ENGLISH SUMMARY

Software applications (applications in short) are an integral part of the way modern-day organizations operate. Organizations in a wide range of sectors have implemented applications in pursuit of a wide variety of organizational goals, such as streamlining internal operations or serving customers in an increasingly digital manner. Given their profound importance for achieving organizational goals, close alignment between the management, provision, design and functionalities of applications and the behavior of their users is desired to facilitate users in accomplishing their tasks as safely, effectively and efficiently as possible.

Workflows of application users in practice change as a result of application implementation, which in turn changes this degree of alignment. The majority of workflow changes are likely intended and carefully planned ahead by e.g. hospital management, end-users and application developers in pursuit of (better) achieving organizational goals. However, due to implementation of an application, workflows may also change in unintended and negative ways, leading to workflow disruptions. With workflow disruptions, we mean discrepancies between application-dictated workflows as programmed by application developers, and the behavior of application users in practice. Application users tend to develop workarounds to deal with workflow mismatches: informal temporary practices to handle exceptions to normal workflow. These workarounds allow users to proceed in accomplishing their tasks regardless of support of the application.

Workarounds are double-edged swords and may be beneficial as well as adverse regarding process efficiency and outcome quality. Workarounds allow users to proceed with their workflow and may occasionally be used to improve these when users feel the application-dictated workflow does not sufficiently warrant safety or quality. However, workarounds frequently also lead to sets of information or work protocols that are unstable, unreliable, and unavailable – thereby potentially jeopardizing process efficiency and outcome quality. Furthermore, they cloak deficiencies as devising workarounds, rather than bringing problems to the attention of application designers who subsequently adapt workflows, causes problems to remain hidden that simultaneously inhibit application and workflow optimization. Moreover, workarounds undermine workflow standardization as they represent alternative ways to accomplish a task, and thereby do not conform to an application-enforced way of working designed to eliminate process variability and safeguard quality.

Because of their potentially adverse consequences, workarounds are a valuable source for application optimization aimed at achieving closer alignment between application-dictated workflows and the behavior of application users in practice. Such optimizations in turn lead to improved process efficiency and quality of outcomes. However, little is known about workaround identification, analysis and resolution related to complex applications used in sectors characterized by a high degree of unpredictability and variability. To gain insights in the latter, this thesis investigated workarounds in the context of an electronic health record system (EHRs) as a backbone and complex type of application used by healthcare professionals in an academic hospital setting.

This thesis consists of seven chapters. Chapter 1 provides a general introduction to this thesis by discussing the importance of software applications in supporting the achievement of organizational goals, how application implementation leads to process changes that in turn may cause (un)intended user-application workflow mismatches, how these workflow mismatches can lead to the development of workarounds by application users to counter these mismatches, how the occurrence and complexity of workarounds likely differs per sector and type of application, and why EHRs as a type of application used by healthcare professionals in academic hospital settings are a suitable domain for studying workarounds in all their complexity. Furthermore, we describe four gaps in current scientific literature on the identification, analysis and resolution of workarounds developed by healthcare professionals using their EHR in academic hospital settings. Based on these gaps, five research questions have been provided that are addressed in Chapters 2–6 of this thesis.

Current literature provides few guidelines for designing and carrying out research to identify, analyze and classify EHR workarounds in academic hospital settings. Chapter 2 provides the study protocol that we used to identify EHR workarounds and subsequently determine their scope and impact on healthcare providers' workflows, patient safety, effectiveness of care and efficiency of care. The study protocol describes an ethnographic approach using a combination of direct observations, semi-structured interviews and qualitative inductive coding techniques to explore EHR workarounds from a holistic perspective and covers the research design and execution process for studies described in Chapter 3, 4 and 5. Other researchers may use the study protocol to design new studies aiming at identifying, analyzing and classifying EHR workarounds. Because the described research approach is in principle domain independent, this means the study protocol may also be used for studying workarounds to types of applications other than EHRs.

As a result of workflow mismatches, application users experience workflow impediments. The concept of waste from the lean management philosophy could be applied within the context of EHR usage to identify and analyze workflow impediments experienced by EHR users as a result of user-EHR workflow mismatches, but has not been explored in current literature. Chapter 3 addresses this deficiency. We applied the lean waste perspective and identified and classified 241 workflow impediments, according to one out of eight types of waste. Relationships were also visible among the identified manifestations of waste: differences in frequency per type of waste, (non)cascading effects of certain types of waste, and proliferating effects of certain types of waste as a result of mimicked and routinized behavior. The knowledge obtained from this study can support (re)design of applications to better match workflows which may subsequently lead to more safe, effective and efficient patient care.

Research into rationales healthcare professionals have for developing EHR workarounds, in particular in an academic hospital setting, is scarce. Insights into rationales may provide valuable clues as to how certain workarounds may most effectively be resolved. In Chapter 4, based on direct observations and semi-structured follow-up interviews with 47 healthcare professionals, data analysis through inductive coding techniques leads to the development of a coding taxonomy containing 15 rationales for EHR workaround development. Three of those 15 rationales do not directly correspond with rationales described in current literature. Furthermore, we associated the 15 identified rationales with the work system components of the Systems Engineering Initiative for Patient Safety (SEIPS) framework (i.e. persons, technology and tools, organization, tasks, and physical environment) to reveal their source of origin. Our results suggest that EHR workaround rationales associated with different SEIPS work system components demand a different approach in order to effectively be resolved.

EHR workarounds can be characterized by a scope and impact. The impact can be positive or negative in relation to patients, staff and/or the organization. Knowing a workaround's scope and impact on patient safety, effectiveness of care, and efficiency of care can inform (re)design efforts of EHRs to further align EHR design with work contexts, subsequently leading to better organization and (safe) provision of care. However, research into the scope and impact of EHR workarounds on patient care processes is limited. Chapter 4 addresses this deficiency by providing insight into the effects of EHR workarounds on organizational workflows and outcomes of care services. The scope and impact of identified EHR workarounds on patient safety, effectiveness of care and efficiency of care was

determined by analyzing each workaround one-by-one with occasional assistance from multiple other experts such as the observed healthcare professionals, EHR developers, quality assurance staff, or hospital management. Results show nearly all workarounds could have a favorable or unfavorable impact on at least one of these dimensions. All identified workarounds related to a number of rationales had a negative impact on patient safety or efficiency of care. Also tradeoffs were observed regarding impact on patient safety, effectiveness of care, and efficiency of care. Our results imply that the potential impact of EHR workarounds should not be underestimated, and that the scope and impact of EHR workarounds should therefore be thoroughly analyzed and taken into account when planning application and related workflow redesign.

EHR workarounds are black boxes in Health Information Systems research. Therefore, a deeper understanding of the attributes (i.e. inherent properties) of EHR workarounds is required, and may also prove useful in devising solutions to lower their incidence. Contrary to scope and impact having an outward focus on workarounds, attributes have an inward focus. In Chapter 5, this thesis presents four identified attributes of EHR workarounds in an academic hospital setting: cascadedness, anticipatedness, avoidability, and repetitiveness. These attributes were defined through analyzing each identified workaround one-by-one with the purpose of revealing recurring characteristics appearing more than once and being applicable to multiple workarounds. Each attribute may be either 'true' or 'false' for each EHR workaround. Our results suggest that EHR workarounds should not solely be typified by their rationales and perceived scope and impact, but also by these attributes. For instance, we found that certain EHR workarounds may have a negative impact on patient safety, effectiveness of care, and efficiency of care and would therefore be prime targets to be resolved. However, when these EHR workarounds appear to be e.g. unavoidable (meaning the workaround is a necessity in order to proceed with one's workflow), the elimination of the workaround to perhaps do more harm than good.

A conceptual framework to address challenges inherent in studying workarounds emerging from EHR usage does not exist. Previous studies that analyzed EHR workarounds may have been limited by a lack of such a conceptual framework, as most existing technology frameworks lack the domain specificity of EHRs and healthcare settings. Nor do these frameworks incorporate a sociotechnical perspective that we argue is necessary since we found that workarounds are not solely the result of technical EHR-related factors, but also of human-, organization- and task-related factors. To overcome this limitation, Chapter 5 offers a framework

specifically designed to support sociotechnical analyses of EHR workarounds in healthcare settings: SEWA (Sociotechnical Ehr Workaround Analysis framework). SEWA defines the work system and its five components constituting the context in which EHR workarounds are developed, rationales for EHR workaround development, attributes of EHR workarounds, scopes of EHR workarounds, and the possible impact of an EHR workaround on clinical processes. Among others, SEWA can be used as a template by other healthcare organizations to examine and typify their EHR workarounds.

Finally, healthcare organizations are compelled to increase their operational efficiency while simultaneously reducing costs. This is no easy task because the delivery of care tends to be distributed across many diverse and distinct specialties and supportive entities. These fragmented organizational structures cause disrupted relationships and poor information flows that together degrade the quality and efficiency of care. Key is therefore to improve the entire system of care delivery rather than optimizing the performance of individual parts of interconnected processes. To assist practitioners in doing so, this thesis evaluates the usefulness and applicability of the PDD modeling technique to model healthcare processes on an end-to-end basis in Chapter 6. A simplified healthcare process was modeled using the PDD technique. Based on this modeled process, advantages and drawbacks of the modeling technique are discussed. It is argued that although the PDD modeling technique may be useful in gaining a holistic perspective on a complex and interconnected healthcare organization, limitations inherent to healthcare processes were identified that may limit the applicability of the modeling technique for modeling healthcare processes, and demands further exploration.