandable solution to focus on the users and their experience without losing the global view. A user story map is created within a story mapping workshop.
To conduct such a workshop effectively, initial results in terms of requirements management must be available: customer exchange, brainstorming about customer expectations, capturing a product vision in the first draft, and rough process modeling of the anticipated system. All results of the requirements analysis flow into the preparation of the upcoming workshop.

Results

Online questionnaire

A quantitative online survey was used to obtain details about the work of nurses in the transition process and to inquire about problems and wishes in Germany.
59 subjects participated in the online survey to determine the experiences and needs of nursing professionals regarding care transition reports, of which 35 met the inclusion criteria. Two of the 35 subjects did not finish the survey, giving a total of 33 usable datasets ($n = 33$). Below, more specific sociodemographic information about the participants is given (Table 1). The systems or software overview is also provided (Table 2).

Table 1. Sociodemographic information of participants

Gender	
Female	67%
Male	30%
No specific gender	3%
Age	
18-24 years	6%
25-34 years	40%
35-44 years	21%

45-54 years	24%
Over 55 years	9%
Care setting	
Short-term care	6%
Acute inpatient care (hospital)	85%
Long-term care (care facility)	9%
Federal state (within Germany)	
Bavaria	97%
Berlin	3%

Table 2. Information about the system/software used

System/software used for the creation of CTRs	
I use software	61%
I do not know	12%
I use a paper form	15%
I use a paper form and software	9%
Specific software used	
Orbis	49%
C&S	3%
SAP	3%
Sic Pflegeassistent	3%
SnapAmbulant	3%
Sorian	3%
Not specified	36%

The results showed that 82 percent of the CTRs are transferred via the patient. This results in a shortened or no preparation time for those needing care. This corresponds with the results from the conducted field observations. The other 18 percent transfer the CTR via fax, patient transfer, electronic patient record, or telephone.

According to the survey, the manual transfer of the CTR into the in-house system takes an average of 45 minutes, and 61 percent of care staff perceive the transfer process as time-consuming.

Regarding what the participants would think about digital transmission of CTR (cross-institutional dispatch and automatic integration into the in-house system), most participants (70 percent) expressed no concerns. The other 30 percent worried about, for example, a possible threat to patient data protection (12 percent). Most respondents hope digital CTR transmission will reduce administrative effort (72 percent). Some participants indicated that they favored the standardization of CTRs (55 percent) because standardization of CTRs would result in relevant information being found more quickly in the future. Based on the answers, the primary consideration in developing a new solution should ensure, for example, that receiving, sending, and creating a CTR is less time-consuming for nurses than in the current process.

Field observations and contextual inquiries

Field observations: The results of field observations at UHA (n = 6) in 2020, presented in summary in [15], showed a high administrative time burden for nurses (see Observation Duration in Table 3 for the CTR transmission process). Manual recording of CTRs resulted in an average time expenditure of 34 minutes. The observations showed that the CTRs were not sent in advance but arrived with the patient. While entering the data into their in-house system, the care staff mentioned that they could not prepare adequately for the patient in advance (e.g., by preparing medications and nursing aids). The field observation also showed that the nursing specialist endures many interruptions while entering the CTR (relatives, colleagues, doctors, telephone, patients, or emergency calls). This shows that they have to switch between different tasks very often. Therefore, the nurse had to refocus on the CTR repeatedly. During the observations, many of the observed nurses complained that the manual transfer of the CTR takes a lot of time. After the observations, it was asked if they believed that digital support of the CTR transmission process might help to reduce administrative workload. All of the observed nurses agreed. Some nurses pointed out that even if only the digital transfer of the CTR works, it will be helpful because they could prepare in advance. To the question of what they think about a standardized CTR, the most common answer was that it would help them a lot, as the CTRs they work with are usually different in their structure and semantics. Lastly, their opinion on automatic data integration was requested; they were curious as to whether something like this is possible, so they do not need to copy and paste information manually. In every observation, one nurse was observed.

Table 3. Overview of CTR transmission process observations, hospital

No.	Facility	Observation duration	Soft-ware	Interruptions	Resource used for transferring data	CTR present (print)
1	Hospital	50min	ORBIS	Relatives, telephone, colleagues, doctor, missing information	Computer, telephone	Present
2	Hospital	25min	ORBIS	Telephone, missing information	Computer, telephone	Present
3	Hospital	40min	ORBIS	Relatives, telephone, colleagues, ambulance	Computer, telephone	Present
4	Hospital	45min	ORBIS	Colleagues, doctor, telephone, patient	Computer	Present
5	Hospital	25min	ORBIS	Doctor	Computer	Present
6	Hospital	23min	ORBIS	Emergency call, colleagues	Computer	Present

After conducting the field observations at the hospital, it became evident that some questions were still unanswered, so one additional contextual inquiry was conducted.

Contextual inquiries: Contextual inquiries (n = 3) in 2021, as shown in [15], and 2022 (n = 2), were conducted at two care facilities and UHA; see Table 4. The results of the contextual inquiries provided a good impression of the observation duration, the confounding factors, and the aids used. For most observations, documents about the patient (e.g., doctor's letter, medication plan, CTR) were available as printouts. These were either sent with the patient or faxed to the referred institution. The latter could occur during registration or after inquiring about missing CTRs or information. The duration of four complete observations in care facilities and one hospital (excluding No. 2 because no input happened) averaged 47 minutes. In observation No. 2, it took 33 minutes to determine that no CTR was present and it could not be sent from the sending facility. However, this required the nurse to make internal and external phone calls. She also needed to delegate procurement actions to colleagues in the facility (e.g., ask colleagues to check if the CTR might not be in the facility after all). In other cases, the CTR was handed out to the patient on discharge but was not necessarily available right after the patient arrived at the receiving facility, when the data was entered into the system.

All nurses of the contextual inquiries noted that the transfer process takes a long time, especially if they need to retrieve missing information and also because they had to refocus on CTR data input due to the many confounding factors.

Another interesting observation was that the nurses at the care facilities entered information from the CTR, doctor's letter, medication plans, and the initial interview with the patient combined in free text fields.

After the contextual inquiries, the same questions were asked as in the field observations. The nurses responded very similarly.

Comparing the average duration of input time in care facilities (excluding No. 2 because no input happened) with the hospital shows that the care staff needs approximately 56 minutes in the care facilities and only 20 minutes at the hospital.

Table 4. Overview of CTR transmission process contextual inquiries, care facilities and hospital

No.	Facility	Observation duration	Soft-ware	Interruptions	Resource used for transferring data	CTR present (print)
1	Care	55min	Con-ntext Vivendi NG + PD	Telephone, colleagues, technical problems	Computer, smartphone, telephone, pen, fax	Present
2	Care	33min	None used	No CTR present	Computer, smartphone, telephone, fax	None present
3	Care	78min	Con-ntext Vivendi NG + PD	Telephone, colleagues	Computer, smartphone, telephone, paper, pen	Present

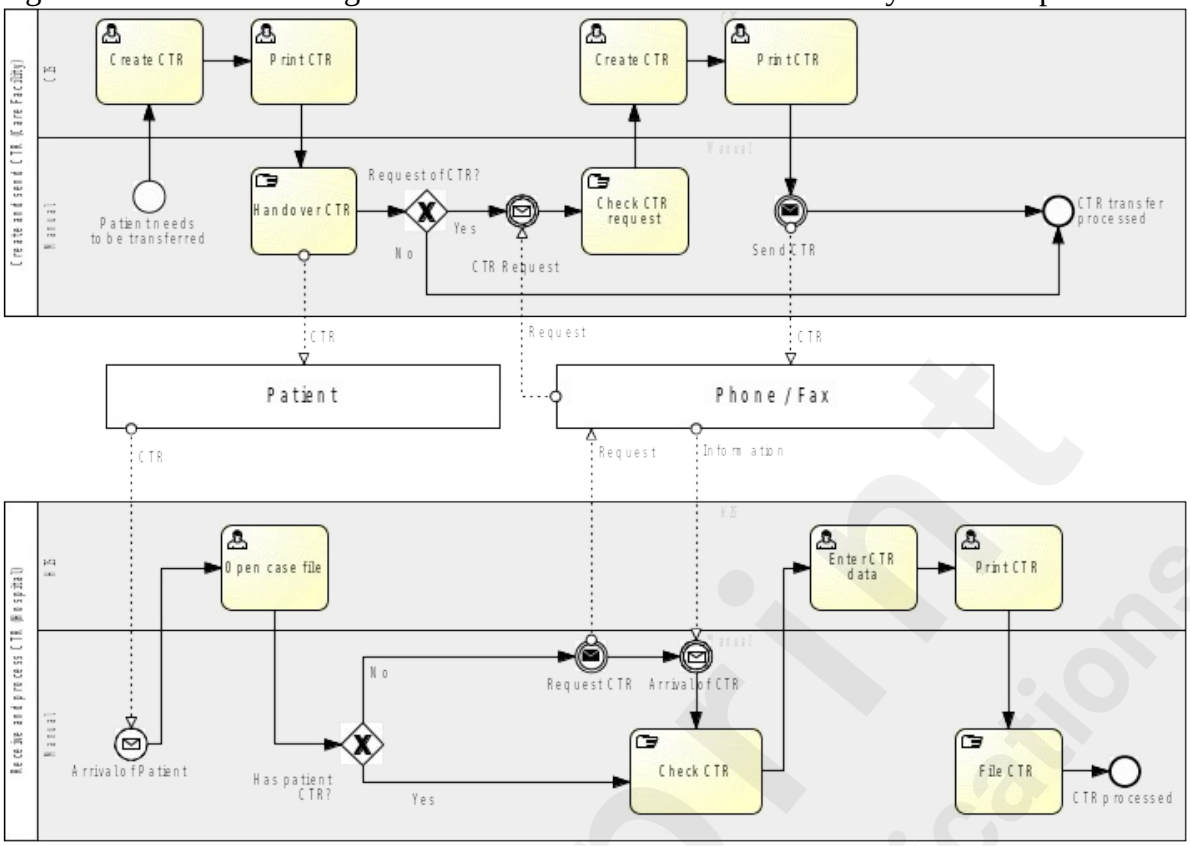
4	Hospital	20min	ORBIS	None	Laptop, paper, patient	Present
5	Care	37min	Sic Pflege-assistent	Telephone	Telephone, paper, pen	Present

BPMN modeling

Based on the findings of the observations, BPMN models were created to better understand all related CTR activities (creating, sending, receiving). These were discussed with the respective facility and found in the previous publication [15]. After this, the process models for the two care facilities were combined into one process, as the activities were identical. Furthermore, the models were divided into different lanes, making it easier to understand which activities are manual and which are software-based (human-computer interaction).

University Hospital (UHA): The process starts with the patient's need to be transferred (see Figure 1, upper lane). The nurse at the care facility creates a CTR, prints it, and usually hands it to the patient. Then, the patient arrives at the hospital, and the nurse opens the patient's case file and checks if the CTR is available and whether it is complete and error-free. If so, she transfers the CTR into the hospital information system (HIS), prints the CTR in its specific structure, and files the CTR manually. After this, the CTR is processed, and the process is complete. If the CTR is unavailable, the nurse calls the care facility. The request is then processed there. If a CTR is missing, the sending facility creates a CTR, prints it, and sends it via fax to the hospital. Next, the nurse checks the document (e.g., the correct CTR for the patient). After that, the CTR is transferred into the HIS, printed, and manually filed. The process is complete.

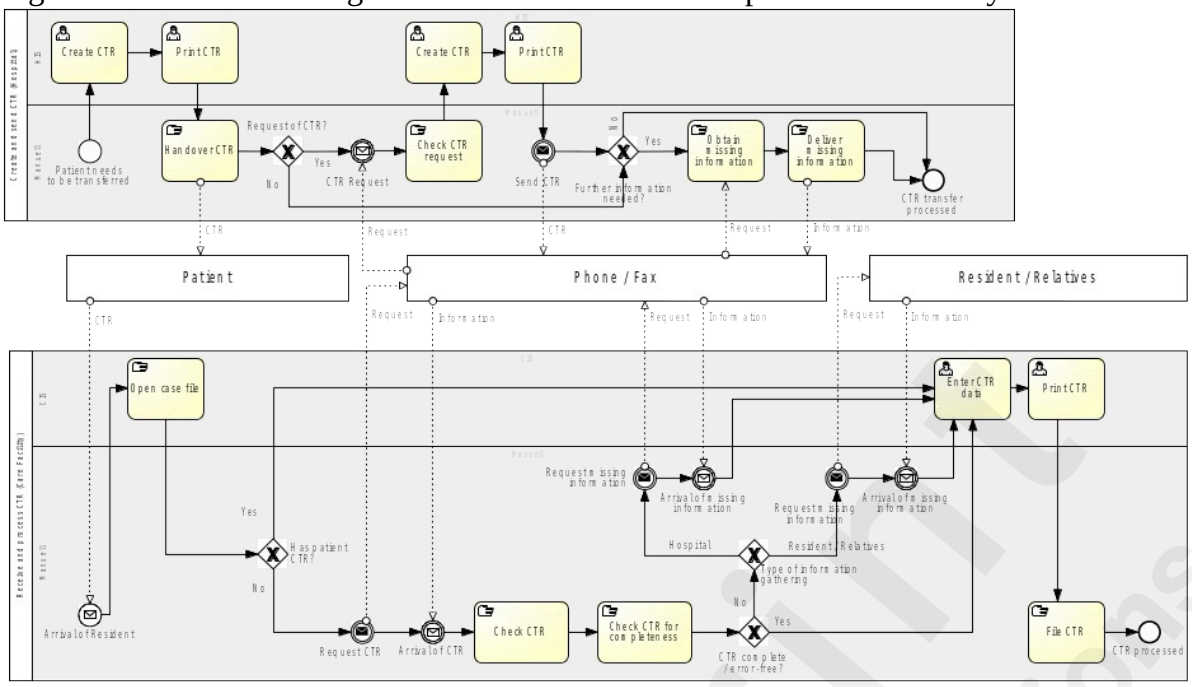
Figure 1: Process modeling: CTR data transfer from the care facility to the hospital



Care facilities: A patient is transferred from the UHA (see Figure 2 for details) to a care facility. At the UHA, the nurse creates a CTR, prints it, and hands it to the patient. After the arrival of the patient (now called resident), the nurse from the care facility logs into their care information system (CIS) and checks if the resident has a printed CTR. If so, she starts transferring the CTR into the system; afterward, she prints the document and files it manually. After that, the process is complete.

If the CTR is unavailable, the nurse requests it from the UHA via phone. In the UHA, the request is checked and processed. A CTR is created, printed, and transferred via fax. After the arrival of the missing CTR, the nurse checks the CTR (e.g., the correct CTR for the patient) and examines whether it is complete and error-free. If there is missing or wrong information, the nurse requests the missing information either from the UHA via telephone or directly through the resident or relatives. After the arrival of the missing information, the nurse starts transferring the CTR, prints it from the CIS, and manually files it. The CTR is processed, and the process is complete.

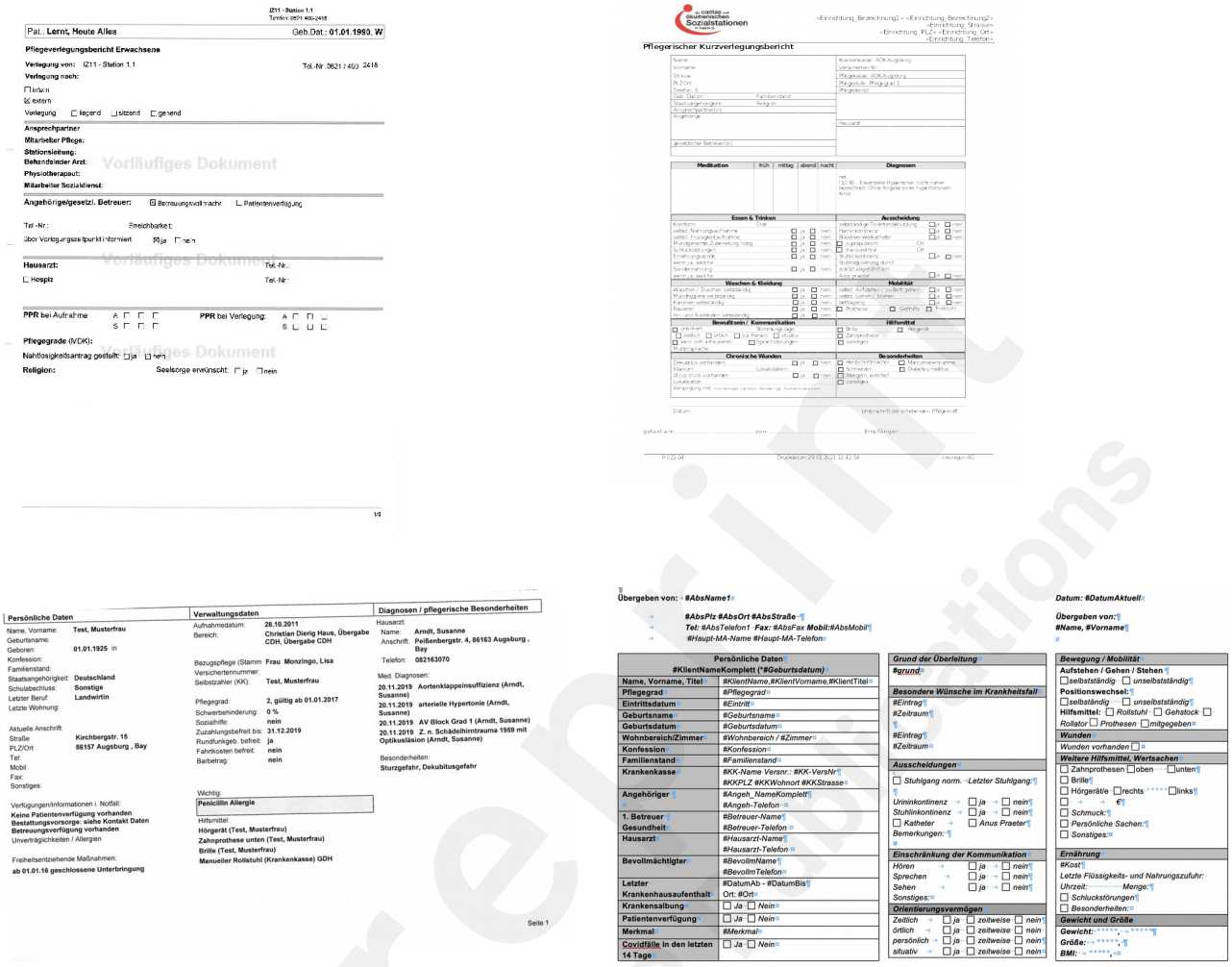
Figure 2: Process modeling: CTR data transfer from hospital to care facility



Semantic analysis of CTRs

As explained under “State of the art”, the data format CTR-MIO (in German PIO-ÜB) has been identified as a suitable exchange format. Due to the existing differences in the data structures and formats of the various in-house systems of the nursing facilities (see Figure 3) and the CTR-MIO, the in-house systems of the nursing facilities must provide a suitable interface to map patient data to and from the CTR-MIO correctly.

Figure 3: Excerpt from care transition reports from one hospital and three care facilities showing the differences in format.



This mapping is often not easy and raises questions because the CTR-MIO is a compromise of many different CTR variants established parallel to each other in Germany over the years.
The semantic analysis was conducted by assigning parts of the CTRs to the data structure of the MIO-CTR (see Figures 4 and 5). In the tree structure on the left, the green root node represents a CTR-MIO resource, and the leaves branching off from it represent the specifications of the resource.

Figure 4: Schematic representation of the semantic analysis

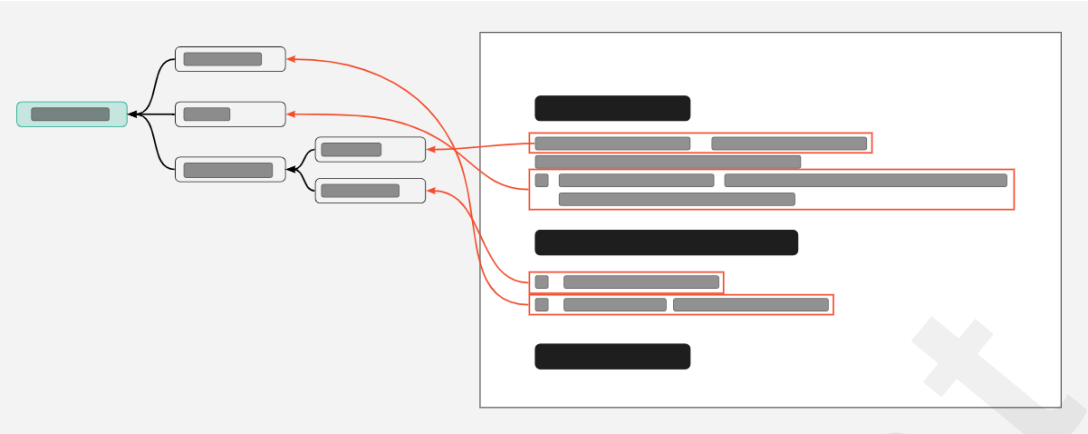
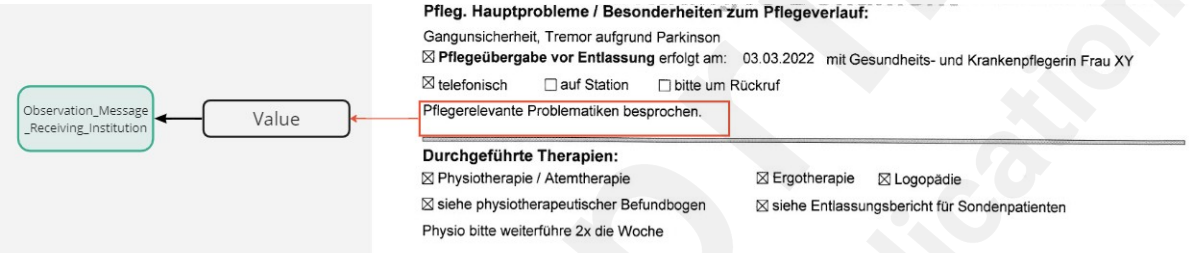


Figure 5: PDF-CTR on the right with a free text field (red rectangle) mapped to corresponding resources on the left (black and green rectangle).



In an initial attempt to map the CTR to the CTR-MIO, there were some entities (e.g., diagnosed diseases, deafness, aphasia, limited vision) that could not be assigned to one field in the CTR-MIO. In some cases, the assignment was not even possible. Furthermore, some fields in the CTR-MIO are implemented as free text fields, which prevents unambiguous, error-free mapping since the user can write any information into a free text field.

Figures 6 and 7 show a section of the mapping between the CTR-MIO and the CTR of both Augsburg University Hospital and one care facility to illustrate the complexity. In the semantic analysis, we could assign 147 out of 148 information objects for the care transfer to the MIO object, while in the care facility, 114 information objects out of 125 could be assigned. Further interviews with care professionals on understanding the care transfer reports revealed that most fill-in fields are not required. That raises the question of the extent to which the arrangement of the individual fields makes sense if some of the most important fields are at the end of the report. The most important fields include patient master data, exemption from co-payment, doctors' prescriptions, information on excretions, and information on aids brought along.

Figure 6: Excerpt of the mapping of CTR of the University Hospital Augsburg to the PIO standard (1 of 6 pages). The X shows that one piece of information could not be mapped.

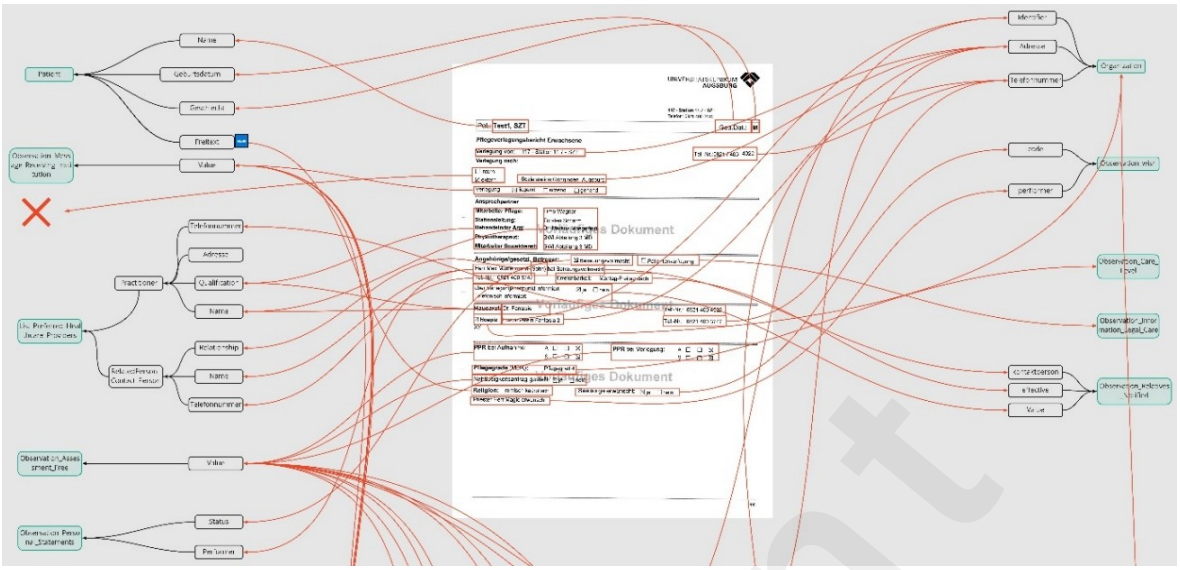
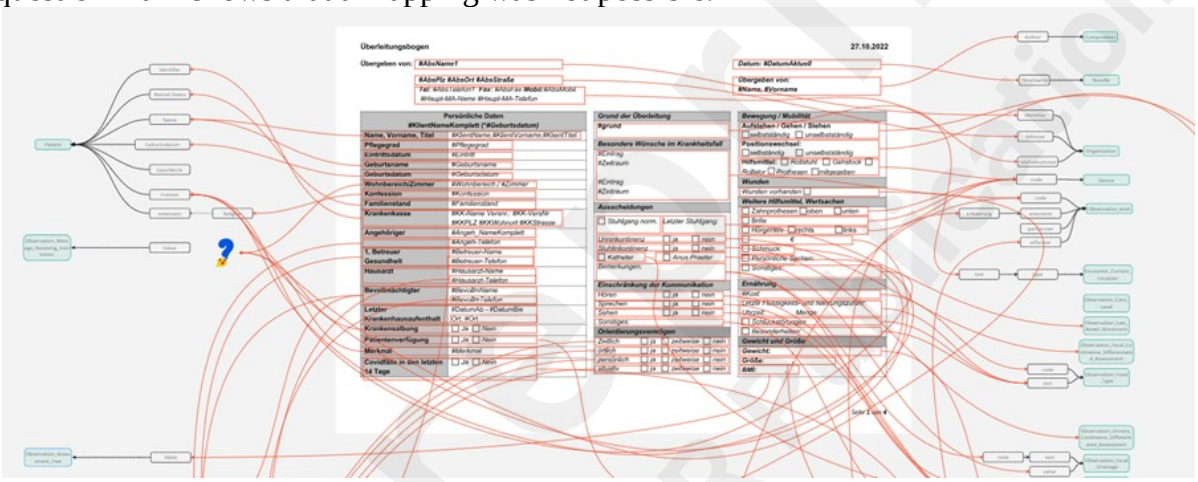


Figure 7: Excerpt of the mapping of CTR of a care facility to the PIO standard (1 of 4 pages). The question mark shows that a mapping was not possible.



Frequency analysis of CTR entities UHA

In this frequency analysis, the authors estimated the minimum requirement of 100 - 200 CTRs to calculate individual entities' relative frequency and avoid unexpected biases that could falsify the results.

An entity is understood to be a single piece of information that is represented in the CTR by its input field.

The UHA presented 204 CTRs; the two care facilities only 50 and 4 respectively.

For this reason, this analysis focuses exclusively on the CTRs of the UHA.

Based on these results, a percentage for each entity could be computed (entity is filled or not filled), and a frequency range was created (commonly used, occasionally used, rarely used). These ranges are used to estimate the frequency of the entities for the nursing transition process and are shown below:

- **100% - 50%:** Commonly used entities
- **49% - 25%:** Occasionally used entities
- **24% - 0%:** Rarely used entities

The results of each entity were presented to care staff (n=2) of the UHA who are involved in the CTR process and discussed. An extract of the result is presented in Table 5. It is important to note

that the frequency analysis was limited to data with no personal information about patients, e.g., date of birth, primary care physician, contact options, and religious affiliation, as the UHA anonymized the CTRs for further processing.
However, during the discussion, the nursing staff stated that all personal data can be classified with high frequency and so as commonly used entities.

Table 5: Extract from the frequency analysis from UHA

Very relevant 100% - 50%	Personal hygiene (98%)
	Orientation ability (97%)
	Dressing (97%)
	Medication: Reference to physician's letter (96%)
	State of consciousness (93%)
	Nutrition (92%)
	Mobility (87%)
	Presence of pain (87%)
	Main diagnosis (82%)
	Last bowel movement (73%)
	Items brought along: Suitcase (59%)
	Degree of care (56%)
Relevant 49% - 25%	Nursing-relevant secondary diagnoses (34%)
	Location of pain (33%)
	Nursing main problems & peculiarities during care (28%)
Less to not relevant 24% - 0%	Medication: Reference to medication plan (11%)
	Free text field about pain (9%)
	Seamless request: Yes / No (4%)
	Pastoral care requested: Yes / No (1%)
	Aids ordered and their retailers: (0%)
	Items brought along: Valuables (11%), insurance card (11%), identification (2%), patient passport (0%), etc.

Even though the information about the main diagnosis (82%), state of consciousness (93%), and nutrition (92%) are rated with high frequency, their placement in the CTR is not adequate as they appear relatively late in the document.
Another finding is that the bowel movement is rated as one of the most essential pieces of information in every observation or interview. Still, it places only at 73% frequency. Surprisingly, nursing-relevant secondary diagnoses (e.g., information about care problems) were given only 34%. Medication information was also expected to be rated higher, but as this information is usually given in the context of the physician’s letter and not with the CTR, the rating was only 11%.
Concerning items that were brought along, many different selection possibilities were given. Valuables (11%) and insurance cards (11%) were the highest among them. Additional information about the individual items is not given.

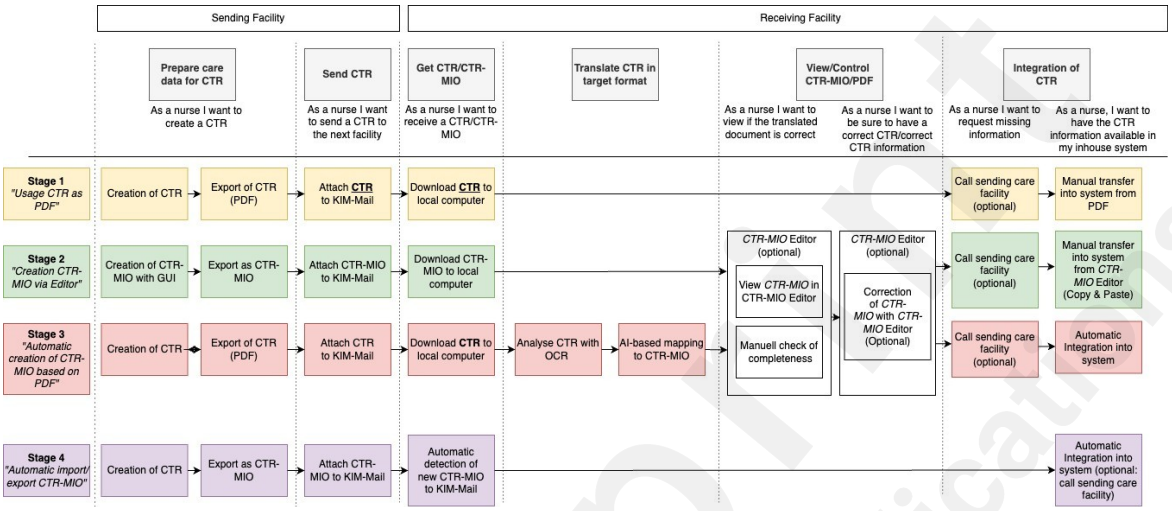
Overall, the frequency analysis results helped to better understand the data exchange in the care transition process.

User story mapping

The workshop was held in hybrid form with seven participants: online (n=2) and live on-site (n=5). They were representatives of healthcare, computer science, design, and IT security domains. Within

several iterative exchanges, the group designed a two-dimensional graphic consisting of a horizontal axis, which depicts the transition process from a hospital to a care facility (possible epics), and a vertical axis, which depicts the technical complexity of the solution with increasing size (possible releases) as well as the associated story cards or future tasks of the team.
In Figure 8 below, the described release stages are on the left, the usage dimension and backbone are on the top, and user stories are in the middle. Intermediate results that were published can be seen in [43].

Figure 8: Complete user story mapping with different release stages

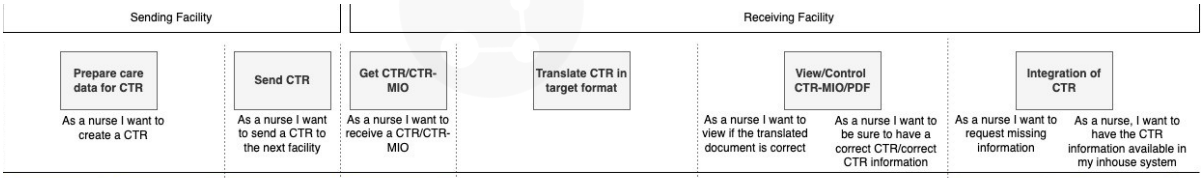


Four release stages are shown on the left, divided into four colors to provide a better division throughout the user stories. Some story cards do not have color, as they apply to multiple release stages. The following describes the usage dimensions, backbone, release stages, and implementation scenarios.

Backbone

The horizontal axis of the user story map shows the main high-level activities that the user has to process sequentially to achieve the primary goal of exchanging patient data between two care facilities. These activities can be called epics and are listed in the top row of Figure 9. Additionally, user stories were formulated for these main tasks, to aid understanding.

Figure 9: Detailed view of the backbone of user story mapping

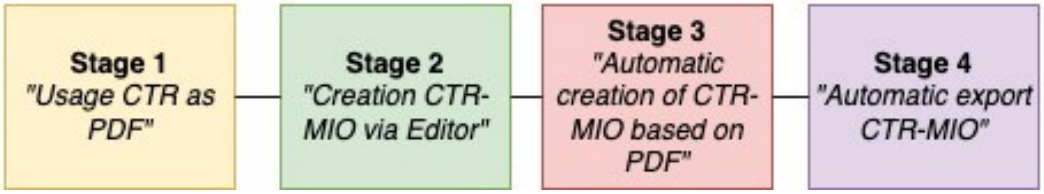


The epics roughly describe the process from the creation of CTRs in the sending facility to the integration of the patient data into the nursing documentation system of the receiving facility, while the user stories in the bottom row of the figure concretize the epics. For each epic, several stages were planned, which are explained below.

Release stages

A short overview of all release stages (1-4, see Figure 10) is given here, followed by a description.

Figure 10: Overview of the four release stages



Release stage 1: Usage of CTR as PDF

The first release requires the least implementation effort but only fulfills the most important basic requirements. The functionality is limited to the digital sending of conventional CTRs in the form of PDFs which are sent via the TI. This can at least solve the problem of delayed data transmission.
This release requires the sending and receiving care facility to be connected to the TI. The sending facility creates a CTR in the facility-specific layout as usual and sends it using the KIM service provided by the TI. KIM can be compared to an e-mail service designed to exchange sensitive patient data between medical facilities. The receiving facility can then retrieve the CTR from the KIM mailbox.

Release stage 2: Creation of CTR-MIO via editor

The care staff should be able to manually create CTRs in the CTR-MIO format. Therefore, a software module, “CTR-MIO editor”, which allows the manual creation and editing of CTR-MIOs, shall be developed and provided. The graphical user interface of the editor shall visualize and structure all information that can be mapped in a CTR-MIO so that the users can find their way around the CTR-MIO structure without any problems. The CTR-MIO editor is a quick and easy solution for care facilities to establish the CTR-MIO standard in their facility. CTR-MIOs are sent via TI as a KIM mail.

Release stage 3: Automatic creation of CTR-MIO based on PDF

Release stage 3 implements an automatic translation of patient data into the CTR-MIO format. It is assumed that the CTR is available as unstructured data (PDF). To map the CTR to the CTR-MIO format, a translator service is needed. This service analyzes the structure of the CTR using AI and extracts text sections with an optical character recognition (OCR) module. The extracted content is mapped to the CTR-MIO format.
The transfer result can be displayed using the CTR-MIO editor (see Release stage 2). CTR-MIOs are still sent via TI. This variant has the potential to significantly reduce workloads for care transitions, as a uniform data exchange format can be generated without additional effort.

Release stage 4: Automatic export of CTR-MIO

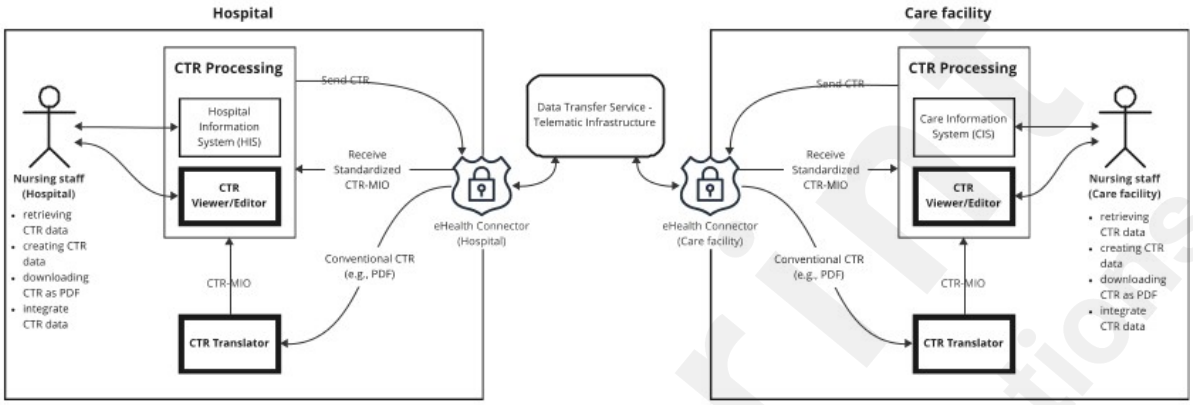
In this release stage, neither a translator service nor the CTR-MIO service is needed. The care staff can create a conventional CTR in the in-house system, export it as a CTR-MIO and transfer it via the TI. The receiving facility can then, after receiving the CTR-MIO, integrate it into their in-house system automatically via import.

Summing up and visualizing the new approach

In the project’s early phase, an initial solution sketch was developed to discuss possible solutions and technical aspects with the stakeholders in the workshop, as seen in [15]. The authors roughly illustrated how two central digital applications could be implemented as interim solutions in a new CTR transition process. On the one hand, the authors proposed a “CTR translator” that transfers PDF

to HL7 and, on the other hand, the “CTR viewer/editor”, which is an application for visualizing the new CTR-MIO standard.
Based on the findings, we developed a new system sketch (see Figure 11), which clarifies system boundaries within the hospital and care facility environment and how our new services shall be integrated. Also, the new standard format CTR-MIO and all release stages are included.
The proposed new process is explained in more detail in the following section.

Figure 11: Overview of a new solution sketch. The highlighted boxes with thicker lines represent the new services, which are temporary solutions until automatic integration is possible.



A nurse practitioner can enter/edit and retrieve CTR data via the hospital/care information system. If their in-house system does not yet support the standardized CTR-MIO format, the CTR viewer/editor can view it or create one. If a patient needs to be transferred, the nurse practitioner can digitally transmit the data to the receiving facility using the Data Transfer Service – TI. This will require an eHealth Connector and corresponding electronic authentication cards for both the sending and the receiving facility. Apart from the CTR-MIO editor, the equipment, as mentioned earlier, provides the minimum level of secure exchange of patient data by sending the CTR. There are three possible scenarios for receiving and processing CTRs. First, if the receiving facility already supports the CTR-MIO standard format and receives a standardized CTR, this can be transferred and integrated directly into the hospital/care information system. Otherwise, if the receiving facility receives a non-standardized CTR (typically in PDF format), it must first be translated into the CTR-MIO standard by a “CTR translator” to be transferred later to the hospital/care information system. On the other hand, if the receiving facility does not yet support the CTR-MIO standard and receives an already standardized CTR, the care facility can view the CTR with the help of the “CTR viewer/editor” and subsequently export the CTR as a PDF file or copy the data manually to the hospital/care information system.

Discussion

Principal results

Our research showed that despite ten years of progress in digitalization in Germany, the average duration of creating a CTR (53 min) had barely changed depending on the care facility (average time at UHA = 34 minutes, care facilities = 47 minutes, statements about duration within online questionnaire = 45 minutes). The most influencing factors are the time-consuming creation of CTRs, the lack of implemented standard formats for CTRs, many proprietary software solutions, and, in general, the late timing of CTR transitions.
Thus, it is (still) necessary to optimize transition management by digitalizing CTRs and streamlining the CTR transmission process, improving the care staff’s working conditions. The existence of a

standard format since Dec 2022 (CTR-MIO) is an essential step towards a standardized digital solution. However, implementation in practice is only likely to be achieved by a step-by-step modular approach.
Software manufacturers are reluctant to implement the new standard as this is resource-intensive, and they may not be eager in some cases to have all their data fully interchangeable as this could jeopardize their business model. Thus, manufacturers are not expected to implement the new CTR-MIO standard soon without support, incentives, or regulatory pressure.
Lacking the ability to regulate, we plan to support establishing a fully digital, seamless transfer solution of CTRs through a step-by-step approach developed in the user story mapping workshop described above. For stage one (data transfer via TI), we accompany and assist our cooperating partner institutions in installing the necessary infrastructure to connect to the TI. We plan to offer experience reports, stating, for example, where the difficulties lie, and best practice reports on solving common pitfalls. This could lower the entry hurdle, especially for care facilities. For stage two (creation of CTR-MIO via editor), we are developing an open-source software where CTR-MIOs can be created, viewed, and edited. This has several benefits:

(1) Development of a user interface where all necessary input fields, dependencies between entries, and a general layout of the information are realized. In this way, a dialogue with the target group (care professionals) and user tests are possible. People working in the field are seldom capable of understanding a 2000-page data format specification. However, they are the experts working with the resulting documents. By showing them a concrete realization of the specification, they can better discuss implications or detect missing information. We plan to collect the findings and forward them to the standard issuing organization mio42 GmbH.

(2) Bridging the gap for continuous digital transfer if not all institutions support the new digital standard. Of course, this should be only an interim solution. However, institutions that are not capable of reading/importing CTR-MIOs when they get one, e.g., via the TI or an electronic health record, are at least capable of opening and viewing it. On the other hand, institutions unable to export/send CTR-MIOs via their in-house system could create them and then send them by appropriate means.

(3) Serving as a blueprint for software manufacturers who want to implement and visualize the new CTR-MIO format. Typically, health software manufacturers have tight resource constraints. This could reduce their effort and help spread the standard earlier.

Release stage 3 introduces an automated process to convert patient data into the CTR-MIO format from unstructured PDFs, using a translation service with AI-based mapping. The prerequisite is that initial training of the AI system to find the respective fields as well as mapping of these fields to the CTR-MIO format is required. Once operational, this system streamlines care transitions by generating a uniform data format with reduced effort.
As with all such systems, thorough checking of whether this automatic conversion was successful by the care professionals would be necessary (human-in-the-loop). Again, this should also be only an interim solution, as the direct output of CTR-MIO from one system and the direct import into another system (Stage 4) would be the ultimate goal.

Limitations

Our study has some limitations regarding the field observations and the online survey. The COVID-19 pandemic made access to cooperative facilities more difficult as all studies had to be planned well in advance, and there were still several postponements. The results of the field observations and the online survey had only a limited number of participants and thus might not represent the nationwide

care sector due to the low number of participants.

Conclusions

The findings of this paper conclude that a future solution should simplify the overall CTR transmission process by minimizing the manual transfers into the in-house systems, standardizing the CTR, and providing a secure digital transfer. Doing so could positively impact the overall care process and patient experience. With our solutions, we attempt to support care staff with their daily activities and processes until nationwide state regulations are implemented successfully, but we do not know how long this will take.

Acknowledgments

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Conflicts of interest

None declared.

Abbreviations

CTR: Care Transition Record
CTR-MIO: Care Transition Record – Medical Information Object
FHIR: Fast Healthcare Interoperability Resources
HL7: Health Level 7
TI: Telematics Infrastructure
CIS: Care Information System
HIS: Hospital Information System
TUA: Technical University of Applied Sciences Augsburg
UHA: University Hospital Augsburg

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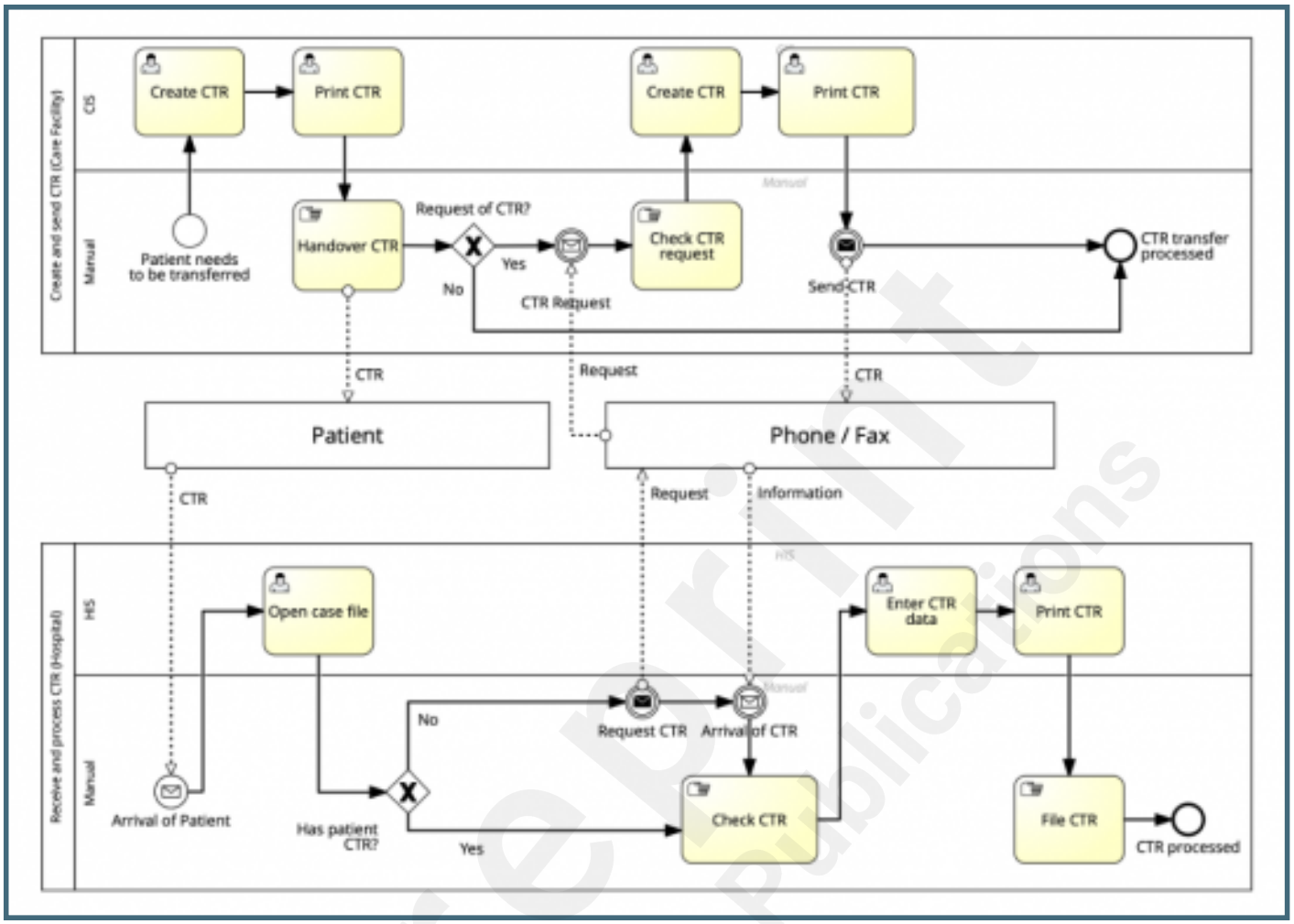
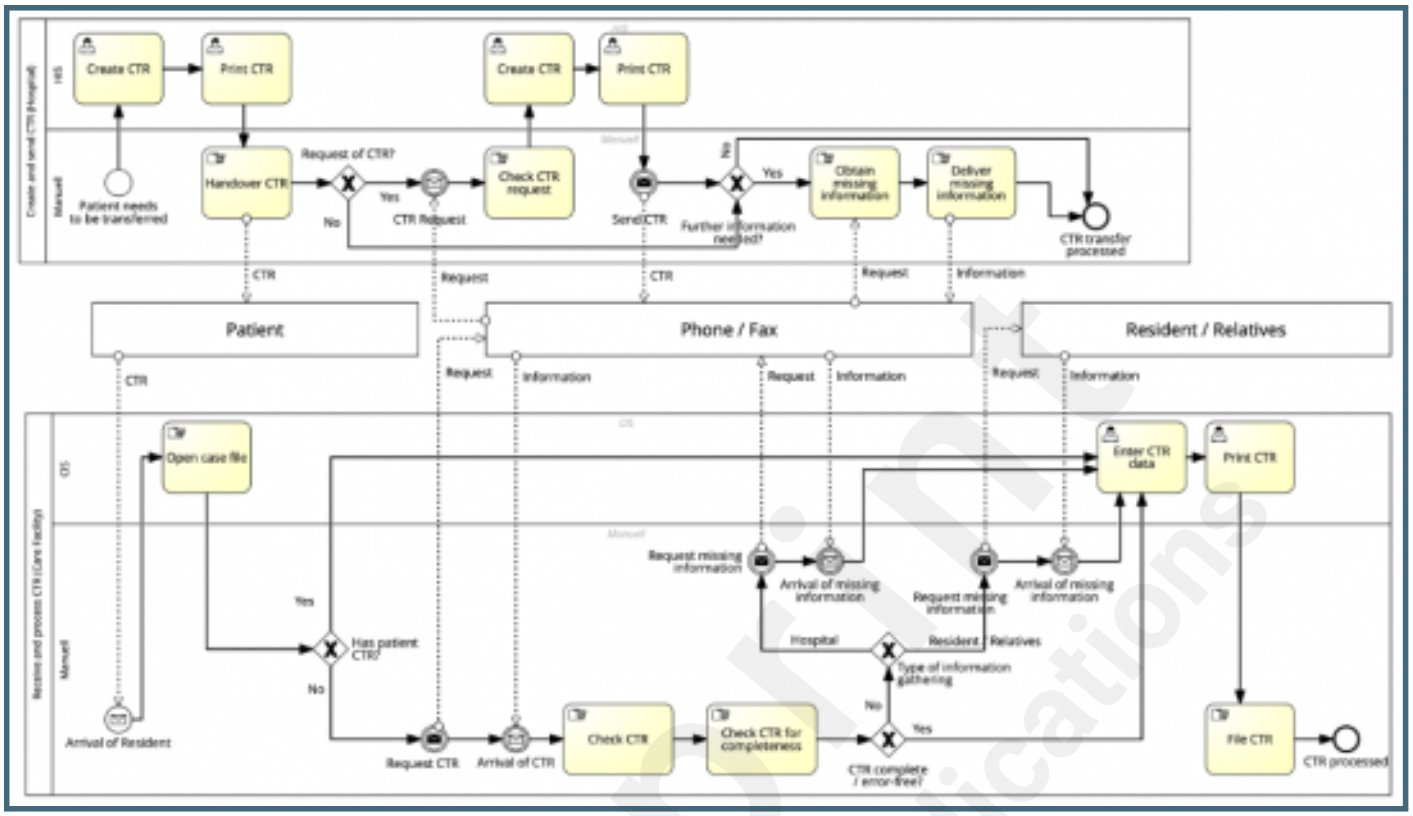
Supplementary Files

Figures

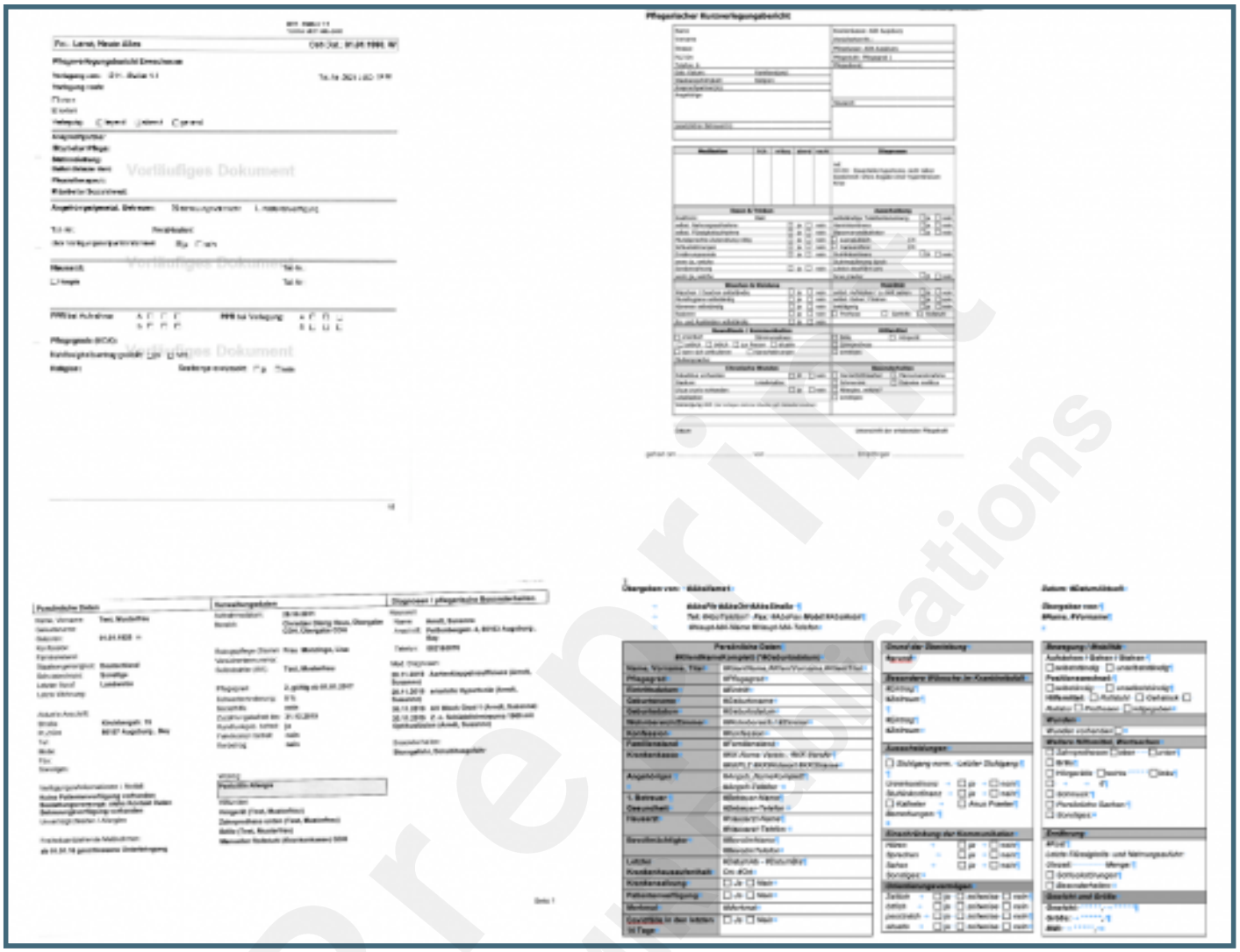
Process modeling: CTR data transfer from the care facility to the hospital.



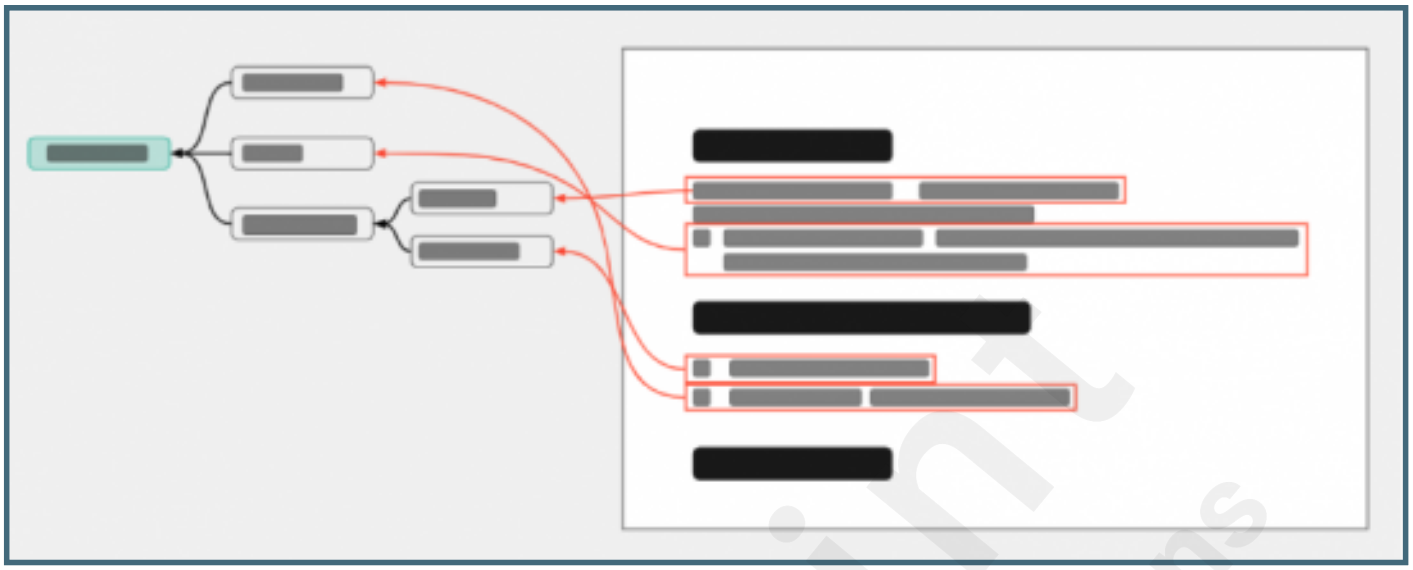
Process modeling: CTR data transfer from hospital to care facility.



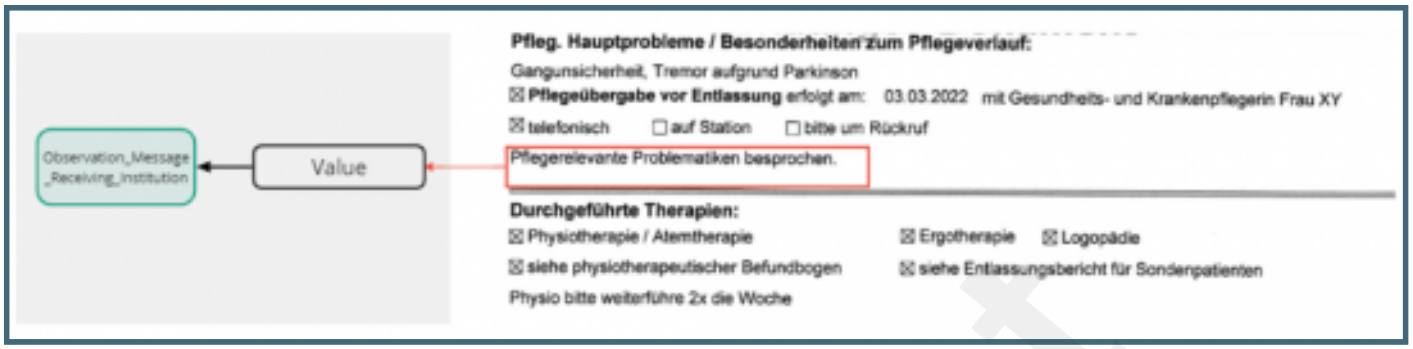
Excerpt from care transition reports from one hospital and three care facilities showing the differences in format.



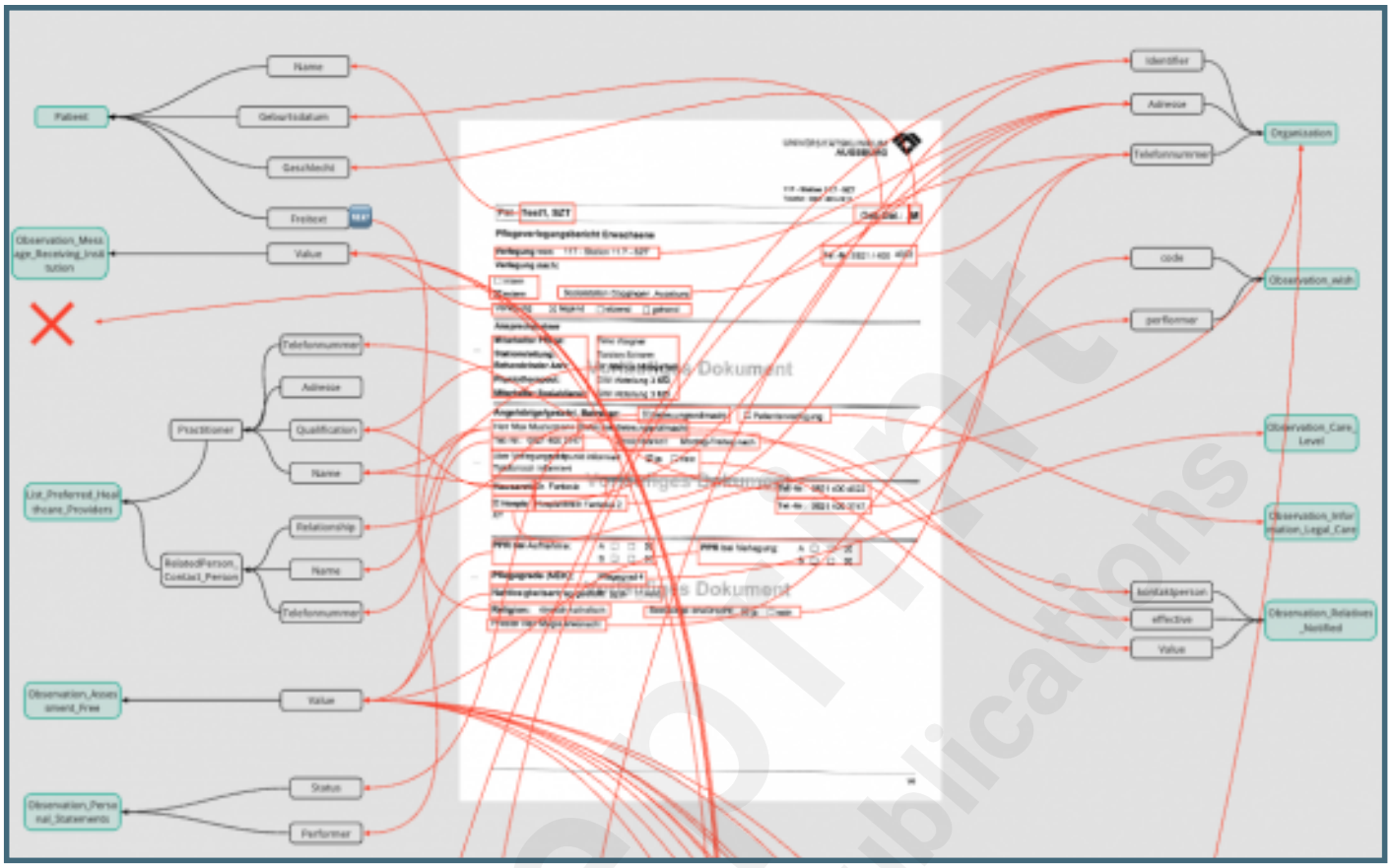
Schematic representation of the semantic analysis.



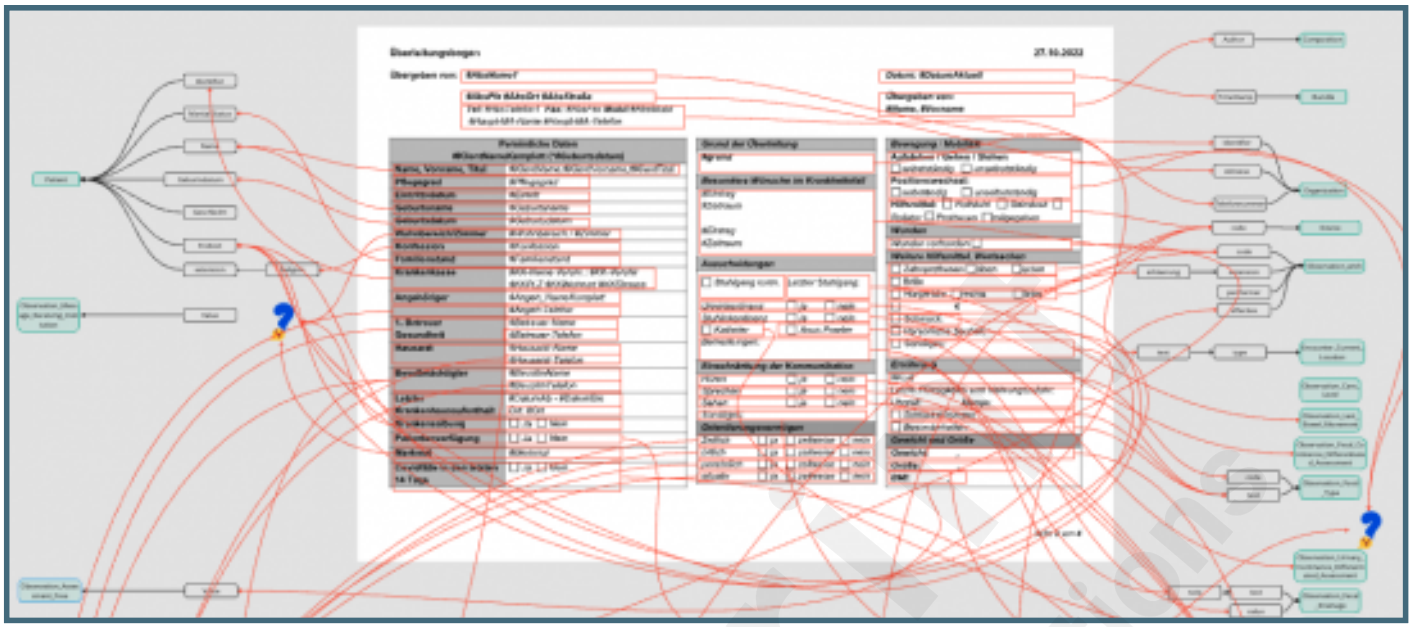
PDF-CTR on the right with a free text field (red rectangle) mapped to corresponding resources on the left (black and green rectangle).



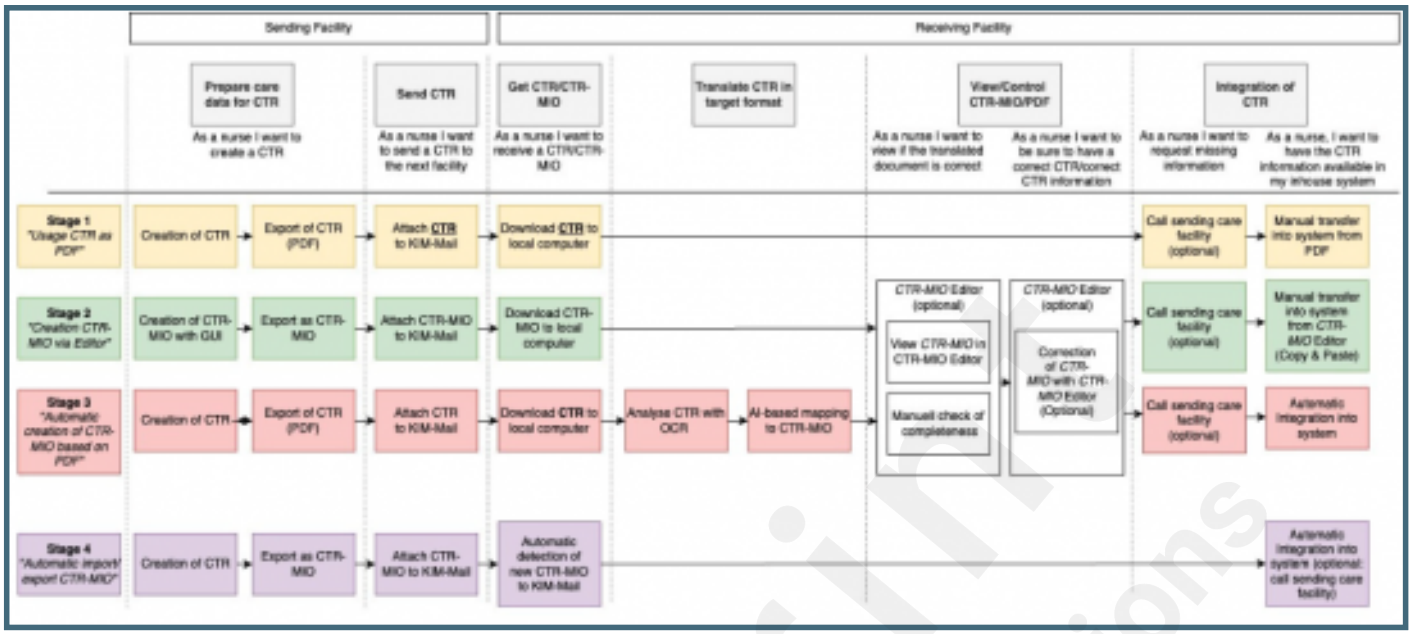
Excerpt of the mapping of CTR of the University Hospital Augsburg to the PIO standard (1 of 6 pages). The X shows that one piece of information could not be mapped.



Excerpt of the mapping of CTR of a care facility to the PIO standard (1 of 4 pages). The question mark shows that a mapping was not possible.

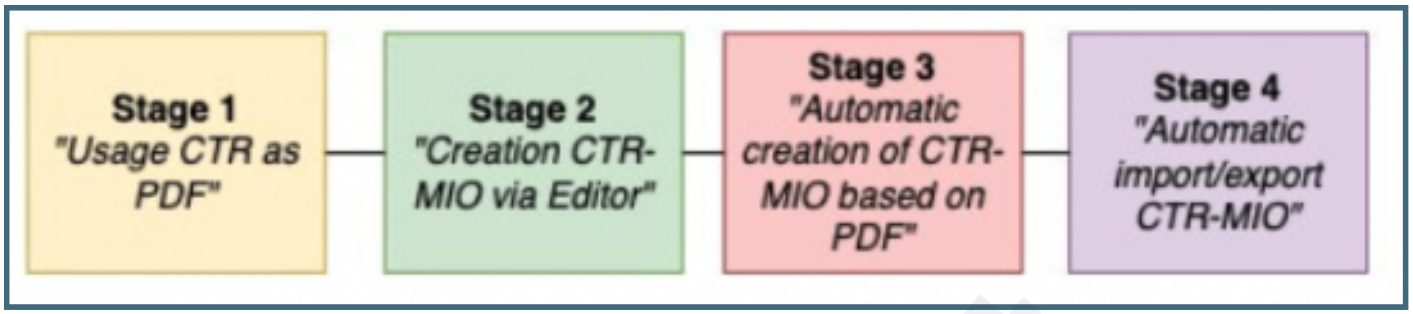


Complete user story mapping with different release stages.



Detailed view of the backbone of user story mapping.

Overview of the four release stages.



Overview of a new solution sketch. The highlighted boxes with thicker lines represent the new services, which are temporary solutions until automatic integration is possible.