IRIS BEEREPOOT

WORKAROUNDS

THE PATH FROM DETECTION TO IMPROVEMENT

Health Information Systems are built to support work processes in healthcare organisations. In advance, it is difficult to plan how those processes will run in practice. Nurses, doctors, and other healthcare professionals, run into obstacles when using these systems in their daily work. In an attempt to circumvent these obstacles, they use so-called workarounds: intentional deviations from the prescribed work process. These workarounds are common in healthcare organisations and can have both beneficial and detrimental effects on healthcare processes.

This PhD thesis sets out from the conviction that workarounds – beneficial or not – can serve to indicate misalignments between information systems and the work processes they are supposed to support.

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The Path From Detection to Improvement

Iris Beerepoot

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Workarounds

The Path From Detection to Improvement

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(met een samenvatting in het Nederlands)

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Preface

Every nurse, doctor, or other healthcare professional is familiar with them: workarounds. In hospitals, workarounds in the context of information systems use are widespread. Surprisingly, not much attention is paid to them. This PhD thesis is aimed at changing that.

December 2021, Hoorn

Nederlandse samenvatting

Zorginformatiesystemen zijn gebouwd om werkprocessen in ziekenhuizen te ondersteunen. Vooraf is het echter lastig in te schatten hoe die processen precies gaan verlopen. Verpleegkundigen, artsen en andere zorgprofessionals lopen in de dagelijkse praktijk tegen obstakels aan in hun gebruik van deze systemen. In een poging deze obstakels te omzeilen, gebruiken ze zogenaamde *workarounds*: intentionele afwijkingen van het voorgeschreven werkproces. Deze workarounds komen vaak voor in zorginstellingen en kunnen zowel voordelige als nadelige effecten hebben op de processen in ziekenhuizen. Aan de basis van dit proefschrift ligt de overtuiging dat workarounds – voordelig of niet - kunnen dienen ter indicatie van een problematische afstemming tussen werkprocessen en de informatiesystemen die ze horen te ondersteunen. Gebruikmakend van een breed scala aan methoden en technieken bieden we een aantal oplossingen rondom het detecteren en analyseren van workarounds in zorginstellingen, alle met als doel om werkprocessen in de zorg te verbeteren. We dragen bij aan de wetenschappelijke literatuur en de praktijk van zorginstellingen in de vorm van (1) het bieden van inzichten rondom de factoren die van belang zijn bij het ontstaan van workarounds, (2) het bieden van inzichten in de juiste manier van adresseren van verschillende soorten workarounds, (3) het bieden van methodologische ondersteuning voor het detecteren en analyseren van workarounds, en (4) het bieden van methodologische ondersteuning voor het vertalen van kennis over workarounds naar direct bruikbare ideeën voor procesverbeteringen.

English Summary

Health Information Systems are built to support work processes in healthcare organisations. In advance, it is difficult to plan how those processes will run in practice. Nurses, doctors, and other healthcare professionals, run into obstacles when using these systems in their daily work. In an attempt to circumvent these obstacles, they use so-called workarounds: intentional deviations from the prescribed work process. These workarounds are common in healthcare organisations and can have both beneficial and detrimental effects on healthcare processes. This PhD thesis sets out from the conviction that workarounds – beneficial or not – can serve to indicate misalignments between information systems and the work processes they are supposed to support. Using a wide range of methods and techniques, we offer a number of solutions for detecting and analysing workarounds in healthcare organisations, all with the aim of improving work processes in healthcare. We contribute to the scientific literature and healthcare practice in the form of (1) providing insights into the factors that are important in the emergence of workarounds, (2) offering insights into the correct way of addressing different types of workarounds, (3) providing methodological support for detecting and analysing workarounds, and (4) providing methodological support for translating knowledge about workarounds into actionable ideas for process improvements.

Acknowledgements

Throughout my PhD project I have received tremendous support, for which I am deeply grateful. First and foremost, I owe the selection of the topic of workarounds and the start of my PhD to Inge. Not only have you been a great mentor into research and the academic world, but you have also been a fun roommate and a great companion on international travels.

I consider myself extraordinarily fortunate for being able to call Hajo my other mentor. I have had the pleasure of getting to know you well these last couple of years and am very grateful for the many hours that you freed to chat about work and life in general. I fondly look back at wonderful times spent with you in Israel, California, Vienna, Munich, and Rome, and I hope you will not tire to be my personal tour guide many times more.

My PhD would also not have been the same without my direct colleagues, first at the VU and then at the UU. I could not have asked for better companions to start a PhD with than Jelmer and Isaac. We may have had our struggles around Lemon Cove and beyond, but we had them together, making them futile when compared to the fun we had. Jelmer, every research project is more enjoyable when you are part of it. Isaac, every dinner is better when in the presence of you and your family, and the cheese breads of course. I am deeply grateful for your friendship.

I am also grateful to the other members of the research group, who all contributed in some way to the book that is currently in front of you. Xixi, whose knowledge is invaluable and whose kindness and cheerfulness is infectious. Vinicius, whose enthusiasm and interest knows no bounds. Ünal, who is characterised by a willingness to go out of his way to help everyone everywhere. But also Jan Martijn and Nico, whom I have not had the pleasure of working with intensely yet, but with whom I have had great conversations nonetheless. What makes our group complete is colleagues such as Sietse, Jens, Wouter, and Suhwan, who each contribute invaluable knowledge and ideas to our crazy group of individuals. I also want to give special thanks to Henrik and Han, who are no longer always (physically) part of the group, but whose contributions are highly valuable and their research still very much influences ours.

Essential to this book is also the research and discussions that have taken place outside of the research group and university walls. I have had the pleasure of meeting and collaborating with researchers from all around the world, such as the team of Pnina and Irit in Haifa, Marcelo and Sara from São Paulo, Bart from the VU in Amsterdam, Claudio in Rome, Stefanie in Munich, Jan Mendling and Jan Recker, Jorge and Victor in Santiago, Niels from Hasselt, Teus from the Utrecht

Medical Center, and Barbara and Francesca in Sankt Gallen. All of these great researchers have in one way or another influenced and improved my research work. I also acknowledge the many master students that I have had the pleasure of working with in the context of their thesis, in particular Ayoub, Victor, Ruben, and Denise, who produced works that formed the basis for interesting publications. Last but not least, I am extremely grateful for the exceptional scientists that make up my assessment and doctoral examination committee.

None of this work would have been possible without the opportunities given to me by ilionx, formerly ICTZ, and the amazing people who work there. This includes Caspar, Dirk, and Ruben, who expressed their interest in this topic at the very start, but its continuation in the form of a PhD project should in large part be attributed to Mirjam. I also want to thank Mirjam for teaching me the ways of the organisation and for my development as an organisational professional, together with Dimitri and many other knowledgeable people at ilionx. Last but not least, I would like to give special thanks to the hospitals that opened up their organisations for me and the knowledge they made accessible. I have profound respect for all of the healthcare professionals who work hard to provide the needed care to patients on a daily basis.

In private setting, my biggest gratitude goes out to my mom, who has provided me with the needed listening ear and safe haven for all my life. My gratitude also goes out to the trio of men that has been invaluable in the renovation of my home: Peter for all the wood and electrical works, my dad for his demolition work and visits to the recycling centre, and Pieter for his meticulous finish and for being the best work buddy there is. Furthermore, my gratitude goes out to my sister for trying to understand what I do, and the same goes for my friends and teammates, not in the least for providing me with the needed distraction when I was deep into writing or just received a rejection.

Because of all mentioned people and others, this PhD has been an absolute joy. I will try my hardest to play a positive role in those of others, just as you did in mine.

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Chapter 1

Introduction

In only a few decades, hospitals have experienced major developments in *Health Information Systems* (HISs). These HISs have caused a shift from paper-based to computer-based information processing, and from departmental to global coordination (Haux, 2006). Systems that were traditionally used by caregivers now also give access to patients as users. Where the focus used to be on patient care, present-day HISs offer additional modules targeted at healthcare planning and clinical research. Not all developments have been immediate successes, nor were they always enthusiastically welcomed by healthcare professionals. To illustrate the frustrations that emerge once a new HIS has been implemented, let me draw on this excerpt from a junior doctor:

> **Tuesday, 20 June 2006.** Our computer system has been upgraded and, as happens eleven times out of ten when the hospital tries to make life easier, they've made everything much more complicated. It certainly looks much whizzier (and less like an MS-DOS program from school), but they've not actually fixed any of the massive clunking problems with the software, they've just slapped an interface on top of it. It's the equivalent of treating skin cancer by putting make-up over the lesion. (…)
>
> The blood tests now all live in a drop-down menu, and to order one involves scrolling down an alphabetical list of every test any doctor has ever ordered in the history of humanity. To get down to 'Vitamin B12' takes 3 minutes [and] 17 seconds. And if you press the letter 'V' rather than wading down there manually, then the system crashes so badly you have to turn the computer off at the wall and all but use a soldering iron to get it working again. Ninety-nine per cent of the time we order the same dozen tests and yet, rather than prioritizing those at the top of the list (even the easyJet website knows to put the UK above Albania and Azerbaijan), they're scattered throughout a billion tests I've never heard of or requested. Who knew there were three different lab tests for serum selenium?
>
> As a result, there's a very narrow window of anaemic patients I will now order Vitamin B12 levels for. If you're only mildly anaemic I'm not wasting the day with my finger pressing on the down arrow for three minutes. And if you're severely anaemic, I won't order it because you'll probably be dead by the time I've done so.

From: Kay, A. (2017). *This is going to hurt: secret diaries of a junior doctor*. Pan Macmillan.

This humorous but realistic excerpt symbolises the concept of a *design-reality gap* that is often used to evaluate HIS success or failure (Heeks, 2006). The redesigned system includes a modern interface that is assumed to help healthcare professionals in their work, but in practice, it is a step back from the perspective of the doctor. Because of the complexity of healthcare work and the wide span of HIS implementations (Berg, 2001), reducing the gap between design and practical use is no easy task.

The illustration also demonstrates how healthcare professionals consciously change their behaviour in response to the design-reality gap. Within the information systems research field, we refer to the concept of a *workaround* when a user intentionally makes changes to the *designed way of working* in response to a perceived *blockage* (Ejnefjäll and Ågerfalk, 2019). In the example, the *designed path* for the doctor would be to order Vitamin B12 for anaemic patients, whether mild, normal or severe. However, the doctor perceives a blockage in his path: scrolling down the menu takes too long and may even cause the system to crash. Therefore, he chooses not to order the medication for certain groups of patients. Although this example is put jokingly, such changes in behaviour can have severe consequences in healthcare contexts. Workarounds used by physicians as well as nurses can seriously compromise patient care (Debono et al., 2013). On the other hand, they may just as well offer those working in healthcare the ability to continue providing the needed patient care despite obstacles (Kobayashi et al., 2005).

This PhD thesis sets out from the conviction that both beneficial and detrimental workarounds indicate misalignments between designed work practices and the actual work practices of healthcare professionals. It lies at the intersection of two fields of study, that of Information Systems (IS) and Business Process Management (BPM). In the former, workarounds have been studied intensively, but none of them have focused on systematically detecting and analysing workarounds with the aim of improving healthcare processes. In the field of Business Process Management (BPM), researchers have developed methods and techniques for analysing business processes and recommending improvements, but they have not paid significant attention to systems users circumventing the prescribed ways of working and using these circumventions to an organisation's advantage.

This thesis aims to fill the gap of analysing and addressing misalignments between designed and actual work practices. Specifically, we aim to contribute solutions to the challenge of detecting and analysing health information systems workarounds and consequently improving healthcare processes. By drawing on methods and techniques from both IS and BPM, we contribute to existing literature and practice by providing methodological guidance for the detection of workarounds, as well as for translating knowledge about workarounds into actionable improvement ideas. Additionally, we provide insights into the factors involved in the emergence of workarounds and the appropriate way of addressing different types of workarounds. In the following sections, we position this research within the two fields of study.

1.1. Workarounds in Scientific Research

The first empirical studies on workarounds, defined as such, are discussed in two papers by Les Gasser (1986) and Gerson and Star (1986). Both studies discuss processes in the workplace, and how they evolve as a result of changing circumstances. Because of these changing circumstances, the authors recognise that designing a perfect system is an impossibility, and in response, people start engaging in 'articulation work'. Although these first studies on workarounds emerged in general IS work settings, interest in the concept became especially widespread within the field of Medical Informatics from 2004 onwards. From that time we find a number of seminal papers published predominantly in the Journal of the American Medical Informatics Association. In this period, published papers were particularly concerned with antecedents and effects of workarounds in healthcare organisations, where the phenomenon was typically related to unintended and unexpected consequences of the introduction of technology in organisations (Ash et al., 2004; Koppel et al., 2008; Vogelsmeier et al., 2008). Outside of healthcare, workarounds have been analysed in the service and public industry (Ferneley and Sobreperez, 2006) and the transport industry (Ignatiadis and Nandhakumar, 2009), among others. However, the majority of workarounds research to date is still conducted in healthcare settings.

Whereas the central concept within IS research is often the system, within the field of Business Process Management, *process models* have long been the main topic of study (Dumas et al., 2013). Models are often used to specify and communicate the predefined rules or constraints within a business process. Once a process participant deviates from these rules or constraints, this is referred to as non-conformance. In recent years, the derived field of conformance checking (Carmona et al., 2018) has emerged that a significant number of researchers have contributed to. Similar to workarounds studies, researchers on the topic of non-conformance distinguish between some intended path on the one hand, and some repetitive pattern of behaviour that deviates from that path, on the other. Within conformance checking studies however, the intended path is formalised in the form of a process model, and typically, this model is compared to so-called event logs that capture actual behaviour of process participants (Van der Aalst, 2016).

Not only do the IS and BPM field differ in focus, they also make use of different research methods. IS researchers studying workarounds typically make use of qualitative methods for data collection. In the majority of studies performed to date, researchers observed workers for a period of time, and combined this information with insights from semi-structured interviews. For example, Flanagan et al. (2013) performed observations of 120 clinicians and 118 patients over 11 outpatient clinics. Two days were spent at each site. Similarly, one of the researchers in Stevenson et al. (2016) spent 62 hours shadowing nurses and performing additional semi-structured interviews. Indeed, Koppel et al. (2015) stress the importance of shadowing clinicians and conducting interviews or focus groups to capture the motivations and decision processes behind the use of workarounds. As for the analysis of the collected data on workarounds, this part is often aimed at identifying different workaround types and discovering the direct causes of their emergence. As such, researchers typically identify several dozens of workarounds over a large number of processes, and categorise them based on their characteristics (Koppel et al., 2008; Yang et al., 2012).

Contrary to the IS field, studies published in the BPM field have typically made use of methods such as simulations, design science or engineering, and formal proofs (Recker and Mendling, 2016). Recently, the dominant way for collecting and analysing process-related data has been to employ process mining techniques (Van der Aalst, 2016). Process mining techniques help discover and analyse business processes using event data that are collected from information systems. Within the subfield of conformance checking in particular, process mining allows researchers to check large amounts of process executions against a predefined set of rules or constraints. In extension, it is possible to check conformance with process models over longer periods of time, pointing out changes in behaviour (Bose et al., 2011). Although process mining requires high effort in the extraction and pre-processing stages, it does not require the researcher to spend hours on end at the organisation of study. In addition, making use of event logs may provide a more objective view on behaviour compared to the use of interviews and observations such as in typical workaround studies. However, process mining is not without limitations either. Not all behaviour is detectable in the event data, and the data cannot give insights into the reasons behind the use of workarounds (Outmazgin and Soffer, 2013). Interviews and observations, on the other hand, are used to collect rich data on a phenomenon, but are very labour-intensive and require access to process participants.

1.2. Research Approach

In order to benefit from the advantages of both streams of research methods, in this thesis, we employ different approaches to detect and analyse workarounds. Table 1 provides an overview of the different research methods used throughout the thesis. Our main research approaches include a literature review, design science, case studies, and action research. Within these approaches, we have made use of observations, interviews, focus groups, interactive workshops, process mining, and qualitative comparative analysis, to collect and analyse data.

Table 1 - Overview of Research Methods and Techniques Used

Chapter → Method/technique ↓	2	3	4	5	6	7	Organisation(s)
Literature review	√						
Design science		√					*A*
Case study(s)		√	√	√	√		*A, B, C, D, E, F*
Action research						√	*F, G*
Observations		√	√	√	√		*A, B, C, D, E*
Interviews		√	√	√	√		*A, B, C, D, E*
Focus group					√		*C*
Interactive workshops						√	*F, G*
Process mining			√			√	*F, G*
Qualitative comparative analysis					√		*C*

The studies that make up this thesis have been applied in seven healthcare organisations in order to generalise beyond individual organisations. Table 2 provides an overview of the studied departments over the seven healthcare organisations involved, and the period in which the studies were undertaken. The organisations correspond with those in Table 1.

Table 2 - Overview of Healthcare Organisations Studied

Organisation	Department	Period of study
A	Orthopaedics & surgery	April – June 2017
B	Urology & cardiology	April – June 2018
C	Urology & pulmonary	May – July 2018
D	Nursing wards, medical rehabilitation	May – July 2018
E	Therapists, medical rehabilitation	July – August 2018
F	Nursing wards	January – May 2020
G	Outpatient clinics	March 2021

1.3. Contributions

The contributions made in this thesis can be categorised along three lines: (1) the *detection* of workarounds, (2) the *analysis* of workarounds, and (3) the *improvement* of processes in response to workaround detection and analysis.

1.3.1. Detection

Our main contribution in the context of detecting workarounds is twofold. First, we propose the Workaround Snapshot Approach (Section 3.4.3), with which researchers and healthcare organisations alike can systematically capture workarounds using qualitative methods. Second, after applying the approach over five healthcare organisations, we demonstrate the suitability of process mining for detecting a diverse subset of these workarounds (Chapter 4). Combining qualitative methods with process mining opens up a wide array of opportunities for further analysis and monitoring.

1.3.2. Analysis

Once workarounds are detected, they can be analysed to assess how they are best acted upon. In this context, we provide three main contributions. First, we demonstrate how workarounds emerge as a result of complex power manifestations (Chapter 5). Second, we outline the factors influencing a healthcare organisation's decision to accept or reject a workaround (Chapter 6). Third, we illustrate the impact of these and other decisions on the organisation in the form of an Action Impact Matrix (Chapter 3).

1.3.3. Improvement

In terms of improving processes in response to the detection and analysis of workarounds, we provide two main contributions. First, we demonstrate how using qualitative methods alone can already result in concrete improvement ideas that can be implemented directly (Chapter 3). However, we also demonstrate how augmenting qualitative findings with process mining techniques can give a more complete picture of the use of workarounds on which to base improvement initiatives. To support the process of translating insights on workarounds to concrete improvement ideas, we present the FEI Funnel (Section 7.4.1). The FEI Funnel provides a step-by-step approach for drilling down on process mining insights to find meaningful opportunities for improving processes.

1.4. Thesis Structure

Figure 1 provides an outline of the structure of the thesis. In Chapters 2 and 3, we make the argument that workarounds can be used to enable process improvement, but that they first need to be detected and correctly analysed before they can be acted upon. The subsequent chapters build on this idea and are all related to detection, analysis, and improvement in the context of workarounds, but have different foci. Chapter 4 predominantly focuses on detection of workarounds, whereas Chapters 5 and 6 are more geared towards analysing workarounds in detail. The method proposed in Chapter 7 assumes that detection and analysis have already been completed and focuses on improving healthcare processes based on that knowledge. In the following sections, we discuss the research questions, methods, and main contributions of each chapter in detail.

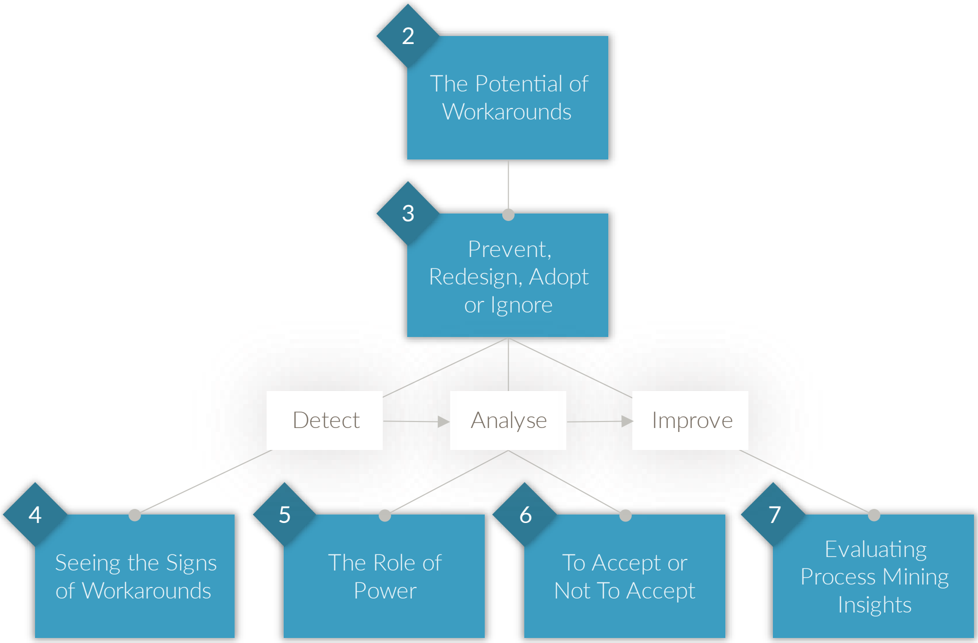

Figure 1 - Outline of Thesis Structure

1.4.1. Chapter 2 – The Potential of Workarounds

In Chapter 2, we ask the research question: *How can organisations unlock the potential of workarounds for improvement?* Based on a literature review, we identify five key activities necessary to unlock the potential for workarounds for improvement. Moreover, we provide a background for positioning research activities that target workarounds for organisational improvement.

1.4.2. Chapter 3 – Prevent, Redesign, Adopt or Ignore

In this chapter, we ask the question: *How can explicit knowledge of workarounds in healthcare processes enable improvement?* Using design science with a case study, we propose three artifacts: the Workaround Snapshot, the Workaround Action Matrix and the overarching Workaround Snapshot Approach. We contribute to existing research in moving from how and why people work around, to how this knowledge can be made explicit.

1.4.3. Chapter 4 – Seeing the Signs of Workarounds

This chapter centres around the question: *How can qualitative detection methods and process mining be combined to detect and analyse workarounds?* Through a multi-case study we demonstrate a mixed-methods approach to the detection of a set of diverse workarounds. We illustrate how certain characteristics in the data signal the existence of workarounds, which can then be quantitatively processed.

1.4.4. Chapter 5 - The Role of Power

The central question in this chapter is: *What is the role of power in the emergence of workarounds?* Based on a multi-case study using qualitative methods, we distinguish two main types of power that are involved in the emergence of workarounds: (1) hierarchical differences between actors and (2) system restrictions. Our study unpacks the link between power and HISs, illustrating how actors respond to hierarchical differences and system restrictions by exerting their 'power to work around'.

1.4.5. Chapter 6 – To Accept or Not To Accept

In this chapter, we describe *which characteristics are associated with healthcare processes and under which conditions a workaround should be accepted or rejected*. By performing a case study in combination with qualitative comparative analysis, we contribute to the current literature on addressing workarounds in healthcare settings by providing insights into the factors influencing the organisational decision to accept or reject a workaround.

1.4.6. Chapter 7 – Evaluating Process Mining Insights

In the final chapter before the conclusion, we ask the question: *How can process analysts evaluate process mining insights with healthcare professionals in order to generate actionable process improvement ideas?* Through action research at two locations (organisations F and G), we introduce and illustrate the FEI funnel, a novel three-staged method consisting of process familiarisation, domain explanation and improvement ideation. The method aims to support process analysts when evaluating process mining insights with healthcare professionals.

Chapter 2

The Potential of Workarounds[1]

Abstract. Several studies have hinted how the study of workarounds can help organisations to improve business processes. Through a literature review of 70 articles that discuss workarounds by information systems users, we aim to unlock this potential. Based on a synthesis of recommendations mentioned in the reviewed studies, we describe five key activities that help organisations to deal with workarounds. We contribute to the IS literature by (1) providing an overview of concrete recommendations for managing workarounds and (2) offering a background for positioning new research activities on the subject. Organisations can apply these tools directly to turn their knowledge on workarounds into organisational improvement.

Keywords: Workarounds, Information Systems, Process Improvement.

2.1. Introduction

People often use Information Systems (IS) different from their designed usage. IS users' deviations from designed procedures are also known as *workarounds*, defined by Alter (2014b) as follows:

> "A workaround is a goal-driven adaptation, improvisation, or other change to one or more aspects of an existing work system in order to overcome, bypass, or minimize the impact of obstacles, exceptions, anomalies, mishaps, established practices, management expectations, or structural constraints that are perceived as preventing that work system or its participants from achieving a desired level of efficiency, effectiveness, or other organisational or personal goals".

Workarounds are inherently about human agency. No matter how technologies are designed, humans can always choose how they use technologies to perform their

[1] This work was originally published as:

Beerepoot, I., I. van de Weerd and H. A. Reijers. (2019). The Potential of Workarounds for Improving Processes. Lecture Notes in Business Information Processing (Vol. 362 LNBIP). Springer, Cham.

work (M. C. Boudreau and Robey, 2005; Azad and King, 2008a; Leonardi, 2011). Workarounds are also inherently related to processes. There is always a prescribed process that users deviate from, such as the process of administering medication (Halbesleben et al., 2010) or accessing patient data (Röder et al., 2015). Whereas they have been viewed negatively in the past, current literature calls for a more positive perspective on workarounds (Azad and King, 2017; Cresswell et al., 2017). Several studies point out the potential of workarounds for identifying poorly-designed processes (Petrides et al., 2004; Lalley and Malloch, 2010) and for involving IS users in process improvement efforts (Safadi and Faraj, 2010a; Azad and King, 2012; Cresswell et al., 2017).

To find out how workarounds can be used for improvement and how IS users can play a role in process improvement efforts, we raised the following research question: *how can organisations unlock the potential of workarounds for improving processes?*

Our contribution with this work is twofold. First, by analysing and synthesising the literature describing the potential of exploiting workarounds for improving processes, we propose five key activities necessary to unlock this potential, providing organisations with the means to use the workarounds for improvement. Second, we provide a background for positioning new research activities that target workarounds for organisational improvement.

The remainder of this paper is structured as follows. We first describe the methods we used. In the subsequent section, we sketch the preconditions for workarounds, after which our proposed activities for achieving process improvement are discussed. Finally, we present our conclusions and a research outlook.

2.2. Methods

We performed an in-depth literature review, following the guidelines by Kitchenham and Charters (2007) and the checklists by Webster and Watson (2002) and Vom Brocke et al. (2015). The aim of this study is to present an integrated and representative overview of existing studies on how organisations can use workarounds for improvement. Figure 2 visualises the search and selection process.

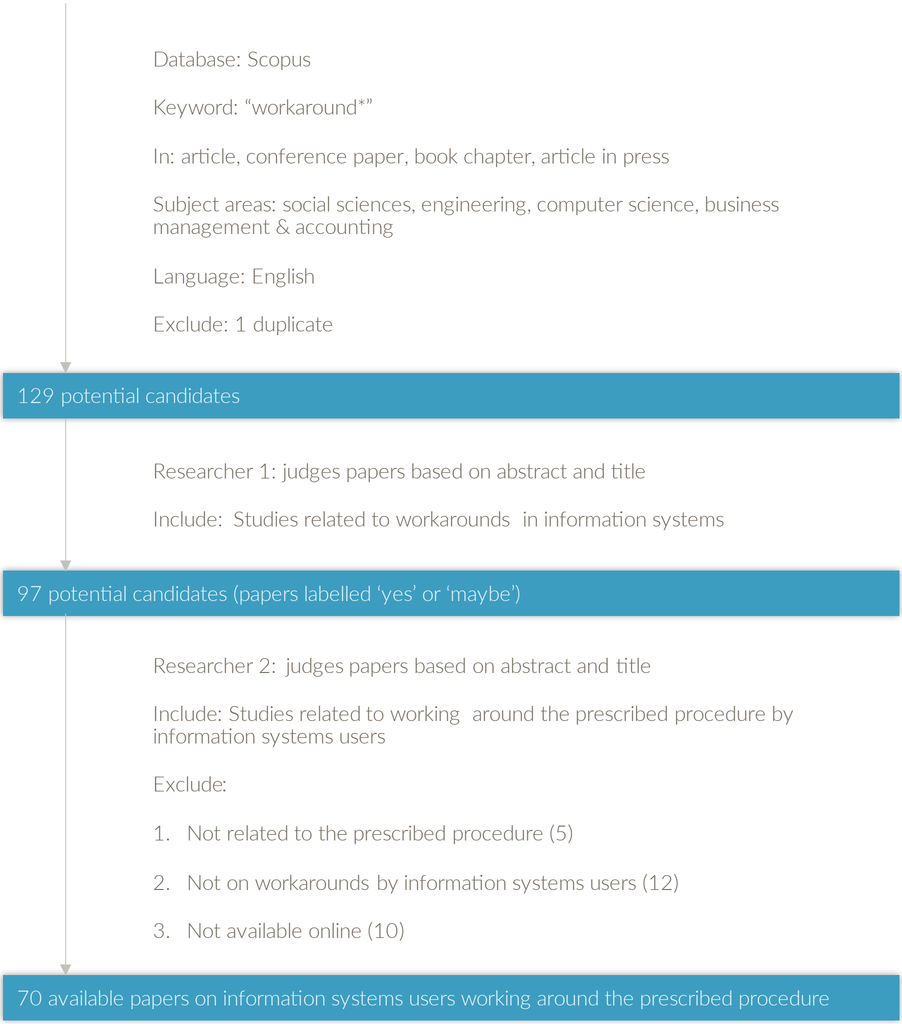

Figure 2 - Search and Selection Process

To collect a broad sample of papers, we used the Scopus database to retrieve our candidate papers. The search on Scopus for articles mentioning workarounds resulted in 129 potential candidates. We carried out two screening rounds to narrow our sample. In the first round, the first author judged the papers based on their titles and abstracts. Studies that actually focused on the use of workarounds during the interaction with information systems were included. Studies that were not included were papers primarily proposing some technical workaround to solve an erroneous software design. Using the workaround definition by Alter mentioned in the introduction, we excluded 32 candidates during the first screening round. These articles were not related to workarounds in information systems. As a result, 97 potential candidates were left for screening in the second round. These articles were labelled either 'yes' or 'maybe' and were further screened by the second author. Studies that were excluded in this round were either not focusing on working around a prescribed procedure, not on workarounds by information system users, or not available via our university's online library. Our final result was a sample of 70 papers on information systems users working around prescribed procedures.

Figure 3 visualises our analysis and synthesis process. We focused our analysis on the ways in which organisations can exploit workarounds for process improvement. Our aim was to develop a framework that gives insight into both the potential of workarounds for improvement and how this potential can be realised.

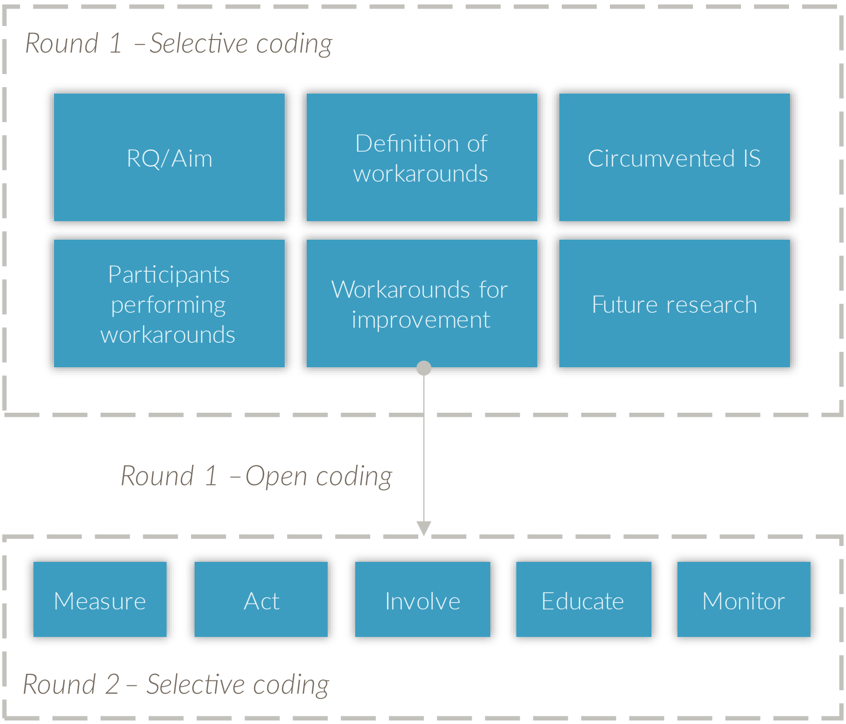

Figure 3 - Analysis and Synthesis Process

For our first coding round, we imported all papers into Atlas.ti[2], a software program used to guide qualitative data analysis. The first and second author selectively coded the articles, regularly discussed the codes and adjusted them if necessary.

While selectively coding the literature in the first round, the number of quotations coded 'workarounds for improvement' increased rapidly (529 quotations by the end of the first coding round). Because of this large set of quotations, we decided to

[2] https://atlasti.com/

use open coding next to selective coding. Doing so, we created sub-codes for the code 'workarounds for improvement'. We found that the analysed papers include many recommendations for using workarounds for improvement, and that these recommendations could be clustered into five groups. The recommendations related to detecting and gathering information on workarounds (the 'measure'-group), acting on or addressing workarounds (the 'act'-group), involving end users of the information system (the 'involve'-group), training and educating end users (the 'educate'-group) and monitoring workarounds over time (the 'monitor'-group). In the second close-reading iteration, we focused exclusively on the five clusters of recommendations to unlock the potential of workarounds for process improvement. We selectively coded the papers using the five sub-codes. Before we discuss the five activities in more detail, we give a general introduction to the emergence of workarounds. Based on the literature review, we discuss when they emerge and what their effects are.

2.3. The Emergence of Workarounds

2.3.1. Dysfunctionality as a Cause of Workarounds

Several authors believe that the cause of workarounds is a dysfunctional environment (Morath and Turnbull, 2005; Zhou et al., 2011; Dunford and Perrigino, 2015). There are several reasons why process participants perform workarounds (Outmazgin, 2013). Our literature review reveals that this is done to overcome 'constraints' (Zhou et al., 2011; Zimmermann et al., 2017), 'incompatibilities' (Nadhrah and Michell, 2013), 'inadequacies' (Spierings et al., 2017), 'flawed specifications' (Alter, 2015b), 'unrealistic processes' (Alter, 2015b), 'obstacles' (Huuskonen and Vakkari, 2013; Reiz and Gewald, 2016), 'mismatches' (Blandford et al., 2014; Barata et al., 2015; Van Beijsterveld and Van Groenendaal, 2016) or 'misfits' (Yang et al., 2012; Drum et al., 2016). In the healthcare setting, for instance, clinicians sometimes feel constraints in achieving their goals: "many workarounds occur because the health IT itself can undermine the central mission of the clinician: serving patients" (Koppel et al., 2015).

Other causes for workarounds are tensions that might exist. An example is the "tension between top-down pressures from the external environment and bottom-up constraints from day-to-day operational work" (Azad and King, 2012). Workarounds are used to relieve this tension and balance top-down pressures such as compliance rules and bottom-up time-constraints. Another tension that potentially causes workarounds is the one between standardisation and flexibility. Carayon and Gürses (2005) found that hospital nurses enact more workarounds when they are coerced into using standardised routines. The same was concluded by Van Beijsterveld and Van Groenendaal (2016), who established that the inability to customise the system leads participants to engage in workarounds. Without such customisations, they become dissatisfied and start to resist the system (Safadi and Faraj, 2010a).

2.3.2. The Effects of Workarounds

Many workarounds add value (Zimmermann et al., 2017), save time (Huuskonen and Vakkari, 2013) or improve efficiency (Park et al., 2015). They allow participants to continue work (Kobayashi et al., 2005; Ferneley and Sobreperez, 2006; Saleem et al., 2011) by offering a temporary solution to an obstacle (Van Der Sijs et al., 2011).

Apart from the positive effects, workarounds can affect an organisation negatively in two ways. First, although they can increase efficiency in some situations, they affect efficiency negatively in others (Van Der Sijs et al., 2011; Brooks et al., 2015; Drum et al., 2015; Reiz and Gewald, 2016). When participants feel the need to enact workarounds to achieve their goals, this causes frustration (Wheeler et al., 2012), discontent (Morrison, 2015) and disengagement (Brooks et al., 2015). In addition to this, workarounds affect other activities in the process, threatening to decrease the overall outcome of the process (Drum et al., 2015) and bringing security issues with it. When using the setting of healthcare organisations again, this could mean endangering the safety of patients (Zhou et al., 2011; Barrett and Stephens, 2017).

The second major negative effect of workarounds is a loss of transparency. Workaround activities are usually hidden (Petrides et al., 2004; Azad and King, 2008a) and management and IS vendors are often unaware of them (Drum et al., 2016; Waheed, 2016; Woltjer, 2017). This leads to managers and IS vendors having an inaccurate view of system usage, as workarounds mask "underlying system weakness" (Morrison, 2015, p. 1). It "creates the illusion that dysfunctional systems are indeed functioning" (Wears and Hettinger, 2014). Working around bugs in the system, for instance, leaves manufacturers unaware of them (Waheed, 2016), which means that nothing is done to solve them. Similarly, if management is not made aware of dysfunctionalities, they will not address those either. Alternatively, if they do make decisions on processes, they are "based upon an illusion of actuality and not on the reality of workplace activities" (Sobreperez et al., 2005, p. 1). Managers could be making important decisions based on incomplete information (Drum et al., 2016), which gives a false sense of compatibility between information systems and work processes.

2.3.3. Workarounds as Feedback Resources

Organisations can use knowledge of workarounds to improve processes and ISs. The majority of studies on workarounds suggest that workaround activities have the potential to bring about improvement in organisations. They are especially useful for guiding IS redesign since they contain information about necessary customisations of the IS (Safadi and Faraj, 2010a). They "offer a blueprint for identifying the pressing information gaps that need to be resolved when considering improvements in an information flow" (Petrides et al., 2004, p. 101). Similarly, workarounds can help improve the design of work processes, because they give insight into the day-to-day activities of participants and their needs to perform these tasks (Safadi and Faraj, 2010a). They may even guide organisations in re-evaluating the entire process environment by challenging "the ability and coherence of processes and systems that no longer serve the organisation, its employees, or its customers" (Alter, 2015a, p. 4).

The undertaken improvement efforts, in turn, lead to increased efficiency (Reiz and Gewald, 2016), better communication (Alter, 2015a) and improved satisfaction on the part of participants (Safadi and Faraj, 2010a; Malaurent and Avison, 2015; Barrett and Stephens, 2017). By approaching workarounds as feedback resources (Safadi and Faraj, 2010a), organisations can perform corrective actions and make improvements to processes. In the next section, we derive from literature a set of five activities that help organisations to unlock the potential of workarounds for improvement.

2.4. Five Activities to Improve Processes

2.4.1. Measure

Many authors stress the importance of knowing why participants perform workarounds, described as 'motivations' (Nadhrah and Michell, 2013; Barata et al., 2015), 'reasons' (Outmazgin, 2013; Outmazgin and Soffer, 2013), 'obstacles' (Huuskonen and Vakkari, 2013) or 'antecedents' (Ferneley and Sobreperez, 2006). Others simply call for an understanding of participants' work practices (Saleem et al., 2011; Park and Chen, 2012; Blaz et al., 2016) because they consider the way people work and work around prescribed processes imperative for deciding on a strategy. Van Beijsterveld and Van Groenendaal (2016, p. 372), for instance, argue that "actual misfits require a different solution strategy than perceived misfits do". Similarly, Röder et al. (2016) debate that whether the intention of the participant is positive or negative should be the basis for deciding on a resolution strategy.

In contrast to focusing on the motivations of workarounds, other authors focus on the consequences instead. Drum et al. (2015, p. 138), for example, state that "the motive underlying the workaround, while interesting, does not afford a satisfactory understanding of workarounds. Rather, we believe it is more beneficial to focus on the outcomes generated by workarounds". Also interesting in terms of consequences of a workaround, is its downstream effect (Alter, 2014a, 2015a). According to Drum et al. (2015, p. 137), "the use of workarounds often constrains or decreases the overall effectiveness of the system, especially for those 'downstream' from the workaround who must deal with its outcomes". Others take both motivations and consequences into account (Huuskonen and Vakkari, 2013; Nadhrah and Michell, 2013; Barata et al., 2015). According to Röder et al. (2016), consequences can be further specified into risks and benefits. These risks and benefits can provide a basis for improvement efforts (Gasparas and Monteiro, 2009; Röder, Wiesche and Schermann, 2014; Alter, 2015b; Barata et al., 2015; Zimmermann et al., 2017).

In terms of the means to measure workarounds, several authors suggest to identify the workarounds in situ, at the practice level (Ali et al., 2010; Zhou et al., 2011; Blandford et al., 2014; Furniss et al., 2014). This can be achieved by performing interviews, observations, shadowing and focus groups (Koppel et al., 2015). Several studies on workarounds, however, pointed out quantitative limitations, for instance not knowing the frequency of workarounds (Halbesleben et al., 2010) or the expenditure of money, time and effort (Van Beijsterveld and Van Groenendaal, 2016). A way to overcome this is the use of process mining techniques that "use event data to extract process-related information" (Van der Aalst, 2011, p. 1). This enables organisations to meet the demand for measuring "the actual value of workaround time and effort compared with the original process" (Nadhrah and Michell, 2013). Outmazgin and Soffer (2013) showed that process mining techniques can indeed be used to detect certain types of workaround behaviours, although others were not reflected in the event log. Also, the motivation of participants to perform workarounds and relevant situational factors are difficult to determine using these techniques. Therefore, more traditional techniques such as performing observations remain to have value (Koppel et al., 2015).

In sum, we propose that the first necessary activity to achieve process improvement is to measure workarounds. Specifically, what needs to be measured is the motivation of the participant to perform the workaround and the associated consequences. Our view is that this can best be done in the form of a hybrid approach, by performing qualitative observations of participants and using quantitative process mining techniques.

2.4.2. Act

According to Drum et al. (2017, p. 59), "workarounds must be addressed". However, as mentioned in the previous section, different types of workarounds must be addressed differently. One rule of thumb that is frequently mentioned in the literature is to manage workarounds by controlling risks and maintaining benefits (Nadhrah and Michell, 2013; Alter, 2014a; Zimmermann et al., 2017). Specifically, organisations are advised to facilitate or adopt appropriate workarounds and prevent or block the inappropriate ones (Nadhrah and Michell, 2013; Alter, 2015a; Brooks et al., 2015). According to Park et al. (2015, p. 1:19), the evaluation of appropriate and inappropriate workarounds is not an easy task, as "careful internal analysis might be necessary to identify which adaptations […] should be supported, rather than merely eliminating problematic immediate adaptations". More authors advise organisations against simply eliminating workarounds, as doing so may result in negative outcomes (Azad and King, 2012;

Spierings et al., 2017; Zimmermann et al., 2017). Eliminating the underlying *reasons* to perform workarounds, however, is recommended and expected to lead to positive results (Reiz and Gewald, 2016).

Acting on workarounds may entail activities such as process redesign, disciplinary actions (Outmazgin and Soffer, 2013), improvements in the technology or control routines (Gasparas and Monteiro, 2009). Usually, these actions fall into two categories: (1) customisations to the information system and (2) changes to the structure of the organisation (Van Beijsterveld and Van Groenendaal, 2016). A concrete example of an organisational action that was suggested in two separate studies is ensuring that participants have physical access to specific process roles. In Halbesleben et al. (2010), this entailed relocating a pharmacist to a nursing unit. In Tucker (2016), it involved increasing the nurses' access to the process owner. In both cases, this was shown to improve the process: in the first it led to a decreased amount of rework and frequency of workarounds; in the second it caused participants to enact less inappropriate workarounds.

To summarise, we argue that organisations can exploit the measurements of workarounds from the previous section in order to make decisions on how to address them. By evaluating which workarounds are appropriate and which are not, they can facilitate the former and prevent the latter.

2.4.3. Involve

Various authors comment on the improvement potential of involving participants in designing and diffusing IS. Wheeler et al. (2012, p. 553), for instance, state: "in the case of workarounds, organizations could capitalize on the mindfulness of employees by encouraging employees to share their workarounds in order to improve task design". Insights from users can guide system design (Park and Chen, 2012; Blandford et al., 2014) and decrease resistance towards the system (Malaurent and Avison, 2015; Barrett and Stephens, 2017). Tucker (2016, p. 1142) believes that "designing work that considers the natural responses of employees when they encounter operational failures will be helpful in creating improvement programs that are successful over multiple dimensions, such as safety and efficiency". By giving process participants "a way to contribute" (Alter, 2015a, p. 3), allowing them to "reinvent, redefine or modify" (Barrett and Stephens, 2017, p. 1007) and "speak up about operational failures" (Tucker, 2016, p. 1127), they participate in forming new work routines that fit their needs. Designers cannot foresee perfectly how their system is used (Park and Chen, 2012), but by involving users in the process, misfits can be resolved. This involvement of participants needs to be facilitated by the organisation. Halbesleben et al. (2010), however, point out the complexity of gathering different participants with different roles. Safadi and Faraj (2010a) also indicate that participants often lack the time needed to communicate all the necessary information.

To sum up, we join the view of most authors and propose the involvement of participants in the improvement of processes. They are known to be willing to contribute improvement ideas. We suggest to exploit this willingness and have participants contribute solution strategies, starting with the participants already known to perform workarounds.

2.4.4. Educate

What is also stressed in studies on workarounds is the need to set up suitable educational programs (Hustad and Olsen, 2011; Wheeler et al., 2012; Alter, 2014a; Furniss et al., 2014; Drum et al., 2016; Reiz and Gewald, 2016). Ongoing training and coaching of participants can enable both the efficient and appropriate way of working (Zhou et al., 2011; Alter, 2015a; Drum et al., 2016; Reiz and Gewald, 2016) and the prevention of workarounds caused by ignorance (Furniss et al., 2014; Tucker, 2016; Van Beijsterveld and Van Groenendaal, 2016).

One topic that should be addressed in the educational program of participants is the downstream effect of enacted workarounds, which we discussed earlier in the section on measuring workarounds. According to Drum et al. (2017, p. 44), "system users are often unable to fully comprehend their place in the task chain, and thus are unaware of the implications of their actions on information quality". In training and coaching efforts, users need to be explained the broader implications of their actions and how their goals relate to the bigger process (Alter, 2014a; Drum et al., 2016, 2017). Drum et al. (2017) in fact noticed a 'light bulb effect' when participants were made aware of the broader implications of their actions, leading to improved work practices thereafter.

Another topic on the agenda of training programs on workarounds, is the encouragement of users to speak up about obstacles they perceive in their daily work (Campbell, 2011). Only then will their voices reach decision-makers who can then make informed decisions (Kobayashi et al., 2005). It also allows the sharing of best practices and the recognition that they are not the only ones struggling (Campbell, 2011).

In sum, we propose to focus especially on educating participants in improvement efforts. Ongoing training and coaching of participants may cause a decrease in resistance and ignorance and eventually in a decrease of workarounds.

2.4.5. Monitor

In his work on engineering for emergent change, Alter (2014a) argues an operational work system is dynamic, rather than static and unchanging. A dynamic system that is always in flux requires a different way of handling than a static system. As such, problems "cannot be easily 'fixed' in a single step (workaround) or using a single, one-time set of measures" (Park et al., 2015, p. 1:17). When measures are put in place, additional workarounds may develop (Van Der Sijs et al., 2011). An attempt has to be made in avoiding these additional workarounds (Azad and King, 2008a), although some emerging workarounds simply cannot be avoided (Vieru and Arduin, 2016).

As the development of additional workarounds is unavoidable and their evolution cannot be predicted, the system needs to be monitored over time (Alter, 2014a; Zimmermann et al., 2016). Outmazgin (2013) suggests monitoring the extent to which participants fail to comply with the prescribed process. Similarly, Alter (2014a) suggests to track the effectiveness of workarounds and their downstream effects. This could provide decision-makers with the tools to perform corrective measures and notify them whenever workarounds occur (Alter, 2015b).

Again, process mining techniques offer a valuable means to accomplish the ongoing monitoring of workarounds (Outmazgin, 2013; Drum et al., 2017). It allows for 'conformance checking', i.e. checking the extent to which participants work around the prescribed process (Rozinat and Van der Aalst, 2008). It would also allow for the tracking of the frequency of workarounds over time, their performance in relation to the prescribed process, and its impacts downstream (Van der Aalst, 2011). However, monitoring workarounds using process mining has not been extensively researched yet. This opens up opportunities for future research.

To sum up, we recommend organisations aiming for process improvement to monitor their processes and particularly how participants work around the prescribed process. Using process mining techniques, the evolution of these workarounds can be tracked, together with its frequency, effectiveness and downstream effects. Figure 4 contains the full set of activities that organisations can draw from to use workarounds for improvement.

Figure 4 - Five Activities to Unlock the Potential of Workarounds for Improving Processes

2.5. Conclusion and Outlook

Over the years, many studies in IS have discussed the potential of studying workarounds for improving the alignment of IS and work processes. However, they do not provide insight in the necessary activities to achieve this improvement. In order to solve this research gap, we carried out a literature review in which we analysed existing studies that describe workarounds in organisations. We determined five activities organisations need to perform to unlock the potential of workarounds for improving processes. First, we propose that organisations need to detect these deviations and identify their motivations and consequences by observations and process mining techniques. Second, organisations should use this analysis of motivations and consequences for deciding whether to facilitate or prevent workarounds. Third, organisations can benefit from involving users in the decision-making process by letting them generate improvement ideas. Fourth, we propose to invest in educating and training end users to prevent the deviations in the first place and to make users aware of the broader implications of their actions. Last, monitoring workarounds can lead to continuous improvement in the long run.

Chapter 3

Prevent, Redesign, Adopt or Ignore[3]

Abstract. The complex and variable nature of healthcare work makes alignment of health information systems to healthcare processes a challenge, causing the emergence of workarounds. We developed three artifacts to use knowledge of workarounds to address this misalignment and enable the improvement of work systems. (1) The Workaround Snapshot, in which the necessary social and technical information about a workaround is captured, such as motivation, impact on the work system, and possible actions that can be taken. (2) The Workaround Action Impact Matrix, which illustrates the possible decisions that can be made. (3) The Workaround Snapshot Approach, a socio-technical approach that uses the previous artifacts to enable continuous improvement. Following the principles of design science, the artifacts are demonstrated and evaluated through a case study at a Dutch hospital, where we identified and examined twelve workarounds. The approach has proven to enable the organisation to make well-informed decisions on actions to be taken, which at times result in direct improvement of the work system. We contribute to existing research in moving past the identification and categorisation of workarounds, towards using explicit knowledge of workarounds to improve the work system.

Keywords: Workarounds, Work System, Process Improvement, Health Information Systems.

3.1. Introduction

In healthcare organisations, working around the prescribed procedures is the norm, rather than an exception (Koppel et al., 2008, 2015). An example of such a workaround in healthcare is a nurse writing information about patients on a piece of paper, instead of using the portable Computer on Wheels (COW). After doing their rounds, they enter the patient checks in the Health Information System (HIS). Yang et al. (2012) define such workarounds as "alternative procedures employed by users to accomplish a task in response to a misfit between computer-based and

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existing work processes". In healthcare, this misfit between computer-based and existing work processes is especially evident (Kobayashi et al., 2005; Vogelsmeier et al., 2008; Safadi and Faraj, 2010a; Nadhrah and Michell, 2013). A possible reason for this is the complex and variable nature of healthcare work (Ash et al., 2004; Kobayashi et al., 2005; Koppel et al., 2008; Cresswell et al., 2017), which makes alignment of HISs to healthcare processes a major challenge (Lenz and Kuhn, 2004). Although information systems (ISs) are a key factor in providing healthcare professionals access to the needed information and thereby improving the quality of healthcare, the existence of IT-related workarounds may have a negative effect on patient safety and security (Koppel et al., 2008; Vogelsmeier et al., 2008; Röder et al., 2015).

To make managing them even more complex, healthcare processes are subject to change because of new technologies and changing responsibilities, leading to a need for healthcare work systems to continuously adapt to new conditions (Berg, 1999; Lenz and Kuhn, 2004). Knowledge of workarounds potentially offers a means to do so. Whereas workarounds can have negative effects (Ash et al., 2004; Patterson et al., 2006; Azad and King, 2008a; Outmazgin and Soffer, 2013) and are often used as a form of resistance towards a system (Ferneley and Sobreperez, 2004; Pollock, 2005), their existence can also be viewed positively (Halbesleben et al., 2008). Knowledge of workarounds can signal important issues in process alignment, can help mitigate risks and may even offer a blueprint for identifying misfits that need to be resolved (Petrides et al., 2004; Vogelsmeier et al., 2008; Safadi and Faraj, 2010a). According to Safadi and Faraj (2010a), "workarounds are knowledge about the IS but in the context of work needs". However, to derive these work needs, tacit knowledge about the requirements of IS users should be transformed into explicit knowledge that enables improvements to IS and work processes.

As workarounds exist at the intersection of technology and its use by human actors (Cabitza and Simone, 2013), gathering explicit knowledge about them requires attention to both the social and technical aspects of the environment. Therefore, we take a socio-technical perspective on healthcare processes, where we recognise the recursive shaping of work processes and information systems (Leonardi, 2012). In this socio-technical perspective, it is useful to think of the healthcare environment as a work system: "a system in which human participants and/or machines perform work (processes and activities) using information, technology, and other resources to produce specific products/services for specific internal and/or external customers" (Alter, 2013). To discover how analysing workarounds and translating them into work needs can aid healthcare organisations in improving their work systems, we ask the following research question: *how can explicit knowledge of workarounds in healthcare processes enable the improvement of work systems?* We start by sketching the theoretical background, after which we discuss the methodology. Then, we present and evaluate our artifacts and conclude with a discussion and conclusion.

3.2. Literature Review

3.2.1. A Socio-Technical Perspective

First, it is important to distinguish workarounds as behavioural activities from the actual tweaking or hacking of a technology (Cabitza and Simone, 2013). We focus specifically on the first, on the behavioural activities that emerge when a technology is implemented and being used by social actors in an organisation. Especially in terms of compliance, these workaround activities have often been viewed as negative phenomena (Röder, Wiesche and Schermann, 2014). However, they are also seen as potentially beneficial activities (Safadi and Faraj, 2010a; Cabitza and Simone, 2013; Nadhrah and Michell, 2013; Röder, Wiesche and Schermann, 2014; Cresswell et al., 2017). They are believed to enable the identification of gaps between work processes and their representation in the information system (Petrides et al., 2004) and draw attention to things that need fixing (Lalley and Malloch, 2010). Being aware of how processes are worked around, allows for the redesign of these processes such that gaps can be resolved (Cresswell et al., 2017).

Attention to workarounds also allows for the bottom-up involvement of process participants (Azad and Faraj, 2011). They contain information about behaviour of users, thus acting as a feedback resource that may be used to improve the system (Cresswell et al., 2017). Several scholars believe the involvement of users is crucial in developing an information system that fits the work processes (Ciborra, 2004; Helfert, 2009; Lalley and Malloch, 2010; Safadi and Faraj, 2010a). As such, users can take ownership in shaping the features of the information system (Bednar and Welch, 2009). Involving caregivers in the design of healthcare systems and integrating the entire socio-technical system "is especially helpful for health care", because of the complex characteristics of the environment and high demands regarding the care of patients (Ackerman et al., 2017).

3.2.2. Continuous Monitoring of Workarounds

Not only do workarounds signal misfits between work processes and IS and provide feedback of users; they are also "tangible behaviours" that can be observed, which makes them suitable for identification and analysis (Safadi and Faraj, 2010a). However, they will only surface when the information system is in active use (Ash et al., 2004). According to Ciborra (2004), it is highly important in the IS discipline to pay attention to the usage of technology in everyday life. This means studying the matching "between plasticity of the artefact and the multiform practices of the actors involved" (2004). Therefore, analysis of workarounds is only possible in the post-implementation phase of an information system, when users start interacting with the technology and enact a technology-in-practice (Orlikowski, 2000). Important to recognise is that, as social context continuously changes, so does the interaction of users with the technology. As work processes change, new requirements will surface, and thus new workarounds will emerge. Existing ones will evolve and stabilise because of their evolutionary characteristics (Cabitza and Simone, 2013). Gaps between the work process and the information system will always remain present (Petrides et al., 2004). Hence, the fit between work processes and information systems must be evaluated continuously (Koppel et al., 2008). Constant vigilance is crucial here (Ash et al., 2004). Only when the work system is continuously monitored can underlying problems be addressed and resolved (Koppel et al., 2008; Vogelsmeier et al., 2008).

3.2.3. Addressing Workarounds

Up until now, research related to workarounds has focused on how and why people work around. In what ways knowledge of workarounds can lead to improvement of work systems, is still unclear. However, it is believed that by addressing them, it has the potential to do so. To move from knowing that people work around and how they do it, towards using this knowledge to improve the work system, well-informed decisions need to be made. In previous work, researchers have discussed several actions that can be taken regarding workarounds. For example, ignoring them is often harmful (Alter, 2015), while formalising or institutionalising is believed to be advantageous (Koppel et al., 2008; Azad and Faraj, 2011; Yang et al., 2012; Cresswell et al., 2017).

The different types of actions mentioned in literature can be clustered into four groups (Table 3). In this research, these four action groups are key. We aim to find out whether knowledge about workarounds can be made explicit in such a way that this knowledge enables an organisation to make a well-informed decision on any of the four actions, and by doing so, to enable the organisation to improve its work system.

Table 3 - Possible Actions Regarding Workarounds

Action	Definition	Examples of synonyms used in literature
Prevent workaround (Nadhrah and Michell, 2013)	Developing countermeasures to prevent a workaround from happening.	Prohibit (Röder, Wiesche, Schermann, et al., 2014), eliminate (Vogelsmeier et al., 2008), demonise (Cresswell et al., 2017), modify IT (McGann and Lyytinen, 2008)
Adopt workaround (Nadhrah and Michell, 2013)	Transforming a workaround into a formal process.	Formalise (Cresswell et al., 2017), institutionalise (Azad and Faraj, 2011), ‘Pave the cowpath’ (Cabitza and Simone, 2013)

Redesign process (Dumas et al., 2013)	Reorganising processes to resolve the misfit that resulted in workarounds.	Fit (Gasser, 1986), embellish process (McGann and Lyytinen, 2008)
Ignore workaround (Alter, 2015a)	Not taking any action regarding the workaround.	Tolerate (Röder, Wiesche, Schermann, et al., 2014)

3.3. Research Approach

Our research follows a design science research approach. Hevner et al. (2004, p. 75) describe that in the design science paradigm, artifacts are built and applied in order to achieve "knowledge and understanding of a problem domain and its solution". In this study, our goal is to develop artifacts that make knowledge about workarounds explicit and thereby enable improvement of work systems in the healthcare domain. We follow the Design Science Research Methodology of Peffers et al. (2007), as illustrated in Figure 5.

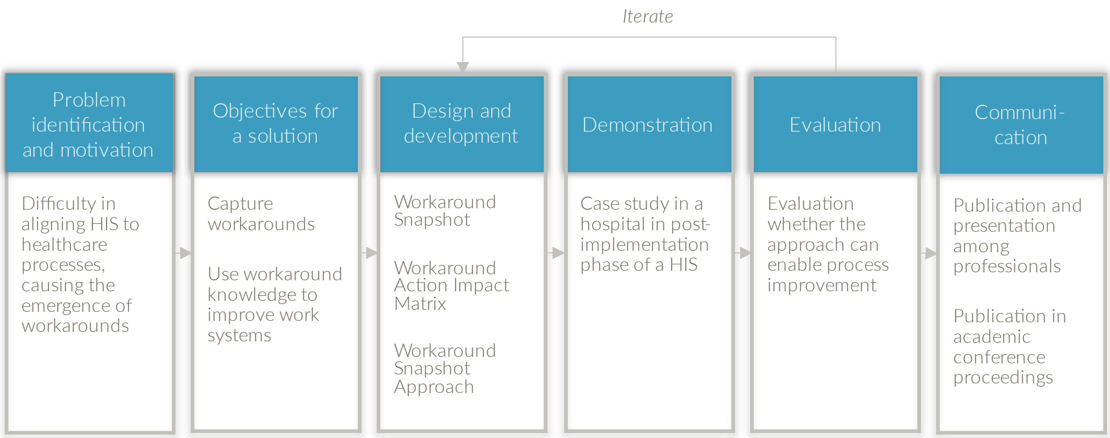

Figure 5 - Design Science Research Methodology (following Peffers et al., 2007)

We first identified the problem: the challenging alignment of Health Information Systems to healthcare processes. If they are not well-aligned, workarounds emerge, which may have negative effects on the work system.

We then defined our objectives for a solution to the identified problem. Our solution should be able to capture workarounds in a structured and meaningful way and use this knowledge to improve work systems. Workarounds should be captured as enactment of ´technologies-in-practice' (Orlikowski, 2000), with a focus on how the health information system is engaged and interacted with in everyday practice and how this enacts structures of technology. By integrating a 'practice lens' in our approach, we focus specifically on how people use the health information system, how they interact with it, and how they enact the technology-in-practice by working around the system.

In the design and development phase, we developed three artifacts: the Workaround Snapshot to capture workarounds, the Workaround Action Impact Matrix to evaluate and decide on action, and the Workaround Snapshot Approach that uses the previous two artifacts to identify, evaluate and monitor workarounds in order to enable improvement of work systems. Our approach is a socio-technical approach that focuses on human agency and how users of a HIS enact and construct the technology.

As an important part of design science entails the demonstration and evaluation of an artefact, we demonstrate and evaluate our artifacts in a case study. Performing a case study allows us to carry out a detailed and intensive analysis of the case (Bryman, 2015), examining the complex environment a healthcare organisation often is. The case type is representative (Yin, 2017): a hospital that is amid a digital transformation, representing many other hospitals and hospital departments in the post-implementation phase of a HIS. The first results of this study have been presented to a professional audience. In this paper, we will present our full study and evaluation results.

The remainder of this paper is structured as follows: we start with the artifact descriptions (Section 3.4), followed by the evaluation of the artifacts through the case study (Section 3.5), and finish with a discussion (Section 3.6) and conclusion (Section 3.7).

3.4. Artifact Descriptions

3.4.1. Artifact 1: The Workaround Snapshot

Alter (2015a) proposed a method to capture knowledge of a work system in the form of a 'work system snapshot': a summary of different elements of a work system, such as customers, products, major activities and technologies. Inspired by this, we propose the creation of 'workaround snapshots' to make knowledge about workarounds explicit. A workaround snapshot contains the essential information about the social and technical aspects of the deviation and forces the creator to keep the information concise, so that it allows for quick analysis.

The structure of the snapshots is shown in Table 4. Included in the snapshot is the creation date, a list of the types of workers involved, and a concise textual description of the workaround, which is to be readable by someone without extensive knowledge of IT and/or healthcare. It also contains a process model of the workaround to illustrate both the activities of the prescribed model and the deviations. A description of the impact of the workaround on the work system is included as well, as a workaround can simultaneously have a positive effect on one factor and a negative effect on another (Röder, Wiesche, Schermann, et al., 2014;

Andrade et al., 2016). To illustrate this trade-off, the snapshot includes a devil's quadrangle of impacts (Dumas et al., 2013).

The last two components of the snapshot include a description of the motivation of the worker to work around and an inventory of possible actions to be taken, based on the four actions mentioned in Table 3. Actions belonging to the *prevent* cluster are actions where a decision is made to actively prevent the workaround from happening. Actions belonging to the *adopt* cluster are actions where the workaround is considered the best available way of performing a task and this alternative is actively distributed. The *redesign* cluster includes actions that redesign the work process, resulting in the prescribed process being altered. The last cluster, *ignore*, includes actions that leave everything as-is.

Table 4 – Structure of the Workaround Snapshot

Snapshot Component	Content
Date of snapshot	Date the snapshot was created.
Workers	Roles that are involved in the workaround.
Description	Concise textual description of the workaround.
Process model	Process model.
Impact	Impact of the workaround in terms of the devil's quadrangle.
Motivation	Description of the worker's motivation to work around.
Possible actions	Inventory of actions that can be taken: prevent, adopt, redesign, or ignore.

By creating workaround snapshots, we aim to transform tacit knowledge about the needs of healthcare users, into explicit knowledge that can be utilised to improve the work system.

3.4.2. Artifact 2: The Workaround Action Matrix

To represent the possible actions, we propose the Workaround Action Matrix in Figure 6. *Ignoring* a deviation requires low management effort and no changes to the prescribed process. *Prevention* of a workaround, on the other hand, requires high management effort, but does not require changes to the prescribed process either. It may, however, entail changes in the information system, in order to prevent users from circumventing the system. The *redesign* cluster of actions differs from *prevention* in the sense that the prescribed process is altered, and therefore requires a high management effort. Lastly, *adoption* of a workaround does require changes to the prescribed process but does not require as much effort from management as the *redesign* and *prevent* cluster, as it is already in use and its value to achieve a goal is already recognised by users.

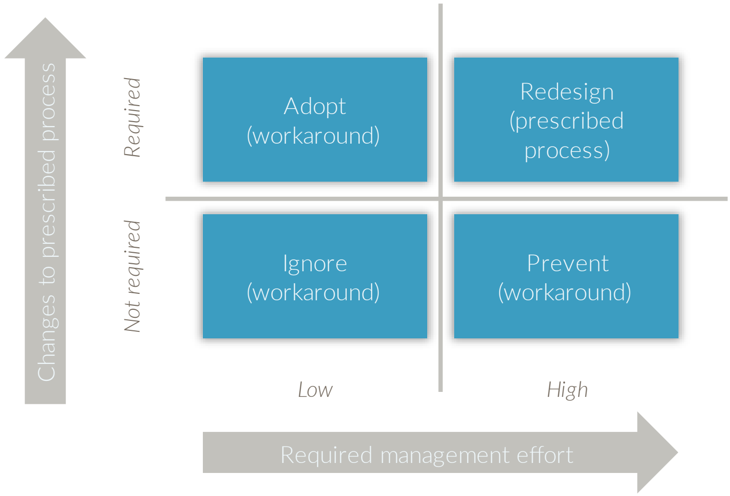

Figure 6 - The Workaround Action Impact Matrix

By subdividing the possible actions into the different boxes, a decision-maker can easily determine what the required effort is for a certain action and whether changes to the prescribed process are necessary if that action is chosen.

3.4.3. Artifact 3: The Workaround Snapshot Approach

The snapshot and the action matrix are core elements of our approach, but it is not sufficient to develop snapshots alone. To enable continuous improvement, there needs to be a continuous workflow of evaluating and addressing workarounds. The technology-in-practice and how it is enacted by users should be monitored continuously, to allow the organisation to recursively shape the work system based on the needs of its users. At the start of this workflow is the identification of the deviation: the trigger. A deviation is identified when workaround activities are spotted in an observation or interview. A snapshot is subsequently created for this workaround, which is iteratively improved through discussions with all those involved. When all components of the snapshot are filled in, a well-informed decision can be made on an action to be taken. The chosen action is recorded, after which the process is monitored for the agreed time frame. At the end of this period, the workaround is evaluated. The snapshot is adjusted accordingly, and a decision is made whether the action needs to be changed. The workaround is again monitored, evaluated, etc., resulting in the model illustrated in Figure 7.

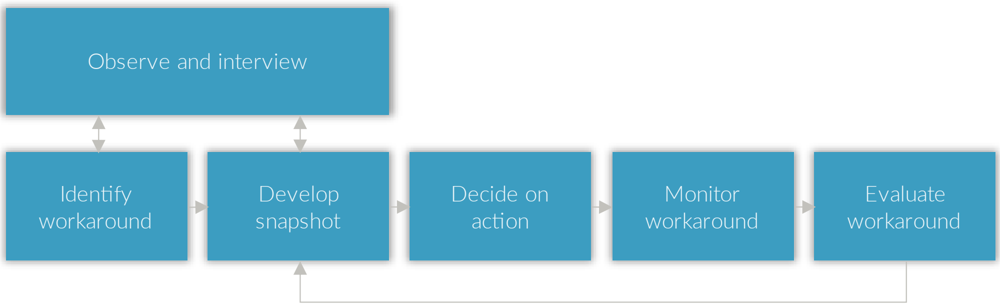

Figure 7 - The Workaround Snapshot Approach

3.5. Case Study

The case study was executed at a Dutch peripheral hospital. Data was collected at one ward during the months of April, May and June 2017. The first author received full access to the ward, which consists of around thirty clinical beds and is run by a team of nurses, caregivers and helpers. Also working on the department are surgeons, orthopaedists, physicians and physiotherapists. The team lead of the ward allowed the researcher to observe everyone there and interact with both the nurses and physicians. A nursing suit was provided to not draw attention to the research being done.

3.5.1. Data Collection and Analysis

Data gathering mainly took the form of ethnographic observations and interviews that were carried out by the first author. Secondary data in the form of internal documents were provided by the ward's team lead. Initially, interviews with the team lead were planned to uncover the prescribed processes. Interviews and observations with nurses and physicians would follow afterwards, through which the actual process would be discovered. However, the discovery of workarounds turned out to be more of an iterative process where interviews and observations merged. To decide whether a nurse's or physician's activities were indeed workarounds, regular visits to the team lead were necessary. Interviews turned into observations when participants eagerly showed how they worked around an obstacle in the process or when a colleague asked them to perform a task. Active observations, where the researcher asked the participant to show the execution of a specific task, alternated with passive observations, where the researcher would watch the participants perform their daily work.

During six hours of interviews and a further sixteen hours of observations, data were collected from eight nurses, five physicians, one pharmacist, and the team lead. Twelve workarounds were identified and worked out in detail. One HIS consultant from ICTZ who played a large role in the previous phases of the HIS implementation and with a background in nursing was consulted during two sessions, to gain additional information about the problems underlying the different workarounds and the possible actions that can be taken to improve the work system.

As soon as sufficient information was gathered on the workarounds, they were presented to the team lead. After discussing each deviation, the team lead was encouraged to answer a set of questions, with the aim of verifying the used approach. We provided the same information to a second team lead from another ward and asked her for a response, in order to verify the application of the approach and recognition of the workarounds outside the ward of the case study.

The first author recorded and transcribed the interviews and took notes during the observations. All transcripts, notes and internal documents were collected in qualitative analysis software Atlas.ti and coded there. Coding of the interview transcripts and observation notes was done deductively, on the basis of the components of the snapshot, i.e., 'workers', 'description', 'impact' and 'motivation'. The results from the interviews and observations and associated codes were regularly discussed with the second author and edited if necessary.

3.5.2. Identified Workarounds

Snapshots were created for all twelve workarounds identified in the case study. Table 5 lists the found workarounds and includes the sources from which the information was collected. The following sections present a few illustrative examples of the snapshot components Process model, Impact, Motivation, and Possible Actions. The content of the snapshots is based on the assessment of the participants, not on the assessment of the authors. The last section includes an overall evaluation of the applicability of the approach to the case.

Table 5 - Identified Workarounds (N=Nurse, P=Physician, Pha=Pharmacist, T=Team lead)

ID	Workaround description	Source
WA1	No or partial entering of medication (a) and calling for missing medication (b)	N1, N3, N8, P4, T
WA2	Entering patient checks on paper instead of Computer on Wheels (COW)	N1, N2, T
WA3	Logging in with someone else's user account	P3
WA4	Using the activity plan alternatively	N1, N3, T
WA5	Executing dismissal checklist only partially, not at all or not in time	N1, N3, N4, N5, T
WA6	Not adequately performing the second check during administering medication	N1, N3, T
WA7	Performing an extra visual check during printing of home medication	P1, P2, P3

WA8	Walking away from the computer without locking	Several Ps and Ns
WA9	Irregular check of rush orders	N1, N3
WA10	Checking of occupancy other departments than their own	N3, T
WA11	Not sending home medication to pharmacy (in time)	N1, Pha, P3, P5, T
WA12	Entering medication in activity plan instead of administration register	N3, N4, T

3.5.3. Process Model

The first workaround, WA1, involves incomplete information about medication of a patient that has returned from the operating room. As the team lead explains:

> *"The physician is responsible for settling everything related to medications, but they don't, causing the nurses to constantly be confronted with questions about pills, things that are incomplete, so they need to call after it. And then the physician says: I just got my hands covered in blood, so it will take half an hour".*

Figure 8 shows the process model for WA1. The physician responsible for entering this information, does not do so sufficiently, forcing the nurse responsible for administering the medication to call the physician for more information and subsequently entering the information ad-hoc. The first difference between the prescribed activities and the workaround activities is that in the latter, the physician does not enter the medication information correctly. This affects the activities later in the stream, as the nurse notices the information is not present. Because of this, the nurse needs to ask for the information, an activity that is not necessary in the prescribed process. The physician is then interrupted in his work, which would not happen if the information was entered correctly. Lastly, the nurse needs to perform another activity: entering information ad-hoc. Therefore, by working around the entering of information at the start, new activities are added later in the stream. This relates to the *cascading effect* of workarounds as referred to by Kobayashi et al. (2005), who found that one workaround may initiate further deviations down the line.

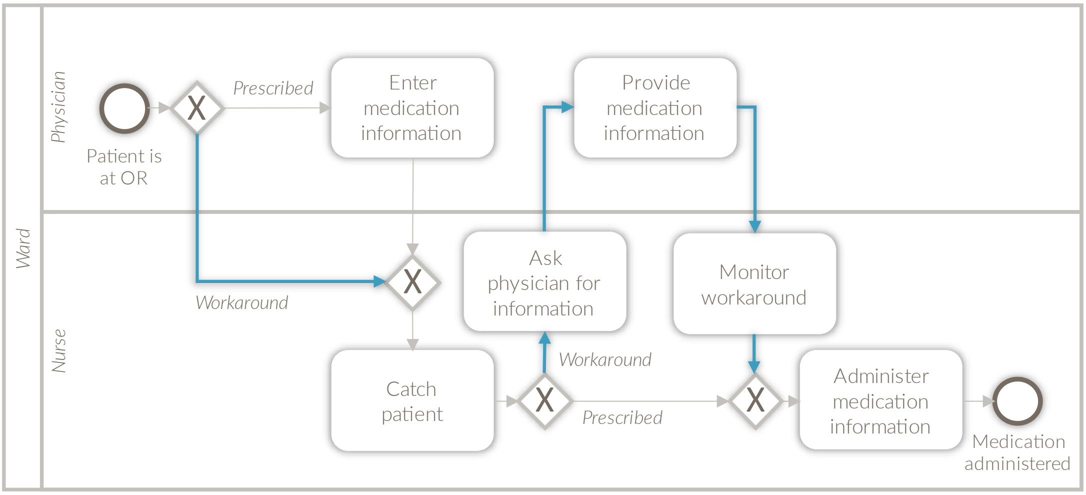

Figure 8 - Process Model for WA1

3.5.4. Impact

An illustrative example of the impacts trade-off is WA6, illustrated in Figure 9. When one nurse administers certain medication to a patient, a second nurse is required to check whether the right medication is given to the right patient at the right time. However, it sometimes occurs that the second nurse simply gives his or her personal code, so that the order can quickly be signed off without the actual check executed. Nurse:

> *"It is about trusting each other. If someone needs to walk along every time until you put that pill there… we won't be able to do our jobs"*.

The impact on cost in this case is neutral, as there are no costs involved in not checking the medication, unless the hospital is caught and fined. The impact on time is clearly positive, as all activities involved in the check are omitted. The impact on the flexibility of the worker is positive as well, as the second nurse is available to perform other tasks. The impact on quality is negative, as errors may not be identified in administering medication.

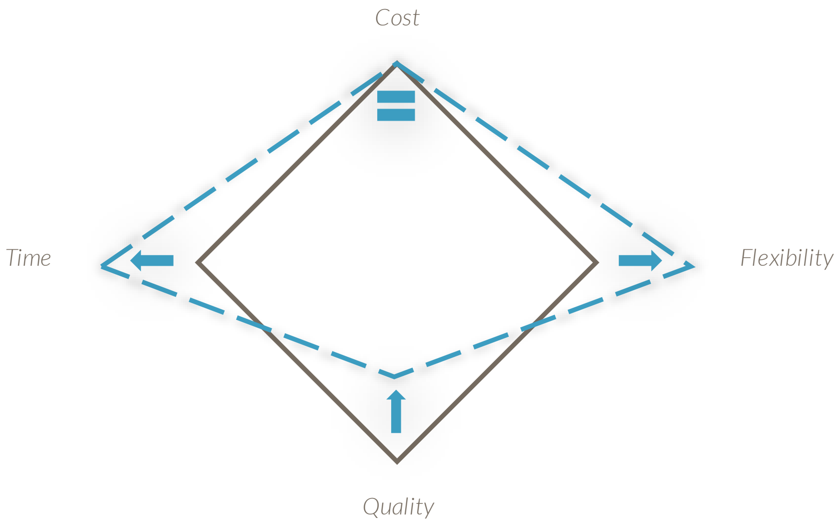

Figure 9 - Devil's Quadrangle of Impacts for WA6

3.5.5. Motivation

WA2 relates to the process of entering information about the regular patient check-up. Five Computers on Wheels (COWs) are present at the ward, to enable immediate entering of information at each patient's bedside. However, many nurses choose not to use the COW and write the information on a piece of paper, after which they enter it in the system one after another. Nurse:

> *"I need to do more things at once, and people ask a lot of questions during checks. So I rather perform my checks and write them down, do my stuff and when I have some time I sit down for a while and fill them in quietly".*

When asked for their motivation to work around, they say they prefer to enter the data in a quiet place, as it allows them to concentrate better. Entering the data using the COW means they spend more time at a patient's bedside, resulting in other patients asking them for help.

3.5.6. Possible Actions

WA3 concerns a co-assistant in the last stage of his study, who consistently logs in on another physician's account. Co-assistant:

> *"So every morning, I log on as one of the physicians. [...] Imagine I would only have that co-assistant login... Well, I wouldn't be able to do anything".*

His own user account does not allow him to do anything other than view information and perform the most basic tasks, although he is entitled to perform other tasks for physicians because of his seniority. Four actions can be performed here. The first is to consider a new system role. This role can be attributed to all co-assistants in the last stage of their studies and equipped with the specific capabilities they need. This action is a form of *prevention*, as the aim is to prevent the co-assistant from performing the workaround (i.e., logging in with someone else's account). By creating a new system role, there is no longer a need to log in with the physician's account and the deviation can be prevented. In this case, the HIS is changed, but the prescribed process remains the same: i.e. using your own account and performing the work. Another *prevention* option is to prohibit the workaround by actively monitoring and prohibiting the logging in on someone else's account. This, however, is labour-intensive, difficult to monitor and denies co-assistants the possibility of executing their work.

Another example is WA5. This concerns nurses not executing the patient dismissal checklist completely and/or in time. *Redesign* may entail the development of a new checklist. The hospital makes use of standard content, meaning that this content is supplied by the HIS provider and based on a default hospital. Therefore, the standard checklist includes tasks that are not relevant for the nurses of the ward, which results in them not following the checklist at all. It also means that the checklist cannot be edited. However, it is possible to create a new list from scratch and add just the elements that this ward needs. The workaround may also be *prevented* by organising a meeting in which attention is paid to the checklist and the tasks that should be completed. Such a meeting may increase understanding and compliance.

3.5.7. The WSA as an Enabler for Process Improvement

The Workaround Snapshot Approach has been evaluated by discussing the snapshots with the team lead of the ward. Questions that were asked related to the comprehensibility and completeness of the snapshots, the team lead's awareness of the workarounds presented and his thoughts on the added value of the possible actions. Whether the actions chosen by the team lead were actually implemented, could not be verified within the time frame of this study.

According to the team lead, all snapshots were clear and understandable. Not once did he find the snapshot lacking essential information. Many snapshots provided the team lead with new information, especially regarding the possible actions that can be taken. For example, the team lead was unaware of the possibility of using the HIS on a tablet, making him consider the purchase of tablets in favour of COWs. He was also unaware of the possibility of developing an entirely new patient dismissal checklist that is tuned specifically for the ward. A last example is the possibility of facilitating the physicians in keeping track of their patients through the development of a convenient layout in the HIS.

Many workarounds caused the team lead concern and urged him to undertake action. Regarding WA1, for instance, the team lead chose a combination of both *redesign* and *prevention*. For WA2, the team lead chose to *prevent* the use of paper in favour of COWs:

> *"what I prefer is that they use the COWs".*

When asked why, he said:

> *"I'd rather have quality of care than a small stroke of efficiency".*

The actions chosen by the team lead are represented in the Action Impact Matrix in Figure 10. *Adopt* was not once chosen: it was most often either *prevent* or *redesign* or a combination of the two. In two cases, the team lead said not to act, which translates to choosing to ignore. Notable is that the two workarounds where he said not to act, i.e., to ignore, were indeed one where flexibility was positive and quality was neutral (WA2), and one where both flexibility and quality were positive (WA10). All others had a devil's quadrangle where flexibility or quality were negatively impacted, therefore it was deemed necessary to undertake action. Although time and cost are important, the most crucial factors for the team lead in terms of impact are quality and flexibility. The team lead strongly believes the information from the snapshots enables the organisation to improve the work system, and he answered positively to the question whether he sees value in a re-inventory of the workarounds after a year.

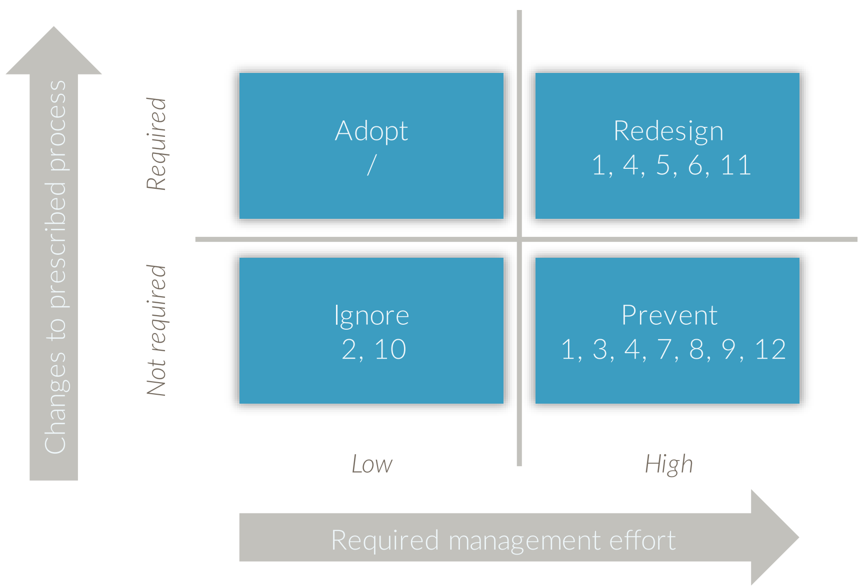

Figure 10 - Intended Decisions Represented in the Action Impact Matrix

In order to get an indication of the generalisability of the approach, a second team lead was interviewed. She considered the snapshots clear and comprehensive, recognised the issues related to medication and considers them a top priority. Nurses using paper instead of COWs are not considered concerning by either team leads, especially if it helps them concentrate better. Employees logging in under another name is not unique to the one ward either, as on others it also happens that new nurses have already worked for two weeks before they get a HIS tutorial. By default, nurses do not get an account before they have had the tutorial, so they must have worked on someone else's account for the time being.

The general belief is that the creation of workaround snapshots enables the team leads to improve their work systems. Both team leads expressed interest in performing subsequent analyses after the final stage of the implementation has finished.

3.6. Discussion

3.6.1. Creating Snapshots and Using the Action Matrix and WSA

With little time on site, the Workaround Snapshot Approach enabled us to draw a comprehensive picture of the technology-in-practice and its enactment, by encouraging workers to talk about their usage of the system. The creation of the snapshots was an iterative process that required repetitive consultation of different informants to confirm the information about the workaround. In business process management studies, involving different domain experts is a standard practice, as one person is rarely aware of an entire process (Dumas et al., 2013). By developing snapshots, one gathers knowledge of different domain experts and by presenting this combined knowledge in a clear and concise manner, this holds great value for the organisation. By presenting the team lead with information about deviations he was unaware of, the WSA also allows for the voices of the system's users to reach decision-makers, a feat that is often difficult to achieve in organisations (Cabitza and Simone, 2013). By listening to the voices of the HIS users and making decisions based on their needs, users start playing a role in the construction of the work system as well.

The proposed components of the snapshot have proven to be very encompassing. The Possible Actions component has turned out to be especially useful, by providing new information in terms of solutions other process participants had been unaware of. The representation of the Possible Actions through the Action Matrix enabled structured evaluation of possible decisions for the team lead. With regards to the impact of a workaround, there is a trade-off involved, as few of them have a negative impact on all factors. On the contrary, some of them have great benefits on time, cost, quality and/or flexibility, which corresponds to the idea that workarounds can in some ways be beneficial (Safadi and Faraj, 2010a; Cabitza and Simone, 2013; Nadhrah and Michell, 2013; Röder, Wiesche and Schermann, 2014; Cresswell et al., 2017).

One necessity for identifying workarounds and developing snapshots, is for the participants to be willing to share this information. Lalley and Malloch (2010) proposed the development of a new culture of user involvement and sharing. Process participants in such a culture need to be encouraged to share their ways of working so that awareness can be achieved. Organisations need to be proactive in identifying workarounds and addressing them (Koppel et al., 2008), creating standard procedures for identifying, monitoring and evaluating workarounds. They hereby become more responsive so that they can react to changing needs (Lenz and Kuhn, 2004). By developing such procedures, they are on track to grow, instead of build, their work system (Atkinson and Peel, 1998). This approach also corresponds to the idea that technologies should not merely be handed to users and left there, but that they should continuously evolve and adapt to the organisational context they are part of (Cabitza, 2014).

Similar to creating a culture of user involvement for participants to share information on issues and deviations, decision-makers should also be allowed to admit that some workarounds will be tolerated. Tolerating workarounds can be beneficial (McGann and Lyytinen, 2008; Huuskonen and Vakkari, 2013; Miller and Wedell-Wedellsborg, 2013). Especially when efficiency gains are expected, managers are often willing to tolerate deviations (Röder, Wiesche, Schermann, et al., 2014). The same goes for decision-makers in healthcare. Not all issues can be solved at once: choices must be made regarding solutions to invest in. There is another trade-off here in terms of choosing the workarounds that are most in need of a solution. If using paper instead of COWs is preferred by workers, the impacts are not considered problematic, and an alternative is costly, it may be acceptable to tolerate this deviation.

One pattern found in the causes of workarounds is communication. At least one-third of the deviations identified in this study have something to do with information not being communicated correctly. This corresponds to one of the two types of unintended consequences Ash et al. (2004) defined in the use of health information technology: issues related to the communication and coordination the system is supposed to support. Another pattern concerns the use of standard content. The vendor of the HIS aims to equip hospitals with standard content, as opposed to customising the HIS for each hospital. This allows them to support hospitals more easily, but it brings side-effects with it. Although this has not been studied in depth as this was not the focus of the research, some workarounds may actually be the result of this standard content. For example, by deploying a standard patient dismissal checklist that is not tuned to a specific hospital ward, users are overwhelmed by the number of tasks and sometimes choose to dismiss the checklist altogether. By introducing standard content that does not suit the work process, this may in fact pave the way for other deviations. This "self-defeating propagation of additional computer workarounds", should be avoided (Azad and King, 2008a).

However, we acknowledge that customisation of the HIS to the organisation in question is not always possible. As Safadi and Faraj (2010a) note, there is always the trade-off of improving processes through customisation versus the costs that are involved with customisation. Different strategies in resolving misfits have advantages and disadvantages and choosing one depends on many factors, e.g., the size of the organisation, whether it regards a perceived or imposed misfit, etc. (Van Beijsterveld and Van Groenendaal, 2016).

The findings in this study have several implications for practice. The Workaround Snapshot Approach not only enables an organisation to make explicit how and why people work around, but to utilise this knowledge as well. Creating snapshots allows for the gathering of knowledge from different domain experts, empowering the organisation to make a well-informed decision. We propose to illustrate the impact of a workaround on the work system using a devil's quadrangle, and to take action by preventing, adopting or ignoring workarounds, or redesigning the prescribed process. We thereby go beyond the design and development of the technology and broaden our view to the entire socio-technical work system.

3.6.2. Limitations and future work

There are limitations to this study as well. First of all, the case study has been performed on a single ward in a single hospital. We therefore consulted a second team lead to verify the findings, who recognised many deviations, although in slightly different form. The interest in a re-inventory of workarounds and the belief that awareness of deviations can lead to an improvement of the work system is shared, but application outside these wards and this hospital remains to be verified. Second, this research has not reached saturation in terms of the workarounds identified on the ward. We identified twelve deviations, but more may exist. Moreover, the interviews and observations were performed by one researcher, resulting in only one perspective on the deviations, although the approach to the development of snapshots through discussing the information with many different participants allows for multiple perspectives. The inventory of workarounds and their frequencies is not intended to be exhaustive but intends to explore the application of the approach in an actual hospital ward.

The study presents a first step towards realising improvement of work systems by making knowledge of workarounds explicit. Further research might validate the application of the approach on a larger scale and over the course of years. Longitudinal research would allow for the tracking of changes over time and analysis of the effect of actions taken on the work system. Future research may also focus on methods to uncover workarounds, such as the automatic detection and monitoring of workarounds through process mining (Van der Aalst, 2011). Finally, the assumption that workaround knowledge can be used for continuous improvement of work systems aligns with the work of Feldman and Pentland (2003), who state that organisational routines are not only related to stability, as assumed in the traditional understanding of organisational routines, but also "a source of flexibility and change". Moreover, Truex et al. (1999) claim that systems should continuously be adjusted and adapted, like the organisations they serve. This opens opportunities for future research such as investigating in which healthcare process workarounds are more or less likely to emerge, and under which circumstances healthcare process should be allowed a certain degree of flexibility.

3.7. Conclusion

In this study, we investigated how explicit knowledge of workarounds can enable the continuous improvement of work systems. We explored whether knowledge about workarounds can be made explicit and thereby enable an organisation to make well-informed decisions on actions to be taken. In order to capture the knowledge needed to accomplish work system improvement, we proposed three artifacts: the Workaround Snapshot, the Workaround Action Matrix and the overarching Workaround Snapshot Approach. These socio-technical artifacts have proven to be valuable tools in analysing deviations that emerge from the misfit between healthcare work processes and the health information system. We contribute to existing research in moving from how and why people work around, to how this knowledge can be made explicit and utilised. The creation of workaround snapshots, by capturing knowledge from different types of participants, contributes to raising awareness about workarounds in terms of impact, motivation and possible actions that can be taken. The case study shows that the approach enables an organisation to make well-informed decisions, as several proposed actions bring about immediate improvement to the work system.

Chapter 4

Seeing the Signs of Workarounds[4]

Abstract. Workarounds are intentional deviations from prescribed processes. They are most commonly studied in healthcare settings, where nurses are known for frequently deviating from the intended way of using health information systems. However, workarounds in healthcare have only been studied using qualitative methods, such as observations and interviews. We conducted case studies in six Dutch hospitals and use a mixed-methods approach that draws not only on interviews and observations, but also on process mining, to detect and analyse eight workarounds that occur in a clinical care process. We contribute to theory by demonstrating that it is possible to use data to determine the occurrence of a rich variety of workarounds found using qualitative methods. Practically, this implies that workarounds that are identified qualitatively can be further analysed and monitored using quantitative methods. Once identified, workarounds also provide an attractive starting point for organisational learning and improvement.

4.1. Introduction

As healthcare professionals are frequently confronted with unpredictable situations, it happens that they deviate from procedure. So-called *workarounds* are defined as intentional deviations from prescribed practices (Alter, 2014b; P. Boudreau et al., 2016). They are often studied in relation to how prescribed practices are supported by information systems, and how these systems are used differently in practice (Ferneley and Sobreperez, 2006). Although workarounds can be regarded as harmful noncompliance to carefully designed procedures, there is another side to that coin (Alter, 2014b). Workarounds provide information systems users flexibility in dealing with unpredictable circumstances (Röder et al., 2016). The COVID-19 crisis attests how important such flexibility actually is. Workarounds can also be seen as sources of valuable knowledge on what blockages users perceive in their daily work (P. Boudreau et al., 2016). Studying them enables

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[4] This work was originally published as:

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organisations to analyse organisational performance and improve processes (Röder et al., 2016).

To date, there is a large body of knowledge on workarounds that are identified with *qualitative* methods, particularly in the healthcare sector (Koppel et al., 2008; Yang et al., 2012; Debono et al., 2013; Beerepoot and van de Weerd, 2018a). However, qualitative methods are labour-intensive and it is uncertain whether they are effective to determine whether users reveal all their workaround behaviour (Van Beijsterveld and Van Groenendaal, 2016). Additionally, qualitative methods make it difficult to collect information on the frequency of workarounds and their evolution over time (Halbesleben et al., 2010). Recently, attempts have been made to detect workarounds quantitatively using *process mining* (Outmazgin and Soffer, 2016; Weinzierl et al., 2020). Process mining techniques use so-called event logs, extracted from an IT system, to perform process analyses on those data. Early studies have demonstrated that some types of workarounds are detectable with process mining. Utilising qualitative as well as quantitative approaches can enable the preliminary qualitative identification of workarounds, which can then be further analysed and monitored by studying workaround behaviour in data. Additionally, using quantitative methods, new types of workarounds may be found in addition to the ones established using qualitative methods. Therefore, there is a clear need to evaluate the suitability of a *mixed-methods* approach to detecting and analysing workarounds (P. Boudreau et al., 2016; Ejnefjäll and Ågerfalk, 2019).

It is an open question whether quantitative workaround detection – in addition to qualitative detection - is possible in a healthcare setting. The few quantitative workaround studies to date were conducted in sectors that are very different from healthcare. Healthcare processes are particularly complex, involve many different actors, and are characterised by high uncertainty (Winter et al., 2010; Wager et al., 2017). Therefore, it is reasonable to expect different types of workarounds in healthcare processes than seen in other domains. Additionally, existing studies focus predominantly on *control-flow workarounds*, i.e. situations where users deviate from the prescribed order of activities. This is arguably a rather narrow perspective, since many other perspectives on work processes exist.

With this study, we aim to enable the detection of workarounds specifically in healthcare processes. Furthermore, we purposefully take a broad perspective on processes by looking beyond the control-flow perspective, e.g., by also considering timing aspects. We carried out six case studies, collecting data from a number of healthcare professionals and analysing large sets of operational event data. For this analysis we use process mining techniques next to observations and interviews, which is a novel approach. Our main contribution is that we demonstrate a mixed-methods approach to the detection of a set of very diverse workarounds. We illustrate how certain characteristics in the data signal the existence of workarounds, which can then be quantitatively processed. In addition, we suggest how healthcare organisations can keep such workarounds under control and use these as a starting point for quality improvement. This specifically answers the call formulated by Röder et al. (2016).

The paper is structured as follows. We start by synthesising the existing body of knowledge on workarounds and their detection using qualitative and quantitative methods in Section 4.2. Subsequently, in Sections 4.3 and 4.4, we describe our research approach and present the results of our case study, respectively. We discuss the implications of the results to theory and practice in Section 4.5 before concluding this paper with Section 4.6.

4.2. Theoretical Background

4.2.1. Definition and Detection of Workarounds

In the Information Systems discipline, there is an ongoing debate on how workarounds need to be defined. In most studies, they have four characteristics ascribed to them (Ejnefjäll and Ågerfalk, 2019). The first is that there is a certain *designed path*, the norm on how work should be done. The second is that users perceive some kind of *block* in the way the ideal path is meant to be followed. Users come up with a workaround that is aimed at achieving the same, overall *goal* as the normative path, which is the third characteristic. Fourth and last, the workaround is *intentional*, i.e. the deviation is not a mistake or an instance of fraud or sabotage.

Apart from a few exceptions, workarounds have only been identified using *qualitative* data collection methods, such as interviews, observations, and document analysis (Ejnefjäll and Ågerfalk, 2019). To the best of our knowledge, there are only four works that use *quantitative* methods to study workarounds. Two studies by Laumer et al. (2017) and Van de Weerd et al. (2019) are similar in that interviews are paired with a survey to enrich the information collected on workarounds. A third study by Weinzierl et al. (2020) draws on process mining and machine learning techniques to detect workarounds in open datasets with artificially added deviations to them. In a fourth study by Outmazgin and Soffer (2016), a real-life dataset was used to detect workarounds in a purchasing and intake processes. They distinguished six generic workaround types, of which four were considered detectable. The studies by Weinzierl et al. and Outmazgin and Soffer demonstrate that process mining techniques have the potential to detect workarounds using quantitative techniques, i.e. by the analysis of data. However, they also show that not all workarounds are detectable using process mining, and that workaround information obtained qualitatively is necessary to get a complete picture of deviant behaviour.

The open question that concerns us in this work is how qualitative detection methods and process mining can be combined to detect and analyse workarounds in healthcare. This is of interest since healthcare is the domain that has been the focus of workarounds research, while it is also known for its complex processes involving many different actors. The question is relevant because the use of a mixed-methods approach to study workarounds in healthcare can enable a more complete identification of workarounds, and possibly provide new quantitative insights and theories (Ejnefjäll and Ågerfalk, 2019).

4.2.2. Multi-Perspective Conformance Checking

In order to explore the quantitative detection of workarounds in healthcare, we draw on the field of *compliance checking* (c.f. Outmazgin and Soffer, 2016). Workarounds can be viewed as a form of intentional incompliance. Specifically, taking into account the characteristics of workarounds as mentioned in the previous section, workarounds are instances of intentional noncompliance where the goal remains the same as when following the designed path.

In the context of process mining, compliance is commonly analysed using *conformance* checking techniques. Along with *discovery* and *enhancement*, *conformance* has always been one of the main types of process mining (Van der Aalst, 2016). For all three types of process mining, an event log is necessary. An event log consists of a number of events that usually contain at least the following information for each event: the *activity* that was executed (e.g. recording a patient's heart rate), the *case* it refers to (e.g. a specific patient or patient admission, also often referred to as *process instance*), and the *timestamp* (the date and time the event was executed). The event log can also contain information on the *resources* that execute the activities or include additional *data* attributes. When using process mining for conformance, an event log is checked against a set of rules or model that indicates how the process should run. One of the classic examples of this is checking whether the four-eyes principle has been enforced. In the context of healthcare this could relate to two nurses checking medication to ensure that the right medication is given to the right patient.

Even though conformance is considered essential in order to improve processes, it has not received nearly as much attention as discovery (Munoz-Gama, 2016). Within conformance checking research, there is a strong emphasis on the *control-flow perspective* of a process, which refers to the order of activities in the process. Other perspectives such as the data, resource, and time perspective are often considered 'second-class citizens' (Mannhardt et al., 2016). The *data perspective* relates to the variables that are associated with cases and that may be modified during the execution of activities. In the context of conformance, taking a data perspective involves analysing the conditions behind the execution of paths within the process. Taking the process of recording a patient's heart rate, one focuses on the variables (the heart rate) that correspond to the activities (recording heart rate). The *resource perspective* refers to the actors who perform the activities. Conformance checking from a resource perspective may include comparing resource restrictions with the behaviour seen in the log. Last, the *time perspective* is relevant in terms of conformance when there are certain time constraints in place. Examples of time aspects that can be analysed from the log are processing time, i.e. the time it takes for an activity to finish, and waiting time, i.e. the time between two activities.

In this study, we respond to the call for exploring the use of qualitative as well as quantitative methods to detect workarounds. Specifically, we focus on the detection of workarounds in healthcare, which has only been studied qualitatively. Process mining techniques have been used in several healthcare case studies before (Rojas et al., 2016), but none of them have focused on the detection of workarounds specifically. We draw on conformance checking techniques, an area of process mining that is relatively underexposed. Additionally, we take a broad perspective on processes, paying equal attention to the data, resource and time perspectives as on the control-flow perspective.

4.3. Research Method

We conducted a multiple-case study, involving six Dutch healthcare organisations (Table 6). In cases A through E we used qualitative methods to detect 51 workarounds, using observations and interviews. In Section 5.4 we report on the detailed methods used in these cases. Below, we focus specifically on the research methods used in case study F, where we used quantitative techniques to detect the workarounds identified in cases A through E. All six case studies were executed in line with the ethical procedures of Utrecht University and the hospitals of study. The involved participants from the hospital have given consent to the researcher to gather data on the workarounds and report on them. As to ensure compliance with the General Data Protection Rights (GDPR) data regulations, no individual data of patients or employees were collected. All data extracted for process mining were anonymised before they were provided to the researcher, through end-to-end encrypted servers.

Table 6 - Overview of Case Organisations

Case	Organisation type	Department
A	General hospital	Orthopaedics and surgery
B	District hospital	Urology and cardiology
C	District hospital	Urology and pulmonary
D	Specialised centre	Rehabilitation
E	Specialised centre	Rehabilitation
F	Top clinical	Clinical wards

Case study F has taken place at a Dutch top clinical hospital, which admits around forty thousand patients a year. The hospital uses a Health Information System (HIS) that is supplied by one of two main vendors in the Netherlands. Supporting the project, a core team was composed that consisted of a policy officer, a nurse, an IT application manager, a business intelligence specialist, and the first author of this paper. From here on, we will refer to this team as the hospital workarounds team. We will refer to the authors of this paper as the research team.

4.3.1. Data Collection

In consultation with the hospital workarounds team, we - as research team - chose the clinical care departments as the focus of our study, in particular focusing on nurses. Nurses are especially known for their use of workarounds (Yang et al., 2012; Debono et al., 2013; Koppel et al., 2015) and choosing the clinics as the area of focus allows for the analysis of the interaction of nurses with other caregivers and professionals, besides patients. This interaction between different healthcare professionals has proven to be an active breeding ground for workarounds (described in detail in Chapter 5). The main processes that involve nurses in clinics include treating, transferring, and discharging clinical patients. To bring further focus to our work, we made the decision to focus on the set of processes that fall under the main process of *treating a clinical patient*.

Even for the process of treating a clinical patient, a hospital of this size gathers a tremendous amount of process data. To get a good understanding of where workarounds might be found, we chose one document as the base for our analysis: the official hospital handbook that lists all formalised agreements on how caregivers are to work with the HIS. We used this handbook as the description of the intended, normative behaviour.

To determine which processes might contain workarounds, we drew on the list of 51 workarounds identified using observations and interviews with healthcare professionals during case studies A through E. For each workaround in the list, we determined whether it could potentially occur in hospital F as well, taking into account the scope and specifics of our study. We categorised each of the relevant workarounds into four process perspectives, according to the nature of the deviation. Last, the remaining workarounds were discussed with the hospital workarounds team. For the purpose of this study, the team chose two typical workarounds of each category that were feasible to explore using a data-driven approach. Table 7 illustrates the processes and perspectives the workarounds belong to. For example, in the process of screening a patient for malnutrition, one control-flow workaround, one data workaround, and one resource workaround were identified.

Table 7 - Workaround Types Found Per Process

Process	Control-flow	Time	Data	Resource
Screening a patient for malnutrition (1)	x		x	x
Recording the vital signs of a patient (2)	x	2x		
Placing a medication order (3)			x	x

The data necessary for analysing the workarounds were pseudonymised and provided to the research team by the business intelligence department of the hospital. We then transformed the data to the required event log format using Power Query. We created four event logs: one for each process, with the medication order process being the exception, as this process was separated into two logs. Table 8 provides information on the event logs created.

Table 8 - Event Logs

Process	#cases	#events	1st event	last event
1	33,613	169,384	2/7/18	23/7/20
2	4,850	86,849	31/8/19	13/1/20
3A	14,874	48,697	30/3/18	2/8/20
3B	10,639	35,301	31/3/18	2/8/20

After creating the event logs, we used the PAFnow process mining plugin for Power BI[5] to guide the interactive sessions with the hospital workarounds team. PAFnow provides a set of custom process mining visualisations that can be used alongside regular data visualisations, allowing for the creation of dashboards not possible using other tools. The algorithm is closed-source but is comparable to the idea outlined by Leemans et al. (2019).

4.3.2. Data Analysis

The data analysis was again performed in close collaboration with the hospital workarounds team, during three interactive sessions in which all members participated. The analyses were prepared by the research team using the process mining plugin for Power BI. The aim of the sessions was to arrive at patterns that signify the occurrence of workarounds, to which we will from here on refer to as *workaround signs*. The workaround signs are used to describe what characteristics we find in the data that can be used to establish the occurrence of a workaround. The sessions were also used as an opportunity to discuss any implications of these workarounds in terms of security and how to address them to improve the processes and increase security.

4.3.3. Evaluation

When consensus on the workaround signs was achieved with the workarounds team, the results were presented to a user group of clinical nurses. This group consisted of eight representatives of the clinical wards, who get together regularly in a formal user meeting. Next, we distributed an online survey to the eight nurse representatives, asking them for each of the workarounds whether they recognised it (1), what their motivation is for using the workaround (2), and whether they think the HIS or agreements need to be changed (3). Of the eight representatives

[5] https://pafnow.com/en/

we approached, six responded. The answers to the open questions were coded with either 'motivation' or 'improvement' and included in the corresponding descriptions in Section 4.4.

4.4. Results

In this section, we discuss the different perspectives of workarounds that we found in the hospital of study. For each perspective, we describe the workarounds on two levels. We first describe the documented agreement, extracted from the handbook as described in Section 4.3.1. We do so on a rather abstract level. Second, we provide the workaround sign that signifies whether the workaround has occurred, doing so on the same, high level. Then, we give an example of the high level workaround by describing in-depth one of two specific workarounds found in the hospital. We continue by describing the detection of the example workaround on this more in-depth, detailed level. Last, we explain what the motivations are of the nurses to use this particular workaround, and what suggestions were collected on improving the clinical process in question. Note that the workarounds that were not described in-depth, follow the same pattern: i.e. the same documented agreement and workaround sign applies.

4.4.1. Control-Flow Workaround

The two control-flow workarounds we found can be described as activities being re-sequenced in the process in order to improve the flexibility and efficiency of the process.

Documented Agreement. A process instance should execute a set of activities in a particular order.

Workaround Sign. For a process instance, all activities are executed, but a certain activity is carried out earlier than normally planned (i.e. two activities are swapped).

Example. The agreement in the process of screening a patient for malnutrition is as follows: nurses *screen* patients for malnutrition after they have been *hospitalised*. However, such screening activities are sometimes brought forward in the process in order to relieve nurses in the clinic. The specific workaround that we found in the case study can be described as follows: caregivers screen patients for malnutrition before they are formally hospitalised, but after arrival at the hospital.

This workaround is illustrated in Figure 11. As the *order of activities* is different when comparing the designed path (solid line) to the workaround path (dashed line), this is a control-flow workaround.

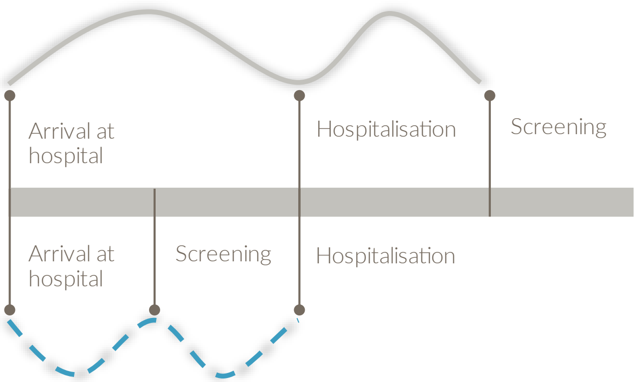

Figure 11 - Illustration of Control-Flow Workaround

Detection. In order to detect this workaround, we traced the paths of patients arriving at the hospital. The date and time of the following activities were needed for this purpose: arrival at hospital, hospitalisation, and screening. We determined an instance of a patient arriving at the hospital as a workaround when the following was true: *screening* was performed after *arrival at the hospital*, but before *hospitalisation*. Table 9 provides a snapshot of a process instance extracted from the dataset of the study, that was automatically detected as a workaround.

Table 9 - A Detected Instance of a Control-Flow Workaround

Registration ID	Date	Time	Activity
60933	13/9/2019	15:39	Arrival
60933	13/9/2019	15:48	Screening
60933	13/9/2019	18:24	Hospitalisation

Motivation(s) and Improvement. According to the nurses of the clinics, the main motivation for this workaround is to increase efficiency by already performing the screening at the outpatient clinic or during preoperative consultation. As this is a potentially beneficial practice, advancing malnutrition screenings could be encouraged, or even widely institutionalised and supported through the HIS. Shifting tasks to those present at the outpatient clinic or preoperative consultations is likely to leave the nurses at the clinic with more time on their hands with no obvious drawbacks.

4.4.2. Time Workaround

The two time workarounds we found can be described as activities that are properly executed within the set time constraints, but only reported upon at a later time because of technical or schedule restrictions.

Documented Agreement. A process instance should execute an activity before a certain time or within a certain time constraint.

Workaround Sign. For a process instance, the activity is executed within the time constraint but reported in the system at a later time.

Example. The agreement in the process of recording the vital signs of a patient is as follows: nurses *record* the vital signs of a patient before the doctor visits (*before 9AM*, excluding the patients that have been hospitalised on that day). *Registration* in the system is to be done immediately afterwards. Portable computers are available to support this process. However, a specific workaround that was detected in the case study is that nurses record patient scores within the designated time frame, but only register so after the specified time. They use paper or notebooks to keep track of the scores and sit down behind a computer later in their shifts.

This workaround is illustrated in Figure 12. As the difference between the designed path and the workaround path is the time of registration, this is a time workaround.

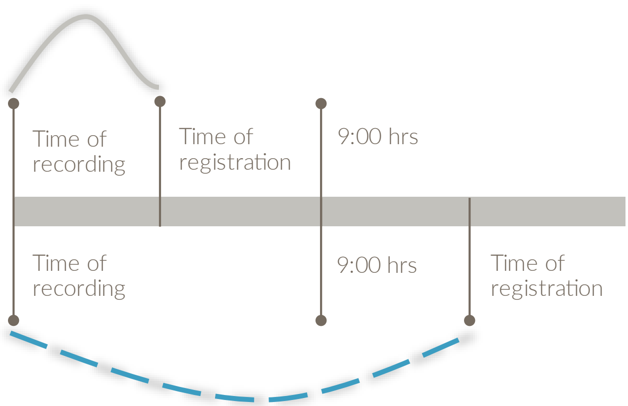

Figure 12 - Illustration of Time Workaround

Detection. In order to detect this workaround, we needed to trace the time of recording and time of registration of vital signs of a patient. The registration time is automatically logged by the system and nurses enter the time of recording manually. We determined an instance of a vital signs recording as a workaround when the following was true: time of recording was before 9AM, but time of registration was completed after 9AM. Table 10 provides a snapshot of a process instance extracted from the dataset of the study, that was automatically detected as a workaround.

Table 10 - A Detected Instance of a Time Workaround

Registration ID	Date	Time	Activity
89	1/10/2019	08:00	Recording
89	1/10/2019	11:04	Registration

Motivation(s) and Improvement. Nurses note that they experience significant time pressure before visits, such that it is easier to register the recordings later. Also, there is a shortage of portable computers, particularly around 9AM. By registering the recordings on different times during the day, the use of computers is less of a problem. This process can be improved by providing the nurses with more portable computers, or by setting different time constraints in order for the use of portable computers to be more distributed over the day.

4.4.3. Data Workaround

The two data workarounds we found can be described as performing an activity that would not need to be executed according to the value associated with the case because of additional knowledge or other reasons.

Documented Agreement. A process instance should execute an activity when the activity is associated to a certain data value or the data value is within a certain range.

Workaround Sign. For a process instance, the activity is executed even though the value was not equal to the supposed value or not within the supposed range.

Example. The agreement in the process of screening a patient for malnutrition is as follows: the result of the malnutrition screening of a patient is a *value* from 0 to 7. When the value is equal to or higher than 3, nurses need to order a *consultation* with a dietician. The system supports this decision process, by presenting the user with an advice based on the value and providing them with a shortcut to organise the consultation. However, a specific workaround that was detected in the case study is that of nurses planning a consultation with a dietician, even though the malnutrition value is less than 3.

This workaround is illustrated in Figure 13. As the difference between the designed path and the workaround path is the value of the malnutrition screening, this is a data workaround.

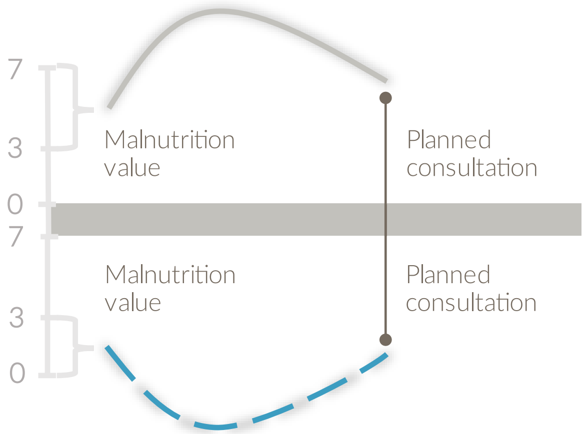

Figure 13 - Illustration of Data Workaround

Detection. In order to detect this workaround, we needed to trace whether a patient's malnutrition screening was followed by a planned consultation. Additionally, we needed to capture the value of the malnutrition screening. We determined an instance of a malnutrition screening of a patient as a workaround when the following was true: malnutrition *value* was less than 3 and a *consultation* was planned. Table 11 provides a snapshot of a process instance extracted from the dataset of the study, that was automatically detected as a workaround.

Table 11 - A Detected Instance of a Data Workaround

Registration ID	Date	Activity	Value
37230	5/1/2020	Recording	1
37230	6/1/2020	Consultation	N.a.

Motivation(s) and Improvement. According to the nurses of the clinics, there are clinical factors outside the scope of the malnutrition screening that make nurses decide to order a dietician consultation. For example, patients with swallowing problems in need of tube feeding do not necessarily achieve a malnutrition value of 3 or higher, but do benefit from a consultation with a dietician. The process can be improved by including in the advice other important clinical factors besides the malnutrition value.

4.4.4. Resource Workaround

The two resource workarounds we found can be described as resources performing an activity outside of their responsibility, because of abstinence of the responsible actor.

Documented Agreement. An activity should be executed by a specific actor type (e.g. nurse or physician).

Workaround Sign. For a process instance, the activity is executed by a different actor type.

Example. The agreement in the process of placing a medication order is as follows: *physicians* and *specialised nurses* prescribe medication for patients, after which they themselves or regular *nurses* administer the medication. In emergency situations, nurses can employ a one-time medication order to place and sign an order that was not prescribed by the physician or specialised nurse. However, the specific workaround that was detected in the case study was that of nurses using one-time medication orders in non-emergency circumstances.

This workaround is illustrated in Figure 14. As the difference between the designed path and the workaround path is the *actor type* performing the activity of prescribing medication, this is a resource workaround.

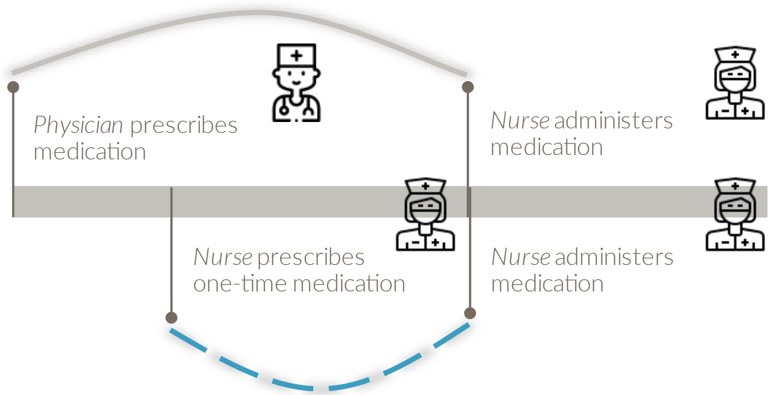

Figure 14 - Illustration of Resource Workaround

Detection. In order to detect this workaround, we needed to trace the *one-time medication orders* used by nurses. However, by merely tracking the one-time medication orders, it does not become clear whether a specific instance has been an emergency situation or not. Therefore, to put these numbers into perspective, we needed to run a comparison to the *total number of medication orders* of that ward. Thus, we determined an instance of a one-time medication order as a workaround when the following was true: the *one-time medication order* is beyond the threshold percentage comparing one-time orders to the *total number of medication orders* of the ward. Table 12 provides a snapshot of a process instance extracted from the dataset of the study, that was automatically detected as a workaround. On the surface, this specific event resembles a normal case of a ward entering a one-time medication order. However, this particular ward frequently orders one-time medication, much more than other wards when comparing total medication orders.

Table 12 - A Detected Instance of a Resource Workaround

Ward ID	Date	Time	Activity
10102033	6/2/2020	16:42	Morphine

Motivation(s) and Improvement. According to the consulted nurses, they use the one-time medication order in non-emergency situations when the physician is either unavailable (e.g. at home or in the operating room) or not prepared to enter the prescription. The overall process can be improved by better supporting physicians in the prescription of medication, e.g. by configuring the system in such a way that they are reminded of this and advised that it saves them time to follow up on this advice.

4.5. Discussion

In this study, we performed five qualitative case studies in healthcare organisations to identify 51 workarounds using observations and interviews. In the sixth case study, we detected eight of those using the quantitative method of process mining. The detection and analysis of these workarounds revealed a number of insights related to the different levels of information on which workarounds can be described, their use as a source of organisational improvement, the combination of different process perspectives for improving workaround detection, techniques for detection, and the combination of qualitative and quantitative methods for studying workarounds.

4.5.1. Different Levels of Workaround Information

Workarounds can be described on different levels: a high, very general, level, and a lower, more specific level. On a high level, workarounds in healthcare seem similar to those that take place within other sectors. When comparing our high-level workarounds to the ones identified in relation to purchasing and intake processes (Outmazgin and Soffer, 2016), some, but not all, are quite similar. For example, in a purchasing process, the general workaround 'Bypassing process parts' was identified, referring to activities that were bypassed such that other activities were performed before their time. Similarities can be found with our control-flow workaround (Section 4.1). Another workaround that was identified in a purchasing process was 'Incompliance to role definition' where resources perform activities not under their responsibility, similar to our resource workaround (Section 4.4).

The differences between workarounds in healthcare and other sectors reside on the more detailed level. On the more detailed level, the title 'Bypassing process parts' does not do justice to the care process workaround that we found. Bypassing activities or skipping them altogether has negative connotations, whereas the workaround we found was anything but negative. Likewise, although the identified resource workaround would fit best in the category 'Incompliance to role definition', it is not the nurse who commits incompliance: the workaround is rather a way for nurses to flexibly respond to the behaviour of physicians.

By generalising workarounds into high-level workaround types, information is lost on the complex interactions between actors and the system, interactions that tell the story of how the workarounds came to be (Beerepoot, Koorn, et al., 2019). What is also "lost in translation" is the clinical knowledge of the actors, as well as other contextual information. There is room for further tapping into the potential of the data and time perspective to enrich process analyses with more context, thereby giving broader insights into the environment surrounding workarounds.

4.5.2. Workarounds as a Source of Organisational Improvement

Organisations can respond to workarounds in different ways and choosing the right response depends on the context (Röder et al., 2016; Beerepoot and van de Weerd, 2018a; Beerepoot, Ouali, et al., 2019). According to Boudreau et al. (2016), sharing workarounds can be seen as a process of knowledge management. Indeed, our results show that sharing workarounds may benefit the organisation. If deviations such as bringing forward screening activities are formalised across departments, it would leave clinical nurses with more time on their hands. If information on the limited number of portable computers would be shared across the organisation, there may well be solutions available. Demystifying the use of workarounds and antecedents for using them is key in improving the processes in which they occur (Petrides et al., 2004; Vogelsmeier et al., 2008; Safadi and Faraj, 2010a).

Simply checking whether users conform to documented procedures may give an incomplete and possibly harmful picture of work done. For example, hospitals might check the conformance of the malnutrition screening process. They might extract data on the hospitalisation of patients and analyse in how many cases this hospitalisation was followed by a malnutrition screening. However, this would exclude all patients who were already screened before hospitalisation and thus present a number that is too pessimistic. A more comprehensive picture would be gathered by taking into account the workaround of activities being brought forward in the process. Similarly, in the same process of malnutrition screening, a hospital might be interested in the conformance to the rule that malnutrition values between 3 and 7 are followed by a consultation with a dietician. Merely analysing the patients having received a malnutrition value in that range would exclude patients who received a lower value but consulted with a dietician anyway. Taking into account the use of workarounds – whether or not detected using qualitative methods - in quantitative analyses will improve data quality and subsequently the quality of process analyses.

4.5.3. Improving Workaround Detection by Combining Process Perspectives

The discussed examples of the four perspectives demonstrate that workarounds can occur in very different shapes and sizes. The multi-perspective approach not only helped categorise the workarounds but can also be used to guide their detection. An interesting avenue for future work is to combine different process perspectives to enable a more precise detection of workarounds. For example, consider the time workaround example (Section 4.4.2) identified in this study. We checked whether the time of recording was completed within the time constraint and the registration was completed afterwards. Combining this with a resource perspective, we might check whether multiple cases where this behaviour is found are ascribed to the same resource, making it plausible that a particular nurse registered multiple recordings in batch.

4.5.4. Process Mining Techniques to Detect Multi-Perspective Workarounds

In this study, we used PAFnow to detect the workarounds because of the following reasons. First, the hospital uses Power BI, and as PAFnow is a plugin for Power BI, it allows the organisation to integrate the created dashboards into their current tooling and monitor the workarounds over time. Second, the custom process mining visualisations can be used alongside a broad array of other visualisations offered by Power BI, allowing for the creation of dashboards incorporating different process perspectives. It is worth mentioning that the workarounds can also be detected using other process mining techniques and tools, such as Disco and Celonis. One can also model each workaround sign as a data-aware Petri net and use the multi-perspective conformance checking technique to detect the workarounds (Mannhardt et al., 2016; Van der Aalst, 2016).

4.5.5. Combining Qualitative and Quantitative Methods for Studying Workarounds

The final major insight that can be drawn from this study is that different research methods are necessary to detect and understand the use of workarounds in practice, which confirms earlier studies on workarounds. As Ejnefjäll and Ågerfalk (2019) stated: "Since workaround behaviors can take different forms in different settings, we need to understand the context and phenomena before using quantitative data-collection methods, which makes studying workarounds ideal for multi-method research that combines qualitative and quantitative methods". Indeed, in order to detect workarounds, one must first learn what the designed paths are and what that behaviour looks like in the data, before one can start identifying workarounds. However, as mentioned earlier in this discussion, even when there is a documented model of intended behaviour to compare the logged behaviour to, not all workarounds will be detected. We propose the use of a repository of known workarounds that have been identified using qualitative methods. This way, there is a starting point for the quantitative process mining analysis. The process mining analysis in turn can help extend the repository with new workarounds detected. As such, a combination of both qualitative and quantitative methods enables precise and in-depth understanding of workarounds and the reasons they exist. Future work may focus on further building this repository of workarounds that exist in different types of organisations and the formation of new and more precise workaround signs that help detect and analyse them. It may also focus on the ways organisations can best respond to them and how workarounds evolve over time. Recent techniques around process drift detection (Bose et al., 2011) can be relevant instruments for revealing this evolution.

4.6. Conclusion

Whereas workarounds have commonly been studied in healthcare, they have only been identified using labour-intensive qualitative methods that possibly give an incomplete picture. In this study, we identified 51 workarounds using qualitative methods and detected eight of them using the quantitative technique of process mining, each viewed from a different process perspective. We demonstrate how very diverse workarounds can be translated to generic workaround signs, which describe characteristics that can be detected in the data using process mining techniques. Once identified, they can be used for process management and organisational improvement. Our work shows the way forward to use quantitative methods in addition to qualitative methods, to detect workarounds in the challenging but highly relevant healthcare environment.

Chapter 5

The Role of Power[6]

Abstract. In this paper we analyse the role of power relations in the emergence of workarounds in Health Information Systems (HISs). Using an explorative multi-case study of five healthcare organisations in the Netherlands, we identify 51 workarounds as well as the power relations that underlie them. We distinguish two main types of power that are important for the emergence of workarounds: (1) hierarchical differences between actors and (2) system restrictions. Our study unpacks the link between power and HISs, illustrating how actors respond to hierarchical differences and system restrictions to exert their 'power to work around'.

Keywords: Health Information Systems, Workarounds, Power, Physicians, Nurses.

5.1. Introduction

Considering the importance of Health Information Systems (HISs) for the quality and efficiency of patient care (Haux et al., 2004; Haux, 2006), the widespread failure of HIS implementations (Berg, 2001; Heeks, 2006) is striking. Determining what distinguishes successful HIS implementations from failed ones is challenging (Heeks, 2006), but in general, "a well-functioning system exemplifies a match between the functionalities of the system and the needs and working patterns of the organisation" (Berg, 2001, p. 144). A mismatch between the two may result in *workarounds*, described as "intentionally using computing in ways for which it was not designed or avoiding its use and relying on an alternative means of accomplishing work" (Gasser, 1986, p. 216). The potential consequences of such workarounds are severe. They include a loss of control over business processes (Sadiq et al., 2007), reduced productivity (Bagayogo et al., 2013), and even financial penalties imposed by authorities (Lu et al., 2007). Therefore,

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organisations typically aim to detect and prevent workarounds. However, technical solutions for preventing workarounds are often limited. While it may be possible to prevent obviously undesirable behaviour (e.g., a nurse prescribing medication for a patient), it is far more difficult to prevent more subtle actions (e.g., a nurse prescribing medication using somebody else's account). What is more, simply preventing a workaround by means of technical barriers ignores the reason why it occurs in the first place. Workarounds may in fact have positive consequences and in some cases, organisations may choose to adopt these (Beerepoot, Ouali, et al., 2019).

In this paper, we aim to develop an understanding of why HIS workarounds occur. Our theoretical starting point is that circumventing an information system (IS) and using it differently than intended can be considered as a manifestation of power. For IS users it is a way of responding to strict controls and aligning the rules enforced by management with the needs of users (Malaurent and Avison, 2016). Against this background, we study the manifestation of power by HIS users and the other power dynamics involved in the enactment of HIS workarounds by raising the question: *What is the role of power in the emergence of workarounds in HISs?* We build on five case studies in Dutch hospitals, recording data through a combination of ethnographic observations, semi-structured interviews, and unstructured interviews, to uncover the power dynamics underlying workarounds in healthcare settings. Our contribution is threefold. First, we unpack the interplay between IS and power, as called for by Koch, Leidner and Gonzalez (2013), Marabelli and Galliers (2017), as well as Simeonova et al. (2018), amongst others. Second, we illustrate how workarounds emerge from episodic power. Specifically, we identified two types of episodic power; *hierarchical power* of different actors over one another and *restrictive power* of a system over the actors. Third, we show how actors use a form of systemic power to *work around the system* in order to reconcile problems that arise from hierarchical and restrictive power. Our findings may help healthcare organisations in managing workarounds that have negative consequences and help HIS suppliers in finding the right balance between restricting users on the one hand and giving them flexibility on the other.

The paper is structured as follows. In the next section, we review the literature on HISs, workarounds, and power dynamics. Then, we discuss the methodology used in the study, after which we present our results. Next, we position our findings within the wider literature of power and workarounds, and finish with a few concluding remarks.

5.2. Theoretical Background

5.2.1. Health Information Systems and Workarounds

Over the last decades, the use of ISs in hospitals evolved from supporting simple administrative tasks to a much broader range of tasks; such systems now also include advanced technology such as clinical decision support systems and electronic health records (or patient records) (Boonstra et al., 2018). Contemporary HISs are aimed at improving communication and coordination among medical professionals, enhancing the safety, quality, and patient-focused nature of care, while aiming to contain costs and increase efficiency (Ellingsen and Monteiro, 2003; Harrison et al., 2007; Azad and King, 2008a). In practice, however, it is often found that realising such benefits is very difficult. Because of the complex nature of healthcare work, designing HISs in such a way that work processes are well supported is a challenge (Safadi and Faraj, 2010b). When HISs do not support work processes sufficiently, HIS users become dissatisfied and start to resist the HIS in the form of workarounds (Azad and King, 2008a; Safadi and Faraj, 2010a; Van den Hooff and Hafkamp, 2017a).

Workarounds have been studied in several industries, such as the transport industry (e.g. Ignatiadis and Nandhakumar, 2009), the service industry (e.g. Ferneley and Sobreperez, 2006), and the retail industry (e.g. van de Weerd et al., 2019). However, the far majority of workaround studies is set in healthcare. The studies set in healthcare show two important effects of workarounds. First, they enable professionals to continue their work despite inadequate IT functionality and in support of their perceived need to bypass obstacles. As Zhou, Ackerman and Zheng (2011, p. 3353) argue, "healthcare professionals are masters at workarounds and oftentimes clinicians view workarounds as the only way to accomplish their work". A second effect of HIS workarounds, however, is that hazards emerge: since workarounds imply deviation from the standard process, they threaten the potential for gains in efficiency of a HIS by reducing process variability and can even negatively affect the quality of care (Azad and King, 2008a; Halbesleben et al., 2010). Previous studies have discussed such effects, but there is still a limited theoretical understanding of the processes through which they emerge. Alter (2014b, p. 1042) claims that workarounds are a well-known but understudied phenomenon, "[…] even in healthcare, where workarounds are widely recognised". Blijleven et al. (2017) observe that although studies have discussed different types of workarounds, their key features and several reasons for them, the specific rationales for the enactment of workarounds and their effect on healthcare professionals other than the one using the workaround, remains unknown.

When we consider workarounds in terms of coping with the conflict between the prescribed procedures encoded in IS and users' situated practices, there are clearly elements of power involved. Imposing prescribed procedures on users requires power; also, being able to work around these procedures requires power. The literature on power in relation to IS provides clues to the involvement of power dynamics in the use of workarounds (R. Alvarez, 2008; Silva and Fulk, 2012; Malaurent and Avison, 2016; Simeonova et al., 2018). However, to the best of our knowledge, no research so far has attempted to provide a detailed account of the power dynamics that precede the emergence of workarounds. Therefore, in our search to provide more insight into these dynamics, we now turn to the literature on power in IS.

5.3. Power and Workarounds

Power is a multifaceted concept, which has been a “regular, if somewhat peripheral” part of the IS literature (Jasperson et al., 2002, p. 398). Research has addressed the use of power in *implementing* IS (R. Alvarez, 2008; Azad and Faraj, 2011; Silva and Fulk, 2012), as well as the way power is manifested in relation to the *use* of ISs, for instance in terms of behaviour monitoring and organisational control (Zuboff, 1988; Leclercq-Vandelannoitte et al., 2014). More in general, literature has discussed how ISs change or reinforce existing power structures in the organisation (Dennis et al., 1997; Hitt and Brynjolfsson, 1997; Doolin, 2004).

In the literature, power has been defined in various ways. Historically, power is often described as something that distinguishes the powerful from the powerless (Dahl, 1957; Emerson, 1962; Jasperson et al., 2002). Other scholars argue that this resource-based view on power does not do justice to its complexity (Hardy, 1996; Dhillon, 2004). Hardy (1996) and Dhillon (2004) discuss three different views on power: (1) as something emerging from organisational decision-making processes (e.g. Bachrachand and Baratz, 1962), (2) as something residing in symbols, rituals, and language that are used to legitimise change (e.g. Clegg, 1989), and (3) as something embedded in the organisational system itself (e.g. Foucault, 1982) in the form of “values, traditions, cultures, and structures of an organisation” (Dhillon, 2004, p. 636).

In this paper, we take a broad perspective on power and look for any manifestation of power, whether it is power as a resource or power residing in any other form. We adopt the proposal of Simeonova et al. (2018), who analysed the concept of power in the context of IS mediated organisational activities. Building on Clegg’s (1989) “Circuits of Power” framework, they distinguish between episodic and systemic power. *Episodic* power is framed in terms of power *over* (also: *ostensive* power), which is the dominant perspective on power (as illustrated by the definitions above). This type of power is focused on themes such as domination and control. A frequently studied example for episodic power in a healthcare setting is the relationship between nurses and physicians. As Currie et al. (2012, p. 940) note: “…extensive research shows how prevailing institutional arrangements tend to strongly favour the autonomy and power of medical specialists over other groups”. Workarounds may emerge then when “those subject to power and control (…) resist by means of challenging or diverting the systems and rules imposed on them” (Doolin, 2004, p. 346). *Systemic* power, on the other hand, is conceptualised as the power *to* (or *performative* power) and related to human agency (Clegg et al., 2006). Studies using a practice lens (Orlikowski, 2000) focus on how human agency plays a role in shaping technology use. They provide multiple accounts of how IT use is enacted in ways that deviate from the intentions of designers and implementers. Systemic power, therefore, relates to users who enact ways of using technology that serve their purpose and interest (Orlikowski et al., 1995; M. C. Boudreau and Robey, 2005; Azad and King, 2008a; Leonardi, 2009; da Cunha, 2013; Mazmanian, 2013). As noted above, to be able to challenge or divert systems, users are required to have the power to deviate from the prescribed procedures embedded in the IS.

Based on the literature reviewed here, we will focus our analysis on how episodic and systemic power play a role in the emergence of workarounds in the use of HISs. We will focus on both (i) the (hierarchical) relations between actors, which may lead certain actors to instigate workarounds in their use of the HIS, and (ii) on the power relations between the HIS and users, i.e., the power of the IS to enforce certain practices on these users. Furthermore, we will pay particular attention to the power of HIS users to *work around* enforced practices. In the next section we elaborate on the methods used in our empirical exploration of these power relations.

5.4. Methods

We conducted an explorative multiple case study (Yin, 2017) to investigate the power relations that are involved in the emergence of workarounds in HISs. A multiple case study allows for a cross-case analysis, as well as building and extending theory (Benbasat et al., 1987). By comparing our results among different healthcare organisations we increase the external validity of our insights (Yin, 2017).

5.4.1. Setting

Healthcare institutions are an interesting research setting for several reasons. First, in terms of power, they are complex organisations with multiple lines of authority (Perrow, 1965; Robinson, 1997). Second, the misfit between computer-based and existing work processes is especially evident in healthcare (Safadi and Faraj, 2010b). Working around the prescribed procedures is seen as the norm, rather than the exception (Koppel et al., 2015). We conducted our multiple case study within five healthcare institutions in the Netherlands. All healthcare institutions use the same HIS, which is used to manage patient logistics, administration, patient records, among other information. Table 13 provides an overview of the five organisations and the number of identified workarounds per organisation. The number of beds is used as it is the standard way of describing the size of Dutch hospitals, as staff numbers continuously change.

Table 13 - Overview of Case Organisations

Case	Organisation type	Department	Hospital size (#beds)
A	General hospital	Orthopaedics and surgery	Around 300
B	District hospital	Urology and cardiology	Around 400
C	District hospital	Urology and pulmonary	Around 500
D	Specialised centre	Rehabilitation	Around 100
E	Specialised centre	Rehabilitation	Less than 100

The five healthcare settings were chosen on the basis of their broad range of organisational contexts. Settings B and C are large institutions with rich resources, while D and E represent smaller organisations with less resources and a flatter hierarchical culture. Setting A sits in between. By studying healthcare organisations of different contexts, we aimed at giving an insight into the emergence of workarounds in different types of healthcare organisations.

5.4.2. Data Collection

For our data collection, we used a practice lens (Feldman & Orlikowski, 2011) to study the daily activities of healthcare professionals. We used multiple sources of data in order to enhance the reliability of the analysis (Eisenhardt, 1989). The main sources of data for this research are (1) ethnographic observations of healthcare professionals, (2) unstructured interviews with the observed professionals, and (3) semi-structured interviews with team leads, IT managers, and HIS experts. From April 2017 to August 2018, we conducted a total of 22 semi-structured interviews and carried out 16 observations which were accompanied by unstructured interviews. In addition, we organised a workshop with HIS experts to reflect on our results. To all participants in the study, it was communicated that they would be participating in a study on the use (in the case of the healthcare professionals: their use) of HISs in hospitals.

As can be seen in the overview of the different employees we observed and interviewed in Table 14, the study participants performed different roles in their respective organisations. In addition to hospital employees, we also interviewed HIS experts that are employed by the organisation that implemented the HISs. These experts hold extensive knowledge of both the HIS and care processes; they often also have a background as healthcare professionals.

Table 14 - Overview of Data Collection Techniques and Informants

Type	Amount	Informants
Observations and unstructured interviews	16 (106 hours)	Healthcare professionals: physicians, nurses, office secretaries, clinical secretary, physician assistant, pharmacist, team lead, therapists
Semi-structured interviews	22 (24 hours)	Team leads, information architect, HIS experts, IT managers and coordinators, care administration employee
Workshop	1	HIS experts

The interviews were tape-recorded and transcribed and during the observations we took notes. We explained to each of the participants that we were studying their use of the HIS and that we were interested in hearing and seeing what obstacles they come across using the HIS. Each time we observed a possibly deviating practice, this practice was discussed with the team leads and HIS experts to determine whether it was indeed a workaround. In this discussion, we used Alter's definition (2014) of workarounds as a reference. We then dived deeper into the workaround and aimed at finding out: What does the workaround entail? What is the prescribed process and what is the workaround? Who are involved? What is the user's motivation to use the workaround? What is the obstacle they perceive?

We organised the interview transcripts and notes in workaround snapshots (Beerepoot and van de Weerd, 2018b). In Figure 15, we provide a screenshot of one of our workaround snapshots. More elaborate examples of components of the workaround snapshots can be found in the original paper (Chapter 3). The idea of workaround snapshots is to capture a description of the workaround, along with the motivation, the resulting effects, and possible follow-up actions. We determined all of these with the help of the different informants and evaluated

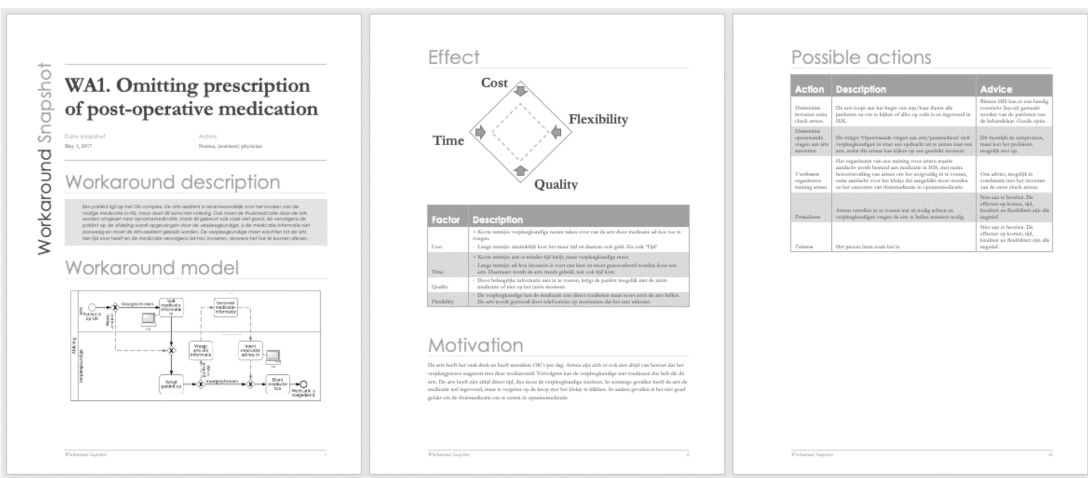

Figure 15 - Example of a Workaround Snapshot

them systematically during the semi-structured interviews. Therefore, the workaround snapshots are the outcome of a structured process of discussing the observed workarounds with all those involved. As such, they provide the required input for the data analysis phase.

5.4.3. Data Analysis

We coded our workaround snapshots and their related transcripts in Atlas.ti. First, all members of the research team separately coded five snapshots, one from each case organisation, and compared their codes. Based on this exploratory coding round, we developed a coding scheme together. Second, the first and second author (the coders) both coded three workaround snapshots separately and then synchronised their coding. During this coding step, we developed sub codes and compared them. Next, we coded another two identical snapshots separately and compared them, which resulted in a mutually satisfactory basis to code the remaining ones. In the fourth step, the coders were randomly assigned half of the snapshots to code. In the final step, each coder checked those of the other. In case of conflict, we discussed the codes until both coders were content. This iterative process ensured that at the end, all snapshots were coded using the same standards and checked by the other coder to ensure reliability.

Table 15 provides two example codes with illustrative quotes.

Table 15 - Example Codes

Code	Description	Example quote
Motivation	Motivation for the workaround, e.g., time, costs, and system limitation	*System limitation*: "Yes there is a shortcut, but not for medication with a varying schedule. [name supplier] had developed that, but they didn't want to provide it when we went live." (Information architect, case A)
Power	Statements that indicate who holds power over whom	*Physician over Nurse*: "This is a bit of a physician's thing, because if they say "I won't do it" they just don't do it. (Nurse team lead, case A)

For each workaround snapshot, we coded one or more power relations. For example, when it was mentioned in the snapshot that the HIS restricted the user in some way (e.g., by enforcing authorisations that prohibit a nurse making changes) and the nurse responded by enacting a workaround (e.g., by entering text elsewhere), we would describe the power relation using the following sequence: System over Nurse; next, Nurse over System. We visualised this power relation sequence as shown in Figure 16, where the solid line denotes the first event and the dashed line the one that follows.

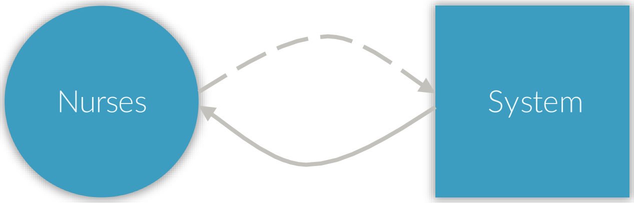

Figure 16 - Example Visualisation of a Power Relation Sequence

5.5. Findings

In total, we discovered 51 workarounds through our interviews, observations, or both. For all workarounds, we analysed the power relations between physicians, nurses, therapists, secretaries, and the HIS. We represented these in power relation sequences. After analysing the sequences, we were able to distinguish two main categories. The first category relates to workarounds that emerged from hierarchical differences between actors. One subcategory of this hierarchical difference concerns actors from different actor types, e.g., between a physician and a nurse. The other subcategory concerns actors of the same type, e.g., between nurses. Workarounds in the second main category emerged from HIS restrictions, which cause users to look for alternatives and initiate the emergence of workarounds. These restrictions can either be *deliberate restrictions* implemented in the HIS's design or *limitations in functionality*, as perceived by users.

Table 16 gives an overview of the range of workarounds we found. It shows typical examples from each type, along with the actors involved: i.e., the *possessor* and *respondent* of power. The possessor is the person who exerts power over a subject, whom we refer to as the respondent. Below, we go into more detail about each of the categories and corresponding workaround sequences.

Table 16 - Overview of the Different Types of Workarounds Including an Example

Workarounds emerging from hierarchical differences			
Actor having power over other actor types	*Possessor*	*Respondent*	*Example*
	Physician	Nurse	Physicians omit registering prescriptions in the HIS, forcing nurses to a one-time prescription which still needs to be approved by a physician.
	Physician	Therapist	Physicians do not search the HIS for a patient's test results, obliging therapists to copy-paste the

			results to a place in the HIS more accessible to physicians.
	Physician	Secretary	Physicians do not request follow-up actions for patients through the HIS, requiring secretaries to look for the necessary follow-up actions in the consultation summary.
Actor having power over actors of the same type	Physician	Physician	Physicians do not enter a formal request for a fellow physician's council on a patient, requiring the consulting physician to enter the formal order themselves.
	Nurse	Nurse	Day nurses do not draft daily schedules for patients, so that night nurses are tasked with drafting them.
Workarounds emerging from HIS restrictions			
Actor overcoming HIS restriction	*Possessor*	*Respondent*	*Example*
	HIS	Physician	The HIS restricts junior physicians from using functionalities through its authorisations, resulting in them signing in using a senior physician's user account.
	HIS	Nurse	The HIS restricts nurses by not allowing them to sign off the registration of medication for a patient without the consent of a second nurse, such that nurses memorise each other's passwords and enter them when the HIS asks for consent.
	HIS	Therapist	The HIS restricts therapists by not providing them with all required fields for entering certain test results, resulting in therapists using text fields meant for other purposes.
	HIS	Secretary	The HIS restricts secretaries by enforcing rules on text fields, forcing secretaries to delete certain information from their text

			fields to make sure that the form accepts their input.
Actor overcoming perceived HIS limitation	Physician	HIS	Physicians find the digital procedure related to medical imaging too cumbersome, causing them to print the image and show the print-out to the patient.
	Nurse	HIS	Nurses ignore the portable computers for recording patient checks, favouring the use of notebooks or paper to write it down and then registering them on a desktop computer.
	Therapist	HIS	Therapists enter the patient's first name in a free text field on the cover sheet of the patient's medical record in the HIS, because they prefer to talk to patients on a first-name basis even though this is not the organisation's policy.
	Secretary	HIS	Secretaries add symbols to text fields to denote extra information about a patient's consultation, because they rather see the information listed in the overview than having to click through the menus.

5.5.1. Workarounds Emerging from Hierarchical Differences

Of all the workarounds, 14 emerged directly or indirectly from one actor possessing more hierarchical power than another. These workarounds can be distinguished from the workarounds in the other groups by their sequence start. This can be an actor having power over an actor of another actor type or of the same type that the actor belongs to. For example, a number of sequences is initiated by a physician having power over a nurse. By contrast, some sequences include instances of workarounds where actors have power over other actors of the same type, e.g., physicians over other physicians or nurses over other nurses. Figure 17 presents a visualisation of the power dynamics involved in workarounds that we have seen emerging from hierarchical power differences. Solid lines indicate the first event in the sequence. Dotted lines indicate subsequent events caused by this event. The numbers along the lines indicate the number of instances we observed of that particular power relation.

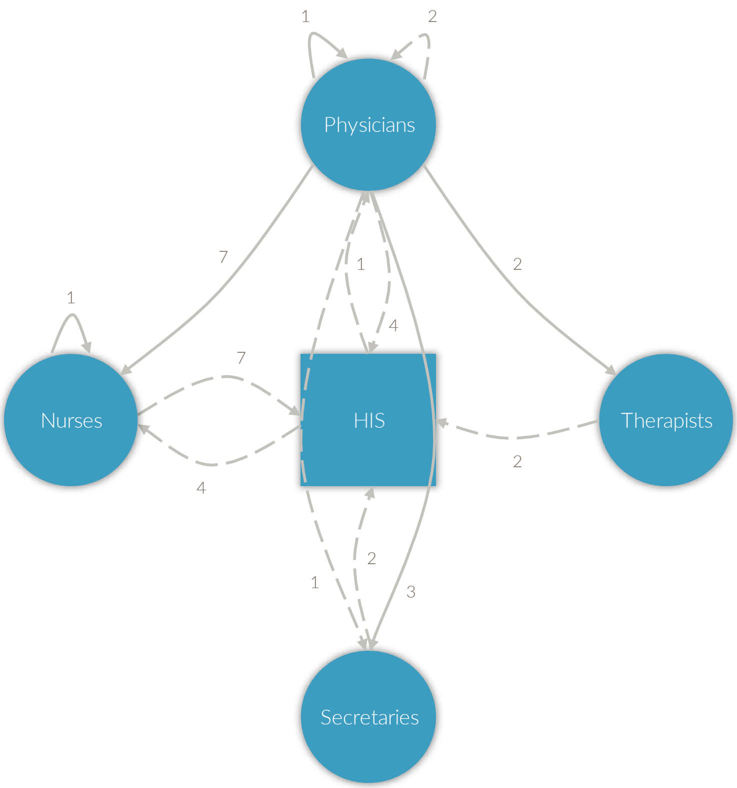

Figure 17 - Workarounds Emerging from Hierarchical Differences

5.5.1.1.Power Between Different Actor Types

An example of a workaround that emerges from hierarchical differences between different actor types was observed in case organisation A. This workaround occurs when a patient is treated in the operating room. Physicians are responsible for entering the necessary medication information for patients into the HIS, but they do not always do so because they are often busy, perform multiple operations per day, and are not aware how their action (or rather their lack of action) impacts the care process downstream. When the patient is transferred to the nursing ward next, the medication information is not present in the HIS. Nurses will typically try to call the physicians to recover this information and find out which medication is to be given to the patient. However, the physicians are often unavailable, since they may be involved in another operation. Therefore, nurses enter and administer the information into the HIS using ad-hoc functionality, which means they administer and register medication that is not approved in advance by a physician. Afterwards, a physician should approve all ad hoc prescriptions and add the complete medication information in the HIS. If this is not done in time, the nurses have to call, administer and register a new ad hoc prescription for the next round of medication. As one of the nurses explains:

> *"it takes the entire day to get it all in there, before someone can get their medicine. Either you keep administering it ad-hoc… because ad-hoc is only for once. While if the physician would just verify it, it would be in there automatically and he would not need to be called all the time." (nurse, case A)*

The team lead adds:

> *"The physician is responsible for that whole area around medication, but they don't do it. Causing the nurses to constantly be confronted with questions about pills, things that are incorrect, the need to make calls, having to go after it. And then the physician says: 'I just got my hands covered in blood, so it's going to take half an hour'." (Team lead, case A)*

In this example, different power dynamics are at play. Because the physicians fail to enter the medication information into the HIS, the nurses are affected. Nurses cannot administer medication that is not registered in the HIS and enact a workaround by calling the physician and entering the information into the HIS themselves as an ad hoc prescription. Thereby, they deviate from the prescribed procedure where physicians are expected to prescribe a patient's medication.

5.5.1.2.Power Between Actors of the Same Type

The second subcategory of workarounds emerging from hierarchical differences relates to power differences between actors of the same type. An example of a workaround in this subcategory was observed in case organisation B. Here, physicians of different specialties ask their colleagues for medical advice on a patient. Following the standard process, the patient's main physician should formally request the consultation through the HIS. In this way, the request appears on the job list of the specialty that is consulted for advice. A physician of this specialty can then accept the request and carry out the consultation. However, some physicians that are asked for advice enter the request for consultation in the HIS themselves. As one of the urologists explains:

> *"I can create it myself. Of course, it's best if people create an order and call us as well. That is the agreement: you ask someone else for advice, so you say: 'I will call you and the request is in there'." … "But ok, sometimes it's busy and you do that for one another." (Urologist, case B)*

The urologist points out that the normal procedure prescribes that the applicant formally requests the consult through the HIS, but that there are instances where he does not follow the procedure and creates the formal request himself. The IT manager of this particular health institution explains that a hierarchy exists even among physicians themselves. Those lower in the hierarchy sometimes accept the deviations from procedure by those higher in the hierarchy:

> *"We always say: 'the urologist and the pulmonary physician, those are the boy scouts.'" … "what they should do is shake the lapels of the surgeon: 'I want you to create the request'. The surgeon is way ahead already. You need to confront each other more." (IT manager, case B)*

This quote illustrates that even between actors of the same type, physicians, there are differences in hierarchy. Those lower in the hierarchy (the urologist and pulmonary physician) do not seem to possess the power to confront the other actors (in this case the surgeon) and force them to follow the procedure.

In our interviews and observations, we have noted multiple examples of nurses, therapists, and secretaries bypassing the HIS and prescribed work practices because physicians are unwilling or unable to perform certain tasks. The hierarchical power that some actors have or lack over other actors sets into motion complex sequences of events that end with users of the HIS enacting workarounds. Hence, forms of hierarchical power may result in another form of power. We term this as the 'power to work around': a reaction of actors at the respondent side of hierarchical power. Not only do actors respond to *hierarchical differences* by enacting workarounds, we see the same response to *HIS restrictions*. This is what we discuss in the next section.

5.5.2. Workarounds Emerging from Restrictions

Many workarounds emerge from the power of the HIS to restrict users in some way. Some restrictions arise from the way the HIS is designed by the suppliers; others are determined by the configuration the organisation's IT department has chosen out of the possible configurations provided by the HIS supplier. In both cases, the HIS supplier plays a large part in determining the restrictions in place. The workarounds in this main category can be distinguished from the workarounds in the other main category in that actors respond to some type of restriction by enacting a workaround, rather than by a difference in direct hierarchical power.

The first subcategory of workarounds emerging from restrictions is related to users of the HIS overcoming restrictions as designed during implementation. Examples of this first subcategory can be found for all actor types. The second subcategory relates to workarounds that emerge when actors try to overcome perceived HIS limitations, e.g. when they ask more functionality of the HIS than it was intended for. Again, we see examples of this subcategory for all actor types. The difference between the two subcategories is that for the first, we can see a clear HIS restriction in place. Therefore, the first event in the sequence is the HIS having power over an actor by restricting them, after which the actor exerts its power to work around the HIS. The sequences of the second subcategory exist of only one event: an actor exerting its power over the HIS by enacting a workaround. There is no clear, deliberate HIS restriction, but there is a perceived HIS limitation according to the actor. In Figure 18, we visualised the different ways in which the restricting power of the HIS leads to workarounds. The figure shows that this restricting power of the HIS often causes a direct response of the actor trying to cope with the restriction, namely by enacting a workaround.

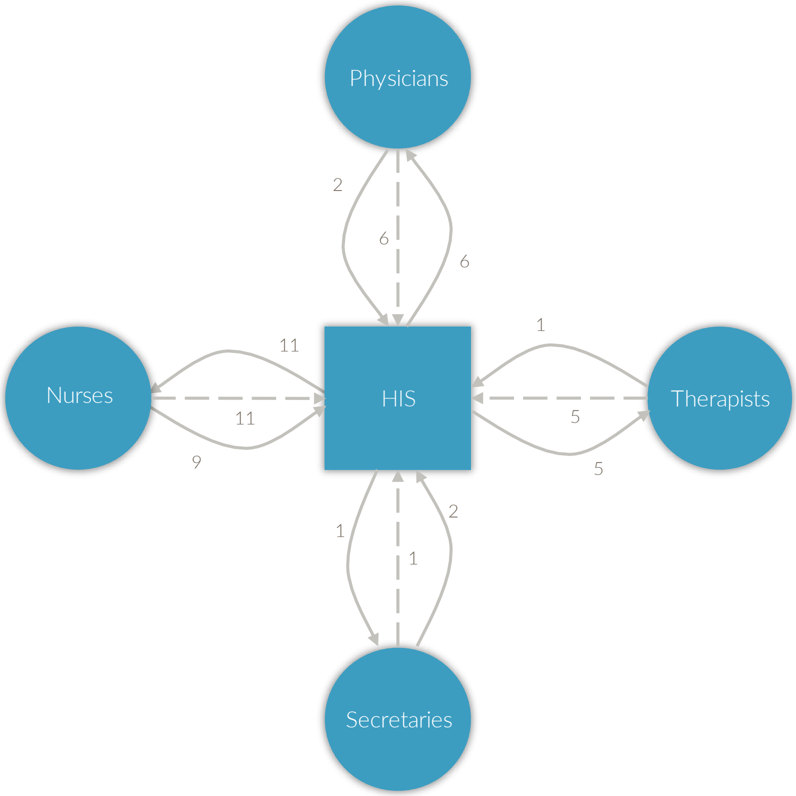

Figure 18 - Workarounds Emerging From Restricting Power of the System

5.5.2.1.Overcoming HIS Limitations

An example of the restricting power of the HIS resulting in a workaround was observed in case organisation A. During their shift, nurses frequently check the so-called *activity plan*. The activity plan is a list of care tasks the nurses need to complete for each of their patients. During their shift, nurses complete such tasks and may add new ones as well. The tasks need to be carried out at specific times. These times are filled in automatically according to a template in the HIS, as designed during implementation of the HIS. However, these times do not fit with the actual schedule of care. Therefore, the nurses ignore the times and type a new one in the text field. One of the nurses explains: *"[The patient checks] are scheduled for 4PM, but they are done at 11AM. We have tried changing it [in the HIS], but the standard template indicates 4PM." (Nurse, case A)*

The nurse is restricted by the HIS in the sense that there is no way to work with times other than the ones listed in the template. The information architect acknowledged that the hospital can indeed not change the configuration of this functionality: *"You cannot configure the activity plan in such a way: during the day shift…, during the evening shift… You need to attach a time indication to it." (Information architect, case A)*

The HIS restricts the nurse, who in turn comes up with a workaround to deal with the restriction, namely by adding the actual time of the task she carried out in the free text field. The supplier of the HIS deliberately works with templates for purposes of standardisation and does not provide the possibility of changing the times.

Another example of a workaround that emerged from the HIS restricting users was observed in case organisation E. Here, a therapist has performed a gait image analysis on a patient and stores it in a blank letter. The letter functionality is normally used by healthcare professionals to send a letter to, for example, the patient's general practitioner. Some therapists use these letters to visualise gait image analyses, since this gives them more freedom to add all kinds of custom visualisations that are not possible in the standard layout for these types of analyses. An example of such a customised visualisation is an overview where measurements of the left knee are on the left side and measurements of the right knee are on the right side. One of the HIS experts agrees that this customised visualisation in the standard layout is impossible: *"Creating a new layout, that is simply not possible in standard content. Then it would have to be a request to* [name of supplier]*. I think they* [therapists] *want to achieve something cumbersome, that* [name of supplier] *will not do." (HIS expert 5)*

The HIS is standardised in the sense that standard content is used even though this sometimes prevents users to work in the way they desire or are used to. This standard content is used by most hospitals in The Netherlands and makes the HIS better maintainable for the supplier. Indirectly, the supplier thereby exerts power on the users of the HIS, since they decide on what the HIS offers. A common response of the users is to deal with the restrictions by working around the HIS.

5.5.2.2.Overcoming Perceived HIS Limitations

Several workarounds emerged not because of an actual, deliberate restriction being in place, but because users try to overcome a perceived obstacle. In our study, physicists, therapists, nurses, and secretaries have all been seen exerting their *power to work around* by enacting workarounds that enable them to circumvent these perceived obstacles. An example of such a workaround was observed in case organisation C. Here, secretaries on the outpatient clinic are tasked with preparing the patient-physician consultations. They check whether everything is in order for the patient to arrive (for example whether the blood test results are in). The overview of consultations for that clinic shows table rows with, among other information, the time slots of the day, the patients that are planned for each time slot, and so-called *descriptions*. A description is a free text field that is meant for entering remarks on a patient that do not fit any of the other fields. The outpatient secretaries have come to use this text field in various other ways. Some enter star symbols in the field to mark the ones they have checked. Secretaries are regularly called by other patients requesting to make an appointment and by their use of star symbols they can keep track of where they were when they got interrupted.

Another use of the description field is to mark which of the secretaries planned the appointment. By doing so, the secretaries know who to ask when they have questions about the appointment. In some clinics, they mark the planner of the appointment by ending the description with a number. This number represents one of the secretaries in the clinic. When asked for the reason for recording this number, the team lead (also working as outpatient secretary) answered:

> *"I have also wondered about that when I came to work here. That was the case. Well, I thought: if that is a sacred cow, then I don't have many problems with it. Let's keep that up." (Team lead, case C)*

In other clinics and settings, people invented similar ways of working. The same team lead continued:

> *"I know from the general practice where I worked some years ago, they would enter '/' and their initials after each sentence you typed and each consultation you planned." (Team lead, case C)*

Apparently, the secretaries feel the need to tick off tasks and to keep track of the appointments they or their fellow secretaries have planned. The HIS does track which user planned the appointment and which user last changed the appointment, but this information can only be retrieved by browsing through to the extra information behind the appointment. By entering this information in the description field, it appears in the overview of patient-physician consultations, which allows for easy access. Therefore, by providing the user with a free text field, the HIS affords its users to keep individual records. The HIS is now used in a way it was not intended to be used and did not promise to provide for.

5.6. Discussion

As stated, in this study, we examined 51 workarounds carried out by various healthcare professionals across five different healthcare organisations. By focusing specifically on the power relations underlying the workarounds, we could distinguish two main categories of workarounds: (i) those emerging from hierarchical differences and (ii) those emerging from system restrictions. Furthermore, we showed how actors *work around the system* in order to reconcile problems that arise from hierarchical and restrictive power. Although the five healthcare settings differed in terms of context and this affected their view towards workarounds and how to address them (Beerepoot, van de Weerd, et al., 2019), the two main categories of workarounds were evident in all five of them.

The different types of power relations underlying workarounds can be further examined using the two types of power relations described in the literature: episodic and systemic power. In the next sections, we will discuss these in more detail and describe how they relate to the workarounds we observed.

5.6.1. Episodic Power and Workarounds

Episodic power is especially evident in the first category of workarounds: those emerging from hierarchical power. Many workarounds are enacted because physicians have hierarchical *power over* other physicians, nurses, secretaries, and therapists. This is a latent form of power, something that exists, rather than the productive force of systemic power. The hierarchical differences observed in this study are testament to the power asymmetry that exists in hospitals (Abbott, 1988; Battilana, 2011; Currie et al., 2012). Our cases show how actors lower in the hierarchy performed work because those higher up failed to do theirs. Pirnejad et al. (2009) have noted similar findings that involve physicians delaying the prescription of medication, resulting in nurses being held up in their work and forced to call physicians. In the meantime, they would ask patients to use their home medication, take it from the pantry, or from another ward's supply.

As the above example and many of our study's examples show, behaviour involving hierarchical power often has consequences for actors 'downstream' in the process. Choices made by actors 'upstream' (i.e. the first event in the sequence) have an impact on the actions and choices of actors in subsequent events (cf Feldman and Pentland, 2003; Drum et al., 2017). Many of our identified workarounds are part of a sequence that starts with one actor deviating from the procedure, whose actions affect the activities of other actors further down the sequence. In the majority of our cases, the actor upstream was also the actor higher in the hierarchy. This finding is in line with that of Simeonova et al. (2018, p. 13), suggesting that "the deep embeddedness of power results in reoccurring and enduring contradictions rather than resolution and change" and "the way IS are deployed often reinforce power structures rather than emancipate subjects". The examples also show that there is often a recursive relationship between different power relations, since "one person's 'power to' may involve asserting 'power over' many other people" (Clegg et al., 2006, p. 191).

The second type of power that can be classified as episodic power is the *restricting power of the IS*. The IS has in a sense *power over* its users. An IS may restrict its users in their desired work practice by means of the ostensive aspects of the routine; the procedures and constraints *inscribed* in the IS (Gosain, 2004). The users can be viewed as trapped in an *iron cage*, similar to the iron cage of oppressive control that bureaucracy brings with it (Weber, 1958). Where citizens are constrained by the rules underlying bureaucratic processes, ISs constrain users in a comparable way (Gosain, 2004).

In the five cases within our study, the supplier of the HIS largely determines the functionalities that the HIS provides and does not provide. This implies that the supplier has a substantial influence on the work practices in health institutions, since they "build into the technology certain interpretive schemes (rules reflecting knowledge of the work being automated), certain facilities (resources to accomplish that work), and certain norms (rules that define the organisationally sanctioned way of executing that work)" (Orlikowski, 1992, p. 410). Aside from the fixed design of the HIS, there is a layer on top of this that can be customised by the hospital. Hospitals are encouraged to stay as close to the supplier's recommended *best practices* as possible. Organisations using all kinds of ISs other than HISs are pressured to use system configurations based on best practice processes (Gosain, 2004). Thus, suppliers largely influence and control the use of these systems, effectively guarding the iron cage. In other words, a system's *power over* users in fact represents the power of the supplier in situations like these.

5.6.2. Systemic Power and Workarounds

If users perceive an IS to be too restrictive and leading to obstacles in their work practices, they start working around the technology (Malaurent and Avison, 2016). Previous studies have shown how a difference between top-down requirements and bottom-up needs often results in a misalignment of ISs and the work practices they are built to support; this causes users to enact workarounds (Markus and Tanis, 2000; Azad and King, 2012; Huuskonen and Vakkari, 2013; Malaurent and Avison, 2016). Our study supports these findings and shows how there is a common dual relationship between the HIS and its users. Physicians, nurses, therapists, and secretaries alike are first constrained by the HIS through its episodic *power over* its users, after which the users exert their *power to* work around. The user is allowed to exercise agency by deviating from the procedure (M. C. Boudreau and Robey, 2005). The power to work around is therefore a systemic power, a productive force which implies agency of the possessor, rather than the more latent form that is episodic power.

All actor types in our study have been seen exerting their power to work around the IS. Possessing the power to work around can be seen as a means of breaking out of the iron cage (Huuskonen and Vakkari, 2013). Contrary to the idea that users are trapped by the designers of the IS, the existence of this power suggests that users are active agents that can appropriate the IS to their own needs. They enact workarounds to better fit the IS to their work practices (Hovorka and

Germonprez, 2010; Azad and King, 2012). Workarounds are in this sense a form of empowerment of users. Again, there is a recursive relationship tied to these power relations, similar to that of the *power to* and *power over* recursion. Empowerment of users inherently means disempowerment of the system (Clegg, 1989).

The two types of HIS restrictions that we distinguished – actual restrictions and perceived limitations – loosely correspond to the two types of ERP misfits as described by Strong and Volkoff (2010): deficiencies and impositions. *Deficiencies* "are problems arising from ES [Enterprise Systems] features that are missing but needed", whereas *impositions* "are problems arising from the inherent characteristics of an ES such as integration and standardization" (Strong and Volkoff, 2010, p. 737). Van den Hooff and Hafkamp discussed these in the context of workarounds, arguing that "imposition misfits will likely lead to workarounds that entail changes in technology use, whereas the perception of deficiency misfits will be related to workarounds in the form of adaptation of routines" (2017b, p. 14). In our study, we observed actors overcoming HIS restrictions (i.e. imposed misfits) and perceived HIS limitations (i.e. deficiency misfits). In both categories, we have seen examples of changes in technology use and adaptation of routines.

5.6.3. Hierarchical Power, Restricting Power and the Power to Work Around

In Figure 19 we illustrate the three forms of power involved in the emergence of workarounds: hierarchical power, restricting power and the power to work around, and how they compare to the episodic *power over* and systemic *power to* discussed in extant literature. The episodic hierarchical power is evident in the relationships between different actors. The other type of episodic power, restricting power, is the means of the supplier to influence work practices of actors through the IS. Both hierarchical and restricting power can result in actors exerting their systemic power to work around the system.

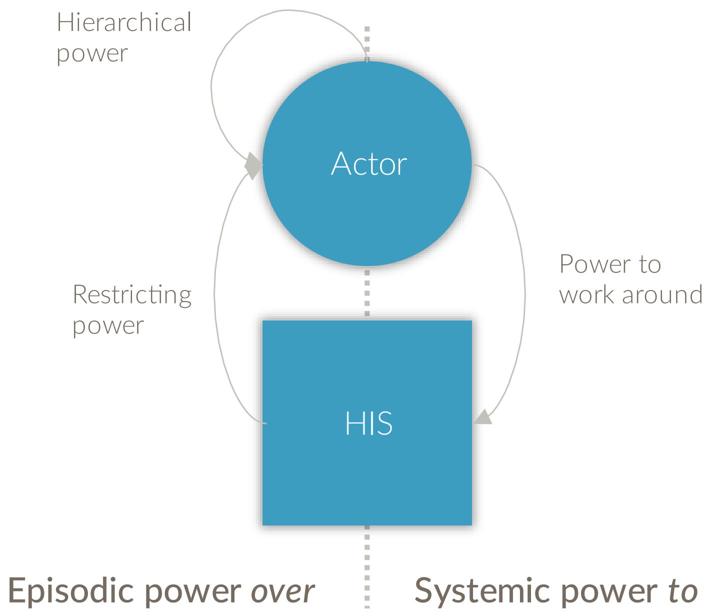

Figure 19 - Overview of the Forms of Power Found in the Study

5.6.4. Practical Implications

The findings that IS users respond to hierarchical differences and restrictions by enacting workarounds both have practical implications for the design and use of ISs within organisations. Although addressing hierarchical issues in healthcare organisations remains a sensitive subject, the workarounds emerging from hierarchical differences may possibly be prevented by creating awareness of the effects one person's actions have on others downstream. For example, our study shows that physicians are often unaware that the care process of nurses stagnates when they do not enter a patient's medication information in the HIS. By making them aware of the consequences of their actions and rewarding them for improving their work practices, the efficiency and quality of care may improve.

Suppliers may use the findings of our study by taking into account that many workarounds emerge from IS restrictions. When they try to enforce too much control in the form of restrictions, they may achieve the opposite effect. Our study shows that workarounds often emerge from restrictions, perceived or real, and they inherently result in decreased control (Lapointe and Rivard, 2005; Ignatiadis and Nandhakumar, 2009). Therefore, designers of ISs need to search for a balance between restricting users – thereby achieving control – and giving them the functionalities and freedom that they desire – thereby preventing them from enacting workarounds. Moreover, decision-makers would need to distinguish between those practices that work around deliberate restrictions and those workarounds that arise from perceived limitations. Overstepping deliberate restrictions might have dangerous consequences, whereas workarounds emerging from perceived limitations might not be as harmful. Both types, however, could indicate processes that need redesigning (Beerepoot and van de Weerd, 2018b).

5.6.5. Limitations and Directions for Future Research

This study has a number of limitations. We only studied cases from the healthcare domain, focusing particularly on healthcare organisations in the Netherlands. Since the healthcare industry is known for the commonality of power dynamics and hierarchical differences (Perrow, 1965; Robinson, 1997), this was a particularly suitable context for our study. However, the forms of power may not be as evident in other domains. We expect similar patterns in other domains that have standardised ISs and highly hierarchical structures. Future research may support whether workarounds in different domains emerge from the same power dynamics distinguished in this study.

Second, in our study we focused on power dynamics that we encountered during our observations and interviews. We did not specifically consider governance and regulatory frameworks that are used in healthcare, although we do discuss how participants are restricted in their activities by the IS. An interesting future research direction would be studying the specific role of such governance and regulatory frameworks in relation to workarounds and how they can influence the frequencies and types of workarounds used.

Regarding the data collection, we identified all workarounds through interviews and observations; i.e. exclusively using qualitative methods. We do not expect to have achieved saturation in terms of the workarounds enacted in the departments studied. The qualitative identification of workarounds may be supplemented by quantitative methods of workaround detection, such as process mining (Van der Aalst, 2011), a set of data analysis techniques that take event logs drawn from ISs as input and is used for process analysis. Although some research has been done on detecting workarounds using process mining (Outmazgin and Soffer, 2013), many types of workarounds cannot yet be detected using data analysis techniques. This provides a highly relevant area for research to come.

Last, we have come to our theoretical findings only after finishing our data collection. Hence, we did not reach theoretical saturation in our data collection. However, we repeatedly encountered the categories of power relations distinguished in this study across several actors. Future research may reveal whether the same findings surface when our framework of categories is used a priori. A possible extension of our framework could focus on the relationship of the power dynamics with the motivations of actors to enact workarounds and the consequences thereof.

5.7. Conclusion

The aim of our study was to reveal how power influences the emergence of workarounds in HISs. We examined this issue by analysing 51 workarounds in terms of the power dynamics involved in their emergence. Our analysis resulted in two main findings. First, workarounds emerge as a response to episodic power. We distinguished two types: those workarounds that emerge from hierarchical differences and those that emerge from HIS restrictions. The second main finding is that workarounds emerge when actors use their systemic power to work around the HIS. This often happens in response to the two types of episodic power described before. The forms of episodic and systemic power involved in the emergence of workarounds are tightly related; the workaround sequences show how episodic power, in the form of hierarchical differences and HIS restrictions, are directly or indirectly followed by systemic power, in the form of workarounds. The power to work around can be seen as a means of breaking out of the iron cage, in the sense that actors are empowered to circumvent the restrictions as put in by the supplier. Although these restrictions are often inscribed in the HIS to achieve a certain level of control, too many restrictions may achieve the opposite: users will start enacting workarounds that are difficult to control.

Our contributions lie in unpacking the link between power and HIS usage. We drew on the literature on episodic and systemic power to explain which power dynamics are involved in the emergence of workarounds. We showed how actors respond to hierarchical differences between actors and to HIS restrictions, terming their activities as proof of the *power to work around*. Thus, power within the use of HIS is not one-sided, but is a recursion of *power over* and *power to* dynamics.

This paper provides a first step towards understanding the relationship between power and workarounds in HISs. We propose that power relations between actors and the HIS can be exposed by tracing the sequence of events that precede the emergence of workarounds. However, it remains difficult to mitigate harmful issues of power, since it is often regarded as a sensitive subject. We hope this study can aid in addressing these issues, thereby improving work practices and the quality of patient care.

Chapter 6

To Accept or Not To Accept?[7]

Abstract. Many healthcare processes are complex and variable, which makes it difficult to align them with rigid information systems. To cope with the resulting misalignment, caregivers invent alternatives, also known as workarounds. Workarounds with negative consequences, such as those that affect the safety of patients, need to be prevented. However, those with positive consequences may be adopted by the organisation. In this study, we set out to discover which workarounds are generally acceptable and which ones should be rejected. We discovered ten different workarounds in a Dutch hospital and analysed these in terms of three characteristics associated with healthcare processes. We found that workarounds existing in knowledge-intensive processes and/or where a patient is involved are generally considered unacceptable. In contrast, workarounds in processes with a high degree of collaboration are likely to be accepted, provided that little knowledge is required and that no patient is involved. We contribute to the current literature on addressing workarounds in healthcare settings by providing insights into the factors influencing the organisational decision to accept or reject workarounds. In addition, we provide healthcare organisations with the tools to evaluate which workarounds are attractive to be established as proper work practices.

Keywords: Workarounds, Health Information Systems, Information Systems, Qualitative Comparative Analysis.

6.1. Introduction

Since the start of the century, health information systems (HISs) have been widely implemented in hospitals throughout the world. Commonly introduced as a promise to achieve better healthcare, many of these implementations were in hindsight judged as failures (Littlejohns et al., 2003; Heeks, 2006). One of the reasons HISs

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are less successful than other information systems is because healthcare processes are more complex than other processes (Winter et al., 2010; Wager et al., 2017). The technologies in healthcare organisations are tasked with supporting the day-to-day processes of caregivers, processes which are inherently variable.

The difficulty of aligning technologies with user needs leads to a 'design-reality gap' (Heeks, 2006). The difference between "where the HIS wants to get us" and "where we are now" is evident. The larger this difference, the more a HIS is considered a failure. What has become clear in multiple studies in healthcare is that we see *workarounds* emerge when such a gap exists between design and reality; or between policy and practice (Debono, Greenfield, Black and Braithwaite, 2010; Yang, Ng, Kankanhalli and Luen Yip, 2012; Debono et al., 2013). Such workarounds can be seen as deviations from the designed policies, which can be viewed both negatively and positively: negatively in terms of security incompliance and positively in terms of ingenious solutions (Safadi and Faraj, 2010a; Cabitza and Simone, 2013; Nadhrah and Michell, 2014; Röder, Wiesche, Schermann, et al., 2014).

In general, there is agreement that workarounds with negative consequences need to be prevented and those with positive consequences may be adopted organisation-wide. However, evaluating workarounds as either positive or negative is a difficult task, since a single workaround may have both positive and negative consequences. What may offer an entirely new perspective on the decision to accept or reject workarounds is to assess them on the basis of the type of processes they are related to. In this study, we ask the research question: *Which characteristics are associated with healthcare processes and under which conditions should a workaround be accepted or rejected?* In doing so, we attempt to discover which workarounds are generally considered acceptable and which factors influence this decision. We thereby contribute to current literature discussing how to address workarounds in healthcare settings. Moreover, the outcomes may help healthcare organisations to evaluate workarounds and successfully act on them.

6.2. Related Work

Traditional information systems focus on the support of repetitive and predictable processes (Combi et al., 2017). These processes are designed prior to their execution in terms of formal protocols that describe how the information system is to be used. However, in contrast to repetitive and predictable processes, healthcare processes are often dynamic and unpredictable (Lenz and Reichert, 2007; Dhieb and Barkaoui, 2011; Combi et al., 2017). Some healthcare processes consist of relatively predictable procedures defined by law, like handling single medical orders or examinations. Other healthcare processes, such as those related to patient treatment, are inherently unpredictable (Reichert and Pryss, 2017).

Processes in healthcare are therefore characterised by both well-defined procedures and the need for flexibility (Van der Aalst et al., 2005).

The unpredictability of some healthcare processes and the difficulty of developing information systems that support these processes may explain the major focus on healthcare organisations in studies on workarounds (Kobayashi et al., 2005; Azad and King, 2008b; Ali et al., 2010; Halbesleben et al., 2010; Safadi and Faraj, 2010a; Yang et al., 2012; Ilie, 2013; Koppel et al., 2015; Reiz and Gewald, 2016). The term ‘workaround’ itself has been defined differently throughout these studies. We adopt the definition by Alter (2014b). This definition allows us to include examples of improvisation and bricolage, loose coupling, bypasses and technology adaptation, but exclude activities that result from “inattention, accidents, or mistakes” (Alter, 2014b). Important in this definition is the idea of temporality. As Safadi & Faraj (2010a) note, workarounds emerge and evolve over time. The workaround reaches the end of its lifecycle when it is used repetitively and becomes established practice. When the workaround has become established practice, we no longer consider it as a workaround.

Several researchers have mentioned actions that organisations can take to address workarounds (Beerepoot and van de Weerd, 2018b; van de Weerd et al., 2019). Some of these actions mentioned relate to accepting workarounds – e.g. tolerating (Röder, Wiesche, Schermann, et al., 2014), formalising (Cresswell et al., 2017), or institutionalising (Azad and King, 2012) these. Others are related to rejecting workarounds – e.g. prohibiting (Röder, Wiesche, Schermann, et al., 2014), eliminating (Vogelsmeier et al., 2008), or demonising (Cresswell et al., 2017) workarounds. Deciding on which workarounds to accept and which ones to reject is a complex task. Röder et al. (2014) shed some light on the willingness of managers to accept workarounds. They determined three factors that have an effect on a manager’s willingness to accept a workaround, namely:

- Expected efficiency gains: positive effect on willingness to accept
- Exposure to compliance risks: negative effect on willingness to accept
- Perceived process weaknesses: mediating effect on exposure to compliance risk

The study by Röder et al. (2014) gives important insights into how managers evaluate workarounds. However, this approach relies on managers’ views on workarounds and their consequences. We aim to contribute to this work and others by taking a different perspective, focusing on the basic characteristics of healthcare processes that can be objectively determined.

In the following section, we describe the methodology of this study. Then, we present the results and discuss our findings in more detail. We close with some concluding remarks.

6.3. Methodology

Our study can be divided into three phases: characteristics discovery, workarounds discovery, and qualitative comparative analysis. We will explain our activities and the goals of the individual phases in more detail below.

6.3.1. Phase One: Characteristics Discovery

The goal of phase one has been to discover the characteristics that are associated with healthcare processes and that can be used to determine which workarounds should be accepted or rejected. The characteristics discovery phase has been performed by the second author in the form of a literature review. This review has resulted in nine characteristics.

6.3.2. Phase Two: Workarounds Discovery

In phase 2, authors one and two have set out to discover a set of processes with workarounds in a Dutch hospital. We have done this qualitatively, through observations and semi-structured interviews. The data have been collected at two wards of the hospital between May and June 2018. Both authors one and two had full access to the two wards and were allowed to speak to all healthcare professionals present on the ward at the time of our study. We captured all the important information around workarounds in 'workaround snapshots', as proposed by Beerepoot and Van de Weerd (2018b). Table 17 presents an overview of the data collection.

Table 17 - Overview of Observations and Interviews Phase Two

Researcher	Ward	Method	Participant(s)	Duration
2	Inpatient	Observations	7 nurses	8.5 hrs
2	Inpatient	Observations	Clinical secretary	1 hr
2	Inpatient	Observations	2 front office members	30 minutes
1	Outpatient	Observations	2 back office members	3 hrs
1	Outpatient	Observations	2 urologists	8 hrs
2	Inpatient	Observations	Physician assistant	2.5 hrs
1	Outpatient	Interview	Team lead outpatient care	1.5 hrs
2	Inpatient	Interview	Team lead inpatient care	1.5 hrs
1+2	N.a.	Interview	Coordinator application management	1 hr

6.3.3. Phase Three: Qualitative Comparative Analysis

The goal of phase three has been to analyse the discovered healthcare processes of phase two, according to the characteristics found in the literature review of phase one. For this purpose, we conducted a Qualitative Comparative Analysis (QCA). QCA is an approach for "systematic cross-case comparisons while at the same time giving justice to within-case complexity, particularly in small- and intermediate-N research design" (Rihoux and Ragin, 2009). It is a research method in comparative case-oriented research that makes it possible to investigate a small number of cases where a specific outcome has occurred, compared to those where the outcome did not occur. QCA uses qualitative data derived from a case study to identify conditions for an outcome. Thus, this method discovers combinations of factors (in this study, characteristics) that explain a certain outcome (Schulze-Bentrop, 2013). In this study, the outcome is the acceptance or rejection of a workaround.

QCA can be carried out in different ways. We used QCA based on Boolean algebra and on examining the minimum combination of variables that may result in either the absence or presence of the outcome (Rihoux and Ragin, 2009). The method identifies different logical combinations of factors, using the AND or the OR expressions, that might be necessary and/or sufficient to produce the outcome. The results of this analysis help to discover combinations of factors that explain a certain outcome (Schulze-Bentrop, 2013).

We organised a workshop with five domain experts to determine for each process whether the characteristic was present: assigning a score of 1 when present and a score of 0 when absent. Additionally, we determined for each process whether the workaround should be accepted or rejected. The domain experts were all employees of the company that implemented the HISs in the five case organisations. They have a combined experience of 74 years of working with HIS in hospital settings, either in an advisory or project management role. Together they have worked in 30 unique hospitals in the Netherlands and Belgium. Additionally, they often have a background as caregivers (education and work experience). Table 18 provides a summary of the workshop participants.

Based on the workshop with domain experts we constructed a truth table and analysed the relationships among the factors. To find and understand the patterns, the truth table was minimised (Ragin, 1994). Finally, based on the found patterns, a descriptive explanation of how the characteristics might influence the outcome is presented.

Table 18 - Overview of Workshop Participants

Participant	Occupation	Years of experience in healthcare	Former occupation
1	Senior Business Consultant & team lead	27	Nurse and senior IT advisor in hospital
2	Senior Business Consultant	28	Nurse and manager IT in hospital
3	Senior Business Consultant	14	IT developer in hospital
4	Business Consultant	4	General IT employee in hospital
5	Junior Business consultant	1	Not applicable

6.4. Results

6.4.1. Discovered Characteristics

The literature review performed in phase one resulted in nine characteristics of processes that might play a role in determining which workarounds to accept or reject. In Table 19, we include exemplary references for each of the nine characteristics. We also give our definition of the characteristic and describe what we mean by a presence or absence of the characteristic.

Table 19 - Characteristics with Definitions

Characteristic	Description
Knowledge (Silvestro et al., 1992; Davenport et al., 1996; Schafermeyer et al., 2010; Davenport, 2015; Di Ciccio et al., 2015)	The knowledge characteristic refers to whether the knowledge required within the process is simple and mainly explicit, or complex. An example of simple knowledge is step-by-step instructions that can be provided for completing a task within the process. Complex knowledge is when the process requires human knowledge-based decision making.
Patient involvement (Lee and Park, 2009; Schafermeyer et al., 2010; Kemsley, 2011; Trkman et al., 2015)	The role of the patient can range from completely passive to highly active. In the most passive form, the patient is not present during the execution of the process and only expects the output from the process. In the more active forms, the patient can determine the order or even actively participate in the fulfilment of the process.

Healthcare professional (Karsh et al., 2006; Zwarenstein et al., 2009)	The role of the healthcare professional refers to the person delivering care to the patient, e.g. a doctor or nurse. A process can be executed completely automatically, meaning that no healthcare professional is involved. It can also be fully performed by the healthcare professional, with no involvement of the system, meaning that the role of the healthcare professional is highest.
Collaboration (Marjanovic et al., 2007)	The collaboration characteristic refers to the presence or absence of collaboration between healthcare professionals. This can range from no collaboration to a highly collaborative process.
Structure (Helfert, 2009; Felin et al., 2012)	The structure characteristic relates to the structures in place to support the process. An example of a highly structured process would be one that is strongly formalised in a workflow management system. An informally developed process would be an example of the opposite of a highly structured process.
Repeatability (Isik et al., 2012)	The repeatability characteristic refers to the extent to which the process can be repeated in a similar way. On the one hand of the spectrum would be a process that is never repeated. On the other hand of the spectrum processes are continuously repeated.
Laws and regulations (Ramezani et al., 2011)	The laws and regulations characteristic refers to the extent to which the execution of a process is constrained by the laws and regulations the organisation has to comply with. In healthcare especially, some medication processes are highly regulated, whereas others are not at all regulated.
Complexity (Cardoso et al., 2006; Martinho et al., 2015)	The complexity characteristic refers to how complex the process is. For example, a process can be highly complex in terms of number of activities, decision points and different participants involved, or it can be very simple.
Predictability (Benner and Tushman, 2003; Lockamy III and McCormack, 2004)	The predictability characteristic refers mostly to the outcome of the process; e.g. whether it achieves the predicted performance outcomes. When the outcome is always the same, it pertains a highly predictable process.

In the next section, we present the results of phase two: the workaround discovery phase.

6.4.2. Discovered Workarounds

During the observations and interviews in the hospital, we observed a total of ten healthcare processes with workarounds. We will describe these workarounds one by one here.

1. Physicians having patients carry medical images

During patient-physician consultations, a physician uses medical imaging devices to discover a patient's physical status. Instead of digitally sending the images directly to the HIS, the physician prints them out. He prefers having the image on paper and considers finding the image in the system too time-consuming. He asks the patient to take the paper to the front desk to have it digitised.

2. Nurses bypassing the verification of a second nurse during medication administration

When a nurse administers medication to patients, the system requests a verification by a second nurse, to ensure four eyes confirm that the right medication is giving to the right patient. It is time consuming for two nurses to go to each patient together and check the medication that is administered, and the nurses have found a way to bypass the verification box, allowing them to circumvent the verification step.

3. Physicians sending themselves a reminder to write a letter to a patient's general practitioner

At the end of patient-physician consultations, physicians send a letter to the patient's general practitioner. In this letter they describe what was discussed, which examinations were performed and which medication the patient is currently taking. Instead of writing the letter at the end of the consultation, the physician chooses to postpone it to another time because of time shortage. He creates a communication order - intended to communicate with other caregivers - and sends it to himself as a reminder to write the letter afterwards.

4. Nurses registering a patient's treatment plan next to that of the physician

Physicians visit patients together with nurses, to discuss the patient's recovery and establish a treatment plan. Physicians register the treatment plan in their part of the system. Nurses are only permitted to treat the patient according to the treatment plan. However, the nurses sometimes feel the plan registered by the physician is incomplete. Therefore, they register the plan themselves in a part of the system they have access to, even though their part of the system is not intended to contain this kind of information.

5. Physician assistant calling physician to update the treatment plan

Physician assistants (PAs) are engaged with treating patients up to a certain level, thereby alleviating the work load of physicians. Instead of waiting for the physician to come to them with news on a patient, PAs sometimes call physicians to review the results of a patient and establish a treatment plan. Otherwise, the patient may be left waiting unnecessarily long for news on their treatment.

6. Nurses leaving score blank and entering it differently

A system functionality nurses often use is a patient's activity plan. In the activity plan, all tasks that need to be done for that patient are listed. One of these activities is calculating a patient's Early Warning Score (EWS). Instead of entering this information directly, some nurses leave it blank, after which they enter it in another view within the information system. The reason for this is that they prefer to have the EWS in the same place as the other scores and measurements, and this way allows them to do so.

7. Nurses calculating a patient's inflow and outflow of fluids manually

Nurses keep track of a patient's inflow and outflow of fluids. The system allows them to view a history of the inflow and outflow of fluids over a period of time. However, they have discovered that this history is not always accurate, which is why they started calculating it manually on a piece of paper.

8. Nurses registering patient information in incorrect time slot or asking next shift to register

Nurses need to register the care activities they performed in the concerning text field in the patient's medical records. When their shift ends, they can no longer edit the text field of the ended shift. What happens is that nurses do not have the time to register until after their shift has finished, or they have forgotten something that does belong in the patient record. To solve this problem, they write the information down on paper and ask the next shift to enter it for them.

9. Physician assistants requesting informal consultation

The physician assistant calls a microbiologist to ask for advice on a patient, which typically needs to be done through the system via a formal request for consultation. However, the information system does not currently allow microbiologists to register consultations. Instead of a formal request for consultation through the information system, the consultation is performed through an informal phone call. This way, the microbiologist can advise the physician assistant, but it cannot be formally registered.

10. Department secretaries entering a star symbol in a free text field

The secretaries are tasked with preparing the physician-patient consultations. They check whether the results from a patient's examinations are all present, to make sure they do not come to the hospital in vain. To indicate that a result is present, they enter a star in the text field behind the result. By doing so, colleagues can take over at any time and continue this preparatory work.

In the next section, we analyse each workaround in terms of their characteristics and outcomes.

6.4.3. Analysis of the Outcomes

During the workshop with domain experts, we established the characteristics of the processes where the workarounds occurred. We then discussed whether to accept or reject the workaround. As mentioned in the related work section, accepting means formalising or institutionalising the workaround throughout the organisation, or tolerating it as-is. Rejecting a workaround entails actively prohibiting, eliminating or demonising the deviation.

For each workaround and each characteristic, we assigned a Boolean 1 when the characteristic was assigned a high value by the workshop participants and a Boolean 0 when it was not. Using the resulting matrix, we evaluated which characteristics seemed to influence the decision to accept or reject a workaround. What became clear at once was that the healthcare professional was highly involved in each process, meaning that all ten cases were assigned a Boolean 1 for the healthcare professional characteristic. The same was true for repeatability, as all ten occurred daily or even hourly. Both structure and predictability were considered difficult to characterise by the participants. Therefore, we did not weigh these characteristics heavily in our analysis.

Following our analysis, we found that knowledge, patient involvement and collaboration played major roles in the determination to accept or reject a workaround. Therefore, we focus on these three characteristics in the following sections, although we include the full characterisation of accepted and rejected workarounds in the Appendix.

A 1 was assigned to a workaround for knowledge when expert knowledge is required to perform the workaround. A workaround received a 1 for patient involvement when the patient is actively involved in the process and physically present when the workaround is enacted. Lastly, workarounds received a 1 for collaboration when more than one caregiver is involved and these are affected by the workaround. Table 20 presents the characteristics and outcomes for each of the 10 workarounds.

Table 20 - Characteristics and Outcomes of the Ten Observed Workarounds

ID	Knowledge	Patient involvement	Collaboration	Outcome
1	0	1	0	Reject
2	0	1	1	Reject
3	0	1	0	Accept
4	1	1	1	Reject
5	0	0	1	Accept
6	0	1	0	Reject
7	1	0	0	Reject
8	1	0	1	Reject
9	0	0	1	Accept
10	0	0	1	Accept

To illustrate our analysis, we will explain workaround W4 in more detail. W4 relates to nurses registering a patient's treatment plan in parallel with the physician. Expert knowledge is necessary in this process, as registering a treatment plan of a patient requires extensive medical knowledge. As the process takes place at the patient's bedside and the patient participates in conversations with the physician and nurse, patient involvement is considered high as well. Since both physicians and nurses are involved in this process and actions performed by one affect the other, collaboration is also high. Therefore, all characteristics are marked with a 1. In terms of the outcome, the domain experts considered rejection the best way to address W4. The reason for this is that the double registration of treatment plans leads to inconsistencies. It is no longer clear where the complete and correct information is stored and this may lead to nurses not administering the correct treatment to patients. The way forward would be to make sure physicians register the treatment plan correctly in the first place.

Table 21 presents a truth table that shows all the possible configurations of the three different characteristics that were considered to affect the decision to accept or reject the workaround. Six of the eight possible configurations are present in our data set of workarounds: B, C, D, E, F and H. The first configuration, A, has no added value, since it contains none of the three characteristics. Configuration A and G were not found in our data set.

Table 21 - Possible Configurations of the Characteristics, with Corresponding Workarounds

Configuration	Knowledge	Patient involvement	Collaboration	Accepted	Rejected
A: 000	0	0	0		
B: 001	0	0	1	W5, W9, W10	
C: 010	0	1	0	W3	W1, W6
D: 011	0	1	1		W2
E: 100	1	0	0		W7
F: 101	1	0	1		W8
G: 110	1	1	0		
H: 111	1	1	1		W4

Figure 20 presents a set-theoretic representation of the data set. In this figure, processes with workarounds that were accepted are marked in blue, while processes with rejected workarounds are illustrated in white.

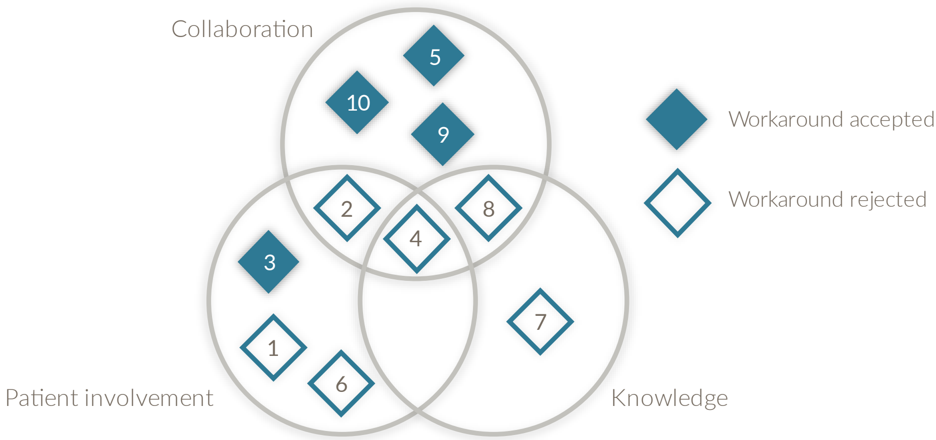

Figure 20 - Set-Theoretic Representation of the Data Set

What stands out is that most workarounds in processes that require expert knowledge and/or where the patient is highly involved (the lower circles), are rejected. Workaround W3 is the only exception. The three workarounds occurring in highly-collaborative processes, but where the involvement of the patient is low and expert knowledge is not necessary (the upper circle), were all accepted. In the following section, we examine these findings in more detail and discuss their implications.

6.5. Discussion

6.5.1. Rejection of Workarounds when Expert Knowledge is Required

The first of the findings resulting from the analysis relates to the requirement of expert knowledge in rejecting a workaround (the lower right circle in Figure 20). The three workarounds where the required knowledge in enacting the process was considered high by the domain experts (W4, W7 and W8) were all rejected. This suggests that in processes where knowledge is an important factor and complex decision-making is involved, deviations are generally unacceptable. W7 (nurses calculating a patient's inflow and outflow of fluids manually) is an example of a rejected workaround where expert knowledge is required. Calculating a patient's inflow and outflow of fluids requires significant knowledge of the types of fluids and medical equipment such as infusion devices. Additionally, performing manual calculations is error-prone. The latter was a major reason for rejecting this workaround.

To negatively view workarounds where expert knowledge is an important factor supports findings by Unger et al. (2015). In the past, several authors (Gronau and Weber, 2004; Nurcan, 2008) argued that the processes that benefit most from flexibility are knowledge-intensive processes. Unger, Leopold and Mendling rejected this viewpoint. They found that – particularly during training phase – negative deviations were more common in knowledge-intensive business processes (KIBPs) than in non-KIBPs. The cause of this seems to be that the users are not yet familiar with the complexity of the process. Several other authors have indeed noted a lack of good training as a cause for workarounds (Saleem et al., 2009; Malaurent and Avison, 2016; Van Beijsterveld and Van Groenendaal, 2016). It is to be expected that workarounds caused by a lack of knowledge of executing the task at hand, whether because of a lack of medical knowledge or knowledge of the information systems, are likely to be rejected by an organisation.

What is important to note when discussing knowledge-intensity in processes is that the meaning of a KIBP is much broader than our definition of the knowledge characteristic. According to Unger et al. (2015), KIBPs have nine characteristics: knowledge-prevalence, collaboration, predictability, complexity, structure, goal-orientation, event-drivenness, repeatability, and frequency and time-horizon. Our approach to the knowledge characteristic is most similar to the knowledge-prevalence characteristic. Similar to our view on collaboration as a distinctive characteristic of processes with workarounds, Unger et al. consider collaboration as a characteristic of KIBPs. As W4 and W8 are both characterised as collaborative and requiring expert knowledge, they can be viewed as KIBPs in this respect and are indeed considered the more negative deviations: those that need rejecting.

6.5.2. Acceptance of Workarounds in Highly Collaborative Processes

Interestingly, we see from the upper circle in Figure 20 that those cases with a high level of collaboration - meaning that other participants are involved in the process affected by the workaround – are more likely to be accepted. However, this is only the case when there is no patient present and little expert knowledge is necessary to perform the tasks. In a previous study, Kobayashi et al. (2005) already pointed out the importance of collaboration when studying workarounds. They found that the effectiveness of a workaround relies on the skills, abilities, and willingness of other participants. Moreover, they argued that one workaround often triggers another, resulting in a cascading effect. Similarly, Unger et al. (2015) found that process participants "did not consider possible implications for other sub-processes resulting from their deviations". Other authors speak in a similar vein of a 'downstream' effect on other participants in the process (Azad and King, 2008a; Alter, 2015a; Drum et al., 2016; Reiz and Gewald, 2016). Workaround W4, which we explained in detail in section 6.4.3 can be seen as an example of this cascading effect. Here, nurses are affected by physicians that do not register a physician's treatment plan completely. Because of this, they come up with a workaround to make sure the patient does receive the treatment they require. Kobayashi et al. (2005) also discovered that principles of fairness and favours are involved in many workarounds: I did something for you, now you will do something for me. In the context of our study, it is interesting that in these kinds of cases, where one workaround affects other participants in the process, the 'downstream' workaround is considered understandable and even desirable taking the circumstances into account. Another example of this can be found in a study by Reiz and Gewald (2016, p. 11), where they found a physician stating: "the important thing is treating the patient, that is what I am doing. If [other department] needs to clean up a bit of a mess then this is just the way it is". They found that this kind of behaviour was socially accepted in the hospital and accepted by all ranks. Indeed, in workaround W4, the nurse's workaround ensures the patient receives the correct treatment. As the patient's treatment plan would otherwise be incomplete, this is tolerated as the quality of patient care is put first. However, it is the 'upstream' workaround that needs to be prevented. The ideal situation would be for physicians to enter the complete treatment plan, so that the downstream workaround is no longer necessary.

6.5.3. Rejection of Workarounds When a Patient is Involved

Apart from workarounds in processes where expert knowledge is required being generally rejected, and those with in highly collaborative processes being generally accepted, we found that most workarounds performed when a patient is present are rejected by the domain experts. According to Debono et al. (2013), workaround behaviour by caregivers can often be traced back to image management: participants convincing their peers of their competencies. For example, nurses attempt to display competency by solving problems and, thereby, protecting patients. They justify the use of workarounds by arguing it benefits the patient. In other cases, they manage their image by *not* using workarounds, demonstrating they choose to adhere to protocol. In the context of our study, there may be a third form of image management involved: one from the organisation's point of view. The reason that many workarounds are rejected when a patient is present may be that deviating from protocol affects how patients view their caregivers and the organisation in general. For example, organisations may fear that physicians having their patients carry medical images with them (W1) reduces their professional image. Workaround W3, in which physicians postpone the writing of a letter by sending themselves a reminder, is the exception. This workaround actually results in the physician being able to give the patient more attention during patient-physician consultation. Therefore, the patient may in fact develop a *better* image of the physician and the organisation in general, which explains why this workaround would be accepted rather than rejected.

6.5.4. Quality of Patient Care

Apart from the influences that expert knowledge and patient involvement seem to have on rejecting workarounds and the collaboration characteristic on accepting workarounds, the benefit for the quality of patient care has become a recurring theme in our discussion on accepting or rejecting workarounds. Workaround W4 is rejected because inconsistency in information may lead to incorrect treatment of patients. Workaround W1 has perhaps been rejected because it negatively affects the professional image towards the patient. Workaround W3 actually benefits the patient in the sense that the physician is left with more time to give the patient the attention he or she wants. It seems that workarounds benefitting the patient are likely to be accepted in general and, as a result, may well be adopted by a hospital. This presents an interesting area for further study, as many studies today recognise the positive side of workarounds in terms of efficiency and inventive solutions, but they are still largely considered harmful in terms of patient safety (Halbesleben et al., 2010; Holden, 2011; Middleton et al., 2013; Blandford et al., 2014; Carayon et al., 2014).

6.6. Conclusion

Workarounds are no longer viewed as purely negative phenomena. Many authors have proposed that workarounds with negative consequences indeed need to be prevented, but that those with positive consequences can be exploited as improvement opportunities by adopting them. In this study, we attempted to assess workarounds on the basis of their characteristics to discover which combinations of characteristics form a deviation that is considered acceptable. We focused on three characteristics that are associated with healthcare processes: (1) knowledge, (2) patient involvement, and (3) collaboration. Using observations and interviews in a Dutch hospital, we discovered ten workarounds in healthcare processes. During a workshop with domain experts, we decided on the characteristics of these workarounds and whether they were considered acceptable or not. Using a qualitative comparative analysis, we analysed the characteristics and outcomes of the workarounds and arrived at three conclusions. (1) When complex decision-making is involved and expert knowledge is required by the IS user to execute the tasks in the process, workarounds are likely to be rejected. (2) When collaboration is involved and actions by one participant in the process affect others, workarounds are generally accepted. However, this only applies when no expert knowledge is required and there is low patient involvement. (3) When a patient is involved, i.e. the patient is present when the process is executed, workarounds are generally considered unacceptable. Interestingly, this does not seem to hold for situations in which patients are positively affected by the workaround. Those types of workarounds may be considered acceptable.

With this study, we contribute to the current literature on how to address workarounds in healthcare organisations. We provide insight into the characteristics associated with healthcare processes and under which combination of characteristics a workaround is considered acceptable. Healthcare organisations may use these insights to evaluate which workarounds are to be accepted. Future research could focus on the discovery and characterisation of more workarounds to test our findings on a larger scale and beyond the setting of one healthcare organisation. Another interesting research strand may be to include other characteristics to discover whether there are more influencing factors involved in deciding which workarounds to accept. Finally, the set-up of this study may also be applied to study which workarounds are accepted in industries other than healthcare.

Chapter 7

Evaluating Process Mining Insights[8]

Abstract. *Motivation*: As healthcare organisations are looking for ways to improve their processes, process mining techniques are increasingly being used. Current process mining methods do not offer support for translating process mining insights into actionable improvement ideas. The aim of this study is to anticipate upon this research gap. *Methods*: We perform action research at two healthcare organisations to develop and refine our method, through several cycles of action and reflection. *Results*: This paper introduces and illustrates the FEI funnel, a novel three-staged method consisting of process familiarisation, domain explanation and improvement ideation. The method aims to support process analysts when evaluating process mining insights with healthcare professionals. For each stage, the FEI funnel highlights the process perspective(s) to which specific attention is attributed. *Conclusion*: Our method complements existing process mining methods and constitutes the first attempt to open the black box regarding the path from process mining insights to actionable process improvement ideas. In this way, it can contribute to a more systematic uptake of process mining in healthcare practice.

Keywords: process mining, healthcare, domain experts, evaluation, process improvement

7.1. Introduction

Healthcare organisations are permanently confronted with the challenge of providing high-quality care with limited resources (Harper, 2002; Dixon-Woods et al., 2012; Mans et al., 2015). To balance increasing care needs with tightening budgets, they are looking for ways to improve their processes in terms of key performance indicators such as clinical outcomes, patient satisfaction, and efficiency (de Mast et al., 2011; Kirchner et al., 2012). To identify process improvement ideas, carefully analysing how the process is currently being executed is a valuable starting point. Process mining can play a pivotal role in that

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respect as it enables the extraction of non-trivial insights from an event log, a data file containing real-life process execution data recorded by information systems (Van der Aalst, 2016; Martin et al., 2020). A key benefit of process mining is its data-driven character, which captures the actual behaviour displayed in processes, which is in contrast to many other process analysis methods that rely on the perceptions of people. Consequently, process mining can, for instance, raise awareness about unexpected process execution patterns or bottlenecks, which indicate areas for process improvement (Mans et al., 2015; Martin et al., 2020). Over the past decade, the process mining research community has proposed a plethora of techniques to analyse processes in a data-driven way, of which many have also been applied in a healthcare context. Common use cases in healthcare include the automated discovery of a process model expressing how the process has been executed in reality, as well as to study whether the real-life process conforms to, e.g., a clinical pathway (Peleg, 2013; Rojas et al., 2016; Dallagassa et al., 2021). While these use cases underline the potential of process mining, it should be recognised that the translation from the output of process mining techniques to process improvement ideas is far from trivial, especially in complex contexts such as healthcare. Close interaction between process analysts and domain experts, i.e. healthcare professionals, is needed to evaluate the insights produced using process mining techniques. The involvement of healthcare professionals is essential to give meaning to particular patterns appearing in the data and to convert findings into actionable ideas to improve the process (van Eck et al., 2015).

While existing process mining techniques enable process analysts to generate a wide range of process analysis insights, translating them into improvement ideas requires providing healthcare professionals with the information they need. Currently, process mining literature does not provide support for this stage in a process mining project. Existing process mining methodologies, such as the PM² methodology (van Eck et al., 2015), recognise the importance of the evaluation of process mining insights with domain experts, but provide limited guidance as to how it should be operationalised in an efficient and diligent way. In addition, it is expected that the healthcare sector has specific information needs in comparison with other sectors. For example, where infrequent behaviour may be disregarded in other domains as irrelevant information, it can be of high interest in healthcare as it might show the need to alter clinical guidelines (Martin et al., 2020). As a consequence of the lack of methodological support for the evaluation stage and the lack of knowledge on information needs of decision-makers in healthcare, the path from process mining insights to process improvement ideas can still be considered as a black box.

Against this background, we derive the following research question: *"How can process analysts evaluate process mining insights with healthcare professionals in order to generate actionable process improvement ideas?"*. To answer this research question, this paper uses action research to introduce a novel three-staged method, the FEI funnel, to support process analysts when evaluating process mining insights with healthcare professionals. Through the stages of process familiarisation, domain explanation and improvement ideation, the method structures the path from process mining insights to actionable process improvement ideas. As such an overarching method to evaluate process mining insights with healthcare professionals has not been defined before, this novel method provides a valuable contribution to process mining in healthcare as a research domain. In particular, by facilitating moving from the analysis phase towards actually improving healthcare processes, our work can contribute to a more systematic uptake of process mining in healthcare, which is marked as a crucial challenge in the field (Martin et al., 2020).

The remainder of this paper is structured as follows. Section 7.2 provides an overview of the related literature. Section 7.3 describes the action research method that has been used to develop and refine the proposed method. The FEI funnel, which is the method resulting from action research, is introduced in Section 7.4. Section 7.5 discusses the introduced FEI funnel in relation to extant literature. The paper ends with a conclusion and recommendations for future work in Section 7.6.

7.2. Related Work

This section discusses the related work. Section 7.2.1 introduces process mining in healthcare. Section 7.2.2 outlines the position of evaluation around process mining methodologies, showing that enhanced support is needed. Section 7.2.3 presents related areas which can be considered in that respect as they aim to enhance the interpretability of process mining insights.

7.2.1. Process Mining in Healthcare

Process mining techniques have been applied more frequently in healthcare contexts than in any other domain (Dakic et al., 2018). Within those applications, we can distinguish the data-driven analysis of *medical treatment* processes and *organisational* processes (Lenz and Reichert, 2007). The former focuses on the patient perspective, studying their trajectory throughout departments or the hospital as a whole. The latter studies aim to give insight into administrative, logistic, financial, or other aspects of the process not directly related to providing patient care. Examples of medical treatment processes that have been studied using process mining techniques include stroke care processes (e.g. Mans, Schonenberg, Leonardi, et al., 2008; Sato et al., 2020), oncological processes (e.g. Dagliati et al., 2017), and the process around sepsis cases (Mannhardt and Blinde, 2017).

As opposed to other domains, healthcare processes are particularly characterised by their complexity. While this may have contributed to the interest of process mining researchers in the healthcare domain, it also makes it challenging to apply process mining in healthcare. Over the years, several authors have pursued solutions to tackle the complexity of analysing healthcare processes. Many of these solutions revolve around the development and application of trace clustering techniques (Mans, Schonenberg, Song, et al., 2008; Song et al., 2008; Bose and van der Aalst, 2009). More recently, increasing research attention has also been paid to event log quality, which is especially relevant in a healthcare context where data recording often depends on a manual action. The presence of event log quality issues such as missing data or incorrect data (Mans et al., 2015), can make the application of existing process mining techniques difficult, or even impossible (Ghasemi and Amyot, 2016; Fox et al., 2018; Andrews et al., 2019, 2020; Martin et al., 2019). Proposals to resolve such data quality issues sometimes include automated techniques or ready-made heuristics, but often require domain knowledge (C. Alvarez et al., 2018).

Both the complexity of healthcare processes, as well as the event log quality issues that typically prevail, result in a heavy reliance on healthcare professionals to evaluate analysis results (Rojas et al., 2016). Many of the studies applying process mining in healthcare result in the discovery of potentially valuable insights, but do not elaborate on the evaluation of those insights with domain experts to assess their value in implementing process improvements. Often, it is mentioned that additional domain knowledge is required to give meaning to the patterns found (Huang et al., 2014; Emamjome et al., 2019; Martin et al., 2020). As such, there is a need for methodological guidance to incorporate the knowledge of domain experts in process mining projects, especially in healthcare contexts.

7.2.2. Evaluation in Process Mining Methodologies

In order to support the use of process mining in research and industry, a variety of methodologies have been proposed to guide the execution of process mining projects in general. These methodologies include among others the Process Diagnostics Method (Bozkaya et al., 2009), the L* life-cycle model (Van der Aalst, 2011), and the Process Mining Project Methodology (PM²) (van Eck et al., 2015). These methodologies generally adopt the following structure: (1) definition of questions, (2) data collection, (3) data pre-processing, (4) mining & analysis of results, (5) stakeholder evaluation, and (6) implementation (Emamjome et al., 2019). Whereas in-depth methodological guidance has been developed for other phases such as data collection and analysis (e.g. (Jans et al., 2019) and (Bozkaya et al., 2009), respectively), existing process mining methodologies lack actionable support for the evaluation stage, especially in involving domain experts (Koorn et al., 2021).

Typically, through analysing an event log, one or more artefacts are produced, often in the form of process models. Evaluation takes place after the analysis and can take one of two forms (Koorn et al., 2021): (1) evaluation of one or more artefact(s), and (2) evaluation of the insights derived from those artefacts. The first type of evaluation, that of the artefact, focuses on the understandability, usability or quality of the object(s) produced during the analysis. Most studies that report on a structured evaluation fall into this category, and focus on the quality of the models generated in the analysis phase using, e.g., metrics such as fitness and precision of discovered models to evaluate how well the models reflect the data (Van der Aalst, 2016). After the quality of the artefact has been evaluated, conclusions can be drawn from them in the form of insights, by applying general or domain knowledge. However, there is less attention to and little guidance for the second type of evaluation that can be performed thereafter and that should lead to actionable improvement ideas. This evaluation focuses on confirming insights and evaluating their relevance and generalisability. As shown in the recent literature review by Koorn et al. (2021), the evaluation of insights is currently performed in an unstructured way and is in need of more methodological guidance. In this paper, we focus specifically on the activity of insights evaluation, depicted in blue in Figure 21.

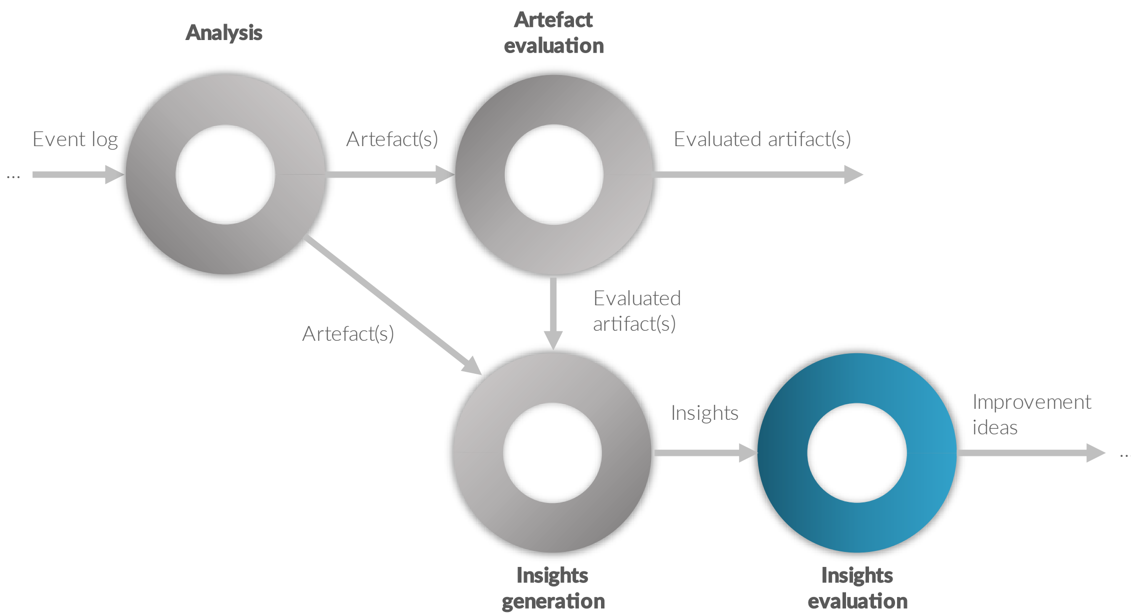

Figure 21 – Illustration of the Analysis and Evaluation Pipeline

7.2.3. Enhancing the Interpretability of Process Mining Insights

Although methodological support is currently missing for how to approach the evaluation of process mining results with healthcare professionals, approaches to enhance the *interpretability* of process mining insights have been developed. These approaches predominantly revolve around breaking down the complexity of healthcare processes in order to make them more easy to understand. In the pre-processing phase of process mining projects, complexity is often decreased by breaking down event logs into smaller logs (Mans, Schonenberg, Song, et al., 2008). One specific technique that is proposed in this respect and that we already mentioned in Section 7.2.1, is trace clustering (Song et al., 2008). For example, trace clustering can be used to break up the log into separate logs for each care trajectory (Lakshmanan et al., 2013; e.g. Caron et al., 2014). Other techniques that can be used during both the pre-processing as well as the analysis stage revolve around the level of abstraction at which the process is studied (e.g. Tax et al., 2016; van Zelst et al., 2020). By abstracting from in-depth details and taking a high-level view of the process, the amount of information presented to the process analyst is limited and, hence, potentially easier to interpret (Mans, Schonenberg, Song, et al., 2008).

The techniques proposed to break down information in an effort to enhance the interpretability of process mining insights currently focuses on process analysts. However, in terms of evaluating analysis insights with domain experts, the same need for breaking up information arises. In their overview of the literature on process mining in healthcare, Rojas et al. note an "absence of a good visualisation of the process models and the results obtained, especially in complex and less-structured processes, such as those found in the healthcare domain" (2016, p. 232). The authors point out the need for improved visualisations and analytics to better guide the interpretation of process mining findings in healthcare settings. Huang et al. reach a similar conclusion in a study undertaken on mining clinical pathways, concluding that the "spaghetti-like" patterns are difficult to understand by clinicians and therefore are not very helpful in analysis and improvement efforts (2014, p. 112). In particular, they note that existing process mining techniques do not tell the whole story; domain experts are needed to provide the meaning and significance to the insights.

Combining process mining techniques with findings from the field of visual analytics may offer means for presenting findings in a way more suited for interpretation and decision-making by domain experts. The field of visual analytics "combines automated analysis techniques with interactive visualizations for an effective understanding, reasoning and decision making on the basis of very large and complex data sets" (Keim et al., 2008, p. 157). It arose in part because of the growing availability of raw data, and the *information overload problem* that is brought with it. Visual analytics techniques and methods are aimed at presenting information in such a way that it is relevant to the task at hand, and as such, supports making appropriate decisions. In recent years, more attention has been paid to the combination of process mining and visual analytics, which can be attributed to two key considerations. Firstly, human judgment is essential in interpreting findings and identifying relevant insights and visualisations are important in this respect (Van der Aalst, 2011). Secondly, the conclusions which are drawn will depend on the type of visualisation that is presented to the observer. For instance, commonly used process mining visualisations such as the dotted chart and the output of the fuzzy miner serve different objectives (Van der Aalst, 2011). Another example is the study by Yeshchenko et al. (2019), who propose a new type of visualisation to identify process changes over time, arguing that such changes could not be identified using other types of visualisations.

Visualisations proposed in process mining can be categorised according to the following four process perspectives (Van der Aalst, 2011; Kriglstein et al., 2016):

- control-flow (concerned with the order of activities)
- time (concerned with temporal aspects)
- organisational (concerned with resources and other organisational information)
- data (concerned with data attributes of events and cases, sometimes also referred to as case perspective)

The four process perspectives are helpful in specifying which type of visualisations are relevant in conducting different tasks. For example, according to a recent study by Klinkmüller et al., "discovery of control-flow is often conducted by analysts to establish a basic understanding of the business process, whereas other problems like the investigation of the time, case or organisational perspectives constitute the actual goal of the project" (2019, p. 2). As such, the process perspectives can be used to describe which types of visualisations best support the interpretation of process mining results by domain experts and can be utilised in providing methodological guidance for the evaluation process.

7.3. Method

With this study, we aim to discover the necessary stages in translating process mining insights into improvement ideas, *with* healthcare professionals. Therefore, we based the study design on action research. Action research is distinguished from other research methods by its collaborative character in which researchers perform a number of cycles of action and reflection within a research setting. Moreover, a characteristic of action research is the dual role of the researcher: as agent of the change on the one hand, and observer on the other (Bradbury, 2015). In the context of this study, these characteristics are reflected especially in the role of the first author, who also acted as process analyst. In that role, the first author was involved in reflecting on the lessons learned as well as taking part in the action.

The study was executed in line with the ethical procedures of Utrecht University and the healthcare organisations of study. The involved participants have given consent to the researcher to gather data on the action research cycles and how they acted throughout the project. For the data analyses, no personal data of individual patients or employees were collected to ensure compliance with the General Data Protection Rights (GDPR) data regulations. All event data extracted were anonymised before being provided to the researcher through encrypted servers. In the following sections, we explain the details of the methods used in the study.

7.3.1. Research Locations

The study was conducted at two separate hospitals in The Netherlands that differ in size and decision-making culture. The two locations make use of different hospital information systems (HISs), representing the two dominant HIS vendors in the country.

Location 1 is a top clinical hospital with around a thousand beds. When improving processes and making changes to the HIS, they take pride in heavily involving healthcare professionals in the decision-making process. In order to take the complexity of different views into account, the team involved in the process mining project included: a policy officer, nurse, application manager, business intelligence specialist, and the first author. Each of them brought valuable knowledge and experience to the table: the policy officer on implementing changes within the organisation, the nurse on particular informal agreements within nursing practices, the application manager on customisation opportunities that the HIS offers, and the business intelligence specialist on the back-end of the HIS and how data is recorded there.

Location 2 is a general hospital featuring around two hundred beds. Being a much smaller hospital, department managers are in close contact with healthcare professionals and support staff, and are aware of the sentiment around processes. As the decision-making lies with the department managers, the team involved in the process mining effort included two of the involved department managers and the first author. Not only did the managers have the capacity to directly implement changes, they were also aware of process changes and developments in other departments through close cross-departmental interaction.

By conducting the study at two clearly different locations and project teams, we aim to provide a generalisable method that is applicable to different healthcare contexts. Moreover, location 1 acted as the location in which we could develop our method in an iterative way. Location 2 acted as a fresh context in which we could apply the findings from location 1 and evaluate the success of our method.

7.3.2. Background on the Process Mining Study

Although this study focuses on the evaluation phase of process mining projects, we will briefly set the scene and describe the preceding phases that were performed. In both locations, the processes that were to be analysed were predetermined by the team involved in the project based on the hospital's priorities. The processes fall under the category 'medical treatment processes'. In particular, we selected processes that were performed on a cross-departmental level, such that results from departments could be compared. For location 1, the decision was made to focus on processes performed on the nursing wards, specifically:

- Screening a patient for malnutrition
- Recording the vital signs of a patient
- Placing a medication order
- Discharging a patient

At location 2, we focused on processes performed at the outpatient clinics, namely:

- Requesting and performing a peer consultation
- Requesting and performing a radiology examination

For each of the processes, a number of questions were defined that were to be answered during the project. Many of these were generic questions related to the three main pillars within process mining: discovery, conformance and enhancement (Van der Aalst, 2011). A number of them were related to a specific subcategory of conformance, namely the use of 'workarounds' within processes. Workarounds are intentional deviations from designed procedures, and some of them can be detected using process mining (Beerepoot, Lu, et al., 2021).

The data necessary for analysing the selected processes and answering the questions were pseudonymised and provided to the process analyst by the business intelligence department of each hospital. We then transformed the data to the required event log format using Power Query, after which we used the PAFnow process mining plugin for Microsoft Power BI[9]. PAFnow provides a set of custom process mining visualisations that can be used alongside regular data visualisations, allowing for the creation of dashboards not possible using other tools. This allowed for presenting information in multiple ways, enabling the process analyst to anticipate upon the needs of the project team.

After importing the event log into PAFnow, the process analyst performed a series of analyses with the objective of answering the predetermined questions for each process. This resulted in a number of dashboards, containing both general information about the process, as well as specific dashboards with information that the process analyst deemed relevant for answering the research questions.

7.3.3. Cycles of Action and Reflection

In line with the iterative character of both action research and process mining efforts, we performed a number of evaluation cycles across the two locations. Each

[9] https://pafnow.com/

cycle represents an evaluation session with the hospital team where the analysis insights of each of the processes were evaluated. Depending on whether new questions about the data arose during the sessions, the researcher would start another round of data processing and analysis. Figure 22 illustrates the cycles of action and reflection, and is further explained below.

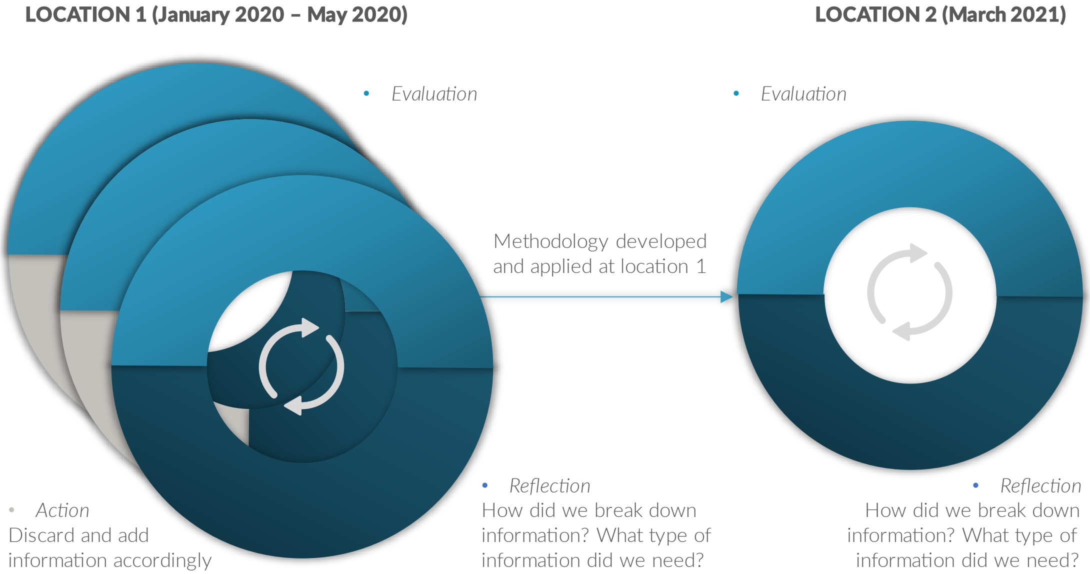

Figure 22 - Illustration of the Method Used

At location 1, we performed three evaluation cycles between January 2020 and May 2020. After those three cycles, no new information was requested by the participants and consensus on the improvement ideas was reached. The *evaluation* sessions were held in the form of interactive workshops and were facilitated by the process analyst, i.e. the first author. During the sessions, the analyst encouraged participants to think aloud with regards to how they interpreted the information presented to them, how they reached their conclusions, and optionally: what information they considered missing. After each evaluation cycle, the first author *reflected* on the discussions through qualitative synthesis (Denyer and Tranfield, 2006). The objective for the qualitative synthesis was as follows: (1) to define the type of information in the dashboards that was considered the most helpful for the evaluation team, and in extension (2) to discover the path for moving from insights to improvement ideas, by abstracting from the dashboards and defining the general steps necessary to fulfil the participants' information needs. In the case of starting a new cycle of data processing and analysis, the analyst took *action* and changed the dashboards accordingly, discarding information deemed unimportant and adding information deemed important. As shown in Figure 22, the third and last iteration did not include an action cycle as no further adjustments to the dashboards were needed.

At location 2, after applying all lessons learned at location 1, only one cycle was deemed necessary by the team, providing evidence for the maturity of the method and its successful application in a different context. As such, the cycle at location 2 only includes the evaluation session and a corresponding reflection afterwards.

The reflection and action cycles shown in Figure 22 resulted in a method providing an overview of the evaluation stages and the type of information that was deemed most helpful in identifying insights to act on. This method is outlined in the following section.

7.4. Results

Based on multiple evaluation sessions at the two locations, we propose a novel method called the FEI funnel. Section 7.4.1 provides an overview of the main stages of the method. Sections 7.4.2 until 7.4.5 describe each of the stages in detail, providing examples from the two locations and the information types, or process perspectives, that were used in each of the stages.

7.4.1. Overview of the FEI Funnel: Familiarisation, Explanation and Ideation

The proposed method, the FEI funnel visualised in Figure 23, consists of three stages: process familiarisation, domain explanation, and improvement ideation. The evaluation takes place after the analysis, therefore, we assume that one or more analyses have been performed by the process analyst without the involvement of domain experts. The stages of the evaluation are aimed at interpreting the insights of the analysis with the healthcare professionals, resulting in one or more improvement ideas. The three stages are performed during each evaluation cycle, i.e. they can be performed multiple times during one process mining project. They are typically facilitated by a process analyst and attended by at least one, but preferably several, healthcare professionals representing different perspectives. Depending on whether new information is deemed necessary to achieve consensus on improvement ideas, another round of data pre-processing and analysis can be performed by the process analyst, before the evaluation with healthcare professionals is continued.

Figure 23 also highlights, for each stage, to which process perspective(s) significant attention is attributed. It is important to note here that each of the stages builds further on the activities of the earlier stage. Therefore, rather than disregarding certain process perspectives later in the evaluation, this should be interpreted as a gradual shift in focus. When moving through the funnel, we start with a rather general view of the process and systematically zoom in on the relevant information to end up with actionable improvement ideas.

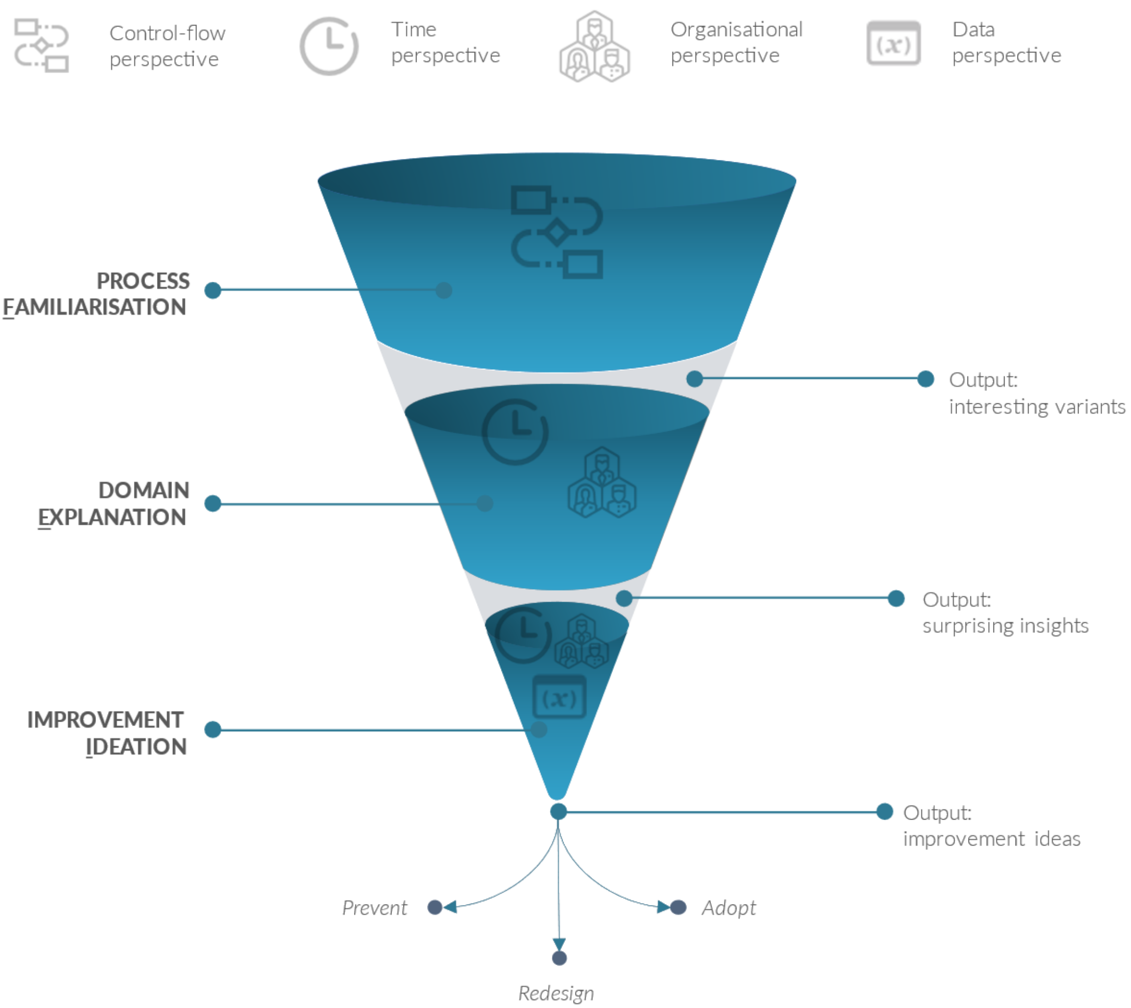

Figure 23 - The FEI Funnel

The first stage, *process familiarisation*, provides the evaluation team with an overview of the process and the order of activities. By presenting the process map and discussing the variants, the participants get a feel of the scope of the process studied, what activities are included and more importantly, what is not considered. Within the process familiarisation stage, the team identifies interesting variants which are considered relevant to zoom further in on. The stage is concluded when the team reaches consensus on a selection of variants that are of particular interest in the context of improving processes. This selection constitutes the input for the next stage.

The next stage, *domain explanation*, concerns further interpreting the selected process variants by applying domain knowledge. Especially regarding temporal and organisational aspects of the process, domain experts can explain certain findings and patterns. Disregarding insights deemed unsurprising by the healthcare professionals allows those involved in the evaluation to further zoom in on the surprising ones. The stage is concluded when the team reaches consensus on the set of surprising insights that may be valuable in deciding on possible process improvements. As such, those insights are the input for the final stage of the evaluation.

The final stage, *improvement ideation*, involves translating the identified surprising insights into specific improvement ideas. At this point in the session, the team performs in-depth discussions related to the time, organisational, and data perspectives of the process. This stage results in specific improvement ideas, which are actionable and constitute the basis for an implementation trajectory. Three key categories of improvement ideas and associated actions can be distinguished:

- *Prevent*, which includes ideas for developing measures to block particular process behaviour in the future;
- *Adopt*, which includes ideas for formalising particular process behaviour into the formal process in the future;
- *Redesign*, which includes ideas for changing the process, for example by making changes to information systems.

These three action types were adopted from the Workaround Snapshot Approach (Beerepoot and van de Weerd, 2018a). At first, they were only used to discuss actions related to the detected workarounds, but found applicable to discuss generic process mining insights as well. Note that with choosing *prevent*, the normative process remains the same, while with *adopt*, it is changed. The difference between *adopt* and *redesign* is that with the former, process behaviour that already exists is formalised, while with the latter, the process as it exists is reimagined. The Workaround Snapshot Approach includes one more action, *ignore*, but as the key premise of the improvement ideation stage is identifying opportunities for process improvement, this was never considered.

7.4.2. Process Familiarisation

The first part of the evaluation, process familiarisation, is aimed at providing a high-level overview of the process and getting the team to understand the meaning of the information in the dashboards. To get familiar with the process, visualisations illustrating the control-flow were particularly helpful to the evaluation team. By showing the order of activities and corresponding variants using PAFnow's Process Explorer and Case Viewer, the team could grasp the available information on the processes and classify the variants into interesting and less interesting ones.

7.4.2.1.Illustrative Example

To illustrate the first stage of process familiarisation and the output thereof, consider the following example from our study. Figure 24 visualises the process of screening a patient for malnutrition. The process typically starts with the patient arriving at the hospital. Afterwards, the patient is usually hospitalised and then screened, although it also occurs that the patient is screened before hospitalisation or that the time of hospitalisation is unknown. After the screening, the results are registered. When the results are registered, the process either ends, or a consultation with a dietician is planned and held.

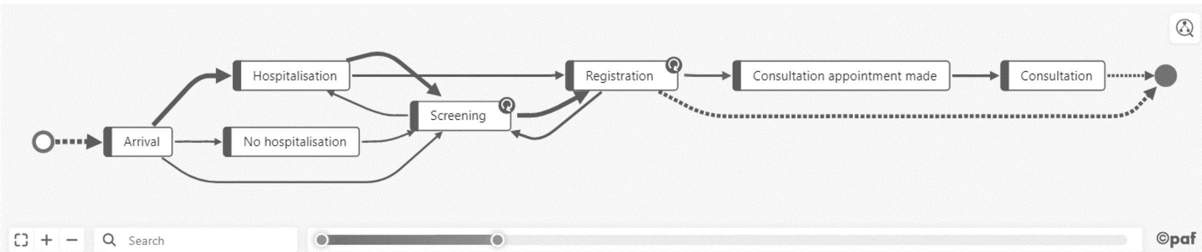

Figure 24 - Process map of screening a patient for malnutrition, courtesy of PAFnow

Discussing the order of activities helped identify interesting process variants to zoom into further. For example, the healthcare professionals deemed it particularly interesting that a number of patients is screened for malnutrition before they are officially hospitalised, which is regarded a positive development. Another variant of interest was that of patients where no hospitalisation time is registered. Last, there was a particular interest in the circumstances in which a consultation is held or not, which is discussed more in-depth in Section 7.4.4.

7.4.3. Domain Explanation

After familiarisation with the process and identification of interesting variants to zoom in on, we would continue with interpreting these variants further using the domain knowledge of the healthcare professionals. During this activity, we particularly made use of visualisations containing information from the time and organisational perspective. In doing so, the domain experts could explain certain insights deemed surprising by the process analyst but not very surprising by the domain experts, when taking into account the characteristics of certain departments, occupations, or time periods. Hiding information deemed unsurprising by healthcare professionals allowed a more focused analysis of results that were surprising to them.

7.4.3.1.Illustrative Example 1

To illustrate the domain explanation stage, consider the process of placing a medication order. In our study, interesting variants for nurses to place a medication order were identified during process familiarisation. Normally, doctors prescribe medication for patients, and nurses often administer this medication. However, in situations where the doctor has not done so and is not available, a nurse can place a one-time medication order and administer it right away. Figure 25 visualises the time of the day where such one-time orders are created.

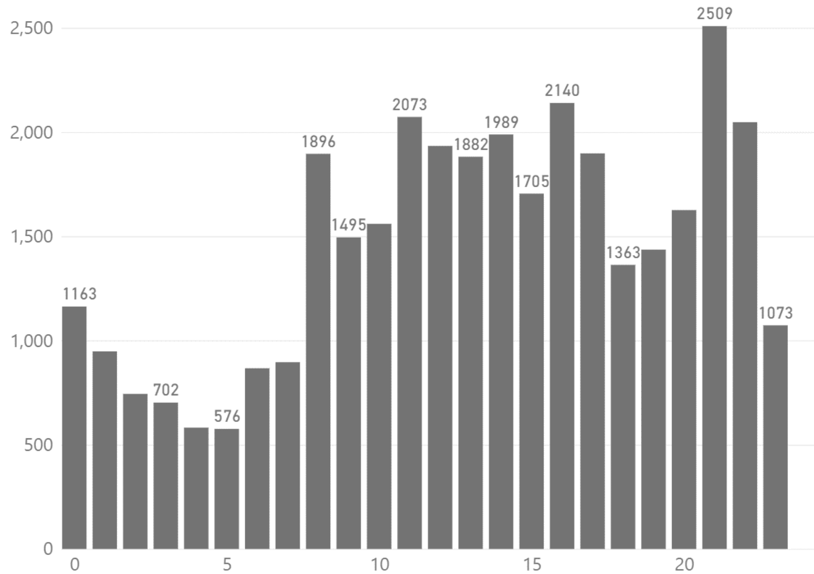

Figure 25 - One-time medication orders during the day

Discussing this visualisation during the domain explanation phase allowed the clinicians to point out that the results largely translate to the usual medication cycles: just before 9 AM, noon, 6 PM, and 10 PM. However, they also noted that during these times the doctor should be available to prescribe the medication rather than have nurses do so, which constituted a surprising finding. The numbers between 10 PM and 8 AM were considered less surprising and because doctors were not available. These insights provided input for the next stage in the evaluation, with the aim of minimising the use of one-time medication orders such that nurses' medication times decrease.

7.4.3.2.Illustrative Example 2

To illustrate the domain explanation stage with another example, consider again the medication order process, but this time the other path of placing a medication order: namely using a particular button that allowed nurses to specify a type of medication that their department had (almost) run out of. Using this functionality would result in the hospital pharmacy receiving an order to deliver the medication to that department. Figure 26 provides an illustration of the frequency with which the functionality was used to request different types of medication, over each of the departments.

Zooming in on the types of medication requested per department allowed the domain experts to point out which results were surprising and which ones were unsurprising. Such information was deemed valuable for assessing whether a specific type of medication should be included in the standard medication set of that department, saving the nurses and pharmacy time. The latter is an example of a *redesigned* process, as changes are being made to the information system, thereby reimagining the normative process.

Figure 26 - Types of medication requested per department

7.4.4. Improvement Ideation

The final stage of improvement ideation is aimed at identifying the key insights and brainstorm for potential improvement ideas. At this point in the evaluation, the unsurprising results are hidden from view, providing the domain experts with a focused presentation of where improvement efforts are necessary. This results in the identification of improvement ideas and the associated actions, categorised as prevent, redesign, or adopt. As in the previous stage, it was particularly helpful to look at the organisational perspective by comparing different departments. Improvements would typically be implemented on the departmental level, and comparing departments helps put absolute numbers into perspective which helps decide where to act. Other than the comparison of numbers over departments, the improvement ideation stage also involved focusing on the time and data perspective.

7.4.4.1.Illustrative Example 1

To illustrate the improvement ideation stage, consider the process of discharging patients from the hospital. Before a patient is discharged from a clinical department, a number of tasks need to be performed, one of which being the generation of a visit summary by a nurse. Figure 27 presents the number of times where such a visit summary was generated for each department, relative to the total number of patient discharges for that department.

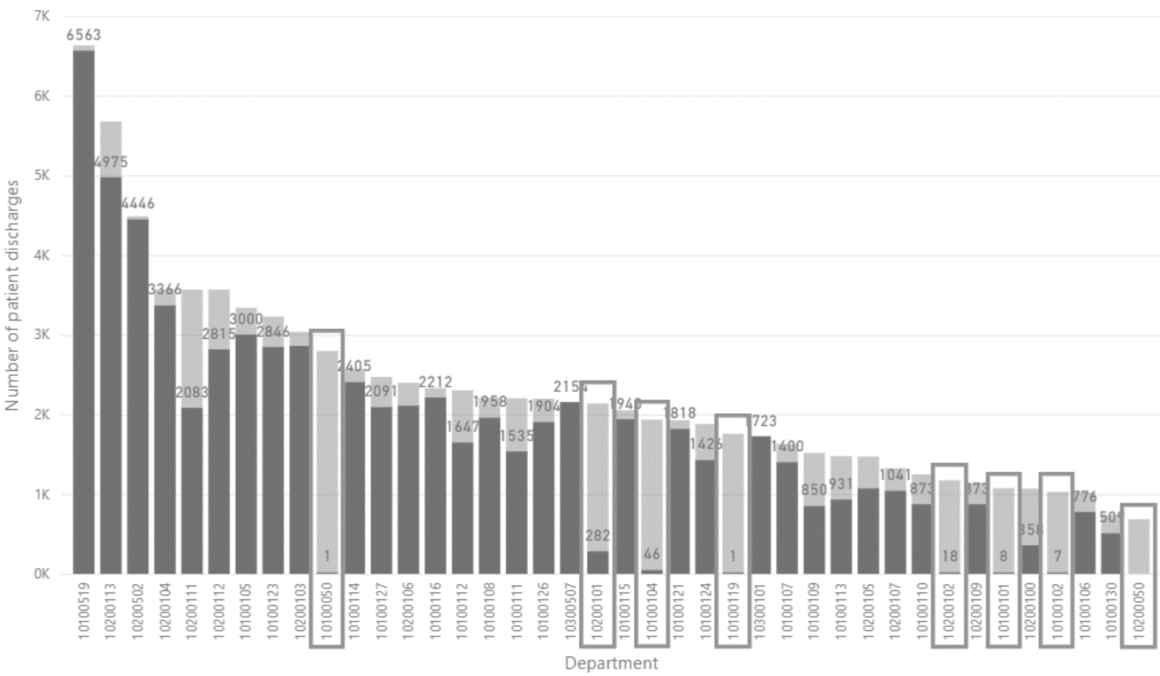

Figure 27 - Portion of cases in which a visit summary was generated at patient discharge

Based on this information, the evaluation team was able to conclude that most departments meet this agreement, but that some departments are surprisingly underperforming in this respect. Drilling down to this particular part of the process and putting the numbers into perspective allowed the evaluation team to identify departments where improvement is possible and necessary. During the improvement ideation stage, plans were made to approach the departments that produced worrying results (examples marked in the figure), to make them aware of the agreement and to monitor the developments over time. As such, the *prevent* action was chosen.

7.4.4.2.Illustrative Example 2

To illustrate the improvement ideation stage with another example, consider again the process of screening a patient for malnutrition as illustrated in Figure 24. One agreement in this process is as follows. The result of the screening is a value from 0 to 7. When the value is equal to or higher than 3, a consultation with a dietician needs to be planned. This value is a data attribute that is tied to the process. Figure 28 illustrates the values of the malnutrition screening, for cases that are not followed by a dietician consultation.

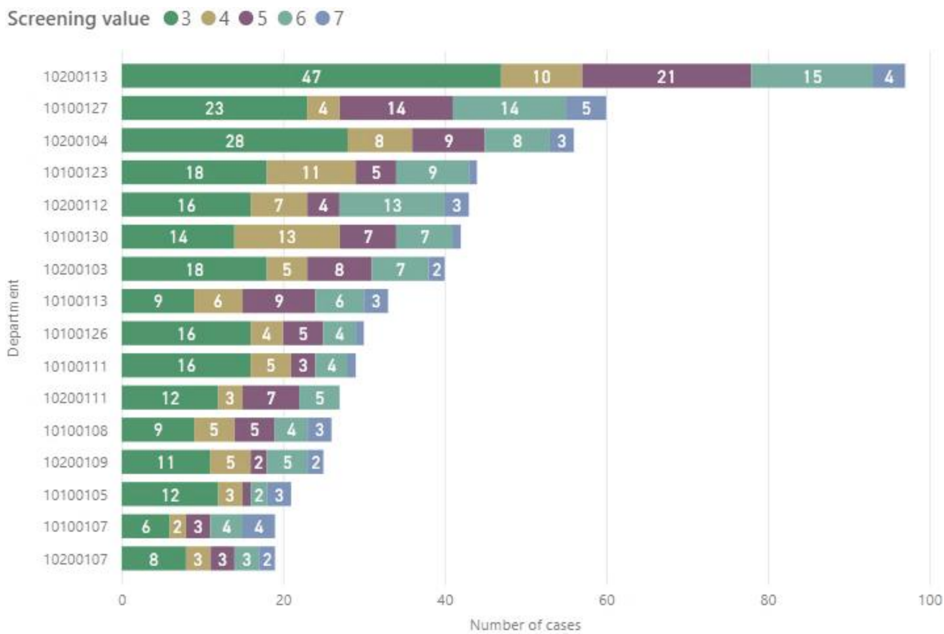

Figure 28 - Values of the malnutrition screening not followed by a consultation

The information presented in the figure allowed the evaluation team to propose targeted action, such as addressing the departments in which a high number of incompliant cases are found and taking measures to enforce compliance. Again, this would count as a preventive action. However, we also came across the opposite: cases where consultations were planned even though the screening value was below 3. Upon discussion of these cases, valid reasons were found to deviate from the agreements. These reasons were consequently included in the list of agreements and thus, *adopted* in the formal process.

7.4.5. Outcomes of Evaluation Stage

After completing the evaluation stage, both hospitals have already started the implementation of the generated improvement ideas or are in the process of doing so. From the start, the hospital of location 1 expressed their wish to learn how process mining works and how they can do analyses themselves. As such, the first author has instructed them in the use of the tool. The created dashboards were shared with the Business Intelligence department of the hospitals, which has since incorporated these in the regular dashboards used in so-called sprints. In these regularly organised sprints, each department meets to tackle issues per theme. Together, they decide on which positive practices to adopt across the department, and which ones to prevent from happening. At these sprints, one or more HIS experts are present, who can propose potential changes to the HIS to streamline the processes.

At location 2, the evaluation stage of the process mining project has only recently been completed. As such, the improvement ideas have not yet been fully implemented, but the decision-makers have taken up the ideas and have expanded the project to include the full set of outpatient processes. This still has to start at the time of writing this article.

7.5. Discussion

In this study, we set out to develop a method to support process analysts when evaluating process mining insights with healthcare professionals in order to convert them to actionable improvement ideas. Although current literature does not provide such a method yet, parts of our findings resemble earlier reflections as mentioned by other authors. We discuss such resemblances and differences in the following sections.

7.5.1. Reflection on the Proposed Stages

The first stage that we distinguish in evaluation efforts relates to process familiarisation. Although this stage has not yet been proposed as a stage in the evaluation of process mining insights, it has been mentioned as a necessary activity for *process analysts* in other phases in process mining projects. For example, Klinkmüller et al. (2019) identify the activity of familiarisation as one where analysts examine domain problems. Other studies mention familiarisation activities in the data preparation or pre-processing phases of process mining endeavours (Carvallo et al., 2017; Valle et al., 2019). As there is evidence that process analysts need to spend time and effort to get familiar with the process, its characteristics and particularities, the same holds for the moment the domain experts are involved in evaluating the findings and making sense of them. In fact, domain experts often lack experience with process mining and process thinking in general, making interpretation of findings difficult and time-consuming (van Eck et al., 2015). Approaching process familiarisation as a dedicated stage in the evaluation with domain experts may help smoothen the path to improvement.

The second stage in our method is domain explanation. Several studies in the field of process mining have hinted at the importance of domain knowledge for interpreting, explaining and enhancing findings (e.g. Baier et al., 2014; Dixit et al., 2015). Focusing and acting on the data alone is believed to give an incomplete picture of the process, and could lead to incorrect decisions. In healthcare, the contextual and domain-specific knowledge that healthcare professionals can offer is believed to be especially vital (Montani et al., 2014; Mannhardt and Blinde, 2017). Including domain explanation as a dedicated stage in the proposed method allows domain experts to systematically interpret findings and distinguish between surprising and unsurprising process mining insights. Paying specific attention to domain explanation can facilitate making correct decisions in the final stage of the method as it sets a clear focus on surprising insights from the perspective of healthcare practitioners.

The final stage in the FEI funnel, improvement ideation, is the least discussed one in current process mining literature. General process mining methodologies that have been proposed often prescribe a process improvement phase after the evaluation has been completed (Van der Aalst, 2011; van Eck et al., 2015). However, how the improvement ideas which are needed in the improvement phase, are generated in the evaluation phase, has largely been unknown. The FEI funnel constitutes a first attempt to structure the various stages of generating improvement ideas starting from process mining insights.

7.5.2. Breaking Down Information

A key characteristic of the FEI funnel is that process information is gradually broken down, enabling the evaluation team to systematically zoom in to identify underlying improvement opportunities. A connection can be made with the activities of slicing, dicing, rolling up and drilling down. These activities were originally introduced in the Online Analytical Processing (OLAP) field, but adopted in the field of process mining by Van der Aalst (2013). Within the context of *process cubes*, these concepts were leveraged to decompose larger problems into smaller, more manageable, ones.

Slicing and dicing is used to discard or hide certain dimensions of the information. Such techniques are predominantly used in pre-processing or analysis stages (van Eck et al., 2015). In contrast, rolling up or drilling down activities are not aimed at removing or hiding events, but at changing the level of granularity at which the information is studied. As such, these concepts are often used in the analysis stage. For example: De Weerdt et al. (2012) propose a methodology to analyse clinical pathway data, using rolling up and drilling down data. Initially, they use roll up to gain insights into the overall behaviour within the process. Afterwards, they drill down to zoom in on certain parts of the data. Outside the healthcare context, drill down techniques have also been used, e.g., in educational settings. Use cases include comparing successful and unsuccessful students in a particular course (Van der Aalst et al., 2013) and identifying student cohorts (Leemans et al., 2020).

Our study shows that the ideas behind such techniques are not only useful in the pre-processing and analysis stage of a process mining project, but they are also valuable when evaluating insights with domain experts. The FEI funnel's first stage of process familiarisation can be seen as a form of *rolling up* to get an overview of the general behaviour in the process. The domain explanation stage can be used to produce sub-cubes containing information on particular variants based on certain temporal and organisational dimensions, also known as *dicing*. Furthermore, *slicing* and *dicing* the cubes allows the process analyst to zoom in further into the improvement opportunities together with the domain experts and hide information from view to prevent information overload.

7.5.3. The Importance of Context

From the previous sections, it is evident that several ideas underlying the FEI funnel are considered valuable in various other phases of process mining projects, such as pre-processing and analysis. However, one element has proven to be especially important in the evaluation phase, even more so than in other phases, and that is context. A common reason for failed process improvement projects, is the lack of context-awareness (Benner and Tushman, 2003; Vom Brocke et al., 2014). Within process mining projects, the results of the evaluation are the input for process improvements. As such, the resulting improvement ideas need to take contextual factors into account in order to be successfully implemented. Indeed, in the evaluation sessions with healthcare professionals, it became evident that deciding on the most appropriate improvement actions depends highly on contextual factors. Insights that may seem surprising at first, are sometimes no longer surprising when temporal and organisational factors are taken into account. Discovered process behaviour may be prevented in one department, but adopted in another, depending on the circumstances within the department.

The importance of contextual factors in generating appropriate improvement ideas also highlights the significance of incorporating multiple process perspectives in process mining efforts. In process mining research and applications, there has been and still is a predominant focus on the control-flow perspective on the process (Mannhardt et al., 2016). The time, organisational, and data perspectives have received far less research attention. In our study, we found a control-flow model to be highly valuable in the evaluation phase of projects, especially at the start of evaluation sessions. However, we also noticed the importance of the other process perspectives and found that the organisational perspective was particularly vital as hospitals tend to strongly focus on individual departments and how they compare to others. Techniques that help to visually compare process behaviour within departments and include contextual information are scarce, but would be highly valuable in facilitating decision-making within hospitals.

7.6. Conclusion and Future Work

In this study, we propose the FEI funnel, which is a novel three-staged method to support process analysts when evaluating process mining insights with healthcare professionals. The method aims to assist process analysts in translating process mining insights into actionable improvement ideas through iterative cycles with healthcare professionals. Within the process mining field, it constitutes the first attempt to open the black box regarding the path from process mining insights to actionable improvement ideas. While process mining research has largely focused on the control-flow of processes, the FEI funnel argues for multi-perspective evaluations with domain experts to arrive at appropriate improvement ideas. As the method is developed using action research at two distinct healthcare locations, we also pay particular attention to the complexity of healthcare processes and healthcare organisations within the stages of process familiarisation, domain explanation, and improvement ideation.

For future work, we aim for a broader application of the FEI funnel in different types of healthcare settings to further substantiate its generalisability. Moreover, future research could focus on the development of visual analytics techniques that better support the evaluation process with domain experts, rather than having a sole focus on the analysis process of process analysts. This could, for example, entail the development of visualisation techniques that help compare process behaviour of departments and visualise that behaviour over time, while taking into account contextual factors. In this way, the generation of high-quality improvement ideas can be facilitated, which can afterwards be implemented to contribute to better patient care.

Chapter 8

Conclusion & Outlook

This final chapter provides a summary of the main results in the context of our contributions. Additionally, we describe a number of workaround problems that remain to be solved. We end with a reflection on the opportunities that arise once the stated problems have been solved.

8.1. Contributions and Implications

This thesis aimed to contribute solutions to the challenge of detecting and analysing health information systems workarounds and consequently improving healthcare processes. In order to outline our key contributions, we adopt the three types of knowledge contributions as described by Ågerfalk and Karlsson (2020): artefactual, empirical and theoretical. The authors argue that these contributions are tightly intertwined with implications for practice, which they subdivide into implications for *research* and *domain* practice. In the following paragraphs, we combine the discussion of our contributions to knowledge with their implications for research practice, and then separately discuss our studies' implications for domain practice, i.e. healthcare organisations.

8.1.1. Artefactual Contributions and Implications for Research Practice

As a result of our design science and action research studies, we developed four artefacts. In Chapter 3, we proposed the Workaround Snapshot Approach to detect, analyse, and address workarounds. This approach includes two more artefacts: the Workaround Snapshot and Action Impact Matrix, which can be used to capture knowledge of workarounds and evaluate the impacts of decisions, respectively. The final key artefact that we proposed in this thesis is the FEI Funnel in Chapter 7, a method for translating process mining insights to actionable improvement opportunities. The artefacts developed in the context of this thesis provide research practice with structure and rigour in studying workarounds in healthcare organisations. Researchers may choose to adopt our artefacts partly or in full, customise them to their specific needs, or propose extensions. Although the artefacts have been validated in the healthcare domain alone, their contents are not healthcare-specific, and thus future work must confirm whether they are useful in other domains.

8.1.2. Empirical Contributions and Implications for Research Practice

By studying workarounds within seven healthcare organisations using mixed methods, we also provided empirical accounts of aspects of the phenomenon not previously covered by research. Specifically, we provided rich descriptions of the detection of workarounds from multiple perspectives using process mining techniques. In addition, we described in-depth the different power dynamics that are at play in the emergence of workarounds. Last, we provided insights into the various process characteristics relevant for the analysis of workarounds in healthcare and their influence on the managerial decision to accept or reject a workaround. Our empirical accounts may be used by research practice for generalising to theory or for developing new empirically-informed artefacts. Our rich descriptions of aspects of the phenomenon and the traces some workarounds leave in the data may be used to illustrate practices in healthcare organisations or to evaluate new data mining techniques.

8.1.3. Theoretical Contribution and Implications for Research Practice

The focus in this thesis lies more on developing artefacts for dealing with workarounds and providing rich accounts of the phenomenon in healthcare organisations, than on developing new theories. Nevertheless, in Chapter 5 we provide a theoretical contribution in the form of an overview of the types of power that are involved in the emergence of workarounds. Not only does our overview explain what happens, it also bears value for predicting what may happen when an actor exercises their hierarchical power towards other actors or when the system is designed too restrictively. As such, our study provides research practice with opportunities for analysing and explaining observed phenomena, as well as possibly predicting the effects of changes made to processes.

8.1.4. Implications for Domain Practice

As can be observed throughout this thesis, workarounds are widespread within healthcare organisations and can have various consequences to healthcare work. Therefore, the implications of our studies' results for domain practice deserve considerable attention. Based on the results of our study, we argue that ideally, workarounds do not exist. If work processes are perfectly designed and supported by information systems, process participants should not feel the need to enact workarounds. Therefore, it is preferred to prevent the emergence of workarounds altogether. However, once they do emerge, which is many times inevitable, organisations would do well to study the reasons for their emergence and act on them accordingly. We might refer to the two situations as *preventive* and *reactive* workaround management.

In the context of *preventive* workaround management, the results of our studies highlight the need for management to be and remain in close contact with process participants. Developing a sharing culture in which their input is encouraged, helps identify obstacles that may later develop into workarounds. In addition, our studies have given insights into the role of hierarchical and restrictive power dynamics in the emergence of workarounds. Preventing their emergence implies finding a balance between restriction and flexibility, as well as balancing the various levels of authority of actors in healthcare organisations.

When *reactive* workaround management is required, the results of our studies may also be consulted. First, in terms of gathering information on which to base managerial decisions, our results show that the combination of interviews and observations with data mining techniques such as process mining leads to the most complete and rich results. Second, we showed that the trade-offs involved in reacting to workarounds are as prevalent in reactive as in preventive workaround management. In order to assess the full spectrum of the involved trade-offs associated with a workaround, we propose a dual assessment: one on the effects that the workaround currently has on the process, and one on the effects that potential responses might have. Additionally, our studies have shown that information collection and assessment is best performed continuously rather than once, as work situations continuously change. In both information collection and assessment, the involvement of process participants with different backgrounds is crucial, and this thesis provides systematic approaches for structuring this involvement.

8.2. Problems to Solve Before We Die

Although this thesis provides a number of solutions in the context of workaround detection, analysis and resulting process improvements, significant problems remain to be solved. Inspired by the 2021 International Workshop on BPM Problems to Solve Before We Die (Beerepoot, Di Ciccio, et al., 2021), we outline a number of workaround problems that we hope to see solved within the coming decades.

First, we identify the problem of *the possible lack of a clear distinction between a workaround and the designed path*. Various definitions of workarounds have been proposed, most of which describing some sort of obstacle in the way of the designed path and some behaviour that works around that obstacle to achieve the same goal (Ejnefjäll and Ågerfalk, 2019). But how do we define the designed path when there is no perfect process documentation to describe it? And what happens when the workaround is institutionalised to such an extent that one might say it has replaced the designed path? Is it then no longer a workaround? And: on what granularity level should we define the goal of the process? Is it still a workaround when the end result is slightly different when the general outcome remains the same?

Second, we identify the problem of *inaccessible domain knowledge in making sense of workarounds*. In our studies, we were fortunate to have access to a large number of domain experts with extensive backgrounds. We have spent hours on end to understand particular work practices and the workarounds that emerged within them. Doing so, we have only scratched the surface of the enormous range of workarounds that exist and the reasons for enacting them. The introduction of data mining techniques such as process mining hold great value for further detecting and analysing workarounds in-depth, but in finding new types of workarounds we remain dependent on domain experts. As healthcare professionals have limited availability, there is a need for approaches that help collect rich domain knowledge in an efficient manner and augment event logs with this knowledge (Calvanese et al., 2021).

Third, we identify the problem of *unrecorded workaround behaviour*. Process mining techniques rely on event logs recording behaviour of users of information systems. By definition, workarounds entail behaviour that deviates from the designed path as often supported by information systems. The user may opt for taking a different route within the system, or ignore the system altogether. In the former, it is unsure whether the behaviour is recorded in event logs. In the latter, it is quite certain that it is not. As such, the event data may give an incorrect picture of the actual behaviour of process participants. Observing participants in real life may help fill in the blank spots, but does rely on availability as outlined in the previous paragraph. Another avenue for exploration may be the inclusion of data from existing devices and sensors to augment the event data, but these data are often of low quality (Cohen and Gal, 2021).

Fourth, we identify the problem of *unknown cascading effects of workarounds*. In order to make proper managerial decisions, it is vital to know the effects of workarounds on different aspects of the process. By discussing the workaround with the different parties involved, we get some idea of the perceived effects, but we cannot exclude the influence of other factors on current outcomes. There lies a complex challenge in connecting certain behaviour to achieved results later in the process. Possibly, we might make use of digital twins for simulating the effect of changes in process behaviour (Dumas, 2021).

Last, we identify the problem of *undetected development of workarounds over time*. Earlier in this section, we already referred to the institutionalisation of workarounds over time. As of yet, we have little insight into where workarounds emerge and how they disperse throughout organisations. Once we have larger repositories of data patterns that indicate workarounds in event data, we can potentially make use of concept drift techniques (Bose et al., 2011) to detect sudden, recurring, gradual and incremental drifts in workaround behaviour.

8.2.1. Opportunities When Problems are Solved

In Section 8.1.4, we discussed the implications of our studies' results for approaching *preventive* and *reactive* workaround management. However, when the problems outlined in the previous section are solved, we argue that we can move towards a form of *proactive* workaround management. We imagine a setting in which the full spectrum of workaround types has already been observed at least once, and identified in event logs. For each type, it is known how it emerged and which aspects of the process it affects. Once new information systems are designed to support work processes or when updated versions are planned, organisations can immediately simulate the consequences that the planned changes will have on the behaviour of the process participants involved. Not only will we know whether workarounds will exist right after implementation, we will be able to predict whether they disappear over time or disperse and become institutionalised. New workaround types may still emerge, but because of the available rich knowledge on similar types, we only require little effort from domain experts to make sense of the new workaround behaviour and map their effects. Managers will be presented with a wide array of options to address workarounds up-front, supported in their decision-making by an elaboration of the different (cascading) effects that each decision will have. Some workarounds will remain in favour of avoiding others, but most will be resolved before they even appear. Workarounds of the past will help to better support work in the future.

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Appendix

Table 22 and Table 23 contain the complete characterisations of rejected and accepted workarounds.

Table 22 - Characterisation of Rejected Workarounds

Characteristic	W1	W2	W4	W6	W7	W8
Knowledge	0	0	1	0	1	1
Patient involvement	1	1	1	1	0	0
Healthcare professional	1	1	1	1	1	1
Collaboration	0	1	1	0	0	1
Structure	0	1	0	0	1	1
Repeatability	1	1	1	1	1	1
Laws and regulations	0	1	1	0	0	1
Complexity	1	1	1	0	1	0
Predictability	0	1	0	1	0	1

Table 23 – Characterisation of Accepted Workarounds

Characteristic	W3	W5	W9	W10
Knowledge	0	0	0	0
Patient involvement	1	0	0	0
Healthcare professional	1	1	1	1
Collaboration	0	1	1	1
Structure	1	0	0	0
Repeatability	1	1	1	1
Laws and regulations	1	0	1	0
Complexity	1	1	0	0
Predictability	1	1	0	1

List of Figures

List of Tables

Publication List

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- Beerepoot, I. and I. van de Weerd. (2018). "Prevent, redesign, adopt or ignore: Improving healthcare using knowledge of workarounds." In: *European Conference on Information Systems*. Association for Information Systems.
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Curriculum Vitae

Iris Beerepoot was born on 20 October 1993 in Hoorn, The Netherlands. In 2012, she started her bachelor in Media and Culture at the University of Amsterdam. After doing a minor in Business Studies in Tromsø, Norway, and a minor in Programming at the University of Amsterdam, she enrolled in the Master Business Information Systems at the University of Amsterdam. For her master thesis, she performed an internship at ilionx, formerly ICTZ. This master thesis formed the basis for her PhD research that followed immediately afterwards. She started her PhD at the VU University in Amsterdam and continued this PhD at Utrecht University from September 2019 onwards.

During her PhD trajectory, Iris taught students in courses such as scientific research methods, theories in Information Systems, Business Process Management, and supervised several master student theses. She presented her work at several venues, such as the International Conference on Business Process Management, the International Conference on Information Systems, and the European Conference on Information Systems. Apart from teaching and research activities, Iris is a leading coordinator for the Girls Club WIN program that introduces girls in secondary school to research in science. She is also actively involved in the BPM community as an organiser of the BPM Problems to Solve Before We Die workshop and co-organiser of the BPM Expert Forum.