Evaluating the Digitalization in the Healthcare Sector: A User-Based Analysis

Inauguraldissertation

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This cumulative dissertation, including the individual research papers belonging to it, was written during my employment as a research assistant beginning in November 2019 at the Department of Management Accounting and Information Systems at the University of Osnabrück. Analyses within the research project “ReKo – Regionales Pflegekompetenzzentrum” (ReKo), in which I was involved in the context of its evaluation, could be partly used.

The conception of this dissertation was only possible with the support of several people. Firstly, I would like to thank my doctoral supervisor, Prof. Dr. Frank Teuteberg, who always supported me with his scientific and methodological expertise during my doctoral research. His input regarding individual contribution plans and his research experience made a decisive contribution to the dissertation. I also want to thank Prof. Dr. Oliver Thomas who was responsible for the co-supervision of this dissertation and did not hesitate to take over this task.

Particularly, I want to thank my project colleagues and co-authors Tim Arlinghaus and Patricia Kajüter Rodrigues for the close and enjoyable teamwork over the past years. Additionally, I want to thank the whole research team of my institute, including Ludger Pöhler, Dr. Eduard Anton, Dr. Thuy Duong Oesterreich, Dr. Julian Schuir, Dr. Alina Behne, Fabia Hettler, Jonas Hammer, Aleksandra Flok and Markus Aptyka. Furthermore, I would like to thank Marita Imhorst, Barbara Meierkord and Albin Sonneck for their help and support with organizational issues. Mrs. Imhorst further contributed to the linguistic design of some publications by proofreading them. I really appreciate having had such great colleagues over the last few years.

Lastly, I want to express my gratitude to my family and friends for their support during the past years. In particular, I want to thank my wife, Dr. Xuanhong Kus-Guo, who has been able to give me advice on specific questions regarding my research while also being considerate during particularly stressful phases of my work. Finally, I would like to thank my parents, Hildegard and Peter, as well as my brother, Christoph, for their continuous support.

Osnabrück, June 2023 Kevin Kus

Notes on the Structure of the Document

This cumulative dissertation is organized as follows: Part A provides a summary of the research conducted in the past years. In particular, this includes the description of the results from the individual research contributions, which have been placed in relation to each other, and the subsequent presentation of implications. At the beginning, the motivation as well as the scientific and methodological fundamentals are presented. Therefore, Part A can be considered as a freestanding contribution, with its own structure, tables, figures, and references.

Part B consists of presenting the individual research contributions in sequence, for which the original format and the corresponding citation style have been used.

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Part A: Introductory Overview

List of Abbreviations

AI	Artificial intelligence
ANT	Actor-network theory
BMG	Bundesgesundheitsministerium (Federal ministry of health)
CM	Case management
CMSW	Case management software
COVID-19	Coronavirus disease
EHR	Electronic health record
IS	Information systems
IT	Information technology
JHU	Johns Hopkins University
PIE	Perceived importance of the ethical issue
ReKo	Regionales Pflegekompetenzzentrum
RQ	Research question
STT	Socio-technical theory
TAM	Technology acceptance model
TI	Telematics infrastructure
UI	User interface
VHB	Verband der Hochschullehrer der Betriebswirtschaft e.V.
WKWI	Wissenschaftliche Kommission Wirtschaftsinformatik

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1 Introduction

1.1 Initial Situation in the German and Global Healthcare Systems

Both the demographic change with a population that is getting steadily older and the shortage of professional workers are posing major challenges that are threatening the quality of healthcare and nursing care services in the German healthcare system (Treviranus et al. 2021).

In 2021, there were approximately five million people in need of care in Germany, representing an increase of 20% compared to the numbers recorded two years earlier (Statistisches Bundesamt 2022). According to the governmental nursing care projections, this number will rise to an estimated 6.8 million people in need of care in 2055 as a result of the ongoing demographic development (Statistisches Bundesamt 2023). Based on these statistics, it can be concluded that there is an enormous need for professional service providers in the healthcare sector in this country. However, it must be stated that there is a severe lack of skilled workers in the German healthcare system, which applies to nursing professions and physicians, particularly in rural regions (Bundesgesundheitsministerium [BMG] 2021a; Schnack et al. 2022). Similar challenges, specifically the combination of increasing average ages of national populations due to demographic changes and a shortage of healthcare professionals, can also be identified in other industrialized countries (England and Azzopardi-Muscat 2017; Flaherty and Bartels 2019).

Additional pressure has been placed on healthcare systems worldwide due to the coronavirus disease 2019 (COVID-19) pandemic. The pandemic has not only led to a substantial increase in workload and a general situation of stress for healthcare service providers, but has also contributed to an acceleration of the digitalization process in healthcare resulting from accompanying contact restrictions and reductions in face-to-face meetings (Kirchberg et al. 2020). Digital efforts in the healthcare sector have been promoted as a result of the pandemic and have enabled, for example, the provision of digital vaccination certificates (Mithani et al. 2022), an increasing offer and usage of telemedicine solutions (Bokolo 2020), and the development of frequently used corona dashboards for up-to-date information regarding the dynamic pandemic situation (Dong et al. 2020; Recker 2021). In addition, separate from the COVID-19 pandemic, there have been national digital initiatives such as the government-initiated development of the German telematics infrastructure (TI), which regulates and enforces the implementation of central digital components such as the electronic health record (EHR) or the electronic prescription (an der Heiden et al. 2021). Information technology (IT), with its potential, can act as a key element in overcoming the challenges of providing adequate healthcare services.

In this regard, the user groups of digital applications and information systems (IS) in healthcare can be manifold, as they not only can include those affected by diseases and further health problems and their relatives but also can refer to professional healthcare service providers (Kraus et al. 2021). The latter can be further differentiated, for example from a micro-level perspective (such as professional caregivers, physicians, or physiotherapists) or from a meso-level view of organizations (such as hospitals or care centers) (Beinke et al. 2019).

1.2 Motivation and Research Aim

Nearly all citizens have had repeated contact with healthcare services during their life. This contact may be as a patient with personal health impairments and the associated use of services or as a relative of a person with health problems. Adequate healthcare can significantly improve not only the physical state of health but also the psychological health condition. Demographic developments are further increasing the societal relevance and complexity of healthcare services because more and more patients, many of whom are multimorbid, need complex healthcare services over a longer period of time, requiring the interaction of various actors in the healthcare system (Treviranus et al. 2021). Accordingly, healthcare services are essential from both personal and societal points of view. Accompanying this, the economic relevance of the healthcare sector in Germany is enormous, underpinned by a gross value of 407.5 billion euros in 2021, which in turn is equivalent to 12.5% of the total gross domestic product (BMWK 2023). In addition, the sector has grown at an annual rate of approximately 4.2 % in recent years, significantly faster than the overall gross domestic product (BMWK 2023).

The possibilities of digitalization offer the potential of overcoming the challenges of nursing and healthcare services in Germany and achieving efficiencies that can be linked to resource savings. For example, customized software solutions can save time for nursing staff by simplifying their daily work (Gagnon et al. 2012), the holistic documentation of a patient's health history in the EHR potentially avoids the unnecessary repetition of examinations and treatments (BMG 2021b), and the provision of telemedicine can enable time-efficient long-distance care for the affected parties (Bokolo 2020). However, these potentials present further substantial challenges, as large-scale initiatives such as the planned development and implementation of the TI with its individual applications such as the electronic medication treatment plan have been accompanied by delays (an der Heiden et al. 2021) or, with regard to the EHR, have not received the population's acceptance underpinned by only a small number of users (Bayerische Staatsregierung 2022; Gematik 2023). In general, it is striking that Germany lags substantially behind most other countries in the level of digitization in the healthcare sector (Messal et al. 2021).

The word eHealth is often used regarding the process of digitalization in healthcare. Although the term has been widely discussed, no consensus definition of eHealth exists (Catwell and Sheikh 2009). Rather, eHealth has received evolving definitions (Meier et al. 2013) which are certainly related to the dynamics of digital developments in healthcare. Therefore, it is appropriate to use the comprehensive and commonly accepted definition of Eysenbach (2001):

"e-Health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve healthcare locally, regionally, and worldwide by using information and communication technology" (Eysenbach 2001, p.1).

In the healthcare sector, it must be noted that central stakeholders affected by eHealth applications as user groups, such as physicians, nurses, or patients, must perform digitalization procedures that may lie far outside of their core competencies, and that at least smaller healthcare institutions usually do not possess any dedicated in-house IT staff. Although elderly people in particular would benefit from digitalization in the healthcare sector, as this would enable better aggregation of medical history, it is precisely this potential user group that did not grow up with IT applications. Accordingly, the use of digital applications is difficult for this group, partly because of a lack of IT skills but also due to physical difficulties that increase with age, such as eyesight problems or tremors, reinforcing the need for extended design requirements.

Therefore, the following research questions (RQs) are addressed within the scope of this dissertation, not only combining two central societal topics, namely digitalization and healthcare, but also considering the characteristic challenges arising in this context and how to overcome them:

RQ1: What challenges can be identified in the digitalization of healthcare and how can these challenges be overcome?

RQ2: How should digital applications in healthcare be designed and accompanied for the respective stakeholders so that the intention to use these eHealth solutions is increased?

RQ3: What are the benefits and possible synergies of eHealth solutions for the respective stakeholders?

1.3 Structure of the Work

This dissertation is divided into five sections. Following this introduction, Section 2 describes the research design in more detail. This description entails enumerating the research contributions contained in this cumulative dissertation, including details of the respective scientific journals and conferences, and placing these contributions in a comprehensive framework that defines the order in which the contributions are presented. The research methods used are also described in more detail in Section 2. In Section 3, the results of the individual contributions are systematically described and placed in relation to one another. Section 4 contains the discussion, which includes implications for research first and implications for practitioners second. In addition, information regarding limitations and an outlook for future research are provided. The dissertation ends with a conclusion in Section 5.

2 Research Design

2.1 Selection of the Research Contributions

This cumulative dissertation consists of ten research publications (cf. Table 1). The author of this dissertation holds first authorship in four contributions, second authorship in five publications, and third authorship in one published article. Seven contributions have been published by major international conferences in information systems. In addition, three journal articles are represented in the publication list. Both the conference papers and the journal publications have undergone a multi-stage, double-blind process of peer review.

Official scientific rankings for publication outlets were considered in the planning process for each contribution. In this regard, all publication outlets used for the research publications have been listed in the VHB-JOURQUAL 3 ranking of the *Verband der Hochschullehrer für Betriebswirtschaft e.V.* ([VHB]; VHB 2015). The list of the *Wissenschaftliche Kommission Wirtschaftsinformatik* (WKWI) also acts as a ranking tool to classify the quality of publication outlets (Heinzl et al. 2008). Only the journal regarding Contribution 10 is not included in the WKWI list, so that the respective journal impact factor of 4.39 according to the Scimago Journal Rank should be mentioned as a second indication for this publication (SCImago 2023). To ensure that the research results can be widely accessible on an international level, the articles have been mostly written in English, and only two articles have been published in scientific journals in Germany and require understanding of the German language. The author of the dissertation performed the main portion of the research work in the first-authored articles (C2, C6, C8, C9) and made relevant contributions in the other publications as a co-author. Prof. Dr. Frank Teuteberg continually reflected on the article structure, provided insights regarding the methodological approach and critically assessed the content in each contribution. A detailed overview of the contributions of individual authors to each publication can be found in Table 1.

<table>
<tr><th rowspan="2">ID</th><th rowspan="2">Bibliographic Information *[0]</th><th colspan="2">Ranking</th></tr>
<tr><th>VHB</th><th>WKWI</th></tr>
<tr><td rowspan="2">C1</td><td rowspan="2">Arlinghaus, T., Kus, K., Behne, A. and Teuteberg, F. (2022): How to Overcome the Barriers of AI Adoption in Healthcare: A Multi-Stakeholder Analysis; in: Proceedings of the 26th Pacific Asia Conference on Information Systems (PACIS 2022). *[1]</td><td colspan="2">Conference</td></tr>
<tr><td>C</td><td>B</td></tr>
<tr><td rowspan="2">C2</td><td rowspan="2">Kus, K., Arlinghaus, T. and Teuteberg, F. (2022): Analyzing Healthcare AI Adoption in China and Germany through the Lens of Socio-Technical Theory: A Literature Analysis; in: Proceedings of the 26th Pacific Asia Conference on Information Systems (PACIS 2022). *[2]</td><td colspan="2">Conference</td></tr>
<tr><td>C</td><td>B</td></tr>
<tr><td rowspan="2">C3</td><td rowspan="2">Anton, E., Kus, K. and Teuteberg, F. (2021): Is Ethics Really Such a Big Deal? The Influence of Perceived Usefulness of AI-based Surveillance Technology on Ethical Decision-Making in Scenarios of Public Surveillance; in: Proceedings of the 54th Hawaii International Conference on System Sciences 2021 (HICSS-54). *[3]</td><td colspan="2">Conference</td></tr>
<tr><td>C</td><td>B</td></tr>
<tr><td rowspan="2">C4</td><td rowspan="2">Kajüter, P., Arlinghaus, T., Kus, K. and Teuteberg, F. (2022): Analysis of Barriers to Digital Linking among Healthcare Stakeholders; in: Proceedings of the 17th International Conference on Wirtschaftsinformatik (WI 2022), Nürnberg, Germany. *[4]</td><td colspan="2">Conference</td></tr>
<tr><td>C</td><td>A</td></tr>
<tr><td rowspan="2">C5</td><td rowspan="2">Arlinghaus, T., Kus, K., Kajüter, P. and Teuteberg, F. (2021): Datentreuhandstellen gestalten: Status quo und Perspektiven für Geschäftsmodelle; HMD Praxis Der Wirtschaftsinformatik (58:3), pp. 565–579. *[5]</td><td colspan="2">Journal</td></tr>
<tr><td>D</td><td>B</td></tr>
<tr><td rowspan="2">C6</td><td rowspan="2">Kus, K., Kajüter, P., Arlinghaus, T. and Teuteberg, F. (2022): Die elektronische Patientenakte als zentraler Bestandteil der digitalen Transformation im deutschen Gesundheitswesen – Eine Analyse von Akzeptanzfaktoren aus Patientensicht; HMD Praxis Der Wirtschaftsinformatik (59:6), pp. 1577–1593. *[6]</td><td colspan="2">Journal</td></tr>
<tr><td>D</td><td>B</td></tr>
<tr><td rowspan="2">C7</td><td rowspan="2">Pöhler, L., Kus, K. and Teuteberg, F. (2021): Understanding pandemic dashboard development: A multi-level analysis of success factors; in: Proceedings of the 16th International Conference on Wirtschaftsinformatik (WI 2021), Essen, Germany. *[7]</td><td colspan="2">Conference</td></tr>
<tr><td>C</td><td>A</td></tr>
<tr><td rowspan="2">C8</td><td rowspan="2">Kus, K., Pöhler, L., Kajüter, P., Arlinghaus, T. and Teuteberg, F. (2022): Vaccination Dashboard Development during COVID-19: A Design Science Research Approach; in: Proceedings of the 17th International Conference on Wirtschaftsinformatik (WI 2022), Nürnberg, Germany. *[8]</td><td colspan="2">Conference</td></tr>
<tr><td>C</td><td>A</td></tr>
<tr><td rowspan="2">C9</td><td rowspan="2">Kus, K., Arlinghaus, T., Kajüter, P. and Teuteberg, F. (2021): Success Factors of Case Management Software Supporting Healthcare Patient Services - A User-Driven Perspective; in: Proceedings of Americas Conference on Information Systems (AMCIS 2021). *[9]</td><td colspan="2">Conference</td></tr>
<tr><td>D</td><td>B</td></tr>
<tr><td rowspan="2">C10</td><td rowspan="2">Arlinghaus, T., Kus, K., Kajüter Rodrigues, P. and Teuteberg, F. (2023): Visualizing Benefits of Case Management Software Using Utility Effect Chains; Sustainability (15:6), p. 4873. *[10]</td><td colspan="2">Journal</td></tr>
<tr><td>C</td><td>-</td></tr>
</table>

Comments

*[0] Prof. Dr. Frank Teuteberg critically reflected on the article structure, the methodological approach and content of all contributions and provided valuable feedback leading to further improvements.

*[1] The author of this dissertation conducted the systematic literature analysis and made noteworthy contributions to the review process. Mrs. Alina Behne was responsible for the structure and visualization and contributed to the interview conduction.

*[2] The author of this dissertation provided theoretical insights regarding socio-technical theory (STT) and national culture research and performed the analyses by allocating the challenges. Mr. Tim Arlinghaus provided noteworthy justifications for choosing Germany and China, contributed to the introduction section and provided valuable feedback regarding the manuscript.

*[3] The author of this dissertation made important contributions to the theoretical background sections in this article.

*[4] Mr. Tim Arlinghaus supported the interview analysis and contributed to the structure of the article. The author of this dissertation contributed to the theoretical background section.

*[5] Mr. Tim Arlinghaus conducted and analyzed the interviews and was responsible for the main part of the results and discussion section. The author of this dissertation contributed to the theoretical background section, including the analysis of relevant literature, and the discussion section. Mrs. Patricia Kajüter assisted during the visualization and validation process and worked in equal parts on the review.

*[6] Mrs. Patricia Kajüter conducted the analysis in the literature section, supported the interview analysis with graphical illustrations, and contributed to the discussion. Mr. Tim Arlinghaus analyzed EHR solutions of the insurances and contributed to the review.

*[7] Mr. Ludger Pöhler and the author of this dissertation worked in equal parts on this contribution.

*[8] Mr. Ludger Pöhler and the author of this dissertation worked in equal parts on this contribution. Mrs. Patricia Kajüter provided valuable support regarding the survey analysis. Mr. Tim Arlinghaus investigated healthcare communications guidelines and contributed to the discussion section.

*[9] The author of this dissertation conducted the literature analysis and was responsible for the results and discussion section. Mr. Tim Arlinghaus conducted most of the interviews and contributed to the interview analysis. Mrs. Patricia Kajüter contributed to the drafting of the theoretical background.

*[10] Mr. Tim Arlinghaus contributed to conceptualization, investigation, resources, writing, review and editing, visualization, and supervision. The author of this dissertation contributed to conceptualization, methodology, literature review, validation, and reviewing and editing. Mrs. Patricia Kajüter Rodrigues contributed to conceptualization, validation, reviewing and editing, and visualization.

Legend

VHB = Verband der Hochschullehrer für Betriebswirtschaftslehre (Translation: *German Academic Association for Business Research*) – Journal Quality Index 3 (VHB 2015)

WKWI = Wissenschaftliche Kommission Wirtschaftsinformatik – Orientierungsliste 2008 (Translation: Scientific Commission Information Systems – Guidance List 2008) (Heinzl et al. 2008)

Table 1. Selection of the research contributions

2.2 Framework of the Research Contributions

Before any analysis of eHealth application usage can be performed, it is first necessary to specify the stakeholders involved. According to the stakeholder theory described by Freeman (1984, p.46), stakeholders are defined as “any group or individual who can affect or is affected by the achievement of the organization’s objectives.” Even though the original theory relates to organizational considerations, stakeholders can also be identified for the healthcare sector. Kraus et al. (2021) differentiate among four main stakeholder groups for the traditional healthcare system: (1) patients, (2) healthcare providers, (3) insurers, and (4) regulatory bodies in the form of political decision-makers. The same groups have been classified as the main stakeholders, referred to as the “four Ps” (patients, providers, payors, and policymakers) in healthcare (Hesp et al. 2015; Lübbeke et al. 2019). Similar classifications can be found in other research that has identified numerous stakeholders in healthcare. These classifications include service users such as patients, providers such as physicians and nurses, and other groups such as health insurers, governments, and research entities (Beinke et al. 2019; Mantzana et al. 2007; Roski 2009). In addition, because of the digitalization of the healthcare sector, the traditional view must be extended. New entities, such as digital companies and software developers, are involved (Kraus et al. 2021). It is important to note that these stakeholder groups interact with each other and should therefore not be considered in isolation (Kraus et al. 2021). In this context, the actor-network theory (ANT) has additionally influenced the framework of the research contributions in this dissertation, since its core idea is the network-like and correspondingly interdependent structure of society (Latour 1996). The concept of ANT can also be applied to the healthcare system with its various stakeholders (Cresswell et al. 2010).

All described four main groups and the emerging IT service providers were considered in the context of this dissertation. However, the direct analyses focused particularly on the potential of eHealth in the context of healthcare service delivery. Accordingly, a focus on patients and healthcare service providers as users of eHealth applications can be identified. Nevertheless, the contributions include deriving recommendations for action for policymakers, health insurers, and IT service providers from these user-based analyses.

Contributions 1-3 examine the acceptance of artificial intelligence (AI) in healthcare. Contributions 1 and 2 highlight the challenges of AI implementation across different stakeholder groups. Contribution 1 also identifies concrete measures to overcome these barriers. The second contribution compares AI implementation challenges in the national healthcare systems of China and Germany. Contribution 3 addresses the ethical justifiability of AI-based surveillance for the containment of pandemics and examines a concrete AI-based application scenario.

Contributions 4 and 5 deal with the digital networking of healthcare service providers and with emerging digital business models in the healthcare sector. Accordingly, Contributions 1-5 focus on emerging technologies, the digital networking of service providers, and digital business concepts in the healthcare sector. Contributions 6-10, in contrast, deal with concrete eHealth applications.

Contributions 6-8 address concrete software solutions for (potential) healthcare service recipients. Contribution 6 includes qualitative analyses to examine the acceptance factors that influence the intention to use the EHR in Germany. In Contributions 7 and 8, COVID-19 dashboards for the population are analyzed and design recommendations are presented. Contributions 9 and 10 examine a concrete software solution for case managers as a subgroup of healthcare service providers.

Most of the contributions focus completely on eHealth-related topics and analyses. Contribution 3 does not focus exclusively on the healthcare sector, as this sector appears in one of three events in a scenario analysis in which AI-based governmental surveillance regarding compliance with COVID-19 measures was examined. Moreover, the digital business model analyzed in Contribution 5 is not limited to the healthcare sector. Figure 1 illustrates the themes and connections of the contributions, for which only the English titles are used to ensure a consistent overview.

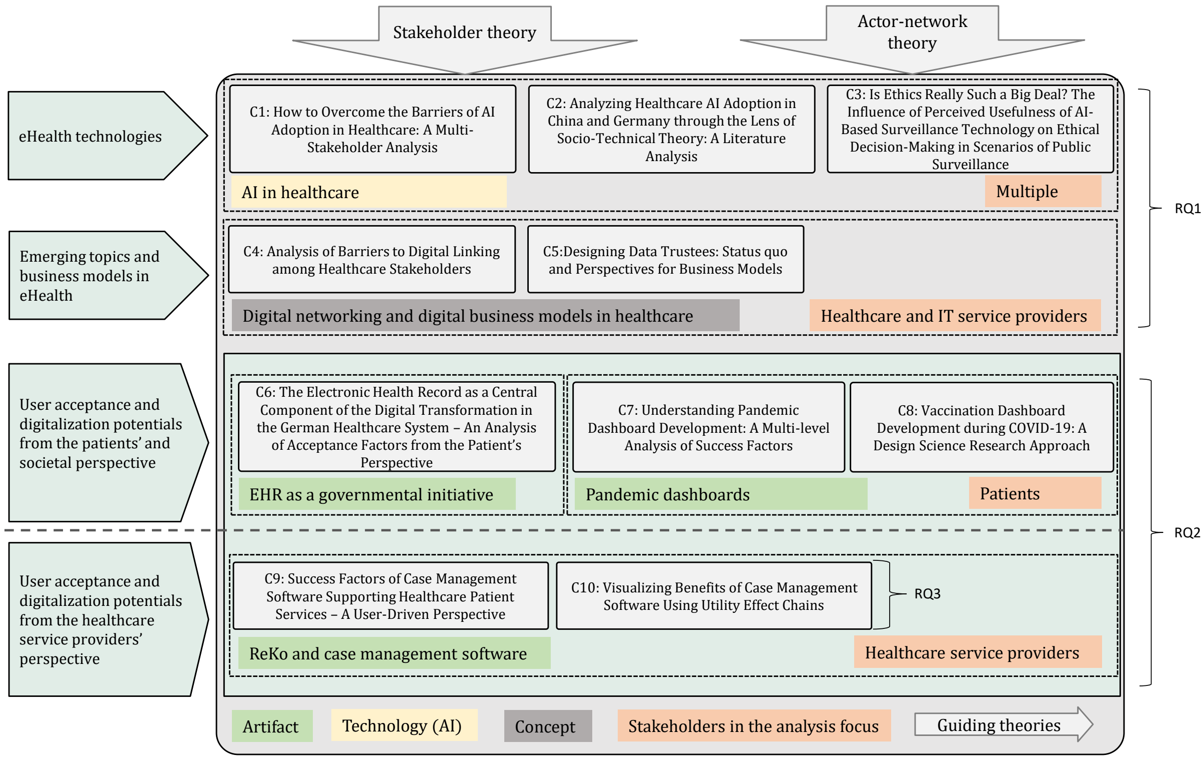

Figure 1. Research framework of the included research contributions

2.3 Research Approach and Spectrum of Applied Methods

IS research has investigated a wide range of issues for decades to better comprehend the implementation of IS (Legris et al. 2003). A well-known example of this research spectrum is the technology acceptance model (TAM) introduced by Davis (1989), which examines the influence of the variables “perceived ease of use” and “perceived usefulness” on the dependent variable “system use” and has received various extensions since its initial publication (e.g. Venkatesh and Bala 2008; Venkatesh and Davis 2000).

In general, two main methodological paradigms exist for IS research. The first is IT design, also known as design science, and the second concerns behavioral science issues such as identifying user adoption factors (Gregor and Hevner 2013; Hevner et al. 2004). The latter, like the TAM, examines interactions among humans, technology, and organizations, aiming to generate and verify theories including causal relationships, whereas the design science paradigm addresses the concrete development and design of IT artifacts (Hevner et al. 2004; Österle et al. 2011). The two paradigms cannot be considered in isolation from each other, as artifact development commonly proceeds by incorporating behavioral theories as a foundation (Hevner et al. 2004; Nunamaker and Briggs 2012). Both paradigms have been considered in the context of this dissertation. Some contributions deal with concrete software artifacts, such as a Case Management software (CMSW) solution and COVID-19 dashboards.

In general, research methods can be divided into qualitative and quantitative methods, which can be further specified in individual cases (Recker 2013). Within the framework of this cumulative dissertation, individual and closed research projects were performed. Consequently, a methodology well suited to answering the individual research questions could be used in each situation. Thus, the combination of the individual contributions within the framework of this cumulative dissertation is based on numerous different individual methodologies and a method triangulation has occurred (Recker 2013). An advantage of a diversified spectrum of methods is that the limitations of individual methods are balanced by the strengths of the other methods applied (Creswell et al. 2003). In summary, this dissertation can be classified as a mixed methods approach, as qualitative and quantitative methods have been combined to conduct adequate analyses and to answer the respective research questions (Venkatesh et al. 2013). Nevertheless, a focus on qualitative analyses can be identified throughout this dissertation.

To specify the different qualitative analyses in the context of this dissertation, systematic literature reviews were conducted for all contributions, following vom Brocke et al. (2009).

Numerous expert interview analyses were also performed. Apart from the acquisition of expert knowledge from the interview partner, interviews offer the advantage that useful findings can be obtained even from a relatively small number of participants, and the answers can also provide completely new insights (Kelle 2006). Particularly in those studies for which only a limited number of participants was available due to either a small number of existing application users or the complex specialist knowledge required, target-oriented analyses using expert interviews remained possible. Interviews can be further categorized into unstructured, semi-structured, and structured interviews (Baumbusch 2010). In this dissertation, semi-structured interviews were usually conducted to allow both the preparation of questions and a flexible reaction to any course of discussion (Doody and Noonan 2013; Gläser and Laudel 2010).

Substantial integration of design-oriented research can also be noted in this dissertation. Contribution 6 refers to the EHR as a central application of the TI, while Contributions 7 and 8 analyze COVID-19 dashboards. In the design science research approach described by Contribution 8, a COVID-19 vaccination dashboard prototype was developed based on successive evaluation cycles according to Peffers et al. (2007). Contributions 9 and 10 refer to a central artifact within the ReKo project, the CMSW Quovero. Table 2 provides an overview of the applied research methods with respect to each contribution.

Method including source	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Qualitative										
Literature review (vom Brocke et al. 2009, 2015)	x	x	x	x	x	x	x	x	x	x
Qualitative content analysis (Mayring 2010)	x	x		x	x	x	x	x	x	x
Expert interviews (Gläser and Laudel 2010)	x			x	x	x		x	x	
Case study (Benbasat et al. 1987; Recker 2013)				x					x	x
Prototyping (Hevner et al. 2004; Peffers et al. 2007)								x		
Workshops, Focus groups (Breen 2006; Myers 2019)								x		x
Quantitative										
Survey (Hunt and Scheetz 2019; Recker 2013)			x					x		
Frequency Analysis (Mayring 2014)	x			x						
Qualitative and quantitative										
Qualitative comparative analysis (Schneider and Wagemann 2012)			x							

Table 2. Applied research methods

3 Summary of the Research Contributions

3.1 Implementation of AI-based Technologies in Healthcare

Before analyzing specific applications for individual stakeholders, it is possible to analyze the use of new digital technologies relevant across all stakeholder groups. Regarding this, AI represents a key trend in the context of digitalization. Although varying definitions of AI exist, it is usually described as “the ability of a machine to learn from experience, adjust to new inputs and perform human-like tasks” (Duan et al. 2019, p.63). The term “intelligence” in AI systems accordingly refers to human-like abilities such as learning from datasets, drawing conclusions from patterns and errors, and improving over time (PwC 2017). In the healthcare sector, the range of possible AI solutions is wide and includes applications such as treatment and surgery with robotics, early disease detection and diagnosis, decision support systems referring to a treatment adjusted to an individual patient’s situation, and enhancing patient autonomy through patient health applications (PwC 2017; Secinaro et al. 2021). Despite these possibilities, AI has not gained widespread acceptance in the healthcare sector (Bughin et al. 2018; Maassen et al. 2021; Sun and Medaglia 2019). This difficulty is due to multi-layered barriers, including user attitudes (Liyanage et al. 2019; Shaw et al. 2019) and technological weaknesses (Dong et al. 2021; Maassen et al. 2021). Contribution 1 (Arlinghaus et al. 2022) examines the barriers to successful AI implementation and describes potential solutions to overcome these challenges. The believe-action-outcome framework according to Melville (2010) was used to structure the research concept and analyses. The data analysis was based on 16 expert interviews with AI experts, physicians, and medical students, as well as on relevant literature, enabling the identification of various beliefs and barriers to AI implementation and obtaining possible stakeholder-related actions to overcome the barriers. The categorization identified social, economic, technological, organizational, political, ethical, and educational barriers, which could be further specified by describing the concrete challenges (cf. Table 3). Among other factors, main barriers were found to be inadequate IT infrastructure, a lack of data quality, but also fear of unknown effects due to AI usage. Table 3 illustrates the identified barriers, including their respective categorizations. In the right column, the respective reference to literature and interviewees can be retrieved.

Building on the identified barriers, solution approaches could be derived and allocated to the overarching categories of collaboration, education, enlightenment, focus change, incentives, political instruments, transparency, technical tasks, and transformation, whereby they could be divided into further individual actions at the granular level (Arlinghaus et al. 2022). In this research, the individual solution approaches were also assigned to relevant stakeholders involved in the healthcare AI implementation process. Stakeholder groups were identified as the government, health institutions, IT providers, physicians, and patients. For example, the use of a developed and standardized IT infrastructure refers to a technical task and requires the actions of IT providers.

	#	Keyword(s)	Short description	References
Social Barriers	SB1	Appraisal	Lack of human characteristics; degraded practitioner-patient relationship	EAI5; (Cresswell et al. 2018; Khaled et al. 2019; Petersen et al. 2019)
	SB2	Acceptance	Lack of trust (regarding data security; interpretability; negative publicity)	EAI6,EC2,EP1,EP2,EP3,ES1,ES2,ES3; (Shaw et al. 2019; Cresswell et al. 2018; Ben-Israel et al. 2020; Lee and Yoon 2021)
	SB3	Understanding	Lack of awareness; exaggerated expectations; misbelief	EC3
	SB4	Fear	Fear of unknown effects due to AI (due to missing knowledge about AI); Existential threat (like job loss)	EP2,ES2; (Shaw et al. 2019; Ivanov and Webster 2017; Geetter and Van Demark 2017; Denecke and Gabarron 2021)
	SB5	Human rights	Discrimination: (1) of people who avoid technology use; (2) because of cultural orientation of software engineer	EP2; (Pesapane et al. 2018; Nuffield Council on Bioethics 2018)
Economic Barriers	EcB1	Investment	Conflict of institutional short-term profit orientation and AI-implementation cost; high fees for use of AI	EAI1,EC2,EC3,EP2,ES1; (Dwivedi et al. 2019; Sun and Medaglia 2019)
	EcB2	Cost-benefit	Vagueness in measuring general profitability	EAI3, EP2
	EcB3	Company characteristics	Unfair economic conditions between institutions; bigger profit-orientation in bigger companies	EP2; (Shaw et al. 2019; Meinhardt 2019)
Technological Barriers	TB1	IT Infrastructure	Lack of a consistently acceptable IT infrastructure as a basis for AI integration	EAI1,EAI2,EAI3,EAI6,EAI7,ES1; (Sogani et al. 2020; Iliashenko et al. 2019; TMF 2017)
	TB2	Data quality	Lack of stable data quality (risk of bias; necessity of real-time data adding; tracking data sources; test-reality outcome discrepancy; wrong interpretation from correlation to causality)	EC3,EP1,EP2; (Shaw et al. 2019; Kelly et al. 2019; Liyanage et al. 2019; Ben-Israel et al. 2020; Ellahham et al. 2019; Ethics Council Germany 2017; Petersen et al. 2019)
	TB3	Complexity	Lack of robust explainability of AI mechanisms (black box)	(Kelly et al. 2019; Ben-Israel et al. 2020; Markus et al. 2020; Cao et al. 2021)
	TB4	Data security	Potential data security breaches; inadmissible data security	(Shaw et al. 2019; Ben-Israel et al. 2020; Ellahham et al. 2019)
	TB5	Data quantity	Dependency on high data amounts, insufficient data quantity	(Dwivedi et al. 2019; Ellahham et al. 2019; Komorowski 2019; Petersen et al. 2019)
	TB6	Disease analysis	Validation of clinical relevance needed	EP3; (Kelly et al. 2019)
	TB7	Mismatch	Gap between technical research and practical requirements	EAI3; (Khanna et al. 2013)
Organizational Barriers	OB1	Admission	Intransparent and strict admission process	EAI3, EAI7
	OB2	Job roles	Team structure not suitable for AI realization, management of new practitioner's role; avoidance of job losses due to AI	(Shaw et al. 2019; Khaled et al. 2019; Ivanov and Webster 2017; Komorowski 2019)
	OB3	Decision management	Reduced decision-making power for physicians; decision-making power merely in management	EC2, EP1
	OB4	Readiness for change	Unwillingness to give up old steps of procedure	EP2; (Pesapane et al. 2018; Ivanov and Webster 2017; Wamba and Queiroz 2021)
	OB5	Shortage of doctors	Increased workload through demographic change, thus less time for new technologies	EP2; (Mindfields 2018)
	OB6	Communication	Lack of cooperation between organizations	EAI2
	OB7	Organizational culture	Lack of ability and willingness of digitalized transformation, less ability for data sharing	EAI2; (Wiljer and Hakim 2019; Recht et al. 2020; Geetter and Van Demark 2017)
Political Barriers	PB1	Global borders	Intransparency through non-uniform governmental handlings; retention of information by some nations	EP2; (Diebolt et al. 2019; Recht et al. 2020)
	PB2	Comparison	No orientation to other countries and neglection of country-specific characteristics	EAI1
	PB3	Regulations: Data protection	Complexity of privacy laws; data protection law not adjusted to new technical possibilities; regulatory reduce innovativeness	EAI2,EAI3,EAI5,EAI6,EP1,EP3; (Pesapane et al. 2018; Ethics Council Germany 2017; Jaremko et al. 2019)
	PB4	Regulations: Admission	Too cautious admission approach; intransparency about set quality standards	EAI7; (Pesapane et al. 2018; Cresswell et al. 2018)
Ethical Barriers	EB1	Failures	Responsibility and dealing with mistakes; liability in case of bad outcomes of AI	EAI3,EP1; (Sogani et al. 2020; Pesapane et al. 2018; Cresswell et al. 2018; TMF 2020; Meinhardt 2019; Petersen et al. 2019)
	EB2	Future direction	Uncertainty about effects of too much information	EC2,EP1
	EB3	Misuse	Misuse of AI applications and data; unclear ownership of data; potential discrimination by employers or insurances	EAI6,EP2; (Pesapane et al. 2018; Liyanage et al. 2019; Thesmar et al. 2019;)
	EB4	Privacy loss	Potential reidentification of data; potential loss of privacy	(Ethics Council Germany 2017)
Education Barriers	EdB1	Training	Need for adequate education programs due to staff's inability of system use (especially long-time employees)	EAI1,EAI7,EC2,ES3; (Cresswell et al. 2018; Khaled et al. 2019; Wiljer and Hakim 2019;
	EdB2	Understanding	Vague understanding of AI	EAI3,EAI7
	EdB3	Cooperation	Asymmetries between research and practice	EAI3,EP1,EP3
	EdB4	Curriculum	Outdated education content for medical students	EAI7,ES1,ES2,ES3

Table 3. Overview of barriers to AI adoption in healthcare (Arlinghaus et al. 2022)

Regarding frequently mentioned actions, the governmental provision of relevant AI-related information, referring to enlightenment, can help to eliminate public misunderstanding. Because this action was highlighted by seven interviewees, it could be considered a key measure with high practical relevance (Arlinghaus et al. 2022).

In addition to stakeholder-based analyses of barriers to AI adoption, national differences in healthcare AI implementation exist. These differences not only are related to national technological advantages but also can be based on social attitudes and cultural characteristics (Eitle and Buxmann 2020). Therefore, Contribution 2 (Kus et al. 2022a) focuses on a cross-country comparison of healthcare AI adoption in Germany and China, as two main economies on their respective continents, by applying socio-technical theory (STT) according to Bostrom and Heinen (1977) as well as national culture research according to Hofstede et al. (2010) as analytical foundations. According to STT, IS and IS adoption are part of technical and social subsystems (Bostrom and Heinen 1977; Oesterreich and Teuteberg 2019). The social subsystem can be separated into two components: structure and people. The structural component encompasses normative aspects such as values and norms and can therefore be associated with cultural characteristics. People refers to the individuals participating in the organizations (Lyytinen and Newman 2008; Oesterreich and Teuteberg 2019). Technology and task dimensions exist in the technical subsystem. Technology implies technical tools, such as healthcare AI applications. The second aspect of the technical subsystem pertains to tasks by which organizational and stakeholder goals are fulfilled (Oesterreich and Teuteberg 2019). Using scientific and practical literature, prevailing challenges for AI adoption in public healthcare in the respective countries were identified in this study. Although many commonalities exist, mainly related to the technical challenges of AI technology, national differences could also be identified, especially in the social system of STT. For example, regarding the structure dimension of the social subsystem, a risk-averse attitude in society combined with lengthy research and development processes has led to difficulties in AI implementation in Germany (Kus et al. 2022a). Stronger legal restrictions, including inflexible personal data protection requirements, ethical concerns, and insufficient IT budgets in hospitals, have also impeded successful AI implementation in Germany (Kus et al. 2022a). By contrast, China experiences much higher investments in AI, underpinned by receiving 60% of the global venture capital invested in this technology between 2013 and 2018 (China Institute for Science and Technology Policy 2018). Additionally, data processing is practically oriented provided that the data can be anonymized or de-identified (PIS Specification 2020). By referring to national culture research (Hofstede et al. 2010), the results can be associated with higher values of uncertainty avoidance and individualism in Germany. Table 4 presents main challenges for each subsystem of STT. The full table can be accessed in the original research publication.

Challenge			G/C	References
Cultural	S1	**Rigorous optimization approach** resulting in long R&D processes and a societal **risk-averse nature**.	G	(Duranton et al. 2018; Kummer et al. 2009; Maassen et al. 2021)
AI Work-force	P1	Provision of **AI training and education programs** for healthcare professionals.	G, C	(Dong et al. 2021; Horgan et al. 2020; Kummer et al. 2009; Maassen et al. 2021; Sun and Medaglia 2019)
Applica-tion areas	TA4	Application of more numerous AI application fields regarding specific diseases in China (cerebral infarction, hyperlipidemia, etc.), especially in the field of medical decision support. In this respect, **greater restraint towards practical use** of healthcare AI in certain medical areas **in Germany**.	G	(Chen et al. 2017; Hu et al. 2018)
Data sharing	TE1	**Necessity of large amounts of data** to train AI algorithms and ensure continuous data supply in order to improve AI outcomes such as accuracy and prediction ability.	G, C	(Bughin et al. 2018; Dong et al. 2021; Liu et al. 2020; Maassen et al. 2021)
S - Structural Dimension, P – People Dimension, TA - Task Dimension, TE – Technological Dimension; G – Germany, C - China				

Table 4. Challenges for each subsystem of STT based on Kus et al. (2022a)

In addition to a holistic view of the implementation of AI technologies in healthcare, specific application scenarios should be considered in a deeper analysis. One subcategory of AI technology use in this respect is surveillance. AI-assisted surveillance can be used in many contexts, including healthcare to prevent the spread of a virus (Neill 2012). This surveillance technique has gained relevance, specifically since the emergence of the COVID-19 pandemic, as it can track patients and identify them in public areas. However, this type of AI has been the subject of heated debates, as the justification for its use from an ethical point of view has often been questioned (Feldstein 2019). In Contribution 3 (Anton et al. 2021), the ethical justifiability of AI-assisted surveillance techniques has been investigated with a scenario-based analysis in which scenario 2, as one of three scenarios, included the tracking of COVID-19 patients (scenarios 1 and 3: jaywalking; pickpocketing). In this context, the fuzzy set qualitative comparative analysis was applied (Schneider and Wagemann 2012). The results help to obtain knowledge about the ethical decision-making process and a thorough comprehension regarding the factors leading to adopting or rejecting AI-based surveillance technologies in specific situations. The introduced research model consisted of the variables “moral equity,” “perceived importance of the ethical issue” (PIE), “perceived usefulness”, and “gender” influencing the dependent variable “moral intent to accept AI-based surveillance technology” (cf. Figure 2).

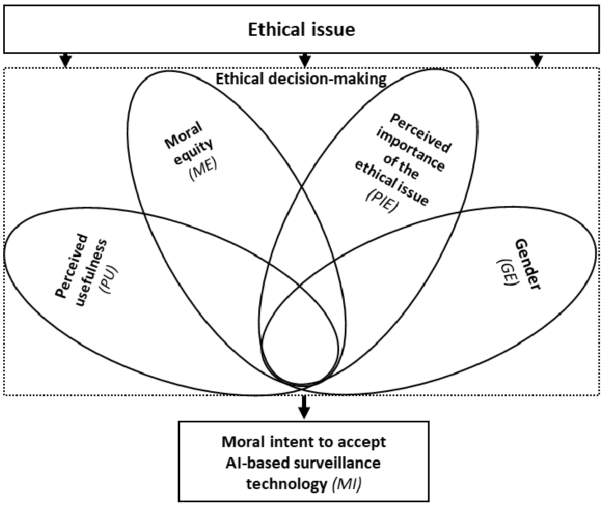

Figure 2. Research model (Anton et al. 2021)

The main findings depended on the respective scenario and regarding scenario 2 (monitoring of COVID-19 patients), PIE as the core sufficient condition leading to a high level of surveillance acceptance is identified (Anton et al. 2021). Additionally, for this scenario, two configurations with PIE as the core condition with differing peripheral conditions led to the moral intent to accept AI-based surveillance. Existing research demonstrates that higher values for PIE entail decisions resulting in ethical behavior (Haines and Leonard 2007; Robin et al. 1996). Based on these explanations, the acceptance of an AI-based surveillance technology to control COVID-19 patients in this setting could be considered ethical. Whereas this finding specifically held for scenario 2, the absence of perceived usefulness dominated the outcome of morally rejecting AI-based surveillance technologies in all three scenarios. Lack of perceived usefulness for the population in scenario 2 might be described with AI-based surveillance not effectively contributing to the containment of the virus. However, if numerous human lives can be saved through the containment of a virus, this potentially ethically justifies the interference in personal rights linked to the surveillance measures.

3.2 Digital Linking and Business Models in eHealth

A potential milestone in digitalization in the healthcare sector can be recognized in the successful implementation of digital linking among stakeholders. Service providers can benefit from improved digital networking by saving time and improving results through more effective data exchange. Several legal regulations, such as the Hospital Future Act and the Digital Care Act, have been established in Germany to enforce digital data exchange among healthcare service providers and provide better healthcare services for patients (BMG 2021c, 2021d). However, IT implementation and digital networking among stakeholders have remained difficult in Germany, as international comparison studies have indicated (Messal et al. 2021). Therefore, Contribution 4 (Kajüter et al. 2022) analyzes existing barriers to digital networking by focusing on the perspective of service providers. After performing an initial literature review, practicing physicians as well as IT managers of clinical institutions such as hospitals and care centers were interviewed to clarify the barriers to digital networking between service providers in the German healthcare system. The identified obstacles could be categorized into individual, legal, financial, institutional, technological, and workforce-related barriers (Kajüter et al. 2022). By adding three dimensions of the barrier-related taxonomy of digital transformation according to Vogelsang et al. (2019), a more in-depth description of the individual barriers was achieved. The barriers mentioned most often across all interviews were data protection, lack of platforms, security concerns, and individual change resistance, with the last two representing individual barriers. By using ANT, mutually dependent barriers could be illustrated and explained including their interrelationships (Cresswell et al. 2010; Latour 1996). ANT posits that a complete network is influenced when one actor (human or software) joins this network or something is changed (Cucciniello et al. 2015). For example, regarding the barriers, individual change resistance and security concerns affect each other and regarding the actors involved, IT service providers and healthcare institutions are mutually dependent. Figure 3 illustrates these influences and dependencies with regard to the five high priority barriers using ANT.

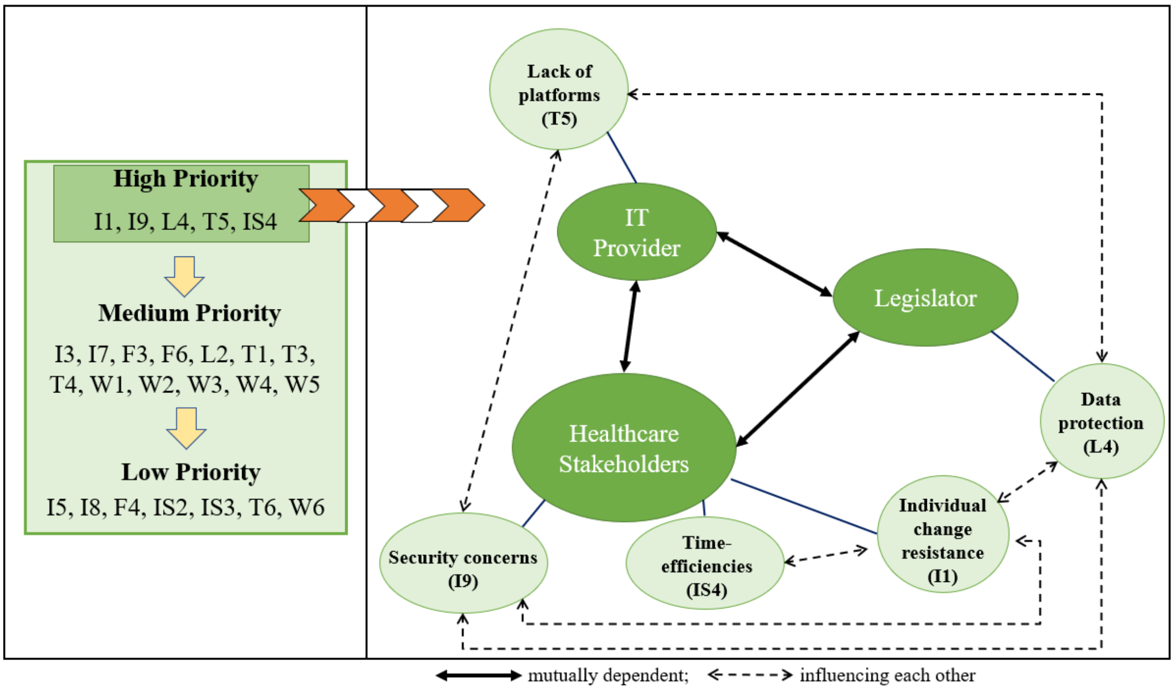

Figure 3. Intertwining of the five high priority barriers (Kajüter et al. 2022)

Service providers include not only the individuals and organizational units that provide medical treatment but also those entities that support the organization of direct healthcare service providers (Kraus et al. 2021). In the context of digitalization and increasingly extensive data sets, data management centers in the healthcare sector are gaining importance because they are responsible for particularly sensitive personal health data. Due to the creation and processing of large amounts of data, which present challenges as described in the initial contributions, there is an increasing need for more comprehensive data protection mechanisms, which are being met increasingly frequently by independent data trustees (Lauf et al. 2023). Typical tasks performed by data trustees include data protection, anonymization, (de)pseudonymization and data mapping (Bundesdruckerei 2019; Rat für Informationsstrukturen 2020). Nevertheless, despite their growing importance, there is no clarity as to how data trustees should be configured in detail (Rat für Informationsstrukturen 2020) and there is no common understanding of the term data trustee (Blankertz et al. 2020). Clarification of these ambiguities is addressed by Contribution 5 (Arlinghaus et al. 2021), in which the data trustee business model has been analyzed in detail by incorporating it into the digital canvas (Schlimbach and Asghari 2020) and implications for the successful integration of data trustees are obtained. The digital canvas can be seen as a continuation of the business model canvas developed by Osterwalder and Pigneur (2011) and is used to describe digital business models in further detail with the aid of nine blocks to be specified. These blocks include (1) customers, (2) market-specific framework conditions, (3) data and values, (4) hybrid products, (5) resource integration, (6) organizational structure, (7) adaptability, (8) revenue mechanisms, and (9) the problem and need (Schlimbach and Asghari 2020). The structured business model analysis of data trustees can be further differentiated between governmental and private-sector data trustees (Arlinghaus et al. 2021), for which the main identified characteristics can be specified for each of the nine building blocks. The revenue mechanisms of governmental trustees are characterized by their mostly cost-covering prices and their focus on research institutions, whereas private trustees are more flexible in terms of pricing and customer base. The results are illustrated in Figure 4. The implications include, among other things, the necessity of information campaigns and certifications for data trustees to increase knowledge and trust regarding this emerging business model (Arlinghaus et al. 2021).

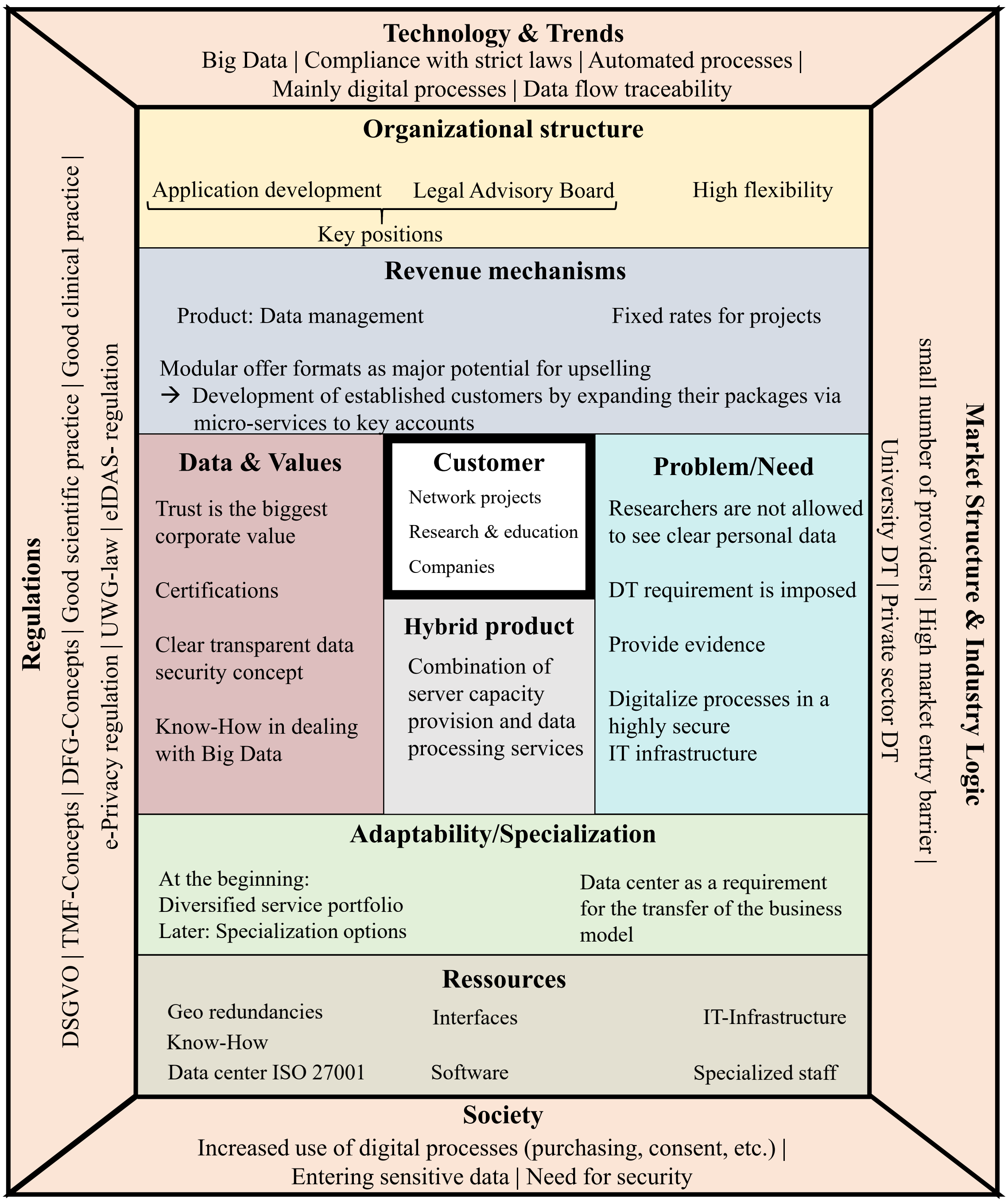

Figure 4. Assignment of the results to the digital canvas based on Arlinghaus et al. (2021)

3.3 Analysis of eHealth Applications

3.3.1 eHealth Applications for Healthcare Service Recipients

The primary recipients of healthcare services are patients, for whom various eHealth applications have been made available within the last few years. As part of TI implementation, the EHR was made available to patients as a holistic solution for rapid digital access to all relevant information regarding their health (BMG 2021b). With the EHR, patients can store and share their health data comprehensively across medical practice boundaries while retaining control over data management, including access authorization for individual healthcare service providers (BMG 2021b; Kolain and Molavi 2019). Since the beginning of 2021, statutory health insurers in Germany have been obligated to offer the EHR as an app free of charge (an der Heiden et al. 2021; BMG 2021b). The app designs of the health insurers can differ from one another. When used effectively, one potential advantage of the EHR is to avoid duplicate examinations (Kus et al. 2022b), so that both patients and service providers can be relieved and insurers can receive cost advantages. The EHR is a central instrument within the framework of the TI for networking the various actors in the healthcare system. With the help of the EHR, the local systems of the numerous service providers, including physicians, pharmacies, hospitals, and care centers, can be aggregated into a communication network (Kolain and Molavi 2019). Consequently, successful EHR implementation requires the participation of both healthcare providers and patients. Nevertheless, it is problematic that despite a considerable time after the introduction, only a conspicuously small proportion of patients (less than 1%) have downloaded the EHR (Gematik 2023; Bayerische Staatsregierung 2022). Therefore, it is crucial to analyze the reasons why the EHR has encountered low acceptance thus far. In Contribution 6 (Kus et al. 2022b), this issue has been addressed by systematically identifying and analyzing the acceptance factors for EHR use from the patient's perspective. First, relevant literature was reviewed in order to gather insights into acceptance factors and barriers to EHR usage from the patient's perspective and to design a basis for semi-structured interviews with 16 (potential) EHR users. From the interviews, six different factors were ultimately identified as having an influence on the intention to use the EHR. These, in turn, could be divided into primary and secondary influencing factors. The interdependent primary influencing factors are relevant during use and, depending on the design of the application, could lead to a positive or negative evaluation and consequently to the ongoing intention to use or a rejection. Specifically, these factors are user-friendliness, media competence, and functionality. The secondary influencing factors, in contrast, are not directly related to user perception when using the application, but play a role even before possible initial EHR use. Namely, these factors are information level, habits and normative influences, and data protection. For all these factors, respective demographic characteristics of potential users within the broader group also influenced usage behavior. Age should be mentioned here as a central demographic characteristic, which often indicated a negative relationship with media competence. Figure 5 provides a clear overview of the factors identified and their respective subcomponents.

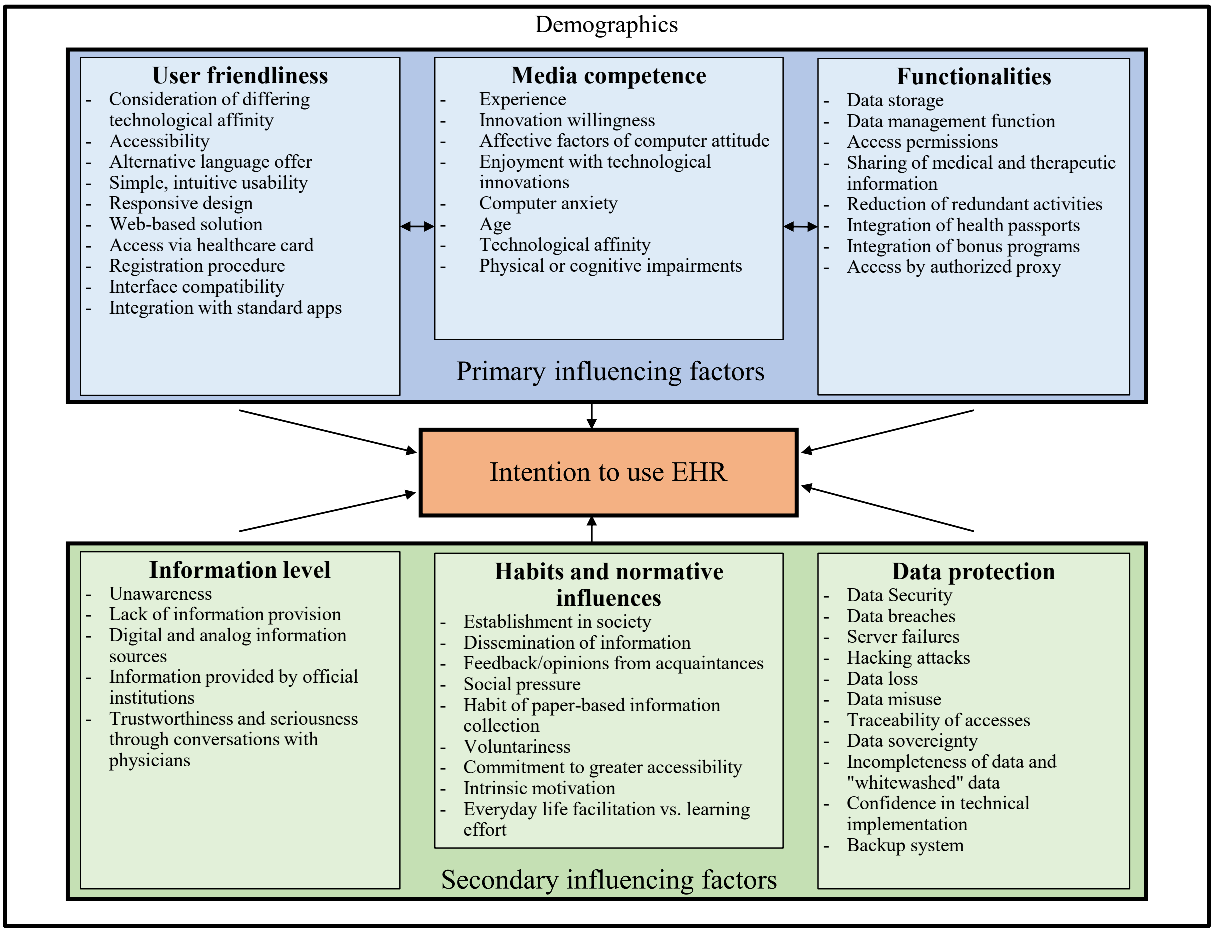

Figure 5. Influencing factors for EHR usage intention with subcomponents based on Kus et al. (2022b)

From a broader perspective, the entire society can also be assigned to the healthcare service recipient role, as every citizen either has used healthcare services as a patient or will do so in the future as a potential service user. Particularly since 2020, in the course of the COVID-19 pandemic, the need for information has increased not only for those suffering from COVID-19 infection but also for society at large to prevent further spread, to be informed regarding general restrictions, and to take correct measures in the case of one's own infection. In this context, effective IS that include dashboards can contribute to adequately informing the population about the dynamic infection process and its impact (Barone et al. 2020; Dong et al. 2020). One well-known example is the COVID-19 dashboard of the Johns Hopkins University (JHU), in which the dynamic infection situation has been continuously updated and international developments have been presented (Devasia et al. 2020; JHU 2023). In general, dashboards involve visual presentations that are based on purposefully selected datasets (Cheng et al. 2011).

In Contribution 7 (Pöhler et al. 2021), a literature analysis and an evaluation of existing and frequently used international COVID-19 dashboards were used to analyze in detail which factors could determine the successful implementation of corona dashboards. Based on the literature, the identified factors were divided into the categories of visualization, functionality, and content. Regarding content, it was concluded that individual key figures such as the total number of infections and deaths and strict updating of the data were essential (Pöhler et al. 2021). Nearly all dashboards presented the incidence rates and further pandemic data including the last update time, which mostly was within the previous 24 hours. In terms of the functionalities implemented for the user, interactivity was found to be of special importance in order to be able to search for or filter information according to personal preferences. Considering visualization, most dashboards included a limited number of graphics and sub-elements (lower than ten) on one screen of the user interface (UI) so that a cognitive overload regarding short-term memory was avoided according to existing research (Miller 1956). Given the relevance of the spread of the virus, it is logical that geographic maps had been included in nearly all dashboards. In addition, it was observed that most dashboards allowed for the simplest and most intuitive operation. To ensure a comprehensive overview, the aim was to gather a wide range of frequently used dashboards. Therefore, dashboards from governmental health authorities of different countries, further public institutions, popular online newspapers, and search engines were analyzed (cf. columns in Table 5).[1] Table 5 summarizes the results of the analysis of COVID-19 dashboards in practice.

	Success factor	**JHU**	**WHO**	**Google**	**RKI**	**UK**	**IND**	**PAK**	**Zeit**	**CDC**	**NYT**
Visualization	Mixed Usage (of visualization and text)	x	x	x	x	x	x	x	x	x	x
	Modest visual elements	x	x	x	x	x	x	-	x	x	x
	Maps	x	x	x	x	(x)	x	x	x	x	x
	Ease and familiarity	x	x	x	x	x	x	x	x	x	x
	Colors usage (moderate colors)	x	(x)	x	(x)	(x)	(x)	-	x	(x)	(x)
	Number of visualizations	8	4	6	9	9	4	17	6	6	7
Functionality	Data sharing option	-	-	-	-	-	-	-	(x)	-	-
	Interactivity	x	x	(x)	x	(x)	x	(x)	(x)	(x)	x
	User-friendliness	x	x	(x)	x	(x)	x	(x)	(x)	(x)	x
Content	Data source knowledge	x	x	(x)	x	x	(x)	(x)	x	x	x
	Reliability	x	x	(x)	x	x	(x)	x	(x)	x	x
	High-level-aggregation	x	x	x	(x)	(x)	(x)	(x)	(x)	(x)	x
	Easy knowledge transfer	(x)	x	x	(x)	(x)	x	(x)	x	(x)	x
	Several data sources	x	x	(x)	x	x	(x)	x	x	x	x
	(Automated) Data currency	x	x	x	x	x	x	x	x	(x)	x
	Automated warnings	(x)	(x)	-	-	-	-	-	x	-	-
	Focus on central information	x	x	x	x	(x)	x	(x)	x	(x)	x
	Mainstream usability	x	x	x	(x)	(x)	x	(x)	x	-	x
	Key figures	x	x	x	x	x	x	x	x	x	x
“x” = fully considered, “(x)” = partially fulfilled or not directly visible, “-” = not included											

Table 5. COVID-19 dashboard comparison regarding success factors identified in literature based on Pöhler et al. (2021)

[1] For the detailed list of the dashboards with links (partly not updated anymore) please refer to the original source.

After the first COVID-19 vaccines were introduced to the market, vaccination dashboards became increasingly important to inform the public regarding the dynamics of the vaccination process and other relevant information about the vaccines. The increased need in the population for information about vaccination might be explained by the rapid approval process of the vaccines using novel mechanisms such as messenger ribonucleic acid (mRNA) and vector technique (Dal-Ré et al. 2021) as well as disadvantageous examples of vaccination campaigns in the past, such as the Pandemrix vaccine against the swine flu (H1N1) virus (Sarkanen et al. 2018). In the study presented in Contribution 8 (Kus et al. 2022c), a design science research approach was used to analyze which information categories in COVID-19 vaccination dashboards were of particular importance to users, which design requirements a COVID-19 vaccination dashboard should fulfill, and which technical challenges must be overcome. After identifying nine issues, eight meta-requirements and three design principles were derived by conducting a literature analysis and a workshop. Subsequently, these design principles were analyzed in detail in three evaluation cycles according to Peffers et al. (2007). In the first cycle, existing vaccination dashboards were analyzed with respect to their interactive elements and the metrics used. In the second cycle, an online survey was conducted to determine which metrics and information categories were specifically important to users. Based on these findings, in the third cycle, a prototype was designed and tested in interviews with IT experts, especially focusing on challenges concerning technical feasibility. Figure 6 illustrates the determined issues, meta-requirements and design principles.

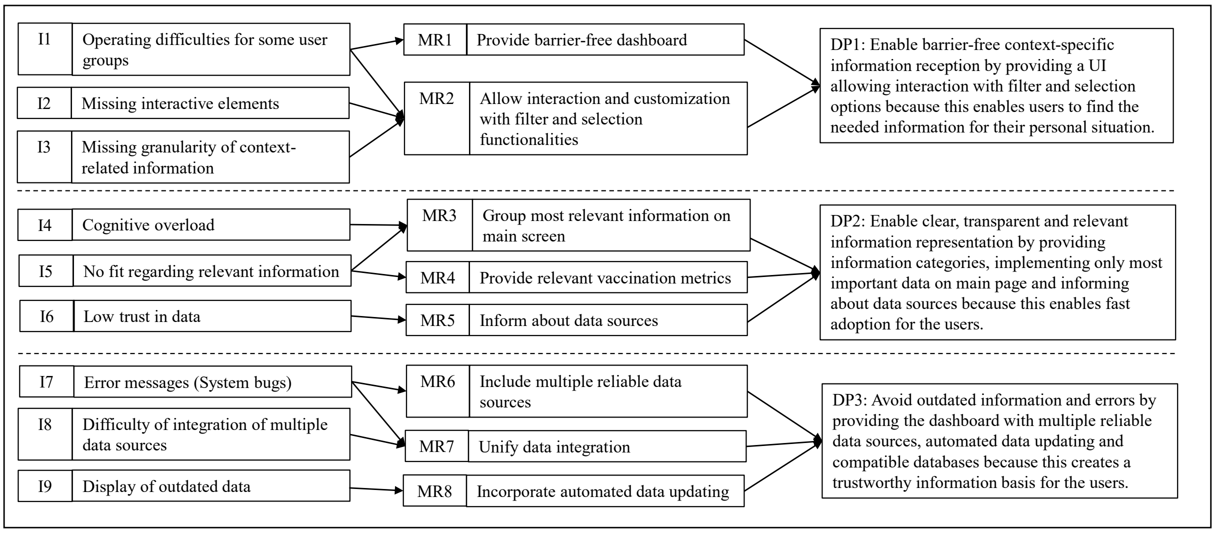

Figure 6. Issues, meta-requirements, and design principles (Kus et al. 2022c)

With regard to the first design principle, related to interactive elements, it was found that beyond straightforward click options for obtaining further information regarding the respective information categories, filter possibilities with drill-down elements, barrier-free elements, responsive design integration, and a moderate design regarding color selection should be implemented. By considering the second design principle, it was possible to differentiate ten information categories to which metrics and further sub-information could be assigned. According to the survey results, the most important metric was the total vaccination rate, which therefore necessarily should be shown on the main screen (Kus et al. 2022c). Moreover, the survey results conveyed that vaccination dashboards should provide information and metrics regarding not only vaccine efficacy but also respective side effects; this data was not consistently implemented by the analyzed dashboards. Figure 7 illustrates the main screen of the click prototype that was developed, including the grouped information categories, and provides information regarding the concrete implementation of the design principles. Some of the subgraphs are based on the dashboards analyzed in the first iteration cycle, such as the vaccination dashboards of the German government and the Zeit online newspaper (BMG 2023; Zeit online 2023).

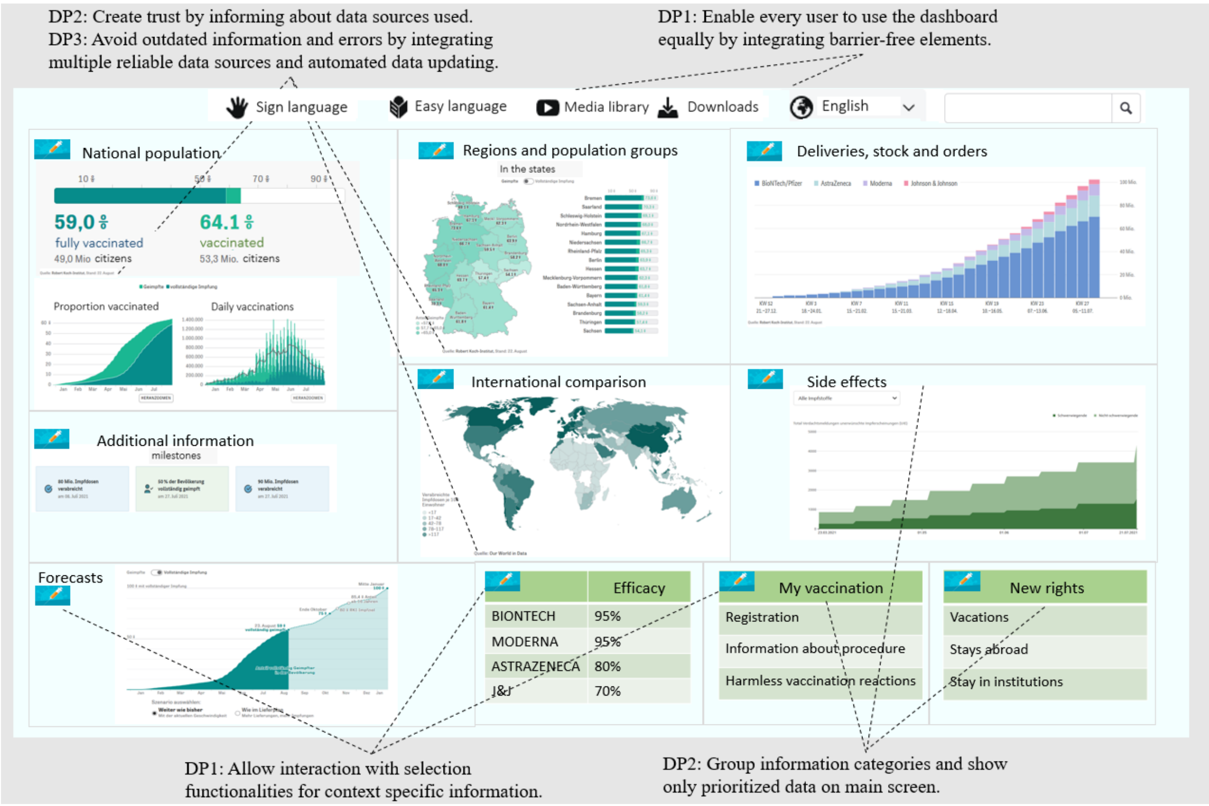

Figure 7. Main screen of the vaccination dashboard prototype based on Kus et al. (2022c)

Referring to the third design principle, based on technical deployment, the insights revealed that a central database should be deployed in order to integrate multiple data sources and incorporate an adequate extract-transform-load process (Kus et al. 2022c).

3.3.2 eHealth Applications for Healthcare Service Providers

In addition to the broader consideration of technologies, business models, digital networking, and applications for patients, the analysis of concrete software artifacts for healthcare service providers is important for obtaining detailed practice-related insights regarding this user group.

The CMSW solution Quovero is a specific software product used by service providers and has been analyzed in this dissertation regarding its success factors and potential benefits. CMSW hereby functions as healthcare services related client management software for case managers to support them in their daily work. Case management (CM) itself is an innovative care concept specifically intended for high-frequency healthcare users, such as multimorbid patients, and pursues the goal of improving the quality of healthcare while simultaneously achieving time efficiencies and cost benefits (Hudon et al. 2018; Klie and Monzer 2008). One characteristic of the CM concept is that every client is accompanied by one case manager throughout the entire healthcare process (Klie and Monzer 2008). The process of CM hereby includes six phases, namely clarification, assessment, service planning, linking, monitoring, and evaluation (Löcherbach 2002).

Case managers involved in the ReKo project have mostly completed nursing education but have also finished CM-related training. In summary, they are expected to provide holistic care services to care recipients and informal caregivers by coordinating health-related services. The CMSW solution Quovero used in the research project ReKo consequently could act as a case study. A typical UI is provided in Figure 8.

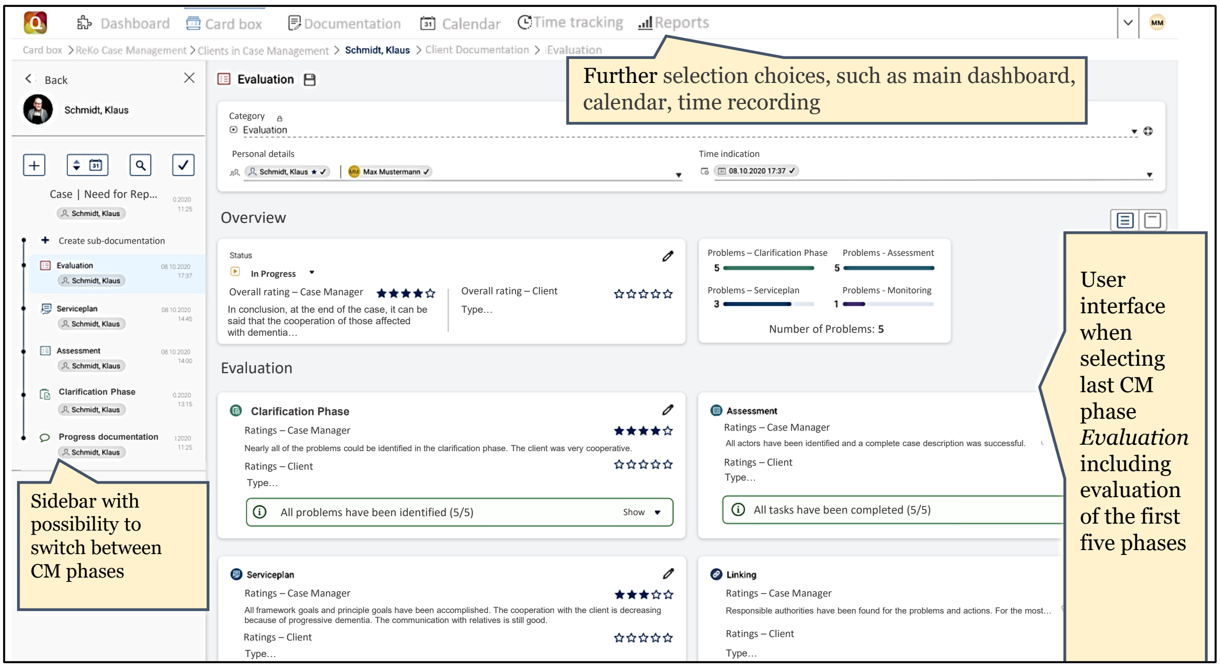

Figure 8. Typical UI of the CMSW solution in ReKo (Kus et al. 2021)

In Contribution 9 (Kus et al. 2021), the specific success factors for a suitable implementation of CMSW were evaluated by analyzing relevant literature and conducting semi-structured interviews with six case managers involved in ReKo. First, software-related factors were identified, which could then be subdivided into either functional factors such as the integration of the specific CM phases into the software, documentation, internal communication between the case managers with a chat functionality, the integration of further service providers, or non-functional factors, not directly visible in the UI design, such as system reliability, training courses and a collaborative software improvement in which the users' attitudes are considered by the developers (Kus et al. 2021). In addition, other factors were identified that are not related to the CMSW itself but are important for its adoption. These factors refer partly to individual factors such as users' experience and self-confidence in their work with IT applications, which can vary considerably within this user group. Furthermore, adoption depends on environmental factors that affect the IT infrastructure and the client relationship. The latter is fundamental to the CM concept, as case managers act as trustworthy coordinators and the first point of contact for patients. Table 6 summarizes the identified success factors. Factors marked in bold, such as the integration of the characteristic CM phases, client-related goal management, and a geographical navigation option for the characteristic house visits, were identified as new factors within the interview analyses. The other factors were also identified in the initial literature analysis.

System adoption factors		CM1	CM2	CM3	CM4	CM5	CM6
Software related factors	**Functional factors**						
	CM phases integration		x	x	x	x	x
	Communication	x	x	x	x	x	x
	Documentation	x	x	x	x	x	x
	Geographical navigation					x	
	Goal management		x	x			
	Guidance		x	x		x	x
	Healthcare provider integration	x	x	x	x	x	x
	Memory and calendar	x	x		x		x
	Overarching insights	x				x	
	Planning option						x
	Task allocation	x	x	x	x		
	Non-functional factors						
	Collaborative software optimization	x	x	x	x	x	x
	Data security						x
	Design	x				x	x
	Flexibility	x	x	x	x	x	x
	Operability	x	x	x	x	x	x
	System reliability			x	x		
	Time efficiencies	x	x	x	x	x	x
	Training	x	x	x	x	x	x
Individual and environmental factors	**Individual factors**						
	Experience			x	x		x
	Knowledge	x		x	x		x
	Motivation		x	x	x		x
	Self-confidence				x		x
	Environmental factors						
	IT infrastructure			x			
	Client relationship		x	x	x		x

Table 6. Identified success factors for CMSW adoption (Kus et al. 2021)

Contribution 10 (Arlinghaus et al. 2023) specifically addresses the benefits of an adequately implemented CMSW, including economic savings. After an initial literature analysis was performed to identify the benefits of care software solutions, focus group discussions with case managers were conducted to gain further insights. The model of utility effect chains according to Schumann and Linß (1993) was used so that cause-effect relationships between single benefits could be identified and presented in a comprehensible way. This approach could also be used to distinguish between tangible and intangible benefits (Oesterreich and Teuteberg 2018;

Schumann and Linß 1993). This distinction is helpful because, in contrast to the more clearly assignable costs of an IT investment, the benefits, in particular intangible ones, are more difficult to assess (Sapountzis et al. 2009). The starting point for the utility effect chains consisted in categorizing tasks into the application areas of the task level, in which four main categories could be identified: communication and collaboration, case planning and coordination, information access, and administration. Subsequently, with respect to the stakeholders involved, the focus group research identified new benefits of CMSW. In particular, these benefits include documentation and communication functions for the case managers, time savings and reduced labor costs for healthcare institutions, decreased waiting times and consistent medical treatment for patients, improved health-related district development, and the prevention of revolving door cases, which can lead to reduced expenses for respective health insurers (Arlinghaus et al. 2023). Figure 9 presents the utility effect chains that were identified in detail, including the task level as a starting point from which the benefit chains could result through the CMSW solution. The letters in the boxes (A to O) connect the tasks with the respective stakeholder-related outcomes.

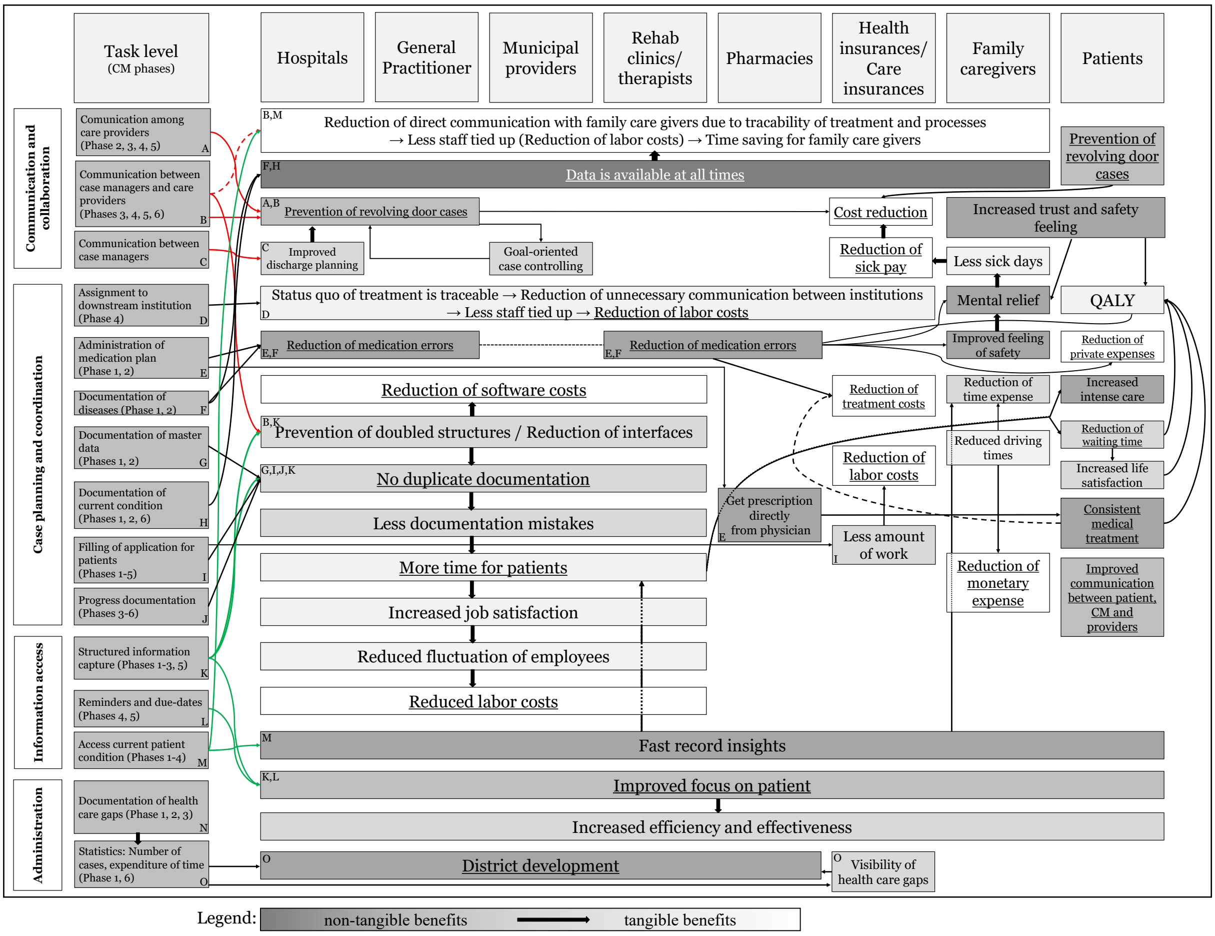

Figure 9. Utility effect chains for the identified tasks and benefits of CMSW (Arlinghaus et al. 2023)

4 Discussion

4.1 Implications for Research

In this cumulative dissertation, research gaps in the analysis of eHealth adoption have been identified and addressed within the framework of ten individual research projects. Taken together, the contributions serve to answer the RQs defined in this dissertation. Contributions 1 to 5 focus on technologies, networking and emerging business models in eHealth, whereas Contributions 6 to 10 deal with concrete eHealth applications.

By answering RQ1, concrete challenges that impede the successful adoption of novel technologies in the healthcare system could be identified. Contributions 1 and 2 analyze challenges of AI technology adoption in healthcare. Contribution 1 provides important insights regarding the categorization of existing barriers and a stakeholder-oriented action approach derived from these insights. Accordingly, it can be seen as a holistic research project that provides an overview for research, which in turn could consider individual stakeholders such as patients or specific AI technologies in more detail. Contribution 2 presents a national comparison between Germany and China, elucidating country-specific differences and challenges in the adoption of AI in healthcare. As this is the first comparison between these two countries on this topic, it provides important new scientific insights by connecting healthcare AI adoption of countries with STT and national culture research. It would certainly be interesting for future research to include other countries into this comparison of national healthcare AI adoption. In Contribution 3, antecedents of moral intent were identified by reviewing relevant literature and subsequently analyzed. The results indicate that PIE acts as a central variable to generate the moral intent to accept AI-based surveillance in the context of containment of a pandemic (C3). Conversely, a lack of perceived usefulness of AI-based surveillance leads to low acceptance levels. This research has extended existing scientific knowledge regarding ethical decision-making (Haines and Haines 2007; Haines and Leonard 2007; Robin et al. 1996) by combining constructs in a new research design and subsequently analyzing it.

In Contribution 4, obstacles to the digital networking of service providers have been identified and categorized to provide a systematic overview. Interdependencies between involved actors have been elaborated using ANT, providing important insights into research regarding the intertwining of barriers to using adequate IT infrastructure in healthcare. Future research may draw on these findings to identify appropriate actions to overcome these barriers possibly by using a similar framework such as the belief-action-outcome framework (Melville 2010) as performed in Contribution 1.

A potential solution to the challenge of managing large amounts of sensitive health-related data can be found in emerging digital business models. Therefore, in Contribution 5, the data trustee business model has been specified using the nine modules of the digital model canvas according to Schlimbach and Asghari (2020). A distinction has also been made between governmental and private data trustees. The paper provides an important contribution to clarifying an emerging business model within the process of digitalization in healthcare. Future research could analyze individual data trustee processes such as pseudonymization or the required digital infrastructure in more detail.

Contribution 6 specifies factors that influence EHR usage from the patient's point of view. It addresses RQ2 by providing concrete insights into the design, which can influence the user's attitude towards the application during usage. Thus, the provision of user-friendliness is of central importance and refers to the integration of barrier-free elements in the context of the broad target group which includes many elderly potential users who often possess physical inabilities and lower technological affinity (C6). In total, the qualitative analysis identified six different acceptance factors and provides new scientific insights regarding the current topic of EHR adoption in the German healthcare system. Referring to potential quantitative analyses, the six described acceptance factors might serve to identify independent variables influencing the usage intention. Accordingly, this research provides insights for further research with acceptance models, which can be methodologically based on models such as the TAM according to Davis (1989), but includes further variables.

Concrete design recommendations were derived from the work described in Contributions 7 and 8 by focusing on COVID-19 dashboards. In Contribution 7, success factors for accurate dashboard design in the healthcare sector were analyzed. Three categories were identified, namely visualization, functionality, and content (C7). Accordingly, by specifying the illustration of geographical interfaces, filter options, and identifying important metrics to be used in COVID-19 dashboards, this contribution enriches existing research by providing a multidimensional analysis of the pandemic dashboards. Contribution 8 addresses vaccination, a major downstream component of the COVID-19 pandemic. A design science research approach according to Peffers et al. (2007) was used to analyze successful design of COVID-19 vaccination dashboards and develop a prototype. The first obtained design principle includes insights regarding the UI with interactive elements and the selection of graphical illustrations (C8). The second obtained design principle relates to content elements, identifying important metrics and information. Insights into adequate technical deployment are provided by the third design principle. As this is the first research article to analyze COVID-19-vaccination dashboards using the design science research approach, it provides new scientific insights into design principles in this specific field. Taken together, Contributions 7 and 8 are relevant for research regarding further healthcare dashboards beyond COVID-19 as the results can be useful for successful dashboard implementation regarding other infectious diseases and respective vaccines.

By referring to applications for healthcare service providers, Contribution 9 provides important insights regarding the design of CMSW to adequately support the novel CM concept of long-term care. Building on a literature review, the case study-related analysis of interviews with case managers working with a newly developed CMSW solution was central to this work. The results have provided important scientific insights into the design of CMSW, including CM-specific functionalities and individualization options, as well as further success factors not directly related to the software (C9). Since the CMSW used in the ReKo case study is developed iteratively and in collaboration with the case managers, a design science research approach with several evaluation cycles, similar to Contribution 8, would be interesting as a research approach.

RQ3 has been addressed in particular by Contribution 10. Through the development of utility effect chains according to Schumann and Linß (1993), not only benefits and relief potentials of CMSW among stakeholders could be identified but also their cause-effect relationships. Thus, utility effect chains in healthcare support to reveal usually hidden subsequent software effects for different stakeholders, such as the prevention of revolving door cases for patients and healthcare institutions, and mental relief for family caregivers and case managers (C10). Overall, these findings can serve as a foundation for further cost-benefit analyses by revealing benefits of software use that may otherwise remain hidden. In future research, the incurred costs can be considered in more detail so that a holistic and quantitative cost-benefit comparison can be conducted.

4.2 Implications for Practice

Many of the insights presented in this dissertation are directly related to practice, as they not only include analyses with practitioners in the context of expert interviews, surveys, and market analyses, and have also been partly published in practice-related publications but also contain concrete recommendations for action.

The contributions focusing on software artifacts provide important insights in the further development of EHRs (C6), dashboards (C7-8), and CMSW solutions (C9) in healthcare. One recommendation for software developers is to consider the wide range of IT competencies of users, which has been analyzed in Contributions 6 and 9. Accordingly, possibilities for individualization and customizability of the UI, depending on the competencies and preferences of users, must be implemented to meet user heterogeneity (C9). In addition to responsive design implementation (C6, C8), AI potentials, such as machine learning algorithms, might assist software developers in providing user-tailored UI and system recommendations (C9). With regard to the EHR, the integration of a wide range of functionalities should be enabled. In addition to the central insight into illness and the history of health-related therapy, this strategy can also include the integration of health passports and proxy authorizations (C6). The incorporation of CM-specific functionalities, such as the guiding six CM phases, into the UI of the CMSW solution could be identified as an important factor for successful CMSW adoption (Kus et al. 2021). To avoid threatening the close relationship between case managers and clients through intensive documentation during home visits, advanced speech-to-text functions in CMSW could be helpful (C9).

Contributions 7 and 8 provide concrete design recommendations for software developers and providers; these recommendations not only refer to content elements such as key figures and IT-related requirements but also specify a user-centered design that takes individual user preferences regarding information selection into account, for example through extensive filter options. These findings can provide important orientation for IT companies in the development and ongoing maintenance of such applications. These products are primarily dashboards aimed at the general public, who not only can obtain important information regarding the pandemic status and development status of vaccinations but can also use them for personal decision-making, for example, to decide in favor of or against physical meetings or to make an informed decision regarding receiving initial or booster vaccinations. The survey results indicated high relevance of information regarding both the efficacy and the respective side effects of a vaccine (C8). Thus, a concrete recommendation for dashboard providers can be made to enable personal decision-making regarding vaccination: The hospitalization rate without being vaccinated can be compared with the hospitalization rate after being vaccinated due to side effects and breakthroughs (Kus et al. 2022c).

Policymakers can also use this information by analyzing the metrics to decide whether contact restrictions should be maintained, tightened, or loosened. In addition, they can use vaccination dashboard metrics, such as local vaccination rates, to decide where new vaccination centers should be opened or closed or whether larger vaccination campaigns need to be launched (Kus et al. 2022c). Contributions 1 and 2 also provide concrete recommendations for action to policymakers, for example by noting that patients and physicians should be better informed regarding the potential of AI through education and communication campaigns so that mistrust and fear of AI consequently can be counteracted (Diebolt et al. 2019; Wiljer and Hakim 2019). Better education and training of the medical professional community in AI competencies should be offered, beginning with the integration of curriculum courses that include AI system usage (Briganti and Le Moine 2020; Recht et al. 2020; Rigby 2019). Including ANT, the interdependencies between actors become very clear, as these government actions will have a significant impact on user attitudes towards AI. Ultimately, policymakers must ensure not only requirements and (international) standards for the use of AI, such as adequate digital infrastructure (Wiljer and Hakim, 2019), but also greater transparency regarding the approval process and legal restrictions on AI usage (Diebolt et al. 2019; Liyanage et al. 2019; Pesapane et al. 2018). Contribution 2 not only presents national differences in AI adoption and country-specific challenges, but also provides concrete recommendations, such as transnational collaboration in AI implementation, to promote implementation and ensure the necessary quantity and heterogeneity of data. In Germany, problems in adoption can be attributed to a higher level of uncertainty avoidance and individualism, which implies a societal skepticism and a stronger protection of privacy rights (Kus et al. 2022a). Therefore, the aforementioned extended governmental information and education campaigns seem to be especially important here to overcome unfounded skepticism regarding AI tools in healthcare. In addition, highly restrictive laws hindering the introduction of AI could be redrafted in a more flexible formulation so that the implementation of this generally beneficial technology is not unnecessarily hampered. Data protection rights should be reconsidered, leading to a greater willingness of institutions and individuals to share anonymized data, which would be beneficial to the public through improved medical care.

Implications for policy and healthcare insurers are provided by the analysis in Contribution 6. Since the EHR is politically motivated (BMG 2021b), in addition to health insurance providers, the government should provide further information regarding the EHR, including both online and offline information campaigns. The population must be brought to an accurate information status; otherwise, non-usage can be predicted (an der Heiden et al. 2021). In addition, training courses should be offered to familiarize especially the critical elderly target group with the EHR. Health insurance providers should also ensure that the initial registration process is not excessively complex in order to avoid barriers to first-time EHR usage and, if necessary, consider user incentives that include gamification elements as well as bonus programs for EHR use. Maintaining data security is of central importance, implying that no unauthorized parties, including insurers themselves, are able to access personal health-related data of EHR users.

The research projects analyzing CMSW in the ReKo case study have produced concrete recommendations for action for the implementing healthcare institutions and software providers. In addition to the concrete design-related recommendations for providers, Contribution 9 describes the high relevance of software training for users; this training should be performed in cooperation with the software providers and the implementing organization (e.g., the care center) and should prepare users in depth and raise them to a similar level of competence. User participation in continuous and agile software adjustment is of essential importance in software optimization. This not only improves the application from the user's point of view but also enables the users to create a higher level of identification with the software solution through participation in the development process. From these analyses, it can therefore be concluded that user participation in the development of CMSW has a positive effect on user involvement, subsequently increasing its acceptance. These insights are similar to previous research on system usage analyses (He and King 2008).

The insights of Contribution 10 can reveal important direct and downstream benefits of the software (when used correctly) to institutions such as care centers or hospitals that may need to decide whether to implement CMSW, contributing to an informed business decision that may result in the purchase or lease of CMSW or a decision to use a different solution. Overall, it should be clear for insurances, policymakers, and service providers that the process of digitalization, including the implementation of concrete applications and the respective IT infrastructure, involves substantial initial costs but would enable a more efficient healthcare system with better healthcare services in the long term. However, if they consider the actions discussed, the potential of digitalization can be unleashed by achieving greater acceptance among the persons directly involved in medical services (healthcare service providers and patients), who will be more willing to move away from existing, analog processes and habits. Research institutions will have the overarching task to continuously analyze eHealth adoption.

Table 7 presents the derived implications by referring to the recommended actions, the stakeholders involved, and the initial RQs of this dissertation.

Main finding (MF)	**Implications and recommended actions**
RQ1: What challenges can be identified in the digitalization of healthcare and how can these challenges be overcome?	
MF1a: Adoption challenges of new eHealth technologies such as AI are manifold and can be categorized into different topics such as social, economic, technological, organizational, political, ethical, and education barriers. MF1b: Adoption challenges can be related to national healthcare systems and beliefs, which are expressed in risk-averse attitudes and strict regulations. MF1c: Acceptance of the use of certain technologies requires ethical justifiability. MF1d: Data protection, lack of platforms, security concerns and individual change resistance are barriers hindering the digital networking among stakeholders.	**Policymakers should** • establish information and education campaigns and legal standards for creating a uniform IT infrastructure. • enable less restrictive laws not to unnecessarily hinder the introduction of new technologies and provide a more transparent admission process. • critically assess the ethical justifiability of specific eHealth measures. • intensify transnational cooperation in technology development. • support arising digital business models such as independent data trustees focusing on data security measures. **Healthcare service providers and patients should** • be willing to change habits and move away from unreasonable data protection claims. **Healthcare institutions should** • increase willingness to cooperate and establish digital networks with other institutions.
RQ2: How should digital applications in healthcare be designed and accompanied for the respective stakeholders so that the intention to use these eHealth solutions is increased?	
MF2a: The IT competencies and preferences among eHealth users in healthcare vary strongly. MF2b: Individual care concepts possess specific characteristics. MF2c: User involvement has a positive effect on software acceptance. MF2d: Specific content and key figures as well as interactive elements are important for the users. MF2e: The initial use of applications such as the EHR should be simple and should not raise further difficulties. MF2f: The integration of sensitive health-related data into eHealth applications such as the EHR requires ongoing protective measures. MF2g: The main page of the UI should be well-structured to avoid cognitive overload.	**Software providers should** • always consider the user group characteristics which should guide software design. • allow software customization according to user capabilities and preferences. • provide software training courses. • provide collaborative software development together with users to increase user identification with the software solution. • incorporate the specifics of healthcare concepts such as CM phases into the software solution. • include important content and metrics such as infection rates, vaccination rates, efficacy, and side effects regarding COVID-19 dashboards. • incorporate interactive features such as drill-down options allowing users to search, filter, and customize information. • enable accessibility through barrier-free elements. **Healthcare insurances should** • simplify the initial registration process for EHR usage. • guarantee and communicate data security measures as a high value.
RQ3: What are the benefits and possible synergies of eHealth solutions for the respective stakeholders?	
MF3a: The benefits of eHealth solutions such as CMSW are manifold and include aspects such as documentation and data availability, reduction of redundant entries, stress reduction and improved communication, cost savings and consistent treatment, the prevention of revolving door cases, and improved healthcare. MF3b: Utility effect chains help to visualize the cause-effect relationships among the identified benefits. MF3c: Benefits can be allocated to numerous stakeholder groups such as hospitals, general practitioners, caregivers, and patients. MF3d: Benefits can be tangible or non-tangible.	**Healthcare institutions should** • use insights for informed decision for or against the implementation of specific software solutions. • not hesitate to initially invest in specific eHealth solutions in order to receive long term benefits. • care about the interdependencies and cause-effect relationships of benefits. • incorporate a balanced decision-making process regarding software selection, incorporating the benefits and costs incurred and allowing for quantitative considerations. **Software providers should** • develop software solutions that provide benefits not only for the implementing institution but also for users and other stakeholders such as patients and informal caregivers.

Table 7. Stakeholder-oriented recommendations for successful eHealth implementation

4.3 Limitations and Future Research

Although all contributions presented in this dissertation have passed a multistage double-blinded review process and have been published in journals and conference proceedings listed in the VHB ranking, the individual publications and consequently this dissertation as well are not free of limitations.

First, the focus on qualitative research and analyses must be emphasized. Particularly in the case of studies of service providers such as those performed for Contributions 4, 9, and 10, it was difficult to generate a sufficiently large number of study participants for meaningful quantitative surveys due to the professional requirement profile (medical specialists, IT managers, etc.) or the limited number of system users in the form of case managers in the ReKo research project. Nevertheless, it cannot be denied that quantitative surveys can be useful to prove or disprove acceptance factors in a statistically valid manner. This evaluation could be performed to a greater extent in future research regarding the topics that were analyzed, especially if the CM concept were to become established on a broader basis, with more participants consequently available. In addition, quantitative economic evaluations of the eHealth applications and technologies considered in this dissertation would be useful, as they could, for example, serve as holistic decision support for potential system-implementing institutions.

Another limitation of individual contributions lies in the fact that some analyses were performed at specific time points. For example, interview surveys on a software solution thus reflected a certain development status of the application. The survey regarding the perceived relevance of individual metrics and content elements in COVID-19 vaccination dashboards was conducted at a time when the majority of the population had already received a vaccination dose. However, it is reasonable to assume that the importance of individual metrics depends on the stage of development of the vaccination campaign. Exemplarily, it may be likely that data regarding vaccine deliveries would be considered more relevant when the stock is short and the majority of the population has yet to be vaccinated (Kus et al. 2022c). Therefore, longitudinal surveys that extend over a longer period would be of particular interest for future research to identify situational changes. In addition, although the user-based analyses produced some recommendations for technical implementation, these recommendations did not go into detail.

Some analyses, such as those related to EHR acceptance, focused on patients as a single user group, although other user groups such as healthcare service providers are similarly of great importance for successful implementation. Therefore, future research could conduct analyses of specific user groups not considered in the single research projects presented in this dissertation.

Regarding the analyses focusing on AI in healthcare, it should be mentioned that, other than those in Contribution 3, which addresses concrete AI-based surveillance in healthcare, these analyses did not address specific AI application scenarios in healthcare. Other researchers might analyze challenges in detail for one specific application scenario, such as surgery with robotics, in order to gain application-related insights.

Finally, it should be noted that these analyses focused strongly on the German healthcare system. Even though individual studies considered international comparisons, several studies were limited to surveys within the German healthcare system or analyzed applications used exclusively in Germany. Future research could make an international comparison of individual applications, such as EHRs. In addition, further components of the German healthcare initiative, such as the electronic prescription, might be considered.

5 Conclusion

This dissertation aimed to answer three RQs regarding digitalization in the healthcare sector. Digitalization can be identified as a key element in meeting the increased demand for healthcare services due to a continuously aging population and a simultaneous shortage of qualified healthcare personnel. By answering RQ1, challenges of the digital transformation in healthcare were systematically identified and solution mechanisms for overcoming the difficulties were developed. Concrete technologies and concepts, such as the use of AI in healthcare, digital networking among stakeholders, emerging business models, and the CM concept, were examined in greater detail. In addition, the challenges were analyzed in relation to the relevant stakeholders. The analyses also included macro-level solutions for national strategies and policymakers as well as micro- and meso-level recommendations for patients, healthcare providers (such as physicians), IT vendors, and health insurance providers.

Addressing RQ2 led to concrete insights regarding the design of software artifacts. In this context, concrete software artifacts were analyzed and design recommendations were formulated, especially with regard to content elements and functionalities, interactive elements, and the structure of the UI. Because the analyses were user-related and involved concrete applications such as CMSW, the EHR, and COVID-19 dashboards, a stakeholder-related analysis was also carried out in each case. Individual observations considered specific user characteristics such as age or divergences in IT affinity among users, which are ultimately relevant for the successful design of an application.

RQ3 relates to identification of the benefits and relief potentials of eHealth applications for the healthcare system. In Contribution 10, this identification was performed by elaborating the utility effect chains of CMSW, considering both quantitatively and partly monetarily measurable efficiencies and benefits of the software while also revealing intangible benefits. The identified benefits were not limited to cost advantages for the implementing institution. They could also bring advantages to other participants, including patients and their relatives as well as case managers. Other contributions have also revealed the advantages of a respective software solution or technology. Even though implementation costs are not to be ignored and eHealth applications are mostly subject to constant further development effort, one point must be stated: Digitalization is playing a key role in meeting the growing demand for healthcare services at a time when human resources are often in short supply. If it is used properly and improved continuously, efficiencies will be created and improved healthcare services will be offered through user-tailored eHealth solutions.

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Part B: Research Contributions

Contribution 1

Contribution 1	
Title	How to Overcome the Barriers of AI Adoption in Healthcare: A Multi-Stakeholder Analysis
Authors	Tim Arlinghaus **Kevin Kus** Alina Behne Frank Teuteberg
Publication outlet	26th Pacific Asia Conference on Information Systems (PACIS 2022)
Medium	Conference
Ranking	VHB-JOURQUAL 3: C WKWI: B
Identification	DOI: - ISBN: 978-1-958200-01-8
Online	https://aisel.aisnet.org/pacis2022/4
Bibliographic information	Arlinghaus, T., Kus, K., Behne, A. and Teuteberg, F. (2022), “How to Overcome the Barriers of AI Adoption in Healthcare: A Multi-Stakeholder Analysis,” Proceedings of the 26th Pacific Asia Conference on Information Systems (PACIS 2022).
Abstract	We present barriers of AI adoption in healthcare on macro to micro level and respective actions to overcome these challenges for each stakeholder group. The findings are verified with results from literature. We used two qualitative methods:(1) a systematic literature review and (2) expert interviews with seven AI experts and nine physicians. We applied a deductive coding scheme. The barriers can be classified in social, ethical, political, economic, technological, educational and organizational barriers. The findings provide that the most hindering barriers are of technological, political and organizational nature. Social and economic barriers are less difficult to overcome, in particular when the benefits of AI application become apparent in practice. From our results, we infer the following four actions: enlightment, regulation, incentives and collaboration. We linked all derived actions with the identified barriers and stakeholders. Thus, we provide a guidance to overcome the adoption barriers of AI in healthcare.
Keywords	Artificial intelligence, healthcare, adoption, barriers, actions, overcome barriers

Contribution 2

Contribution 2	
Title	Analyzing Healthcare AI Adoption in China and Germany through the Lens of Socio-Technical Theory: A Literature Analysis
Authors	**Kevin Kus** Tim Arlinghaus Frank Teuteberg
Publication outlet	26th Pacific Asia Conference on Information Systems (PACIS 2022)
Medium	Conference
Ranking	VHB-JOURQUAL 3: C WKWI: B
Identification	DOI: - ISBN: 978-1-958200-01-8
Online	https://aisel.aisnet.org/pacis2022/126
Bibliographic information	Kus, K., Arlinghaus, T. and Teuteberg, F. (2022), "Analyzing Healthcare AI Adoption in China and Germany through the Lens of Socio-Technical Theory: A Literature Analysis," Proceedings of the Pacific Asia Conference on Information Systems (PACIS 2022).
Abstract	Even though artificial intelligence (AI) has great potential in several sectors, AI adoption in healthcare remains a difficult topic facing several challenges. In addition to the difficulties posed by the technology itself, there are challenges in the social sphere, involving both structural and individual components. Some nations are at the forefront of implementing AI in healthcare compared to others. To date, little AI research considers socio-technical dimensions to explain differences in healthcare AI adoption between countries. We address this research gap by identifying and analyzing challenges by applying the socio-technical theory (STT) with a focus on Germany and China. Some adoption challenges occur independently of national context, whereas others must be considered in the context of country characteristics. In addition, we discuss reasons for the varying adoption rates between Germany and China, include national culture dimensions and suggest propositions for national healthcare AI implementation strategies.
Keywords	Artificial intelligence, healthcare, national adoption challenges, Germany, China

Contribution 3

Contribution 3	
Title	Is Ethics Really Such a Big Deal? The Influence of Perceived Usefulness of AI-Based Surveillance Technology on Ethical Decision-Making in Scenarios of Public Surveillance
Authors	Eduard Anton **Kevin Kus** Frank Teuteberg
Publication outlet	Proceedings of the 54th Hawaii International Conference on System Sciences (HICSS-54)
Medium	Conference
Ranking	VHB-JOURQUAL 3: C WKWI: B
Identification	DOI: 10.24251/HICSS.2021.261 ISBN: 978-0-9981331-4-0
Online	https://scholarspace.manoa.hawaii.edu/handle/10125/70874/
Bibliographic information	Anton, E., Kus, K. and Teuteberg, F. (2021), "Is Ethics Really Such a Big Deal? The Influence of Perceived Usefulness of AI-based Surveillance Technology on Ethical Decision-Making in Scenarios of Public Surveillance," Proceedings of the 54th Hawaii Inter-national Conference on System Sciences 2021 (HICSS-54).
Abstract	So far, ethical perspectives have been neglected in empirical research focusing on the acceptance of artificial intelligence (AI)-based surveillance technologies on an individual level. This paper addresses this research gap by examining the individual moral intent to accept AI-based surveillance technologies deployed in public scenarios. After a thorough literature review to identify antecedents of moral intent, we surveyed n = 112 American participants in an online survey on mTurk and analyzed the data by using a fuzzy set qualitative comparative analysis. The resulting antecedent configurations provide insights into the inherent ethical decision-making process and thus contribute to a better understanding of the causality for accepting or rejecting AI-based surveillance technologies. Our findings emphasize in particular the influence of perceived usefulness of the technology on the ethical decision-making process.
Keywords	Digital Society, AI, EDM, FSQcA, surveillance

Contribution 4

Contribution 4	
Title	Analysis of Barriers to Digital Linking among Healthcare Stakeholders
Authors	Patricia Kajüter Tim Arlinghaus **Kevin Kus** Frank Teuteberg
Publication outlet	17th International Conference on Wirtschaftsinformatik (WI 2022)
Medium	Conference
Ranking	VHB-JOURQUAL 3: C WKWI: A
Identification	DOI: - ISBN: -
Online	https://aisel.aisnet.org/wi2022/digital_health/digital_health/7
Bibliographic information	Kajüter, P., Arlinghaus, T., Kus, K. and Teuteberg, F. (2022), "Analysis of Barriers to Digital Linking among Healthcare Stakeholders," Proceedings of the 17th International Conference on Wirtschaftsinformatik (WI 2022).
Abstract	Digitization affects all areas of public and work life - people connect with friends, family, colleagues, and businesses and exchange data with each other every day via apps and platforms. However, digitization in the healthcare sector is lagging far behind. Instead of exchanging data digitally and striving for efficient digital linking, the healthcare sector often uses the telephone or fax as a means of data exchange. By conducting a case study on the German healthcare sector, this paper identifies six categories of barriers that inhibit digital linking in healthcare: individual, legal, financial, institutional, technological, and workforce-related barriers. They are analyzed using the dimensions of level, IT influence, and perception and applying the actor-network theory.
Keywords	digital linking, barriers, healthcare, actor-network theory

Contribution 5

Contribution 5	
Title	Datentreuhandstellen gestalten: Status quo und Perspektiven für Geschäftsmodelle (Translation: Designing Data Trustees: Status quo and Perspectives for Business Models)
Authors	Tim Arlinghaus **Kevin Kus** Patricia Kajüter Frank Teuteberg
Publication outlet	HMD – Praxis der Wirtschaftsinformatik
Medium	Journal
Ranking	VHB-JOURQUAL 3: D WKWI: B
Identification	DOI: 10.1365/s40702-021-00727-x ISSN: 1436-3011
Online	https://link.springer.com/article/10.1365/s40702-021-00727-x
Bibliographic information	Arlinghaus, T., Kus, K., Kajüter, P. and Teuteberg, F. (2021), “Datentreuhandstellen gestalten: Status quo und Perspektiven für Geschäftsmodelle,” HMD Praxis Der Wirtschaftsinformatik (58:3), pp. 565–579.
Abstract	Dealing with large data volumes presents major challenges to companies when it comes to designing secure digital processes, especially when personal or sensitive data need to be processed. This applies equally to research projects, where data must be handled with the highest level of protection and sensitivity. Data trustees can be used to ensure this high level of data protection and compliance with ethical guidelines. In the meantime, some use cases of private trustees are known, which promise noticeable added value for companies. This article provides initial insights into the business models of data trustees as well as their areas of application. For this purpose, the Digital Canvas was used, which postulates nine pillars of digital business models. In addition, differences between governmental and commercial providers are analyzed as well as the potential of data trustees are highlighted and it is shown that their services will increasingly gain demand in the future. The findings are based on six expert interviews conducted with the heads of data trustees already operating in Germany.
Keywords	Data Trustees; Business Models; Digital Canvas; Data Protection; Data Security; Data Management

Contribution 6

Contribution 6	
Title	Die elektronische Patientenakte als zentraler Bestandteil der digitalen Transformation im deutschen Gesundheitswesen – Eine Analyse von Akzeptanzfaktoren aus Patientensicht (Translation: The electronic health record as a central component of the digital transformation in the German healthcare system—An analysis of acceptance factors from the patient's perspective)
Authors	**Kevin Kus** Patricia Kajüter Tim Arlinghaus Frank Teuteberg
Publication outlet	HMD – Praxis der Wirtschaftsinformatik
Medium	Journal
Ranking	VHB-JOURQUAL 3: D WKWI: B
Identification	DOI: 10.1365/s40702-022-00921-5 ISSN: 1436-3011
Online	https://link.springer.com/article/10.1365/s40702-022-00921-5
Bibliographic information	Kus, K., Kajüter, P., Arlinghaus, T. and Teuteberg, F. (2022), "Die elektronische Patientenakte als zentraler Bestandteil der digitalen Transformation im deutschen Gesundheits-wesen – Eine Analyse von Akzeptanzfaktoren aus Patientensicht," HMD Praxis Der Wirtschaftsinformatik (59:6), pp. 1577–1593.
Abstract	Demographic change and the shortage of specialists in medical and nursing care pose major challenges for the German healthcare system. The electronic health record (EHR), as a central component of digitization in the healthcare system, is intended to support data exchange between the stakeholders, relieve healthcare service providers, and at the same time leave data sovereignty with the patient. In addition to the required IT specialists, the acceptance of the stakeholders, which include the service providers and patients, is of decisive importance for successful EHR adoption. In our analysis, we focus on the factors influencing the intention to use EHR from the patients' perspective, very few of whom have used EHR so far. After an explanation of the EHR and the inclusion of relevant literature, 16 semistructured interviews with patients are conducted to obtain practical insights from (potential) users. Based on this, a category system of acceptance factors influencing EHR use from the patient's point of view is developed. Six acceptance factors are identified: (1) level of information, (2) habits and normative influences, (3) data protection, (4) user-friendliness, (5) media competence, and (6) functionalities. The analysis results are used to derive recommendations for action for EHR providers that can lead to greater EHR acceptance from the patient perspective. Our research makes an important contribution to which factors have to be considered in the development and provision of EHR from the patient's perspective and how potential problems of this user group can be solved.
Keywords	Electronic health record; EHR; Acceptance factors; Patient perspective; E-Health

Contribution 7

Contribution 7	
Title	Understanding pandemic dashboard development: A multi-level analysis of success factors
Authors	Ludger Pöhler **Kevin Kus** Frank Teuteberg
Publication outlet	16th International Conference on Wirtschaftsinformatik (WI 2021)
Medium	Conference
Ranking	VHB-JOURQUAL 3: C WKWI: A
Identification	DOI: - ISSN: -
Online	https://aisel.aisnet.org/wi2021/VDigitization/Track05/4/
Bibliographic information	Pöhler, L., Kus, K. and Teuteberg, F. (2021), "Understanding pandemic dashboard development: A multi-level analysis of success factors," Proceedings of the 16th International Conference on Wirtschaftsinformatik (WI 2021).
Abstract	Although dashboards are already widely used in humanitarian crises, various corporate reports and other fields, the specific success factors for the respective application areas often remain unclear. Especially in the current severe corona pandemic, dashboards are crucial to get an overview of the dynamic infection development. This motivated us to investigate how to successfully design dashboards capable of mitigating crises such as serious pandemics. By means of a systematic literature analysis, we identified scientific success factors of crisis and in specific of pandemic dashboards. Further, we assessed currently used corona dashboards and compared them with our success factors of the literature. In this way, we could discover whether corona dashboards are based on previous crisis dashboards and which specific success factors of current corona dashboards can be worked out for future pandemic dashboard development.
Keywords	Dashboard; Success factors; Pandemic; Corona; COVID-19

Contribution 8

Contribution 8	
Title	Vaccination Dashboard Development during COVID-19: A Design Science Research Approach
Authors	**Kevin Kus** Ludger Pöhler Patricia Kajüter Tim Arlinghaus Frank Teuteberg
Publication outlet	17th International Conference on Wirtschaftsinformatik (WI 2022)
Medium	Conference
Ranking	VHB-JOURQUAL 3: C WKWI: A
Identification	DOI: - ISBN: -
Online	http://aisel.aisnet.org/wi2022/digital_health/digital_health/10
Bibliographic information	Kus, K., Pöhler, L., Kajüter, P., Arlinghaus, T. and Teuteberg, F. (2022), “Vaccination Dashboard Development during COVID-19: A Design Science Research Approach,” Proceedings of the 17th International Conference on Wirtschaftsinformatik (WI 2022).
Abstract	The COVID-19 pandemic has affected the lives of people worldwide since the beginning of 2020. Since vaccines against COVID-19 have become available, the issue of vaccination has become increasingly important. Accordingly, vaccination dashboards are provided to inform the public about COVID-19 vaccination developments. In our study, we used a design science research (DSR) approach to explore what information vaccination dashboards should provide and how they should be designed. In addition to an initial literature review, we analyzed existing vaccination dashboards and derived information categories. Thereafter, we conducted an online survey to identify the most important metrics from a user’s perspective. Our results indicate that, in addition to vaccination coverage, a comparison of vaccination efficacy and side effects is important. Subsequently, a click prototype was developed and expert interviews were carried out to determine how vaccination dashboards should be designed and which technical issues should be considered.
Keywords	Vaccination dashboards, pandemic dashboard development, vaccination metrics, user interface, design science research

Contribution 9

Contribution 9	
Title	Success Factors of Case Management Software Supporting Healthcare Patient Services - A User-Driven Perspective
Authors	**Kevin Kus** Tim Arlinghaus Patricia Kajüter Frank Teuteberg
Publication outlet	AMCIS 2021 Proceedings
Medium	Conference
Ranking	VHB-JOURQUAL 3: D WKWI: B
Identification	-
Online	https://aisel.aisnet.org/amcis2021/healthcare_it/sig_health/22/
Bibliographic information	Kus, K., Arlinghaus, T., Kajüter, P. and Teuteberg, F. (2021), "Success Factors of Case Management Software Supporting Healthcare Patient Services - A User-Driven Perspective," Proceedings of the 27th Americas Conference on Information Systems (AMCIS 2021).
Abstract	Technological development captures almost every sector and affects most people regarding their job life. This implies challenges such as implementing software supporting work processes. With regard to these challenges, the healthcare sector stands out due to necessary restructuring resulting from demographic changes and a lack of employees. To overcome this struggle and to provide optimal treatment for care recipients, customized case management software (CMSW) solutions for healthcare professionals need to be developed and adapted to the users' needs. By analyzing literature dealing with the users' acceptance of software supporting healthcare patient services and interviewing six case managers who use recently developed CMSW, we identify success factors for the implementation of CMSW from a user's perspective. Our findings show that CMSW needs to include both core functionalities such as documentation and the specific case management phases. Also, users should participate in the CMSW development process.
Keywords	Case management software, healthcare, user acceptance, success factors, technological development

Contribution 10

Contribution 10	
Title	Visualizing Benefits of Case Management Software Using Utility Effect Chains
Authors	Tim Arlinghaus **Kevin Kus** Patricia Kajüter Rodrigues Frank Teuteberg
Publication outlet	Sustainability
Medium	Journal
Ranking	VHB-JOURQUAL 3: C WKWI: -
Identification	https://doi.org/10.3390/su15064873
Online	https://www.mdpi.com/2071-1050/15/6/4873
Bibliographic information	Arlinghaus, T., Kus, K., Kajüter Rodrigues, P. and Teuteberg, F. (2023), "Visualizing Benefits of Case Management Software Using Utility Effect Chains," Sustainability (15:6), p. 4873.
Abstract	Labor shortages lead to crucial investment decisions, such as selecting software supporting work processes. The healthcare sector stands out because of additional restructuring due to demographic changes. This is particularly true for the care sector; hence, customized case management software (CMSW) solutions for healthcare professionals are being developed. In an increasingly profit-oriented healthcare system, sustainability, cost-effectiveness and quantification of benefits of investments play a major role. We analyzed research dealing with the benefits of case and care management software and, additionally, interviewed case managers who use recently developed CMSW within a case study. We used utility effect chains to visualize and quantify the gathered benefits of an information system (IS) investment along with the healthcare system in Germany. The findings show that benefits from care management software need to be seen more holistically. Utility effect chains can serve as a helpful instrument for the visualization of indirect benefits in healthcare. The most significant benefits of CMSW were found to be various cost savings for each of the participating stakeholders, a reduction in redundant entries of patient data and the prevention of cost-intensive revolving door cases. Additionally, the insight into patient records reduces time-consuming communication among health experts and family caregivers.
Keywords	case management; cost-benefit; elderly care; healthcare; IT adoption