Process-driven Innovation:
An Analysis of Digital Health Technologies

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Preface

This dissertation has been produced between January 2019 and June 2021 during my employment as research assistant at the Institute of Accounting and Information Systems at the Osnabrück University.

I would like to thank my supervisor Prof. Dr. Frank Teuteberg for always supporting my research interests. In addition, he provided me with an excellent research environment, continuous support and useful feedback. Furthermore, I would like to acknowledge Prof. Dr. Bodo Rieger as co-adviser of this dissertation.

Overall, I would like to thank my team at the institute, especially Jan Beinke, Nicolai Krüger, Julian Schuir, Christian Fitte and Pascal Meier for the collaboration, constant feedback, great conversations and beneficial discussions. These have always shaped and evolved my articles and my research focus. Furthermore, I would like to thank my co-authors: Tim Arlinghaus, Jan Beinke, Christian Fitte, Nicolai Krüger, Kevin Kus, Thuy Duong Oesterreich, Julian Schuir, and Agnis Stibe.

Last but not least, I would like to express my gratitude primarily to my family (Claudia, Mandy, Tobi, Tobi and Tommie) and my lovely friends (especially Andi, Johann, Hendrik, Leoni, Maiki, Nico, Nikki and Soraya) for the never-ending support at each stage and your trust in me. For me, you supported and inspired me, provided my positive energy flow by sharing love and experiences with me over this time. In addition, I want to thank all other friends and people who accompanied me on this journey.

Osnabrück, December 2021

Alina Behne

Notes on the Structure of the Document

This cumulative dissertation is about seven research contributions within the field of process-driven innovation in healthcare. Thus, the structure of this cumulative dissertation provides two parts: Part A reveals an overall motivation, a research plan, research questions, applied methods, and a summary of each research contribution. An overall framework supports the research plan. Moreover, implications for research and practice are derived from the results of the research contributions. Then, Part B presents each research contribution in its published form.

Contents

Part A: Introductory Overview

List of Abbreviations

AI	Artificial intelligence
BMG	Bundesgesundheitsministerium (Federal ministry of health)
EHR	Electronic health record
IT	Information technology
PHR	Personal health record
PLS-SEM	Partial least squares structural equation modeling
PPA	Predictive and prescriptive analysis
RQ	Research question
VHB	Verband der Hochschullehrer für Betriebswirtschaftslehre
WHO	World Health Organization
WKWI	Wissenschaftliche Kommission Wirtschaftsinformatik

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1 Introduction

1.1 Motivation

Healthcare is facing a major transformation in which responsibility is shifting steadily to patients and health delivery is getting more efficient and individualized. This is driven by digital health opportunities such as self-measurement and -informing (Lupton 2017).

> *"Technologies have proven potential to enhance health outcomes by improving medical diagnosis, data-based treatment decisions, digital therapeutics, clinical trials, self-management of care and person-centred care as well as creating more evidence-based knowledge, skills and competence for professionals to support health care."* Global strategy on digital health 2020–2025
> (World Health Organization [WHO], 2020)

The shift from traditional medicine to a partly virtual and patient-centered healthcare delivery has been accelerated by emerging technologies, the vast amount of generated data and the COVID-19 pandemic (Bhavnani, 2020; Shin, 2019). The pandemic situation has caused globally major challenges related to healthcare supply. The potential of digital health is undeniable, as it leads to a massive increase in research and digitalization activities in this field (Boogerd et al., 2015). Digital health technologies are not only expected to reduce costs for the healthcare sector by simplifying administrative aspects but also to improve the quality of healthcare supply and patient well-being (Bukowski et al., 2020; Chang et al., 2017). The term eHealth, which refers to digitalization in the healthcare sector, was coined at the end of the 1990s (Pagliari et al., 2005). The WHO (2020) described eHealth as the secure utilization of information and communication technologies in healthcare, such as platforms and data exchange, for achieving greater efficiency and quality in health-related activities, such as health education and knowledge. Extending this definition, digital health considers also digital consumers and the possibility of them contributing to their healthcare. Thus, digital health covers more technologies such as big data analytics, artificial intelligence (AI), blockchain, virtual reality glasses, robotics, and more (WHO, 2020). Besides data from professional health systems such as physician consultations and blood tests, the digital consumer has recently begun to generate much data with wearables (e.g., smart watches and smart implants), which has paved the way for precision medicine (Hulsen et al., 2019). This dissertation therefore uses the term digital health rather than eHealth to encompass all innovative technologies in healthcare and,

in particular, the digital consumer. Digital health services are gaining popularity and by 2025 are expected to have grown by 75% (Market Data Forecast, 2020).

Nevertheless, growing populations and progress in medical research have led and still lead to an increasing demand for healthcare services worldwide (Schweitzer and Synowiec, 2012). Simultaneously, demographic changes cause the higher share of elderly people in society, who are more likely to suffer from chronic diseases such as cardiac arrhythmia, hypertension, or diabetes (Laumer et al., 2019; Laurenza et al., 2018). These reasons have led to a shortage of skilled workers, which is why digital technologies are required to facilitate work and lean processes. In this respect, the German Minister of Health, Jens Spahn, stated that, "now, we want to speed up in order to make our healthcare system prepared for the digital future" (translated, Spahn, 2019). However, compared with other countries, Germany performs poorly in digitalization in the healthcare sector in terms of policy activities, digital health readiness, and actual data transfer between healthcare stakeholders. In 2018, the Bertelsmann foundation examined a total of 17 countries with its Digital Health Index, among which Germany ranked second to last (Statista, 2021; Bertelsmann, 2020). Thereby, digital health readiness includes technical implementation and digital maturity. In a highly regulated market such as the healthcare system, technical implementation in particular requires the analysis of drivers and barriers for an establishment in the real environment and restructuring of existing processes (Eveleens, 2010; Field, 2008). New approaches already recognize that user-centered design approaches coupled with requirements engineering are crucial for the successful development of innovations and technologies, thus enabling solutions to be logically implemented and technically realized (Gartner, 2020; Hehn et al., 2019). This is underlined by the following quote:

> *"Would Amazon build a new service without putting customers in the center?*
> *Would Tesla build a new electric car without asking clients what they were expecting?*
> *So why in 2019 in healthcare do we not even ask patients what they need?"*
> Michael Seres, Founder of 11.health (HIMSS, 2019)

However, a highly regulated market with fixed structures such as the healthcare industry must be considered alongside processes and the big picture to perform and serve an entire population. Thus, because of the growing population and the high workload, innovation development cannot just be patient-centered to improve the quality of care unless it benefits healthcare providers and process simplification. Successful technological innovations aim to achieve

significant improvements in outcomes, efficiency, effectiveness, and quality by creating new processes, products, and services (Albury, 2005; Laurenza et al., 2018). Ultimately, besides altruistic reasons, healthcare stakeholders act economically and efficiently because the healthcare sector is a service industry (Greenhalg et al., 2004; Laurenza et al., 2018). Services can be improved through analyzing processes, which gives process-driven innovation its reason through digitization.

In the literature, frameworks for innovation management exist to improve the integration of new technologies and other innovations, such as the innovation process model of the phases search, select, implement together with a continuous learning process (Tidd & Bessant, 2021). Within this dissertation, innovative digital health solutions are viewed in a process-driven manner to meet the regulated healthcare system requirements (Field, 2008). A current example is the digital vaccination certificate, or the Digital COVID Certificate, which must be coordinated on a Europe-wide basis (EC, 2021). Therefore, three dimensions have to be considered: the process level, the organizational level, and the environmental level (vom Brocke & Mendling, 2018). In the end, the government rather than the customer decides which devices and technologies are approved for healthcare services (Field, 2008; Thimbleby, 2013). An overview and a deep understanding of promising technologies as well as their diffusion, barriers, and drivers are necessary for integrating technologies into healthcare and restructuring processes (Laurenza et al., 2018). This dissertation addresses the gap in the overarching implementation strategy of digital health technologies, organizational frameworks, and user impact and adoption.

1.2 Aim

The overall perspective of this dissertation is that innovation management needs to be aligned with process improvement, which is crucial for healthcare as a regulated service sector. Healthcare processes and technologies must be standardized and interoperable to deliver it to a population of a country or even a continent (Field, 2008; Meier et al. 2019). Nonetheless, surrounding and user needs should be still addressed in the development process of digital health technologies (Hehn et al., 2019). Subsequently, the technology should not be considered alone but also together with the culture when restructuring processes. Therefore, patients and other stakeholders in the healthcare system must also be involved in investigations, such as the physicians, pharmacists, health insurers, and the government (Thimbleby, 2013).

This cumulative dissertation considers the usefulness and implementation of digitalization in healthcare from several stakeholders' perspectives. Regarding the realization, it presents approaches for integrating emerging digital health technologies in existing structures. Along the research framework of this dissertation, the research contributions outline the current situation of technology-oriented innovations in healthcare. In this context, opportunities and barriers of integrating various promising technologies in healthcare such as big data analytics and self-tracking devices are discussed. In addition, the research contributions illustrate procedures for analyzing individual areas in healthcare or specific digital solutions. Overall, the framework can serve as a guide for innovation management, supporting companies from the analysis of their processes to the search for and integration of new technologies into their business to restructure their processes. Thereby, technologies are seen as a tool to serve an overarching goal – the improvement of the healthcare system – without over-digitalization. The aim is also to demonstrate how the procedure for process and innovation management can be abstracted to a strategy level. Apart from institutions in healthcare, the application of this framework can also assist policy makers to stay strategically up to date, creating awareness of existing or novel solutions. It is necessary to be aware of which technologies exist, their advantages and disadvantages, and their drivers and barriers, to ensure that these are taken into account directly in the integration process. In addition, implications for research and practice are derived to guide scientists, healthcare actors, government and digital health developer.
Overall, an overview of the current state in the area of innovative health technologies and presents key points is provided that must be considered when integrating new concepts in healthcare companies. Within this cumulative dissertation, the following research questions (RQ) are considered:

RQ1: What are the central areas in the field of innovative digital health technologies?

RQ2: What are the main challenges for digital health application and adoption?

RQ3: What could digital health innovation engineering look like?

RQ4: How can process-driven digital health innovations be implemented successfully?

This dissertation presents discussions to answer each of these research questions along with implications for research and practice. Moreover, it provides methods, frameworks, and prototypes for example approaches within the research contributions. The author gained numerous practical insights from healthcare professionals through the research project Apotheke 2.0 (funding code 2818LD021), which focused on digital cross-sector networking

among various healthcare providers and to patients. Table 1 presents the research questions from the selected research contributions for this dissertation and their match to the four overarching research questions.

Table 1. Overview of the RQs in each contribution.

#	Title	RQs of the Research Contribution	Fit to the Dissertation's RQs
A	A Healthy Lifestyle and the Adverse Impact of its Digitalization: The Dark Side of Using eHealth Technologies	1. In which areas of a healthy lifestyle is digitalization applied? 2. How can healthy lifestyle technologies have adverse impacts on people?	RQ1, RQ2
B	Electronic health records as a connectivity tool in the Internet of Health (translated)	1. What use cases can currently be assisted and enabled by eGA in Germany? 2. Which opportunities does eGA offer as a connectivity tool in the Internet of Health? 3. Which challenges exist for the large-scale adoption of eGAs and how can these be overcome?	RQ1, RQ2
C	Understanding the Role of Predictive and Prescriptive Analytics in Healthcare: A Multi-Stakeholder Approach	1. What is the current state of research and practice of PPA in healthcare and which stakeholders might be affected by their use? 2. What are the main use cases, challenges, and benefits of PPA in healthcare and what are the consequences for the different stakeholders of the healthcare sector?	RQ1, RQ2
D	A Framework for Cross-Industry Innovation: Transferring Technologies Between Industries	How can companies approach cross-industry innovation in terms of technology transfer?	RQ3, RQ4
E	FeelFit – Design and Evaluation of a Conversational Agent to Enhance Health Awareness	How can conversational agents for wearable health monitoring systems be designed and implemented to enhance users' health awareness?	RQ3
F	Intersectoral connectivity in healthcare: Process improvement by the utilization of platforms based on a case study in palliative care (translated)	How can processes in healthcare (especially in palliative care) be made more efficient through communication and documentation platforms?	RQ4
G	Learnings from the Design and Acceptance of the German COVID-19 Tracing App for IS-driven Crisis Management: A Design Science Research	1. Which design and functional elements of the German COVID-19 tracing app (Corona-Warn-App) should be enhanced to increase its acceptance? 2. What lessons can be learned for applications in crisis management from the challenges of the Corona-Warn-App?	RQ4

1.3 Structure

This dissertation is structured in five sections, the remainder of which are organized as follows. Section 2 describes the research design, detailing the research contribution and the applied methods. Furthermore, the framework of this dissertation is explained, which provides a logical context to the research questions and the research plan. Section 3 summarizes the main content and results of the relevant research contributions according to the framework structure. In Section 4, practical implications for healthcare deliverers and receivers are provided and the research questions are answered in terms of the research implications. Furthermore, crucial aspects regarding process-driven integration of innovations and restructuring processes in healthcare are discussed. Finally, Section 5 ends the dissertation with the conclusion.

2 Research Design

2.1 Selection of the Research Contributions

For each contribution of this dissertation, a double-blind peer review process was conducted by multiple reviewers of an international conference or popular journal. Table 2 presents bibliographic information of each contribution as well as the respective ranking of the publication outlet.

Table 2. Selected research contributions.

#	Title	Medium	Ranking	Publication Sources
A	A Healthy Lifestyle and the Adverse Impact of its Digitalization: The Dark Side of Using eHealth Technologies	Conference	WKWI: A VHB: C	**Behne, A.,** & Teuteberg, F. (2020). A Healthy Lifestyle and the Adverse Impact of its Digitalization: The Dark Side of Using eHealth Technologies; in *Proceedings of the 15th International Conference on Wirtschaftsinformatik* (WI 2020), Potsdam *[1]
B	Electronic health records as a connectivity tool in the Internet of Health (translated)	Conference	WKWI: C VHB: C	Fitte, C., Meier, P., **Behne, A.**, Miftari, D., & Teuteberg, F. (2019). Die elektronische Gesundheitsakte als Vernetzungsinstrument im Internet of Health, *INFORMATIK 2019*: 50 Jahre Gesellschaft für Informatik–Informatik für Gesellschaft, Kassel *[1]*[2]
C	Understanding the Role of Predictive and Prescriptive Analytics in Healthcare: A Multi-Stakeholder Approach	Conference	WKWI: A VHB: B	Oesterreich, T. D., Fitte, C., **Behne, A.**, & Teuteberg, F. (2020). Understanding the Role of Predictive and Prescriptive Analytics in Healthcare: A Multi-Stakeholder Approach, in *Proceedings of the 28th European Conference on Information System (ECIS),* Marrakech *[1]*[3]
D	A Framework for Cross-Industry Innovation: Transferring Technologies Between Industries	Journal	WKWI: - VHB: C JIF: 1.28	**Behne, A.**, Beinke, J.H., & Teuteberg, F. (2021). Understanding the Role of Technology in Cross-Industry Innovation: Design and Evaluation of a Conceptual Framework. *International Journal of Innovation and Technology Management, 18*(03), 1-27 *[1]*[4]
E	FeelFit – Design and Evaluation of a Conversational Agent to Enhance Health Awareness	Conference	WKWI: A VHB: A	Meier, P., Beinke, J. H., Fitte, C., **Behne, A.**, & Teuteberg, F. (2019). FeelFit – Design and Evaluation of a Conversational Agent to Enhance Health Awareness; in *Proceedings of the 2019 International Conference on Information Systems* (ICIS), Munich *[1]*[5]
F	Intersectoral connectivity in healthcare: Process improvement by the utilization of platforms based on a case study in palliative care (translated)	Journal	WKWI: B VHB: D JIF: -	**Behne, A.**, & Teuteberg, F. (2021). Intersektorale Vernetzung im Gesundheitswesen: Prozessverbesserung durch den Einsatz von Plattformen am Fallbeispiel der Palliativversorgung. *HMD Praxis der Wirtschaftsinformatik.* *[1]
G	Learnings from the Design and Acceptance of the German COVID-19 Tracing App for IS-driven Crisis Management: A Design Science Research	Journal	WKWI: - VHB: - JIF: 2.32	**Behne, A.**, Krüger, N., Beinke, J.H., & Teuteberg, F. (2021). Learnings from the Design and Acceptance of the German COVID-19 Tracing App for IS-driven Crisis Management: A Design Science Research. *BMC Medical Informatics and Decision Making* (accepted). *[1]*[6]

Comments

*[1] Prof. Dr Frank Teuteberg is the co-author of each publication; he critically reflected on the content and method of each contribution.

*[2] Mr. Pascal Meier and Mr. Christian Fitte worked in equal parts on this contribution by elaborating the methodological framework and theoretical foundation of this article. The author of this dissertation conducted the best-practice analysis and made noteworthy contributions to the interview results and the concept of the design. Ms. Dafina Miftari made notable efforts by conducting research and interviews.

*[3] Dr. Thuy Duong Oesterreich prepared the data set and developed the methodological framework for the analysis, and the author of this dissertation and Mr. Christian Fitte worked in equal parts on the paper.

*[4] The author of this dissertation conducted the major part of the research work. The methodological orientation, discussion of the results, and writing of the implications took place during collaborative work with Mr. Jan Heinrich Beinke.

*[5] Mr. Pascal Meier, Mr. Jan Heinrich Beinke, and Mr. Christian Fitte worked in equal parts on this contribution by developing the prototype, developing the methodological framework, and elaborating the results. The author of this dissertation co-created noteworthy on the evaluation concept, conduction, and analysis.

*[6] Mr. Nicolai Krüger and the author of this dissertation worked in equal parts on the paper. The methodological orientation, discussion of the results, and writing of the implications took place during collaborative work with Mr. Jan Heinrich Beinke.

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*) (WKWI, 2008)

JIF = Journal Impact Factor according to Resurchify

The rankings in Table 2 were provided by JOURQAL3 of the *Verband der Hochschullehrer für Betriebswirtschaft e.V.* ([VHB]; VHB, 2015), *Journal Impact Factor*, and the guidance list of the *Wissenschaftliche Kommission für Wirtschaftsinformatik* ([WKWI]; WKWI, 2008). The Journal BMC Medical Informatics and Decision Making is not listed in the VHB and WKWI ranking. However, this journal indicates a high JIF and was ranked with the tier A+ according to the global ranking of management- and clinical-centered e-health journals (Serenko et al., 2008). The author of this dissertation published more research articles during her time as a research assistant that are not presented in Table 2. These articles do not address the main issue of this dissertation or cover a rather specific area. Nevertheless, these articles are considered and cited in appropriate places throughout this dissertation.

2.2 Framework of the Research Contributions

The approach of this dissertation is based on process management aligned with innovation management. Process management – especially process improvement – contains the integration of new solutions such as emerging technologies for internal processes or digitalized services. As closely linked to innovation management, a continuous learning process is pursued (Tidd & Bessant, 2021). An integration of a new solution or innovation causes a process restructuring of the business, which should be oriented to the customer needs. Thus, the structure of this dissertation is guided by the business process management lifecycle according to Dumas et al. (2013). In addition, other process management tools can be applied such as those from continuous process improvement, lean management, or change management. The framework of this dissertation is presented in Figure 1, which clarifies the fit of each step and the targeted research question. In the beginning, a problem occurs, which can be eliminated further through process restructuring with a new solution. The framework illustrates that process-driven innovation should not be exclusively at the process level but also at strategy level in the healthcare sector. At the strategy level, processes and technologies are discovered to obtain an overview of what is available as well as where problems exist (as-is model). Afterwards, problematic processes and promising technologies should be analyzed with respect to their potentials, benefits, and barriers. Subsequently, a solution can be designed or selected and potentially adapted. Then, the business and its processes must be restructured by applying the chosen solution (to-be model). In a final step, the technology adoption must be monitored, considering the acceptance of the innovation in the company, the expected usefulness, and other integration-related factors such as the learning culture (Jacobs and Snijders, 2008).

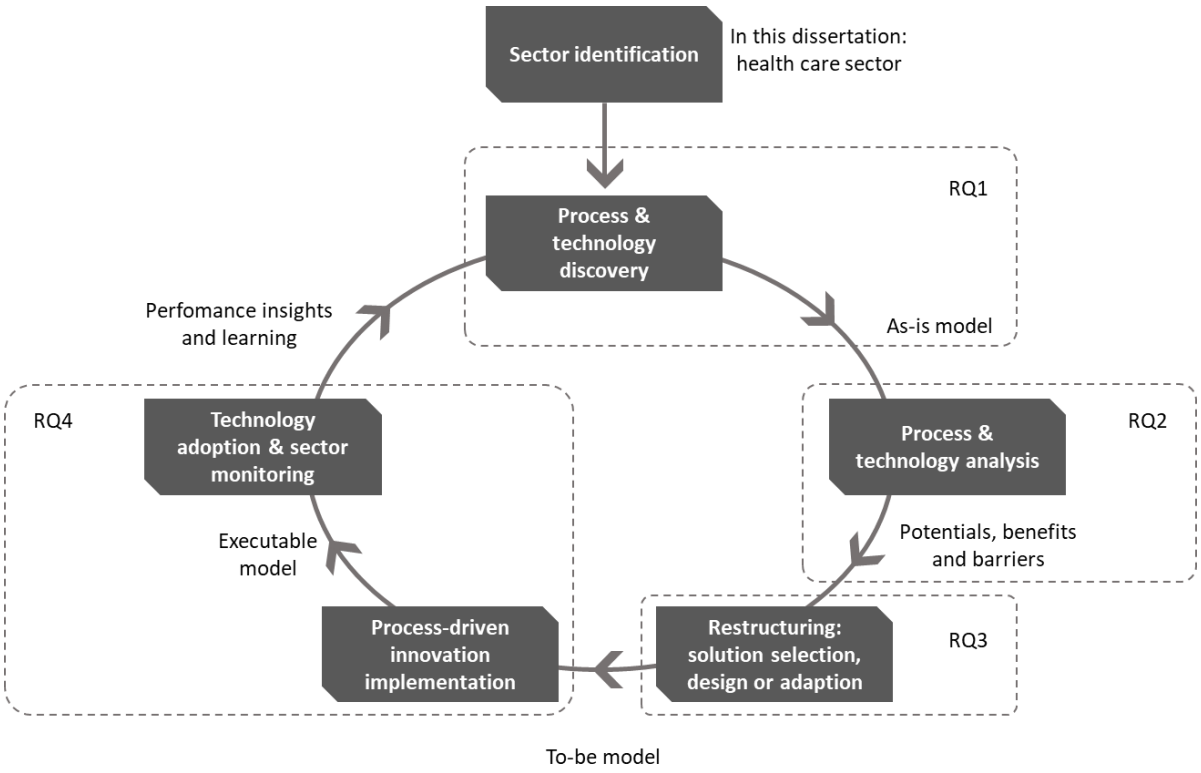

Figure 1. Framework of this dissertation adapted from Dumas et al. (2013).

The structure of this dissertation is structured following this framework. Contribution A initially outlines the range of application areas of digital health technologies. A key distinction can be made between the technologies – on the one hand are those for managing health in terms of prevention, and on the other hand are those for use in the healthcare sector especially for managing disease control. A crucial instrument in the healthcare system is the electronic health record (EHR), which is expected to establish itself as a central interconnection element in the healthcare system from a long-term perspective. This connecting tool is described in contribution B, which addresses the importance of interfacing technologies in healthcare. The changing role of growing data in healthcare and the opportunities of big data analytics are analyzed in contribution C with the help of identifying the main use cases and key benefits and barriers.

With regard to solution engineering in the step restructuring, one approach is the search for and selection of an existing technology. To enhance the innovation level, the search can be conducted in another industry. A procedure for finding and adapting a solution of another industry is described in contribution D, which presents a framework for cross-industry innovation. Furthermore, contribution E demonstrates how a technology can be developed and which aspects must be considered in terms of patient-centered health applications, especially with regard to health literacy.

Once a decision has been made in favor of an innovative technology, such as an AI-based platform, the new technology's integration must then be analyzed. Contribution F deals with the whole process, restructuring phases to shift from an as-is model to a to-be model, revealing the barriers and potentials of various stakeholders connected by an extended platform in palliative care. The barriers can be overcome by means of indicating which actions and stakeholders need to be involved; in particular, acceptance and motivation are key challenges. In contribution G, the acceptance, design and user involvement of a specific emerged digital health technology, the German COVID-19 tracing app, is analyzed and explained in more detail. After implementing an innovation in a process, the adoption is monitored and learnings can be gathered for further restructuring or to transfer this solution to other areas.

2.3 Spectrum of Applied Methods

The dissertation along the research contributions followed a mixed-methods approach with qualitative and quantitative methods to answer the research questions (Recker, 2013; Venkatesh et al., 2016). Since this is a cumulative dissertation, the authors of the research contributions could select the most appropriate methods for their investigation. In the information discipline, there are two main areas: (1) the design of information technologies (IT), better known as design science, and (2) the understanding of issues in behavioral science such as user acceptance (Hevner et al., 2004; Österle et al., 2011; Peffers et al., 2007). Furthermore, research has also been conducted on the economic effects of IT and the management and impacts of IT in organizations (Baskerville et al., 2011). The research contributions address both main areas, whereby the majority of them can be assigned to behavioral science and the management of IT in organizations, understanding why technologies are and should be used in the healthcare system in the future and how to implement them. Contributions E, F and G investigates the design science research paradigm according to Hevner et al. (2004), developing a prototype from the scratch. To explore innovative digitalization in healthcare, qualitative methods enabled the investigation of a still-growing research field. In addition, quantitative methods were used to analyze larger data sets to supplement qualitative findings, namely analyses on surveys (cf. contribution A: $n = 70$; contribution E: $n > 96$; and contribution G: $n \sim 2000$) such as partial least squares structural equation modeling (PLS-SEM) used in contribution G. Table 3 presents the methods that were applied in each contribution.

Table 3: Applied research methods.

	Research Method	Contribution A	B	C	D	E	F	G	References
Quantitative Methods	Experiment					X			Recker (2013); Wilde (2008)
	Survey	X				X		X	Recker (2013); Reips (2002); Wilde & Hess (2006); Likert (1932)
	PLS-SEM, Technology acceptance model							X	Hair et al. (2014); Davis (1989); Pfeiffer et al. (2016); Venkatesh et al. (2016); Xu et al. (2012)
	Quantitative (statistics-based) content analysis			X					Berelson (1952)
Qualitative Methods	Workshops, Focus groups				X	X	X		Morgan (1996); Myers and Newman (2007); Myers (2009); Plattner et al. (2009)
	Expert interviews	X	X	X	X	X	X		Gläser and Laudel (2010); Meuser and Nagel (2009); Myers and Newman (2007)
	Prototyping					X	X	X	Dey et al. (2001); Hevner et al. (2004); Peffers et al (2007); Wilde und Hess (2006)
	Framework				X				Lindner (2020); Wilde und Hess (2006)
	Process management and modelling						X	X	Wohed et al. (2006); Dumas et al. (2013)
	Other qualitative analyses (e.g., content analysis, cluster analysis, argumentation balance)	X		X		X	X	X	Mayring (2001); Myers (2009); Recker (2013); Trang et al. (2020); Witte (2020)
	Case study, process analysis, best-practice analysis		X		X		X	X	Myers (2009); Recker (2013); Benbasat et al. (1987); Eisenhardt (1989)
	Literature review	X	X	X	X	X	X	X	vom Brocke et al. (2009); Webster and Watson (2002)

For all research contributions, a literature review and expert interviews were conducted to create a basis for the state of the art in science and practice. In addition to expert interviews, useful methods are workshops, focus groups, and design thinking for obtaining practical insights. In contribution F, a case study was used to gain deeper insights into behaviors and awareness of restructure processes in healthcare.

3 Summary of the Research Contributions

3.1 Application Areas of Digital Health Technologies and Their Effects

Many potential applications exist for digital health technologies. This is because there are multiple opportunities for embedding small-scale smart technologies into daily life, such as self-tracking devices with sensors and analysis or decision support systems through predictive and prescriptive analytics (PPA). In general, digital health can be used for providing preventive treatment for a healthy lifestyle or improving the professional healthcare system. Both areas are fundamentally diverse, so digital health must be considered as multidimensional or separate.
Personal health tracking and lifetime monitoring are enabled by wearables that can be used for health-related purposes. These include movement, well-being, and vital signs trackers in for example smartwatches and smartphones. Measurement and monitoring through wearables along with the use of miniature sensors offer new potential for real-time personalized medicine and prevention (Haghi et al., 2017; Farahani, 2018). Regarding a preventive treatment for a healthy lifestyle, paper A, entitled *A Healthy Lifestyle and the Negative Effects of its Digitalization: The Dark Side of Using eHealth Technologies*, addresses the application areas and negative side effects of using technologies to manage a healthy lifestyle. These technologies are referred to as healthy lifestyle technologies ranging from health apps to wearables such as fitness trackers and smart clothing (Lupton 2017; Piwek et al., 2016). In the study of contribution A, 70 people were asked which categories they would consider to be part of a healthy lifestyle and whether the application of technology would be useful for this purpose. The answers were subsequently clustered into eight application areas in which the use of digital health technology would be appropriate in all cases (see Figure 2). Comparing the results with Maslow's hierarchy of needs, it became evident that digital health technologies can support the fulfillment of human needs in all areas.

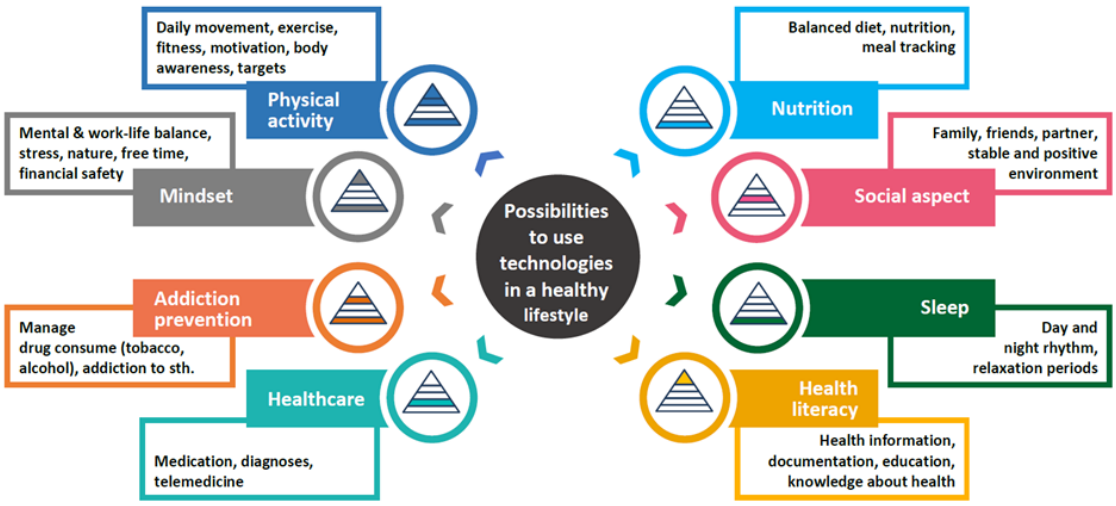

Figure 2. Areas for potential digital health technology use (Behne and Teuteberg 2020).

In practice and in the literature, positive effects of digital health are increasingly highlighted to convince people of the usefulness of these tools, such as more motivation to exercise and improved health literacy (Lupton, 2016; Lupton, 2017). For this reason, in contribution A, discussions with the interviewees were conducted alongside a structured literature review to gather possible structured negative effects from the use of health-enhancing technologies and to present these findings. More negative effects were found in the areas of physical activity (e.g., ignorance of physical warning signals, demotivation), the social aspect (e.g., pressure, feelings of inferiority), healthcare (e.g., inequalities, misdiagnosis), and health literacy (e.g., reliability, less awareness of body reactions). Consequently, even technologies, which are designed to support a healthy lifestyle, can lead to unintended outcomes. Thus, users should be aware of not only the benefits but also the drawbacks when using these technologies so that they are able to interpret different body reactions.

Regarding digital health technologies to support better healthcare services, the Federal Ministry of Health in Germany (Bundesgesundheitsministerium [BMG]) listed new technologies on which the German healthcare system should focus more strongly (BMG, 2021). A distinction was made between two types of technology: (1) the first is the overall connectivity through platforms, which was focused on by contribution B in the context of EHRs. More examples for connectivity may be the creation of a new access for digital health applications ("app on prescription"), the advancement of telemedicine, the electronic prescription, or the establishment of a research data center. (2) Regarding the second type of technology, the BMG also recommends big data analytics technologies such as AI, which could lead to great potential in patient healthcare and was the focus of contribution C.

With respect to information exchange, platforms are a key tool that should meet the objectives of interoperability, standards, and cloud-based solutions (e.g., Lehne et al., 2019; Mariano, 2020; WHO, 2020). According to a German innovation panel, the greatest foreseen value of digital health is in digital interaction between patients and providers at 66% and in data management at 61%, both of which depend on the integration of platforms (BMC 2020). The current digitalization in healthcare is fundamentally based on clinical information systems. Their core element are EHRs, since they are the information carriers of all clinical and medical data of patients (Yang et al., 2015). Therefore, the availability and comprehensive integration of EHRs into clinical information systems form the origin of the digital paradigm shift in the healthcare system and need to be opened to the patients and other healthcare actors in future (Agarwal et al., 2010). Contribution B, entitled *Electronic health records as a connectivity tool in the Internet of Health* (original title in German: *Die elektronische Gesundheitsakte als Vernetzungsinstrument im Internet of Health*), examines the appropriateness and functions of EHRs as a central documentation and communication platform on the basis of literature and eight EHR case studies. Figure 3 presents the multipurpose usefulness of EHRs.

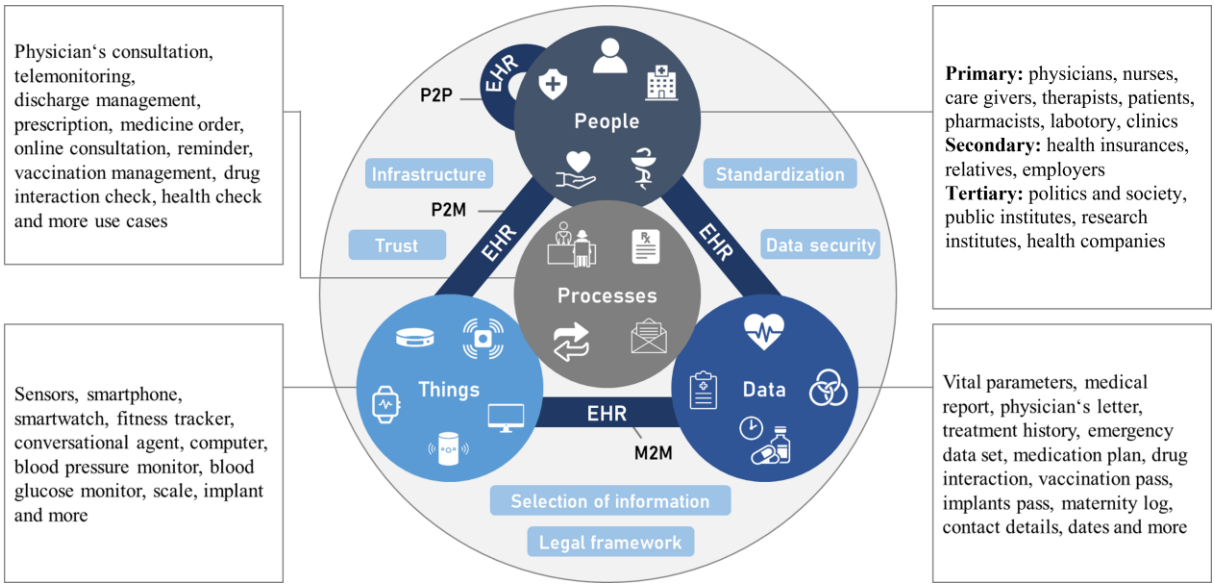

Figure 3. Scope of electronic health records (according to Fitte et al. 2019).

A total of 25 use case functions were identified, which largely focused on communication (eight use cases) and organization or documentation (nine use cases). In addition, there were functions in the areas of monitoring the own health status (four use cases), research (one use case), and system administration (three use cases). In addition to the best practice analysis, nine healthcare providers were asked for their opinions through expert interviews. In this context, they frequently mentioned benefits such as the availability and completeness of health data,

transparency, efficient exchange, and patient empowerment; nevertheless, barriers were not disregarded, including privacy, the regulatory framework, trust, and a lack of infrastructure and of standards. If these barriers were addressed, EHRs could provide a great potential for centrally connecting people, data, things, and processes in the Internet of Things.

In recent years, increasing amounts of data have been generated as part of the digital transformation in healthcare (Shin, 2019). Big data analytics can process these multidimensional and heterogeneous data sets in a reasonable amount of time (Farahani, 2018). On the one hand, big data analytics can be used to improve administrative aspects, such as admission rates and proper staffing. On the other hand, it supports disease prevention, for example, by identifying modifiable risk factors or signaling potential abnormalities (Alyass et al., 2015; Barrett, 2013). Contribution C, titled *Understanding the Role of Predictive and Prescriptive Analytics in Healthcare: A Multi-Stakeholder Approach*, aims to investigate big data analytics – the second recommendation of the BMG – and in particular PPA. Big data analytics concepts can be differentiated in descriptive (level 1), predictive (level 2), prescriptive (level 3), and autonomous analytics (level 4) (Davenport & Harris, 2017). Aside from descriptive analytics such as improvements to intersectional communication (e.g., for a quality check of an ePrescription), there is much more value in using PPA, such as support for diagnoses and treatments and the early detection and prevention of diseases (Behne & Teuteberg, 2020). Thus, using a multi-step research design, contribution C investigated the areas of application in healthcare for PPA as well as their benefits and challenges. For this purpose, a qualitative content analysis of 492 relevant findings from scientific and practical literature and nine expert interviews (three in the field of data analytics and six in healthcare) were conducted using a data analysis software for text coding, interpretation, and frequency analysis. From 2016, publications on the topic of PPA increased significantly in practice as well as in academia, where in terms of the levels of sophistication of intelligence, predictive analytics (level 2 of 4) and less prescriptive analytics (level 3 of 4) were predominantly addressed. Prescriptive analytics can be explained as an extension of predictions with a recommendation for a desired reaction. Nine use cases were identified as the main clusters for the application areas of PPA (cf. Figure 4).

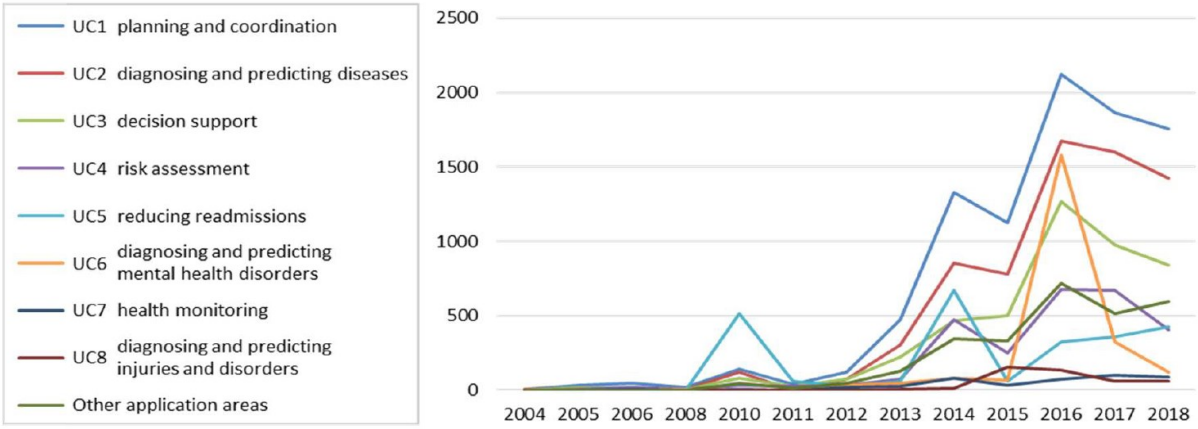

Figure 4. Distribution of main PPA use case clusters (UC1–UC8) in literature per year (Oesterreich et al. 2020).

Furthermore, the key benefits and challenges were analyzed in a structured manner by listing individual barriers (e.g., data challenges, trust, education, or lack of resources) and drivers (e.g., cost reduction or improvement of healthcare, satisfaction, knowledge) in the light of different stakeholders (e.g., physicians, pharmacists, patients, insurances, relatives, and society). In particular, the adoption of new technologies by potential stakeholders was of interest. This can be used, for example, in the political process to better understand different, partly opposing perspectives (Ngwenyama & Nielsen, 2014). Ultimately, practical implications for each stakeholder group were raised, within which it was evident that the performance of healthcare services can be improved and costs can be reduced by PPA.

Faced with time pressure, individuals often unfortunately forget the big picture by focusing solely on a single task (Thimbleby, 2013). As a starting point for inspiring a new solution, existing problems can be identified within a specific area or new technologies can be tested to figure out their fit in the process (Behne et al., 2021a). Overall, the first three research contributions deal with specific technologies, which indicate much usefulness for improvement or restructuring the healthcare delivery, examining the technology's potential, strengths, and drawbacks in advance.

3.2 Achievement of a Suitable Solution

3.2.1 Transfer and Adaption

Once a specific area with its processes and technologies has been analyzed, the next step is to decide which solution fits best. Regarding the simplest approach, there might be an existing solution for an issue that reoccurs in many companies; thus, an existing solution (a new product,

process, or service) can be applied in a similar manner. For rarer problems, a solution can be adapted instead of developing it from scratch. Contribution D, titled *A Framework for Cross-Industry Innovation: Transferring Technologies between Industries*, covers a holistic framework that is understandable in practice, from the search for technologies in other industries to the solution integration and learning from other industries. The results of a structured literature review, eight interviews with experts (mostly of innovation and technology management), and a workshop with five IT and management consultants from the automotive sector were consolidated. Figure 5 presents the overall framework with its four phases: target definition, search for technologies, assessment and decision, and adoption.

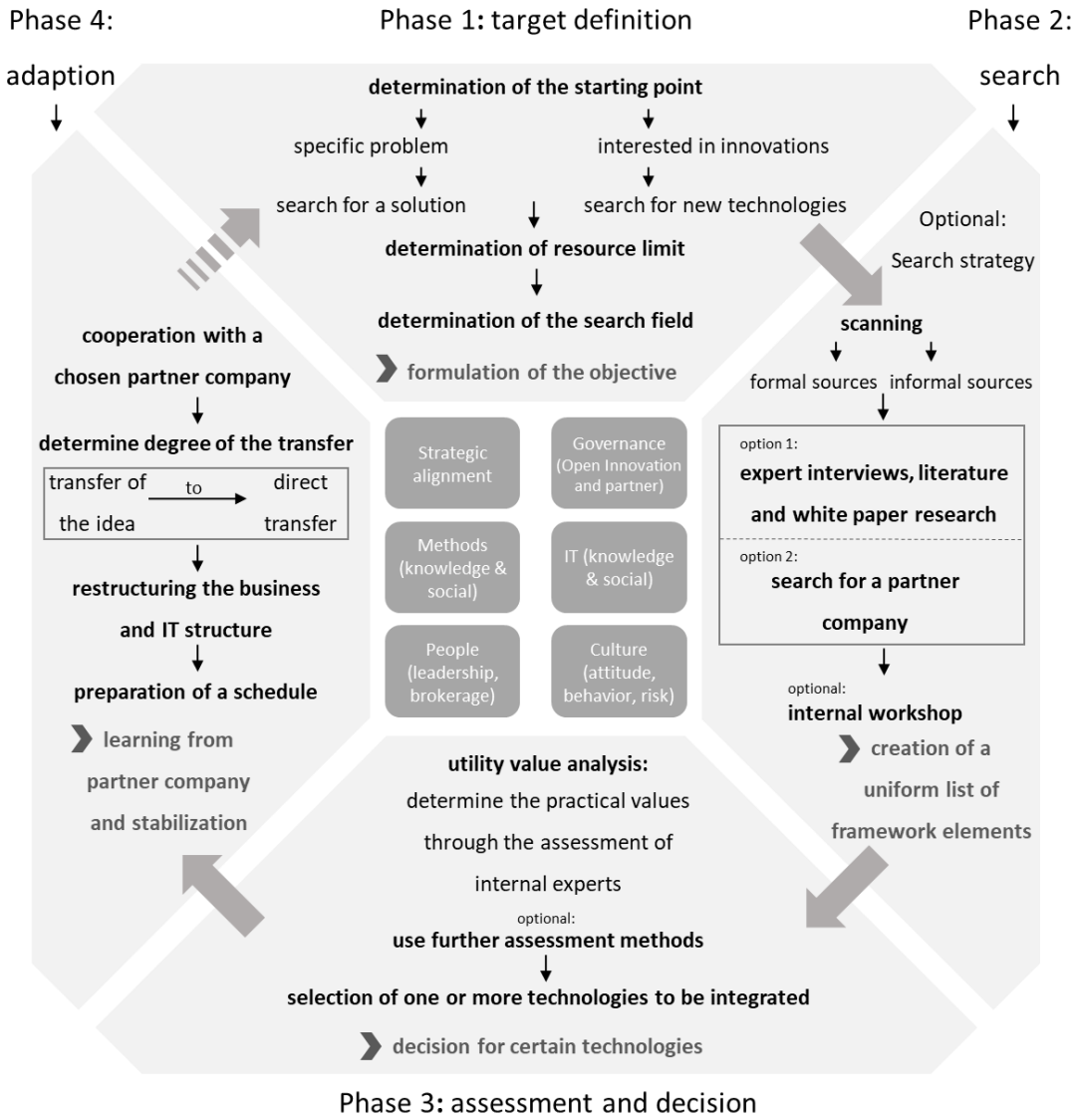

Figure 5. Cross-industry innovation framework (Behne et al. 2021a).

An innovation usually has a high level of innovation if the initial idea comes from a more distant industry, since no competitive pressure or analogous problems exist (Hosseini et al., 2017).

Provided that the company's own problem is seen on a more abstract level, analogical solutions can be uncovered through technology intelligence methods, expert interviews, a partner company, or even internal workshops (Gassmann & Zeschky, 2008). Subsequently, the identified technologies must be evaluated with regard to their fit with the company. According to the last step of the cross-industry innovation framework, the adaption and corresponding restructuring of the processes must be planned.

3.2.2 Design of Digital Health Technologies

In case no suitable solution exists on the market or no analogue solution should or can be found in another industry, an innovative solution can also be developed by the company itself. Besides their improvements regarding efficiency and process simplification, new approaches such as user-centered design and design thinking are crucial for matching the needs of users (Hehn et al., 2019). Contribution E, titled *FeelFit – Design and Evaluation of a Conversational Agent to Enhance Health Awareness*, addresses this point and demonstrates how multiple iteration and evaluation cycles can be used to develop and design a user-centered artifact for increasing health awareness. Smart wearable devices for self-measurement in healthcare to increase health awareness are becoming increasingly common (Watson, 2016). However, they all have their own interface for interacting with them. For example, elderly people in society in particular want or require a unified user interface. Against this background, Contribution E focuses on a multi-method development of a conversational health agent using three iterations of the design science research paradigm of Pfeffers et al. (2007). The goal of the development was to connect the devices via a central platform and to control the different sensors by means of an integrated conversational assistant. Furthermore, these could be displayed on a separate, home-like monitor on demand. This paradigm was methodically implemented with the help of literature research (vom Brocke et al., 2009), design thinking (Plattner et al. 2009), qualitative analysis of workshops (Mayring, 2001), prototyping (Dey et al., 2001), and three surveys. Summarized from individual suggestions, users wished to have a comprehensive system, through which they could not only retrieve data but also use various functions from other apps. This can be a daily reminders for medicals or automatic interfaces with healthcare providers if abnormalities were observed. The main focus was on the context-specific design of an app for the customer and the comprehensibility of the information, especially because health awareness is not always be given. Moreover, clearer information deserves a greater focus because (mis)interpretation by a user with less adequate health literacy can occur.

Figure 6 presents (a) the output of the various values measured using different devices; (b) the dialog between the user and the conversational agent for improving health awareness; and (c) the display on a smart (semi-transparent) mirror, which resembles an interior object.

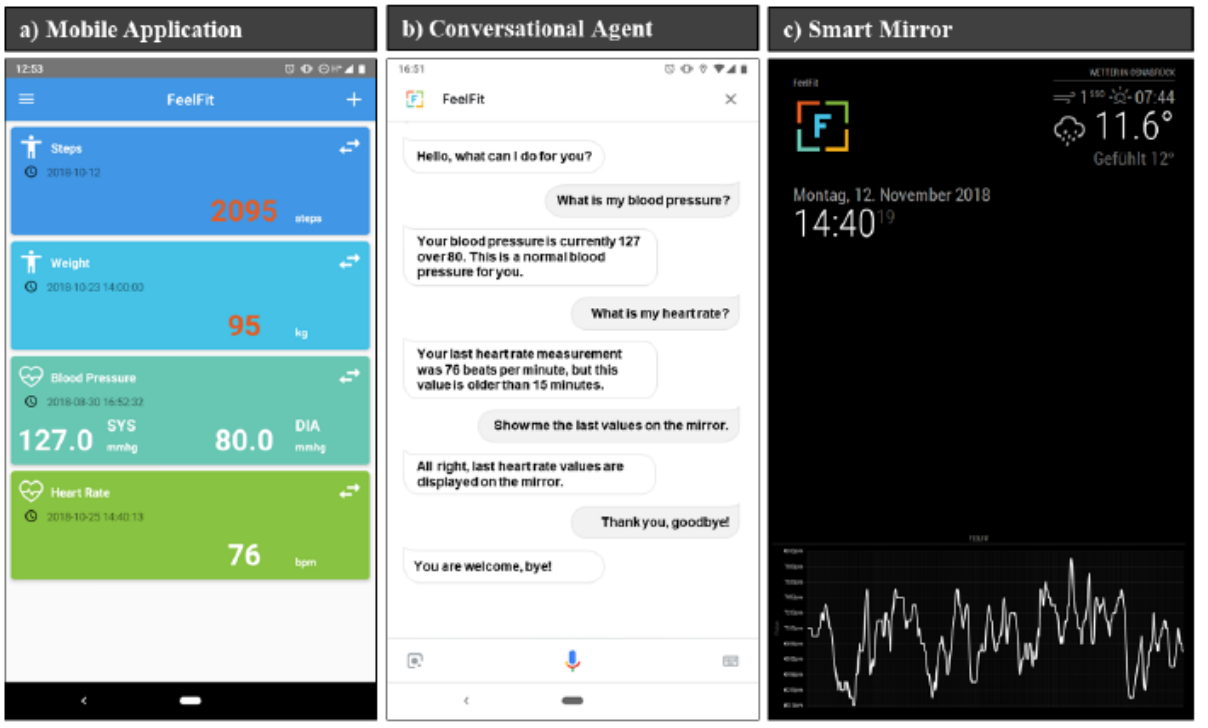

Figure 6. User interface of the conversational health agent (Meier et al. 2019).

3.3 Adoption of Innovations: Acceptance for Integration

As mentioned in contribution D, once a solution has been selected, the processes of relevant stakeholders must be restructured for adoption of the innovation. When integrating a new solution, aspects such as strategic alignment, governance, knowledge and social aspects, leadership, attitudes, behaviors, and risks must be considered. Contribution F, entitled *Intersectoral connectivity in healthcare: Process improvement by the utilization of platforms based on a case study in palliative care* (original title in German: *Intersektorale Vernetzung im Gesundheitswesen: Prozessverbesserung durch den Einsatz von Plattformen am Fallbeispiel der Palliativversorgung*), deals with process management in digitalization. The aim of the study was to improve efficiency using a communication and documentation platform. In Germany, the most frequently used and standardized types of communication are telephone (77%) and fax (22%) (Behne & Teuteberg, 2021; Bitkom, 2021), even though the platform technology is mature enough and offers numerous advantages such as asynchrony, automatic documentation, and multi-user capability.

Based on a literature review, focus groups, expert interviews, process modeling, and process weakness analysis, the study demonstrates how a platform can be further developed in a user-centric and process-driven manner, and also how process implementation can be approached. Initially, the current process of discharging palliative patients to their homes was noted and modeled using Business Process Management Notation. In this process, weaknesses predominantly in the areas of communication and documentation became apparent, which were countered largely by the elected information system for palliative care (ISPC). Based on this, a to-be process with the use of the ISPC was modeled, covering weaknesses and all stakeholders (the clinic, primary care physician, pharmacist, patient, and family members). However, it turned out that it is very difficult to implement a holistically considered target process in which many stakeholders are involved, since restructuring and a lack of know-how often result in a reluctance to adopt new systems (Yogesh & Gaurav, 2019). In process integration, employees in particular are a crucial factor in terms of acceptance, competencies, and routines. Thus, within the case study, a balance of arguments was drawn up which transparently presents all of the benefits and downsides associated with using the platform. This approach of a balance sheet can counteract resistance in changing processes through clear communication and can create incentives through the predominant advantages (Witte, 2020). Nevertheless, a fully planned target process with all stakeholders is not always the desired solution. Instead, the focus should be on subprocesses where the cost-benefit ratio of process integration is little. Thus, the study highlights two parts of the defined target process with less integration effort: the use of the German national medication plan ("*Bundeseinheitlicher Medikationsplan*") for the discharge of palliative patients in clinics and digital exchange between the palliative network and one partner pharmacy through the information system ISPC. In addition, it was illustrated that existing platforms should constantly evolve to meet ever-changing user needs (Winkler et al., 2020).

Whether a technology is actually used is related to the behavioral intention to use and several acceptance factors to this technology (Davis, 1989). Thus, contribution G, titled *Learnings from the Design and Acceptance of the German COVID-19 Tracing App for IS-driven Crisis Management: A Design Science Research*, investigates which improvements of the existing German COVID-19 tracing app might lead to an increased usage. Only if approximately 60% of citizens use the tracking app would there be a measurable impact on the number of infections (Hinch et al., 2020). A multi-methodological design science research approach was utilized to develop a prototype of an enhanced COVID-19 tracing app as an effective tool for crises management. COVID-19 apps can be aimed at contact tracing, tracking, and documenting and

transmitting health data (Krüger et al., 2021). First, a survey of 1,993 participants from Germany was conducted using a technology acceptance model analyzed with PLS-SEM to explore what is required to increase the intention and actual use of social-participatory apps. Second, functional requirements for an improved app are collected from recommendations of epidemiologists and from interviews with IT and health experts. With respect to the front-end, 13 functional requirements are presented, which aim a better content management in terms of situation-related information, health literacy of users and cluster recognition. The six identified functional back-end requirements address an ongoing modification of risk score calculation or test result reports among other. In total, 14 issues, six meta-requirements and three design principals could be derived, which can be seen in Figure 7. Based on these results, an enhanced prototype was developed that was tested by 53 participants in a third step.

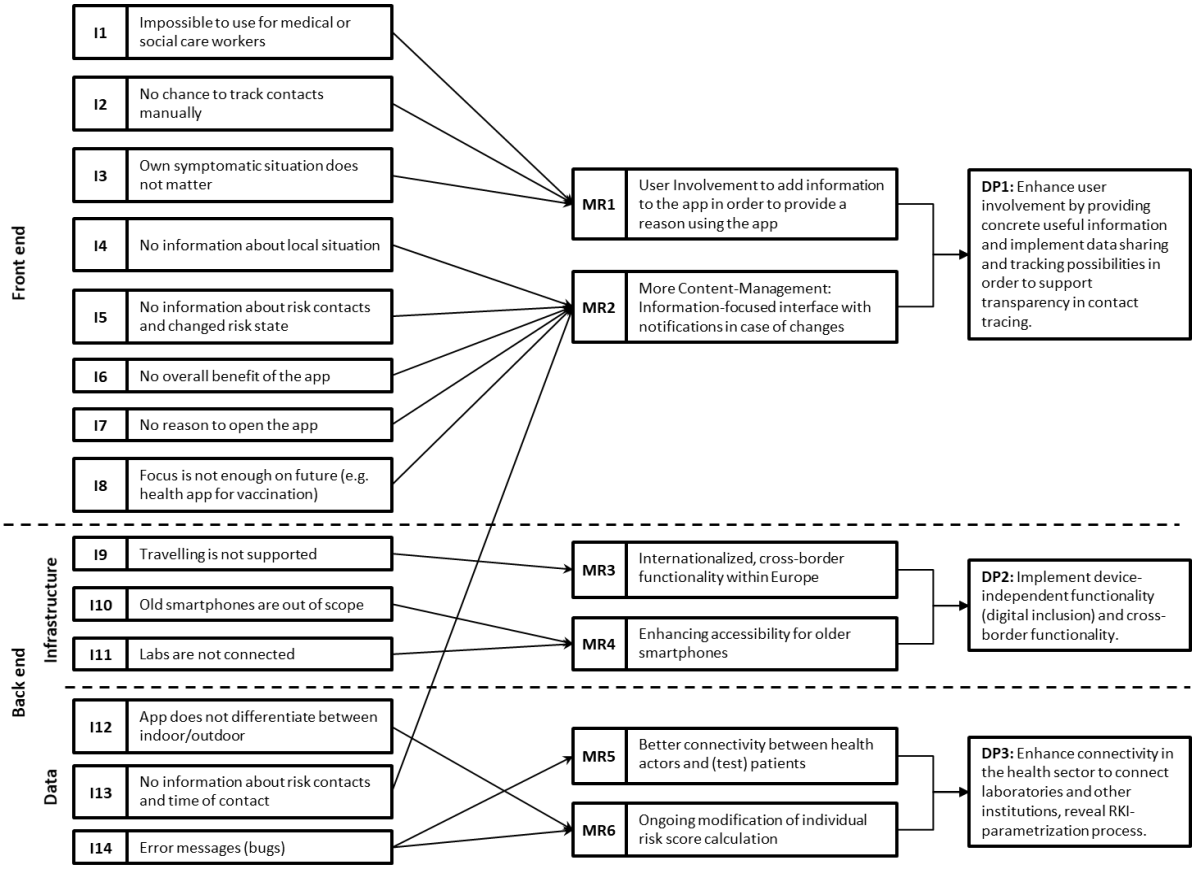

Figure 7. Identified issues, meta-requirements, and design principles for pandemic apps (Behne et al., 2021b).

Overall, contribution G encourages the voluntary involvement of population in the app development process by an open-source approach, more user participation for pandemic-related apps and an agile setup for crisis management in app development and politics because of required flexibility in a pandemic situation since this will not be the last.

4 Discussion

4.1 Implications for Research

In the scope of this cumulative dissertation, the research contributions identify and address several research gaps to explore digital health technologies from various perspectives. A multi-method approach is applied to elaborate the overarching RQs within the digitalization in healthcare (see the four RQs in Section 1.2). Overall, the focus is on the most promising technologies in future healthcare; their risks, barriers, and chances; and how to integrate them into the existing healthcare system. In particular, platforms for more connectivity, self-tracking devices and big data analytics tools are investigated.

RQ1 deals with central areas for the application of innovative digital health technologies. Regarding contribution A, application areas go beyond the dimension of the healthcare system as it finds increasing application in people's everyday lives. Thus, a distinction between prevention in daily life and professional healthcare delivery is made. Both topics are receiving increasing attraction because a healthy lifestyle is one of eight global megatrends (Boumphrey & Brehmer, 2017), and furthermore, health is ranked first in the German value index 2020 based on social media analyses (Wippermann & Krüger, 2020). Addressing the gap raised by RQ1, contribution A structures the application of healthy lifestyle technologies in eight areas, wherein healthcare is one area (see Figure 2). Contributions A, B, and C underline the opportunities and challenges of wearables and other self-tracking devices, EHR platforms for connectivity and a consistent database, and predictive and prescriptive analytic tools in healthcare. As the German Health Minister, Jens Spahn, stated, it would have been beneficial to have had EHRs during the COVID-19 crisis because the most commonly used healthcare connectivity tool are still telephone and fax, making the documentation, analyses, and transparency more complicated (Spahn, 2020; Bitkom, 2021). Nevertheless, since 2021, German health insurance companies have offered an EHR for their members (BMG, 2020). Contribution C reports the application areas of PPA, whereby the three most represented use cases were planning and coordination, diagnosis and prediction of diseases, and decision support. As part of big data analytics, AI plays a crucial role in current digital health (Shin 2019) as AI-enriched clinicians could "make medicine safer, more accurate, and more patient-centered" (Liew, 2020).

In addition to these promising technologies examined in contributions A, B and C, other following technologies gain increasing attention. Virtual, mixed, or augmented reality can serve as education tools for medical students, teleconsultation tools for remote physicians, new

treatment models in medical practices, or as health documentation tools (e.g., Freeman et al., 2017; Schuir et al., 2019; Wang et al., 2017). In the area of healthcare platforms, blockchain, which is categorized as a distributed ledger technology, has been investigated in recent years and shown potential promise for storing sensitive healthcare data due to its decentralized nature (Beinke et al., 2019; Bouras et al., 2020; Meier et al., 2021). Moreover, robotics are useful in healthcare as they can be used in a variety of scenarios, especially for primary health actors. Beneficial tasks performed by robots are physical and cognitive in nature, such as 3D-printing medical devices or medications, transporting and dispatching materials, moving patients, delivering personal messages, and cleaning rooms; further, robots can be performers in surgeries or models for clinical simulation and training (Colpani et al., 2018; Riek, 2017).

In addition to the aforementioned opportunities of digital health technologies, the barriers to be overcome before integrating such new technologies must be determined. Several misfits can occur between a technology and an existing business, which can be considered on the following bases: functionality, data, usability, role, control, and organizational culture (Strong & Volkoff, 2010). To answer RQ2, contributions A, B, and C systematically present barriers to the application and adoption of such digital health technologies using specific technological examples. This area is considered stakeholder-specific, especially for primary stakeholders, namely healthcare providers and recipients. Furthermore, there are secondary stakeholders such as health insurance providers and family members as well as tertiary stakeholders such as society and research institutes. Contributions A and C uncovered the more frequent barriers to application, such as data quality and availability, interface management, health literacy, equality in healthcare, and trust. From practical insights, contribution F emphasized that even if technologies are convincing in terms of common process performance dimensions such as quality, time and costs, they are often not adopted due to organizational resistance or lack of human resources. Thus, barriers can be identified as demonstrated in contribution B and C.

Besides understanding the issues of behavioral research (RQ1 and RQ2), RQ3 and RQ4 deal with theory and prototype-development findings, which are also supposed to be beneficial to society and business (Baskerville et al., 2011). Contribution D enriches the body of knowledge with a framework for cross-industry innovation, searching for technological solutions also in other industries and offering one approach to engineer a process-driven digital health innovation regarding user needs as well as health processes (RQ3). Open innovation strategies, such as the error culture in startups, are crucial not only for each private enterprise but also for public enterprises (Silva et al., 2020). An emerging trend is a third mission of universities next

to research and teaching, namely how universities can further contribute to society and business with innovative activities such as technology transfer (Loi & Di Guardo, 2015). A second approach for answering RQ3 was presented by contribution E and G, which applied the design science research approach to develop an individual, user-centered prototype for a better content management and health awareness. The identified meta requirements and design principles can serve as a starting point for further investigations of user-centered health applications.

To answer RQ4 regarding the successful integration of process-driven digital health innovations, processes and social aspects must be aligned since business strategies such as innovation strategies are connected with business processes (Ould, 2005). Gaining knowledge and an overview of one's own processes, weaknesses, and potential technologies or other innovative solutions enable a continuous improvement in business and thus a better patient care and working condition for professionals. The framework of this dissertation provides guidance for health institutes and policy makers to keep up to date in terms of digitalization in healthcare. Furthermore, contribution F applied process analysis methods to improve existing business structures regarding communication and documentation among different healthcare providers. Contribution G investigates adoption with the example of the German COVID-19 tracing app (Corona-Warn-App); generally, user-centered design is crucial for adoption as users are the most critical driver of innovative technology. Thus, besides the governmental requirements of technology such as data security, users must be convinced about the technology through transparency, acceptance and user involvement.

4.2 Implications for Practice

In addition to gaining theoretical insights, design-oriented business information systems aim to contribute to the further development of application knowledge (Hevner et al. 2004). In the context of this dissertation, this was implemented by constantly involving practitioners in expert interviews and focus groups, conducting case studies, and developing and evaluating a prototype for greater health awareness. The contributions underline the relevance of combining innovation management with process and technology management in the healthcare sector. The overall framework of this dissertation presents an approach for staying up to date in terms of digitalization strategy. A great relevance for this topic was demonstrated within international studies, in particular for Germany, regarding policy activities, digital health readiness, and actual data transfer between healthcare actors (Bertelsmann, 2020).

The current major transformation and emergence of technologies in healthcare, including those investigated in this dissertation, can enable a shift from a hospital-centered disease treatment to a patient-centered health maintenance system with the trend toward prevention (Bhavnani, 2020; Farahani, 2018). The current state of the healthcare system is not sustainable due to the rising costs of demographic change as well as rising expectations for healthcare providers (Laurenza et al. 2018). Opportunities for technologies in healthcare are far-reaching and constantly being enhanced; thus, healthcare providers should always try new technologies and be open to restructuring, for example by using the framework in Figure 1 or the cross-industry framework from contribution D. As a result, innovative ideas can originate from other industries, and thus, outside-the-box thinking might be useful.

With regard to contributions C and F, the support of all stakeholders is needed for a successful digital transformation in healthcare. This can be done through being open to exploring new digital opportunities, building trust in digitalization with patients through education, and engaging in digital collaboration with other healthcare providers (Mariano, 2020). In the end, restructuring processes with digital health technologies can improve not only the quality of care but also the working conditions and the overload of the healthcare system in the long term (Schnell et al., 2019). Thereby, technologies for collaboration should be focused, since collaborative professionals provide more competence and knowledge (contribution F). When offering new digital healthcare services, the transition from the classic to the new approach should be considered since the general concept of the WHO states that healthcare should be accessible to everyone with equal opportunities (WHO, 1998). Nevertheless, regarding innovations enable new opportunities of healthcare, there are always early adopters and some who follow them (Rogers, 1995) – in this context, patience, informing, and explanation are required and should undertaken by healthcare providers (contributions C, F, and G).

As seen in contributions F and G, a major obstacle to the process restructuring of the known procedure is the acceptance of all stakeholders, not the maturity of the technology, which is why the user-centric orientation is crucial (Sawatzky et al., 2018). The acceptance of employees can only be ensured by involving them in the change from the beginning. In this area, new work methods could help so that the ability to innovate and adapt to external influences increases due to more flexible, collaborative, entrepreneurial and autonomous work practices. Thereby, for example, cross-sector collaboration in non-work related tasks or perspective and role switch of employees, can promote the employee satisfaction and emergence of innovations (Aroles et al., 2019). For a successful integration of innovations, work arrangements must change.

In fact, there will be fragmented solutions for the foreseeable future (Thimbleby, 2013), but there are existing functional solutions that should be used and can be enhanced further as presented in contribution F. In the future, having only one single system should not be the one overarching aim; rather, existing systems should be able to communicate with each other through standardized, secure interfaces and data formats. For this purpose, contributions F and G highlight that policy makers should support what can be feasibly implemented with a practical impact, being in touch more often with people from the practical side and should use an agile setup. As a result of contributions A, B, C, and E, regarding trustworthy and sensitive health data, clear guidance, understandable language, ethical and legal aspects, as well as standards regarding interfaces and data protection must be taken into account, whereby users should transparently view and determine access rights. Contribution G indicated that an open-source system approach increases trustworthiness and communication. Furthermore, the case study in contribution F underlines that platform manufacturers should create open standardized interfaces to open their platforms to more healthcare providers than just one group, thus enabling more functions to be covered and collaborative work in healthcare to be easily realized. Furthermore, co-creation of start-ups or mature developers with healthcare providers should be focused more in the development of medical software since such cooperation will lead to innovative and process-oriented ideas (Aroles et al., 2019; Sogani et al., 2020). As a result of the best practice analysis in contribution B, the identified functional requirements can support the further development of EHR platforms.

Contribution F highlights that the structure of task distribution and healthcare delivery to the patient could be reconsidered. The role of chief digital officer begins to be established and should receive more attention in the healthcare sector. This role both ensures the logical use of technology and keeps track of the innovation strategy with digital technologies (Schimpf et al., 2016; Tumbas et al., 2018; van Velthoven et al., 2019). The chief digital officer can perform relevant tasks such as developing new business models, as stated in contributions C and D. Furthermore, physicians and pharmacists among others must transform their skills with digital technologies such as skills of data scientists since medicine delivery will get along with generating an immense amount of healthcare data, (Shin, 2019). As seen in pandemic, in Germany, tasks such as performing COVID-19 tests and setting up digital vaccination cards can serve well other healthcare providers giving them more meaning and not adding more workload to the already overburdened physicians' practices (contribution F). This example highlights again the fact that connectivity among healthcare providers should be prioritized.

4.3 Limitations and Further Research

The selected research contributions were double-blind peer-reviewed in scientific journals or conferences to meet quality and relevance requirements. However, each paper identified minor weaknesses that were noted as limitations while standing as starting points for further research. In general, the limitations of all contributions were the language bias (Rasmussen & Montgomery, 2018) and the imbalance of qualitative and quantitative methods (see Table 3; (Recker, 2013; Venkatesh et al., 2016). Each of the selected contributions exhibited the intensified use of qualitative analyses, yet in four of the contributions (A, C, E, and G), quantitative analyses were applied besides the qualitative analyses. Qualitative analyses are especially crucial in new research fields that have not yet been widely explored, such as innovative technologies in healthcare (Recker, 2013).

Expert interviews or workshops were conducted with only German experts in all contributions, augmenting the literature-based findings. Thus, these insights uncover a narrower perspective within these research contributions. Moreover, there could be a bias in development progress because Germany ranks 16th out of 17 in the Digital Health Index (Bertelsmann, 2020). To counteract this limitation, more methods and thus data triangulation with international data was used to produce more consistent and convergent findings (Mayring, 2001). Nevertheless, more international interviews and workshops would extend the research. Furthermore, qualitative methods as interviews or content analyses can be misinterpreted or distorted. To minimize this risk, at least two authors qualitatively interpreted independently statements or results. Moreover, the acquisition of experiments (contribution E) or survey participants (contributions A, E, and G) was conducted locally or distributed via specific digital channels; hence, the studies may appeal more to digitally affine or extreme (positive or negative) people.

As a follow-up to contribution F, the integration of a digital technology could be monitored until it is actually applied. In addition, questions could be asked as to what the actual reason was for adopting the technology and changing the processes. Furthermore, this dissertation contains detailed investigations of three technology areas, namely self-tracking wearables, EHR, and PPA. However, there are more promising technologies in healthcare for which a detailed, practical-oriented, or scientific analysis would provide clarity, such as the technologies mentioned in Section 4.2 (e.g., virtual, mixed, or augmented reality, blockchain, robotics). Despite the limitations mentioned above, in the healthcare sector, the meaningful findings are, to a certain extent, transferable to other technologies and countries.

5 Conclusion

This cumulated dissertation including its seven research contributions enables a multi-perspective view on the topic of process-driven innovation in healthcare, in particular with a focus on digital health technologies. The framework (Figure 1) underlines the relevance of combining the integration of innovations with process management in healthcare as a regulated service sector to serve a population. Therefore, the current and future state of research and practice of promising technologies including their barriers and benefits were taking into account (contributions A, B, and C). It was described a framework for the identification for promising technical solutions, either adapting (contribution D) and developing (contribution E) the innovation. Moreover, approaches for integrating successfully suitable and emerging digital health technologies in existing structures in healthcare are investigated, in particular the motivation and acceptance of users (contributions F and G).

From the findings, practical as well as scientific implications for innovation management in healthcare were derived. Thus, not only companies can be supported along their analysis of processes to the search for and integration of new technologies into their business, but also healthcare providers, patients, policy makers and digital health developers can be assisted to stay up to date with creating awareness of existing or novel solutions. Regarding growing populations, demographic change and shortage of skilled workers, digital health technologies enable more efficient processes and a shift to more responsibility to patients. In the healthcare sector, technological connectivity between healthcare providers and to patients should be more focused. When integrating innovations, the surrounding and culture (contributions G and F) and other stakeholders (contributions B, C and F) must be taken into account as technology should not be considered alone. Thereby, open-source approaches with voluntary involvement in app development and more user involvement in terms of social-participatory apps could be supportive. Moreover, openness of healthcare actors to new technology, new roles and task distributions in healthcare delivery, new work methods for more innovative ideas and transparency and education for patients might be useful. A bottom-up or top-down approach only cannot be successful, as the healthcare market is becoming a patient-centric market but is still a highly regulated market. Therefore, innovations should be driven top-down on the one hand and bottom-up on the other.

Overall, this dissertation intends to illustrate that a process-oriented integration of new technologies developed with a user-designed approach is appropriate in the healthcare sector.

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Part B: Research Contributions

Contribution A

Title	**A Healthy Lifestyle and the Adverse Impact of its Digitalization: The Dark Side of Using eHealth Technologies**
Authors	Alina Behne Frank Teuteberg
Year	2020
Outlet	International Conference on Wirtschaftsinformatik (WI)
Ranking	WKWI: A VHB: C
Bibliographic information	**Behne, A**., & Teuteberg, F. (2020). A Healthy Lifestyle and the Adverse Impact of its Digitalization: The Dark Side of Using eHealth Technologies; in Proceedings of the 15th International Conference on Wirtschaftsinformatik (WI 2020), Potsdam
Identification	DOI 10.30844/wi_2020_f2-behne
Keywords	eHealth, healthy lifestyle technologies, adverse impact, digitalization
Link	https://library.gito.de/wp-content/uploads/2021/08/F2_Camera-Ready_WI2020_Adverse-Impacts.pdf

Abstract: eHealth technologies strongly influence healthy lifestyles. In addition to numerous advantages and positive effects, we analyze adverse effects of technologies that are used in everyday life to support a person's health or health management. Therefore, we conducted short interviews and a literature review to structure aspects of a healthy lifestyle in eight areas related to the potential technology usage. Based on that, this contribution presents a systematic collection of negative effects of eHealth technologies on end users or patients. With regard to our results, this contribution provides seven scientific and six practical implications.

Contribution B

Title	**Die elektronische Gesundheitsakte als Vernetzungsinstrument im Internet of Health (Translation: Electronic health records as a connectivity tool in the Internet of Health)**
Authors	Christian Fitte Pascal Meier Alina Behne Dafina Miftari Frank Teuteberg
Year	2019
Outlet	INFORMATIK 2019
Ranking	WKWI: C VHB: C
Bibliographic information	Fitte, C., Meier, P., **Behne, A.**, Miftari, D., & Teuteberg, F. (2019). Die elektronische Gesundheitsakte als Vernetzungsinstrument im Internet of Health, INFORMATIK 2019: 50 Jahre Gesellschaft für Informatik– Informatik für Gesellschaft, Kassel
Identification	DOI 10.18420/inf2019_17
Keywords	Elektronische Gesundheitsakte, Vernetzung, Gesundheitswesen, Internet of Health
Link	https://dl.gi.de/bitstream/handle/20.500.12116/24963/paper2_01.pdf

Abstract: Das Internet of Everything bietet große Potenziale, die Gesundheitsversorgung zu verbessern und die Grundlage für ein vernetztes Internet of Health (IoH) zu bilden. Während in den letzten Jahren viele digitale Insellösungen entstanden sind, mangelt es im Gesundheitswesen an einer intelligenten Verknüpfung von Personen, Prozessen, Daten und Dingen. Im vorliegenden Beitrag wird elektronische Gesundheitsakte (eGA) als patientenzentriertes Vernetzungsinstrument im IoH vorgestellt. Für eine Analyse des State of the Art werden zunächst aktuelle Anbieter einer eGA in Deutschland vorgestellt und 25 Anwendungsfälle der eGA identifiziert. Anschließend wird das Potenzial der eGA als Vernetzungsinstrument im IoH herausgearbeitet. Im Rahmen von neun Experteninterviews mit Gesundheitsdienstleistern werden Anwendungsfälle der eGA sowie Herausforderungen für den flächendeckenden Einsatz der eGA abgeleitet.

Contribution C

Title	**Understanding the Role of Predictive and Prescriptive Analytics in Healthcare: A Multi-Stakeholder Approach**
Authors	Thuy Duong Oesterreich Christian Fitte Alina Behne Frank Teuteberg
Year	2020
Outlet	Twenty-Eighth European Conference on Information Systems (ECIS)
Ranking	WKWI: A VHB: B
Bibliographic information	Oesterreich, T. D., Fitte, C., **Behne, A**., & Teuteberg, F. (2020). Understanding the Role of Predictive and Prescriptive Analytics in Healthcare: A Multi-Stakeholder Approach, in Proceedings of the 28th European Conference on Information System (ECIS), Marrakech
Identification	ISBN 978-1-7336325-1-5 (ECIS 2020 Proceedings)
Keywords	Predictive analytics, prescriptive analytics, healthcare stakeholders, challenges, benefits
Link	https://aisel.aisnet.org/ecis2020_rp/102

Abstract: The volume, velocity and variety of data is continuously rising. While many industry sectors are already applying big data analytics for various purposes, the use of big data in healthcare remains limited. A major reason for this development lies in the fragmented structure and conflicts of interests among the various stakeholders in the sector. To date, there is a lack of a comprehensive study that integrates insights from both practical and academic literature with expert knowledge to create a holistic picture of the main use cases, challenges and benefits of predictive and prescriptive analytics (PPA) in healthcare. To fill this gap, we investigated the role of PPA in healthcare from different stakeholder perspectives. We conducted a systematic literature review and applied content analysis to identify the main patterns extracted from the literature. The findings were triangulated with insights gained from 9 interviews with healthcare experts. Overall, we identified 8 use case clusters, 18 key benefits and 10 key challenges for the stakeholders involved. Furthermore, the role of PPA in healthcare is discussed from different stakeholders' perspectives. Our findings reveal that the stakeholders pursue contrasting interests, which require legal regulation such that PPA can diffuse on a wider scale.

Contribution D

Title	**A Framework for Cross-Industry Innovation: Transferring Technologies Between Industries**
Authors	Alina Behne Jan Heinrich Beinke Frank Teuteberg
Year	2021
Outlet	International Journal of Innovation and Technology Management
Ranking	VHB: C JIF: 1.28
Bibliographic information	**Behne, A.**, Beinke, J.H., & Teuteberg, F. (2021). Understanding the Role of Technology in Cross-Industry Innovation: Design and Evaluation of a Conceptual Framework. International Journal of Innovation and Technology Management, 18(03), 1-27
Identification	DOI 10.1142/S0219877021500115
Keywords	Cross-industry innovation; framework; technology transfer; innovation management.
Link	http://www.worldscientific.com/doi/abs/10.1142/S0219877021500115

Abstract: Cross-industry innovation (CII) aims to reuse existing solutions by leveraging the innovative power of partners' knowledge from another industry. CII is a key concept for identifying and adapting potential (disruptive) innovations and technologies and gains importance in recent years. To enable CII in companies, we examine the topic holistically. First, we summarize the existing literature, including frameworks of CII. Second, we conduct expert interviews in order to consider also the practical perspective. We then consolidate the results into a framework with a structured procedure and detailed methods, which can be used by companies. Our contribution has several implications for practice and research. For practice, we derive five recommendations for actions for companies that already use or plan to use CII. For the scientific community, we summarize the state of research on CII and present our framework, which can serve as a starting point for further research.

Contribution E

Title	**FeelFit – Design and Evaluation of a Conversational Agent to Enhance Health Awareness**
Authors	Pascal Meier Jan Heinrich Beinke Christian Fitte Alina Behne Frank Teuteberg
Year	2019
Outlet	International Conference on Information Systems (ICIS)
Ranking	WKWI: A VHB: A
Bibliographic information	Meier, P., Beinke, J. H., Fitte, C., **Behne, A.,** & Teuteberg, F. (2019). FeelFit – Design and Evaluation of a Conversational Agent to Enhance Health Awareness; in Proceedings of the 2019 International Conference on Information Systems (ICIS), Munich
Identification	ISBN 978-0-9966831-9-7 (ICIS 2019 Proceedings)
Keywords	Conversational Agent, Health Awareness, Wearable Health Monitoring System
Link	https://core.ac.uk/download/pdf/301384614.pdf

Abstract: In the course of digitalisation, healthcare systems are undergoing a major transformation. The generation and processing of health-related data are intended to improve health concerns. However, individual health awareness remains inadequate. To counter-act this problem, issues in the fields of health awareness, wearable health monitoring systems, conversational agents, and user interface design were identified. Meta-requirements were derived from these issues and then converted into design principles. We developed the FeelFit conversational agent under consideration of those design principles. FeelFit measures vital parameters with various wearable sensors and presents them, enriched with personalised health information, to the user in the form of a conversation via individually configurable input and output devices. The conversational agent was evaluated by two experiments with 90 participants and a workshop. The results confirm a positive usability and task fulfilment of our conversational agent. Compared to known applications, the participants highlighted the more natural interaction and seamless integration of various sensors as strengths of FeelFit.

Contribution F

Title	**Intersektorale Vernetzung im Gesundheitswesen: Prozessverbesserung durch den Einsatz von Plattformen am Fallbeispiel der Palliativversorgung**
Authors	Alina Behne Frank Teuteberg
Year	2021
Outlet	HMD Praxis der Wirtschaftsinformatik
Ranking	WKWI: B VHB: D
Bibliographic information	**Behne, A.,** & Teuteberg, F. (2021). Intersektorale Vernetzung im Gesundheitswesen: Prozessverbesserung durch den Einsatz von Plattformen am Fallbeispiel der Palliativversorgung. HMD Praxis der Wirtschaftsinformatik.
Identification	DOI 10.1365/s40702-021-00744-w
Keywords	Plattform, Palliativversorgung, Prozessverbesserung, Kommunikation, Gesundheitswesen
Link	https://link.springer.com/article/10.1365%2Fs40702-021-00744-w

Abstract: Eine effiziente Überführung der Patienten in die häusliche Versorgung steht bei der Palliativentlassung insbesondere aufgrund der häufig kurzen Versorgungsdauer im Fokus. Dabei besteht die Herausforderung, dass viele unterschiedliche Akteure an dem Prozess beteiligt sind. Plattformen bieten Potenziale, eine einfache Dokumentation und Kommunikation der an der Versorgung beteiligten Gesundheitsakteure zu ermöglichen. Der vorliegende Beitrag zeigt, wie das Zusammenspiel unterschiedlicher Akteure auf Prozess- und Personenebene untersucht werden kann, um anschließend Prozessschwachstellen zu erkennen und diese mittels Informations- und Kommunikationstechnologien zu verbessern. In Zusammenarbeit mit verschiedenen Praxisakteuren vor allem aus dem Gesundheitswesen aber auch aus der Softwareentwicklung konnten aktuelle Herausforderungen im Palliativbereich erhoben werden. Daran anknüpfend konnte eine Anforderungsanalyse abgeleitet, ein bestehendes System erweitert und anschließend der Entlass- und Versorgungsprozess restrukturiert werden. Dabei werden Bedarfe, Potenziale und Herausforderungen von der Erhebung des aktuellen Prozesses bis zur Implementierung der Restrukturierung hervorgehoben. Es wird deutlich, dass das intersektorale Medikationsmanagement ein Schlüsselelement in der Gesundheitsversorgung ist und die Apotheke die Rolle eines Gesundheitslotsen einnehmen könnte. Bislang ist noch keine standardisierte oder einheitliche intersektorale Kommunikation oder Dokumentation via Plattform im Gesundheitswesen etabliert, jedoch bestehen einsatzbereite Plattformlösungen, die den Austausch erleichtern und den Weg bis zur Entstehung einer einheitlichen Lösung für alle beteiligten Akteure ebnen. Dieser Beitrag zeigt, wie die Erweiterung einer bestehenden Plattform aus dem Palliativsektor es ermöglichen kann, die hier untersuchten Prozesse in Hinblick auf eine sektorenübergreifende, effiziente Zusammenarbeit zu verbessern.

Contribution G

Title	**Learnings from the design and acceptance of the German COVID-19 tracing app for IS-driven crisis management: A design science research**
Authors	Alina Behne Nicolai Krüger Jan Heinrich Beinke Frank Teuteberg
Year	2021
Outlet	BMC Medical Informatics and Decision Making
Ranking	JIF: 2.32
Bibliographic information	**Behne, A.**, Krüger, N., Beinke, J.H., & Teuteberg, F. (2021). Learnings from the Design and Acceptance of the German COVID-19 Tracing App for IS-driven Crisis Management: A Design Science Research. BMC Medical Informatics and Decision Making (accepted)
Identification	DOI 10.1186/s12911-021-01579-7
Keywords	Crisis management, Corona-Warn-App, Tracing apps, Design science, User experience design, Prototype
Link	https://bmcmedinformdecismak.biomedcentral.com/articles/10.1186/s12911-021-01579-7

Abstract: Background: This article investigates the research problem of digital solutions to overcome the pandemic, more closely examining the limited effectiveness and scope of the governmental COVID-19 tracing apps, using the German COVID-19 tracing app (Corona-Warn-App) as an example. A well-designed and effective instrument in the technological toolbox is of utmost importance to overcome the pandemic. Method: A multi-methodological design science research approach was applied. In three development and evaluation cycles, we presented, prototyped, and tested user-centered ideas of functional and design improvement. The applied procedure contains (1) a survey featuring 1993 participants from Germany for evaluating the current app, (2) a gathering of recommendations from epidemiologists and from a focus group discussion with IT and health experts identifying relevant functional requirements, and (3) an online survey combined with testing our prototype with 53 participants to evaluate the enhanced tracing app. Results: This contribution presents 14 identified issues of the German COVID-19 tracing app, six meta-requirements, and three design principles for COVID-19 tracing apps and future pandemic apps (e.g., more user involvement and transparency). Using an interactive prototype, this study presents an extended pandemic app, containing 13 potential front-end (i.e., information on the regional infection situation, education and health literacy, crowd and event notification) and six potential back-end functional requirements (i.e., ongoing modification of risk score calculation, indoor versus outdoor). In addition, a user story approach for the COVID-19 tracing app was derived from the findings, supporting a holistic development approach. Conclusion: Throughout this study, practical relevant findings can be directly transferred to the German and other international COVID-19 tracing applications. Moreover, we apply our findings to crisis management theory—particularly pandemic-related apps—and derive interdisciplinary learnings. It might be recommendable for the involved decision-

makers and stakeholders to forego classic application management and switch to using an agile setup, which allows for a more flexible reaction to upcoming changes. It is even more important for governments to have a well-established, flexible, design-oriented process for creating and adapting technology to handle a crisis, as this pandemic will not be the last one.