The Emergence and Evolution of Workarounds: A Study of Stability and Change

Completed Research Paper

Wouter van der Waal
Utrecht University
3584 CS Utrecht, The Netherlands
w.g.vanderwaal@uu.nl

Inge van de Weerd
Utrecht University
3584 CS Utrecht, The Netherlands
i.vandeweerd@uu.nl

Iris Beerepoot
Utrecht University
3584 CS Utrecht, The Netherlands
i.m.beerepoot@uu.nl

Hajo A. Reijers
Utrecht University
3584 CS Utrecht, The Netherlands
h.a.reijers@uu.nl

Abstract

Workarounds are often assumed to be quick fixes or stable practices. As most processes tend to change over time, we investigate this assumption. In an embedded case study, we analyze 13 years of process data from a large university teaching hospital. We investigate how the ratio of 10 workarounds changes over this period. We find that some workarounds remain stable over time, while others may change suddenly, temporarily, or continuously over time. We use historical documents to identify incidents that influence the use of workarounds and find that the dynamics of a workaround may switch between temporal categories. In contrast to earlier theories, we find that workers seem to adopt workarounds based on an individual need rather than a collective adoption after one person discovers it. In addition to these additions to current theory, we suggest future work that can answer currently open questions surrounding the evolution of workarounds.

Keywords: Workarounds, Healthcare, Process Mining, Business Process Management

Introduction

Management often prescribes specific ways of how a process should be executed. Even when workers try to follow these procedures, they may be blocked from doing so by a misaligned IT system, limited time, limited resources, or mistakes from colleagues. Such obstacles can be worked around by deviating from the prescribed procedure to still reach the original goal (Alter, 2014; Ejnefjäll & Ågerfalk, 2019).

By raising attention to perceived obstacles, workarounds indicate issues with the underlying process or system. While the identification of obstacles can be used directly to prevent the workaround from occurring, the resulting workaround may show advantages over the original process, such as being more efficient (Cresswell et al., 2016). During the redesign of procedures, organizations may choose to adopt such advantageous workarounds in their official workflow. However, as there could also be dangers linked to the workaround, prevention is sometimes preferable instead (Beerepoot & van de Weerd, 2018). Whether a workaround is eventually prevented or adopted, it is clear that it is beneficial for management to be aware of their existence.

Often, the temporality of workarounds is assumed to consist of either workarounds as quick fixes or workarounds leading to long-term stability (Ejnefjäll et al., 2023). This stability may be general or through planned institutionalization after a brief period. Some scholars explored a more dynamic perspective of workarounds and found, for example, that workarounds could evolve (Wong et al., 2022), gradually disappear (Zhou et al., 2011) and go through different stages of development (Safadi & Faraj, 2010; Davidson et al., 2021). These studies are all conducted with qualitative research methods, which means that the workarounds could only be studied individually, over a relatively short period. Some quantitative studies have been conducted that show that it is possible to automatically identify many workarounds within a process (Outmazgin & Soffer, 2014; van der Waal et al., 2024a; Weinzierl et al., 2021; Wijnhoven et al., 2023). However, the focus in these works is on finding workarounds in data at a single point in time, often a long time after the original execution of the process. As such, they do not provide insights into how workarounds may evolve. Given that processes tend to be very dynamic over time (Cloutier & Langley, 2020; Van de Ven & Poole, 1995), we assume that workarounds are more dynamic than currently described. With the present study, we address this research gap by investigating the evolution of workarounds over a sustained period. Understanding the dynamics of workarounds across time would further help manage workarounds, potentially even helping to predict or prevent harmful workarounds proactively.

In this paper, we present the results of an embedded case study, in which we examine ten types of workarounds in an academic teaching hospital over a period of 13 years. By applying automated detection rules on a dataset containing process data from the hospital's information systems, we can detect specific IS-related incidents that alter the evolution of workarounds. While we observe that some workarounds are stable, we also find three additional categories that describe more dynamic behavior. Furthermore, individual workarounds may switch between these categories. After the background, method, and results of this study, we will further discuss how these categories relate to each other and how our new insights into the long-term changes in workarounds fit with current theories.

Theoretical Background

Workarounds are a specific type of deviation from prescribed processes. We adopt the definition of Alter (2014, p.1044): "A workaround is a goal-driven adaptation, improvisation, or other change to one or more aspects of an existing work system 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 organizational or personal goals." Notably, this definition does not assume any temporal nature of workarounds.

Some scholars describe workarounds as short-term fixes (Kobayashi et al., 2005; Debono et al., 2013). Others extend this view by making a distinction between workarounds as temporary practices and workarounds that are persistent over extended periods (cf. Bartelheimer et al., 2023). As Ejnefjäll et al. (2023) explain, most workaround studies focusing on institutionalized workarounds, assume that these workarounds are stable. Some exceptions are related to workarounds that are connected to clear incidents. For example, the sudden emergence of a workaround due to the implementation of a new IS implementation (Alvarez, 2008; Boudreau & Robey, 2005; Koppel et al., 2008) or the sudden disappearance because the organization started to actively prevent it (Malaurent & Karanasios, 2020).

Several scholars have qualitatively analyzed the more dynamic and temporal nature of workarounds, which is in line with the assumption that any process evolves over time (Cloutier & Langley, 2020; Van de Ven & Poole, 1995). For example, Zhou et al. (2011) show that workarounds gradually disappear as users get more familiar with the designed path. Workarounds may also become more common when they are shared among users, during the training of new staff, or during the redesign of processes (Safadi & Faraj, 2010; Weinzierl et al., 2021). These practices can spread the workaround through the organization, potentially even institutionalizing it (Azad & King, 2012; Choudrie & Zamani, 2016; Cresswell et al., 2016; Davison R. M. et al., 2019), or serving as "generative mechanisms for bottom-up process innovation" (Bartelheimer et al., 2023). The dynamic nature of workarounds is further explored by Wong et al. (2022), who suggest that workarounds typically evolve unless they are simple one-time fixes that resolve a situation immediately.

Approaching workarounds as a dynamic, rather than static, phenomenon, aligns with the study of routines. Feldman and Pentland (2008, p. 236) define routines as "generative systems that produce repetitive, recognizable patterns of inter-dependent action carried out by multiple participants". Routines are recurring and collective and may contribute to organizational change (Becker, 2004). Since the inherent nature of these routines is highly dynamic, insights into how people work can be obtained by investigating various types of changes. Indeed, Zhou, Ackerman, and Zhen (2011) note that workarounds can be 'transitory', potentially vanishing as new training is implemented or as changes are made to system usage policies. Delving into the subtleties of workaround evolution, Alter (2014) introduces the concept of 'bricolage', which captures not only immediate improvisations but also the gradual adaptation of routines over time. In a similar vein, Safadi and Faraj (2010), along with Davison et al. (2021), empirically explore the developmental trajectory of workarounds but focus only on the first phases of workaround evolution. Weinzierl et al. (2021) also study the early stages of workaround emergence but note that temporary workarounds may eventually be routinized and "stabilize as an established practice". This makes the lifecycle of these practices crucial to understanding.

As Goff et al. (2021) highlight, the temporal dimensions of workarounds remain an under-researched area. One problem with studying the long-term evolution of workarounds is that qualitative methods such as interviews and observations are less suitable for identifying changes in processes over periods longer than a few months. Some studies use process mining techniques to analyze IS data to overcome this problem. However, up to date, these studies focus only on the detection of workarounds (cf. Outmazgin & Soffer, 2014; Beerepoot et al., 2021; van der Waal et al., 2024a; Wijnhoven et al., 2023). Although Weinzierl et al. (2021) emphasize that "workaround detection methods should consider the life-cycle stage of a workaround", they also solely focus on the emergence of workarounds in their study and not their evolution.

In conclusion, empirical studies predominantly distinguish between temporary and stable workarounds, with little attention given to other possible manifestations. While some researchers explore the evolving nature of workarounds, this has not been rigorously studied, partly due to the lack of appropriate analytical tools previously available. We argue that it is important to study the dynamic nature of workarounds since that would allow us to reveal how workarounds change over time. Unpacking how workarounds emerge and spread through the organization enables organizations to act proactive instead of reactive.

Method

In this embedded case study, we investigate the emergence and evolution of ten different types of workarounds analyzing process data from a Hospital Information System (HIS), supported by interviews and historical documentation concerning system updates. The case study method is especially suitable for complex, contemporary phenomena within their natural context, where the phenomena and context are inseparable (Yin, 2013). Using an embedded case study design allows for an in-depth examination of specific workarounds within the context of two different wards over an extended period.

Context

We conduct our study at the University Medical Center Utrecht (UMCU). This Dutch academic teaching hospital currently employs more than 12,000 people and treats around 220,000 patients annually. The two wards in our study are the Emergency Room (ER) and the Cardiovascular Care Unit (CCU). We selected these two embedded cases because they share commonalities but also have differences such as the number of patients and type of activities that are conducted. The ER has 19 treatment rooms and treats around 18,000 patients annually. The CCU has 10 beds and treats around 1300 patients annually. Both wards use the same HIS: HiX[1].

Data collection and analysis

Our project was approved by the Medical Research Ethics Committee (MREC) NedMec (research protocol number 22/1055). While the data of all patients is collected for medical purposes, patients can opt out of their data being used for research. We removed patients who indicated this after each data collection step.

Table 1 shows the four steps of this study and the data used for each. While the first two steps are essential but not the focus of this study, we do not describe them in detail but instead refer to the previous work (van der Waal et al., 2024b). Note that while we build upon previous work, our previous study was purely focused on workaround detection using data from only one month while we are currently applying the insights for

[1] https://www.chipsoft.com/en

a 13-year longitudinal study with a focus on the evolution of workarounds. The remainder of this section further details the steps of this study.

	Step	Goal	Data Source	Timespan
Focus of previous study	1	Discover workaround candidates	Initial HIS dataset containing two event logs covering 1,613 patients.	1 month
	2	Detect workarounds and determine strict indicator rules	1-hour interview with ER physician 1-hour interview with CCU physician	
Focus of current study	3	Monitor workaround indicators over time	Full HIS dataset, containing two event logs covering 249,633 patients.	13 years
	4	Identify process-altering incidents	Historical documents: presentations, meeting minutes, implementation reports	

Table 1. Data Usage Overview

Steps 1 and 2

In step 1, we used a logistic regression model that combined multiple patterns indicative of workarounds to analyze one month of HIS data. At this point, the goal was to simplify and speed up workaround detection compared to interviews and observations, not to extract all workarounds from the data. With this model, we were able to identify multiple workarounds in the Emergency Room (ER) and the Cardiovascular Care Unit (CCU). In step 2, domain experts were consulted to determine precise rules indicating a workaround's occurrence in a log of a single process execution based on the discovered workarounds. While monitoring any process over long periods is difficult due to inherent process changes (Cloutier & Langley, 2020), these indicators are of such a general nature that they can be applied to strongly differing processes. The resulting workaround indication rules, shown in Table 2, enabled us to recognize ten types of workarounds in various process variants.

Step 3

In our current study, we apply the workaround indication rules to 13 years of HIS data of the UMCU. This allows us to investigate how the process changes over time with a clear focus on distinguishing workaround evolution from its normative counterpart.

Data collection: For every known workaround, we identify the process in which it occurs and extract the corresponding process data from the HIS. We use all data that was recorded in the system; in most cases, the earliest point the process is registered is June 2011 with the introduction of the first version of the current HIS, although for two processes the first logged data is in March 2018 which coincides with a large update of the HIS. To account for the start-up effect of the system, we did not use the data from the initial few months, as this consisted largely of tests related to the implementation, instead of real usage. For the processes started in 2011, we only used data starting from January 2012, for the process in 2018, we started this in July 2018. In all cases, our cutoff point where we stopped the data collection was January 1, 2024. After formatting this data into event logs (van der Aalst et al., 2007), we apply the workaround indication rules to mark all workarounds as such using R[2]. For example, workaround indicator ER1 states that any activity occurring after a patient has been discharged is a clear sign of a workaround. The rationale is that if a patient is not in the hospital anymore, no additional tests can be conducted on the patient. The application of this rule is therefore straightforward. As the activities in an event log are ordered chronologically, any event that occurs at any time after the discharge clearly indicates a workaround. In the ER we analyze seven workarounds; in the CCU three. For each workaround, Table 2 lists a short description, the indicator rule, and the related process data in the full HIS dataset.

[2] The R-code used in this project can be found here: https://git.science.uu.nl/w.g.waal/sword-evolution/

Data analysis: The application of the workaround indicator rules allows us to conduct a synchronic analysis of process data (Berente et al., 2019) in which we analyze when the workarounds occur. After this initial analysis, we conduct a diachronic analysis in which we focus on how action patterns (in this study, workarounds) change over time (Barley, 1990; Berente et al., 2019; Pentland et al., 2021). Specifically, we investigate when and how the ratios of workarounds to normative behavior change. In R, we calculate the ratio of workarounds to normative process executions and present the results in graph form. We use visual inspection of the graphs to identify specific months of interest and analyze changes.

Code	Workaround indicator	Rule: The case is a workaround if …	Slack	Set of cases	Number of cases	Mean case length
ER1	Events after Discharge	any event occurred after discharge. Normative otherwise.	-	All ER patients who were discharged	237,997	13
ER2	Orders before Physician Visit	an order was placed before the patient was seen by a physician. Normative otherwise. Exception: Also, normative if an (emergency) order is placed during Triage.	10 min	All ER orders where the patient was seen by a Physician	1,385,716	2
ER3	Follow-up test before Physician Visit	a follow-up test was ordered before the patient was seen by a physician. Normative otherwise.	10 min	All ER patients with at least one follow-up test where the patient was seen by a physician	22,327	2
ER4	Measurement, Order, Triage, or Treatment before nurse visit	a measurement, order, triage, or treatment was placed or executed before the patient was seen by a nurse. Normative otherwise.	10 min	All ER patients with any order, measurement, triage, or treatment event where the patient was seen by a nurse	227,516	17
ER5	Triage late in the trace	triage occurs after any other event. Normative otherwise.	15 min	All ER patients with a triage event	239,194	16
ER6	Few pain scores before Discharge	a patient was discharged with fewer than 2 pain scores. Normative otherwise.	-	All ER patients who were discharged	241,361	3
ER7	X-ray too close to Discharge	an X-ray was logged right before discharge. Normative otherwise.	20 min	All ER X-rays where the patient was also discharged	64,642	2
CCU 1	Late Logging of Measurement	the logging of the measurement is long after the measurement time. Normative otherwise.	30 min	All CCU measurements	221,647	2
CCU 2	Late Logging of Order	the logging of the order is long after the order time. Normative otherwise.	60 min	All CCU orders	489,623	2
CCU 3	Late Discharge	the discharge is registered long after the previous event. Normative otherwise.	12 hrs	All CCU patients who were discharged	8,272	92

Table 2. Workaround Indicators

Step 4

In the last step of the study, we link incidents such as system updates, reorganizations, and new equipment implementations to changes in the ratios of workarounds to normative behavior.

Data collection. Since some significant changes in the process occurred more than ten years ago, experts are unlikely to remember incidents that may have contributed to the change. Therefore, in the last step of our study, we investigate them further using historical documents, such as presentation slides, meeting minutes, and implementation reports, stored in the UMCU database.

Data analysis. With historical documents, we use a diachronic analysis to identify the related incidents. The link between the identified incidents and the observed change allows us to further develop theory of the role of process-altering incidents in the emergence and evolution of workarounds.

Results

To investigate how workarounds change over time, we analyze the ratios of workarounds to normative process executions. After this, we observe four categories of how this ratio may evolve. Note that this category is not fixed for a single workaround, but it may change.

1) Stable: the ratio does not change strongly over time,
2) Gradual: Over time, the ratio changes slowly but steadily,
3) Temporary: At a specific point in time, the share of workarounds changes but after a while, it reverts to its original level, and
4) Sudden: At a specific point in time, the ratio completely changes.

For each moment the evolution category changes within a single workaround, we are able to identify an incident that facilitated this change by investigating historical documents.

A brief overview of our findings can be found in Figure 1. Categorization of workarounds with links to accompanying incidents. Following our research approach, we first discuss our findings regarding the evolution of the workarounds and the identification of specific months during which this evolution changed. After this, we delve deeper into these dates and discuss the underlying incidents.

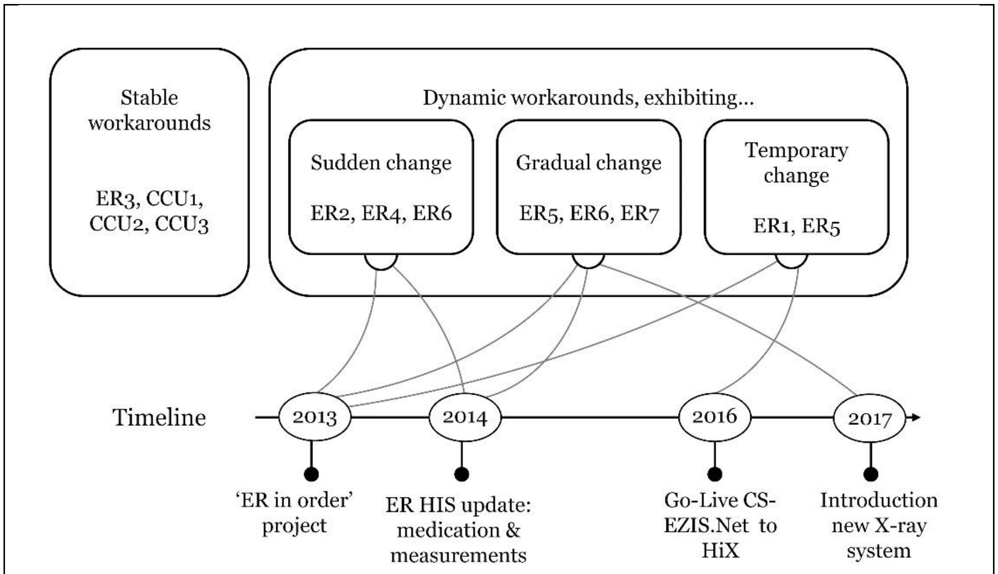

Figure 1. Categorization of workarounds with links to accompanying incidents

Evolution

In the following, we present the evolution of the ratios of workarounds to normative process executions in graph form. In every graph, the grey bars represent the number of process executions. The red line depicts the ratio of workarounds to normative process executions. For readability, the ratio lines are presented using a sliding window of size 5; The value of every month is calculated by averaging the ratio of the month itself, as well as the two months before and after it. This smoothens most singular peaks and makes the graphs less jagged.

Stable

Figures 2 to 5 show processes where the ratio of workarounds to normative is generally stable. There may be some minor fluctuations, but these are to be expected in a hospital environment where the work itself is inherently dynamic. The ratios of Figures 3, 4, and 5 all start very low before increasing to a stable level. This coincides with a very low number of process executions. Therefore, it is highly likely that this initial start should be considered a data quality issue rather than a true change in the process.

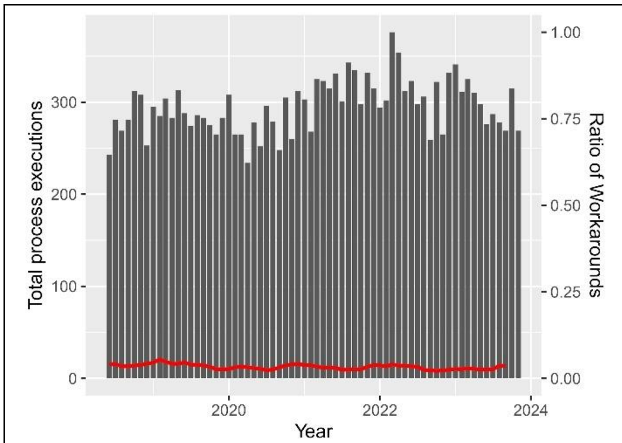

Figure 2. ER3 - Follow-up tests before Physician Visit. This process fluctuates slightly but is generally stable at around 3% workarounds.

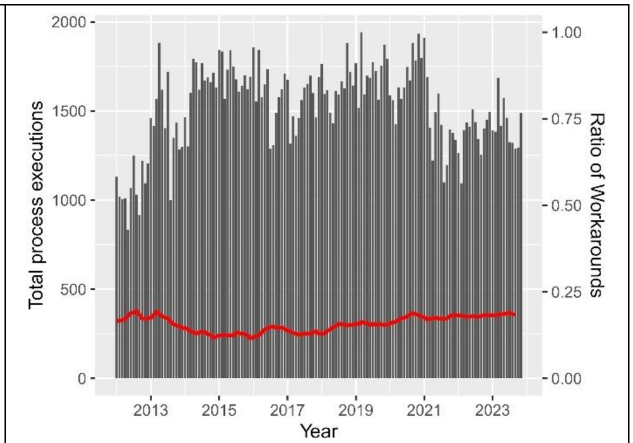

Figure 3. CCU1 – Late Logging of Measurement. The process is mostly stable around 15% workarounds.

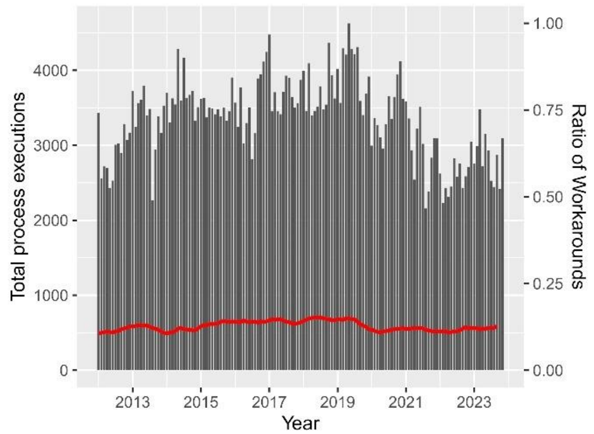

Figure 4. CCU2 – Late Logging of Order. This process is stable at 12% workarounds.

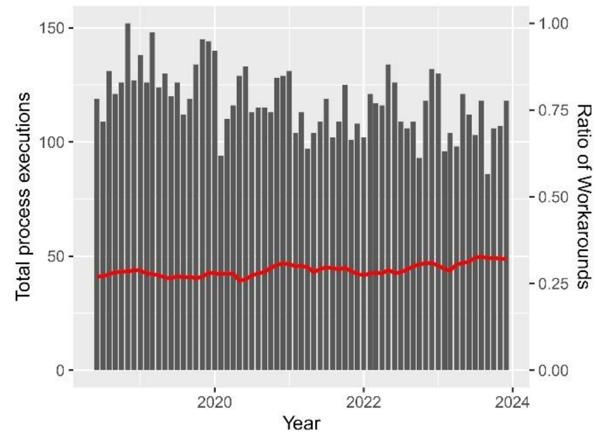

Figure 5. CCU3 – Late discharge. This process is stable at 28% workarounds.

Gradual Change

Figure 6 only shows a gradual change in the workaround ratio between 2011 and 2017. The occurrence of the general process peaks at that time, but the occurrence of workarounds stabilizes.

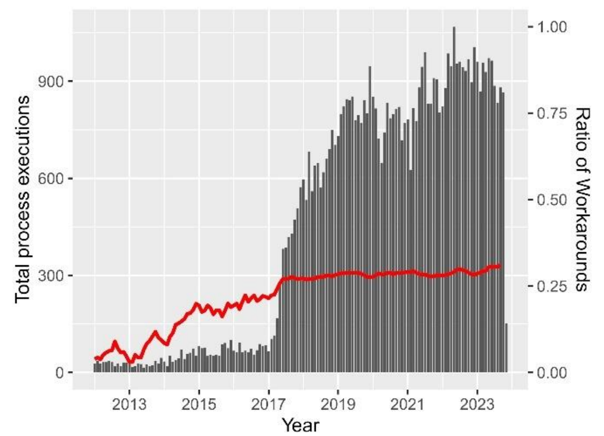

Figure 6. ER 7 – X-ray close to discharge. In the first part, the ratio of workarounds continuously grows from 10% to 30% but it stabilizes in 3-2017 when the process itself becomes more much more common.

Temporary Change

Figure 7 and 8 show a temporary increase in workarounds. In Figure 7, the overall process is generally stable, except for a temporary increase starting in 2016. In 2018, the ratio is back at a similar level as before the increase. In Figure 8, the general workaround version of the process is increasing continuously but the temporary increase shows a clear jump in the trend between 2013 and 2015. Without this peak, the trend would be strongly linear.

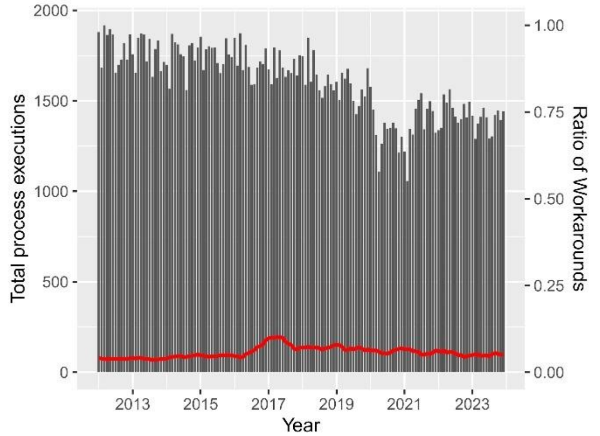

Figure 7. ER1 - Events after Discharge. There is a small temporary increase in workarounds starting in 4-2016. Before and after, the ratio of workarounds is stable at 5%.

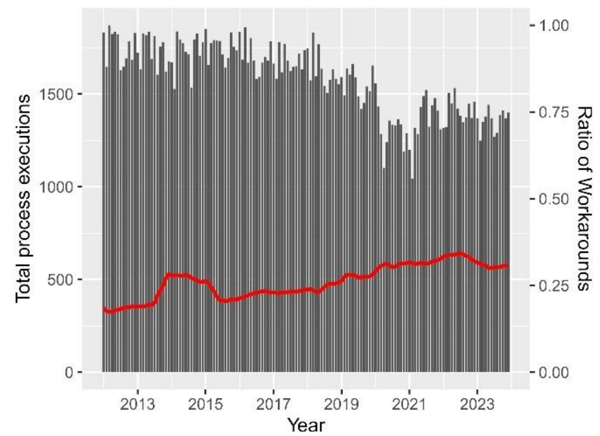

Figure 8. ER5 –Triage late in trace. There is a temporary increase starting at 7-2014. Without it, the ratio of workarounds linearly grows from 17% to 35%.

Sudden Change

Figure 9, 10, and 11 show very sudden changes in the workaround ratio. Apart from these changes, Figure 9 and Figure 10 are primarily stable**.** Figure 11 is very stable before the change but shows a continuous increase after it.

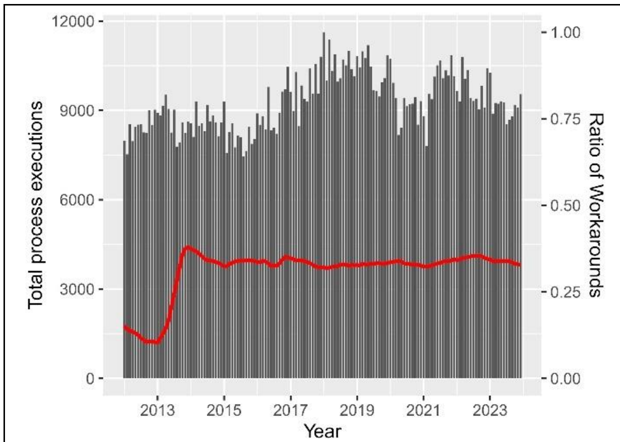

Figure 9. ER2 – Orders before physician visit. At the start, about 15% of the cases are a workaround. After 9-2013, this suddenly increases to 38%.

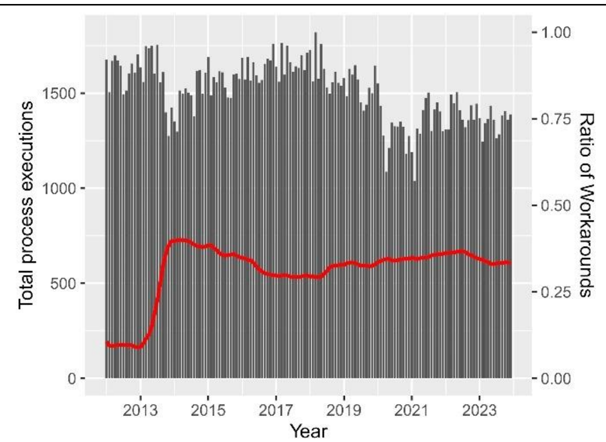

Figure 10. ER4 - Orders, Measurements, Triage, or Treatment before nurse visit. At the start, about 10% of the cases are workarounds. After 9-2013, this increases to 34%.

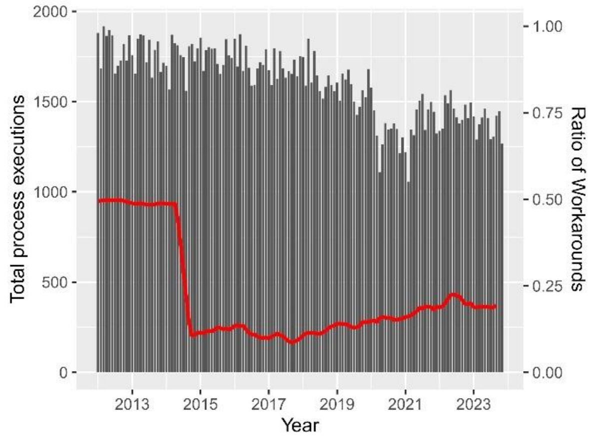

Figure 11. ER6 - Few pain scores before Discharge. At the start, the ratio of workarounds is stable at 50%. After 7-2014, this suddenly drops to 10% and gradually increases to 20%.

Incidents

As shown by the figures in the previous section, we identify four months that seem to strongly influence the use of workarounds: 9-2013, 7-2014, 4-2016, and 4-2017. As described before, we further investigated these months using historical documents: presentations, meeting minutes, and implementation reports. For each month, we find an incident that was likely the reason for the observed change, which we describe in more detail in the following.

September 2013 – Go-Live project "ER in order"

In the initial design of the HIS of the UMCU, most wards, including the ER, used the same structure to log all patient information. Due to the more dynamic work process in the ER, there was a misfit between the HIS and the work, especially in this ward. To improve the functioning of the ER, the specific ER part of the HIS was redesigned to better align with the work. This project is referred to as "ER in order" (in Dutch: "SEH op orde"). The "Go-Live" of the project was on September 24, 2013. While the project was initiated much earlier, it is not likely this would have influenced the daily processes: a large part of the work was behind the scenes where requirements were investigated and system updates were prepared. Instructions to users started a month before the Go-Live with key users and a week before with end users.

At the Go-Live of this project, we see a change in use at workaround ER2 (Figure 9), ER4 (Figure 10), and ER5 (Figure 8). The first two, related to the registration of physician and nurse visits before other events, show a large *sudden* increase in the ratio of workarounds to normative that is *stable* afterward. The last workaround, concerned with the timely logging of triage, shows a *temporary* increase until early 2015 in an otherwise *gradually* increasing ratio. Interestingly, the remaining ER processes do not show any significant change despite this project addressing most processes at the ER.

July 2014 – HIS update: ER medication and measurements tables

After the initial redesign of the ER system, multiple tweaks, fixes, and updates to the system were implemented. Such system updates do not only occur after a large-scale update but are common practice in such a large hospital. However, one large-scale update occurred after the previously discussed "ER in Order" project. This was logged as "Addition HIS medication in combination with measurements on ER". The new connection to the medication and measurement tables was implemented on July 8, 2014. Usually, updates note "Small details", "Adjustments", or "Review" as the primary changes in the script but this specific update was larger in scope. It connected two HIS tables to the general ER system in a new way, which also allowed enforcing new requirements related to the tables for specific activities. The effect of this update on the process can only be seen in workaround ER6 (Figure 11). This workaround is *stable* at 50% before the incident, during the incident we notice a *sudden* decrease in the occurrence of the workaround to 10%, after which the workaround increases *gradually* to 20%.

The indicator of this workaround is always the same: A patient is discharged with fewer than 2 pain scores being logged over their visit. However, we can clearly see a difference in how people work. In the initial stable state, if pain scores were deemed not relevant for a patient, they could be discharged without issues. Since the group of patients that visit the ER does not change much over time in this regard, the initial stability makes sense. After the HIS update, anyone who attempts to discharge a patient without there being at least two pain scores present receives an error message stating that these pain scores should still be measured, all but forcing people to enter additional pain scores before discharge. While it is still possible to perform this workaround in the new state of the system, it now requires very specific knowledge on how to circumvent the error message. As this is not known to everyone, most people are forced to adhere to the guidelines, even if pain scores are irrelevant to the treatment of a specific patient.

April 2016 – Go-Live CS-EZIS.Net to HiX

At the start of the current dataset, the UMCU used the CS-EZIS.Net HIS throughout the hospital. The previous incidents describe updates to the existing system but in the long run, larger updates are required for the continuous effectiveness of any large system. The biggest change occurred in April 2016 when CS-EZIS.Net was replaced with HiX 6.0. While this new HIS was also developed by ChipSoft, it was a large update that had to be introduced to most wards of the hospital at the same time. Surprisingly, we find that most processes were overall unaffected. However, April 2016 coincides with a small increase in workarounds of type ER1 (Figure 7) in an otherwise *stable* ratio. While this increase was *temporary*, workers logged more events after discharge until more than a year later in the second half of 2017.

If we examine the workaround further and see what is logged after discharge, we do find a large difference. Two distinct main events are regularly logged after discharge and make up most of the events after discharge: A ‘measurement’ and a ‘seen by physician’ registration, which may be considered two distinct workarounds under one common indicator. The late ‘measurement’ registration is a common occurrence in many wards in the hospital. For example, we also investigated this workaround at the CCU with indicator CCU1 (Figure 3). When this workaround occurs, measurements are temporarily stored somewhere else, e.g., on paper, and logged at a more convenient or efficient time. This type of workaround generally occurs when nurses are pressed for time. Since this workaround affects patient data, the hospital is concerned about this, especially as the temporary logging elsewhere may not adhere to all privacy standards. The late ‘seen by physician’ registration can only occur in the ER as that is the only ward where the physician visits are explicitly logged. If they do not use the HIS themselves, physicians usually do not feel the need to log in to the system just to place a checkmark while a nurse is performing all other HIS-related tasks. While accurate information about when physicians see patients may be useful for analyses of ER processes, from a treatment perspective there is no incentive for the physician to log this check-in time.

If we look further into the distribution of the distinct workarounds in Figure 12, initially, only measurements were logged after discharge. This gradually moves towards the physician visit being logged after discharge. At the time of the incident, in April 2016, there was a large jump in the ratio, when the late physician check replaced the late measurements. So, instead of an overall stable process, we now note two variants of the process. One workaround is largely prevented with the system update, while another becomes much more common. In this case, the prevented workaround (i.e., a measurement being logged after discharge) is generally considered more problematic, so this tradeoff is most likely positive for the hospital.

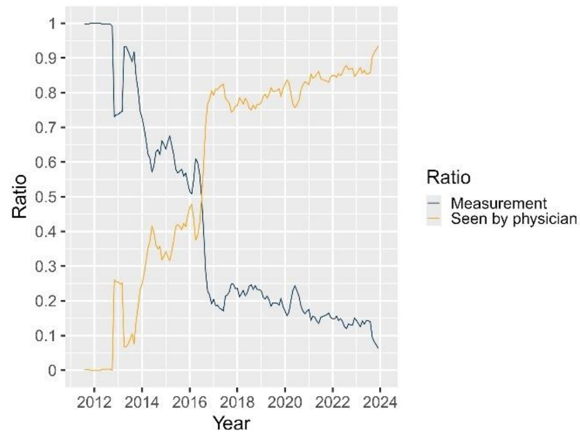

Figure 12. The ratio of the events executed after discharge. (ER1)

The limited effect of the full system update can be explained by the type of system the UMCU opted for. There are two main versions of HiX: custom-built and standard content. The UMCU used the custom-built version. While this more expensive version required much more effort, all requirements could be fit to their current processes. Since they were already familiar with the general setup of the same vendor through their previous HIS, the effect of such an update proved to be limited. In line with this observation, we find no significant changes in our studied workarounds during the update to HiX 6.1 on March 16, 2018. The next large update would be in March 2024, when the UMCU updated to HiX 6.3. With this update, they also shifted from the custom-built to the less development-intensive standard content version. Since the current system cannot be fully customized to the processes, but processes should fit the system, the IT personnel expects more issues. Since the update is less than a month old at the time of writing, we do not have any data to investigate this expectation.

March 2017 – Introduction of new X-ray system

With workaround ER7 (Figure 6) we note a major change that does not coincide at all with any of the other workarounds: In March 2017, the number of times an X-ray is ordered jumps from around 100 executions to around 400 times per month, which then increases steadily to more than 900 times in 2020. If we specifically look at the ratio of workarounds, i.e., the cases in which an X-ray was logged right before discharge, we note that this initially occurs 10% of the time, which continuously grows to 25% in February 2017. One month later, when more X-rays are being logged in general, the ratio jumps to 30% but stays stable despite the continuous growth of the number of X-rays. While there were no exceptional incidents at the ER at that time, the X-ray system itself was replaced in March 2017. This makes it likely that the change in process in the ER was influenced by a change in the Radiology department.

Discussion

We have investigated ten different types of workarounds in two wards of the UMCU using all data available on these in the HIS. While our study does include interviews and unstructured historical data, the core of our approach is the quantitative analysis of process data. This approach allows us to study processes over an exceptionally long period, which would not be possible with qualitative methods such as interviews and observations. Where short-term studies have provided many insights into managing workarounds, they can only be used effectively to react to workarounds and improve processes, the additional long-term insights can be used to proactively address workarounds over multiple years. In this section, we discuss how workarounds evolve and how this corresponds with and diverges from existing literature. We also examine the limitations of our study.

Temporality of Workarounds

Stability versus change

We identified four temporal workaround categories: stable, sudden, temporary, and gradual workarounds. These findings partly correspond with earlier findings in the literature. Most studies into workarounds assume stability when examining them in detail (Ejnefjäll et al., 2023). While we do find that some workarounds are stable, other workarounds show a more complex, dynamic evolution. Research into the emergence of workarounds generally relates IS updates to *sudden* changes (Ejnefjäll et al., 2023). Our identification of the incidents regarding the sudden changes in workarounds ER2, ER4, and ER6 are also IS-related. While the HIS update with ER6 is fully IS-related, the 'ER in order' project we found through ER2 and ER4 is broader than the IS in use as it also incorporates changes on a process design level. However, not all changes facilitated by IS updates are permanent. Workarounds ER1 and ER5 show that increases in workaround usage may only be *temporary*. This follows the observation that workarounds may disappear if the underlying obstacle that required the use of the workaround is solved (Malaurent & Karanasios, 2020). Although *gradual* workarounds are a part of theories surrounding the temporality of workarounds through unofficial modification of procedures (Alter, 2014) or diffusion through sharing (Safadi & Faraj, 2010), these theories state that after this relatively short period of a few weeks, workarounds can be officially adopted. Instead, we find that workarounds that change gradually (ER5, ER6, and ER7) may do so continuously for years.

On top of the new manifestations of workarounds we identified, another new insight pertains to the relations between these categories. In this study, we find that incidents may not only lead to sudden changes, but they may completely change the evolution of the workaround. For example, workaround ER6 (Figure 11) is *stable* for a few years, before the incident leads to a strong *sudden* decrease in workarounds, and it grows *gradually* afterward.

In Figure 13, we visualize the evolution of the workarounds that show any change. We see that most workarounds first have a relatively strong effect that is either temporary or permanent. After a few months, they then settle into either stability or gradual change, which can last for years. Workaround ER7 does not follow this and directly settles without an initial change. While we have no data supporting it, this seems to imply that a direct gradual change without a stronger initial change may also be possible. Half of these workarounds (ER1, ER5, and ER7) settle into a long-term category different from their initial state. This shows that while incidents such as HIS updates may have strong initial effects, the lasting long-term effects should not be ignored when studying how processes change.

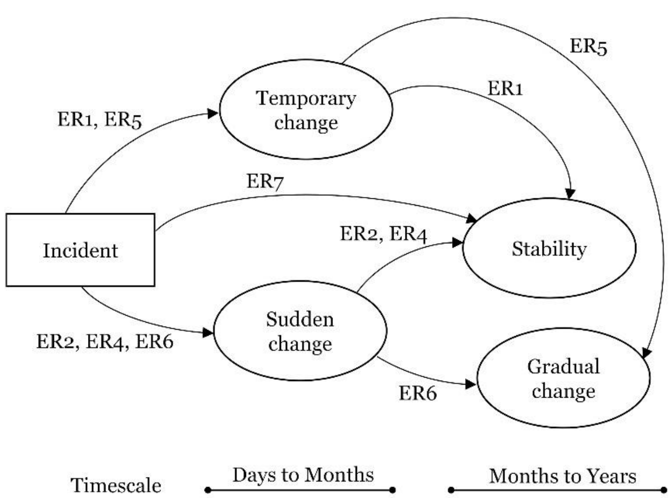

Figure 13. The change in the evolution category of workarounds.

Long-term Change

While details differ slightly, current theories concerning the temporality of workarounds start with the initial workaround as a temporary improvisation, which is then adopted in the process by more people in a period of days to weeks, and finally accepted as formal improvements through planned changes (Safadi & Faraj, 2010; Alter, 2014; Weinzierl et al., 2021). These models take an organizational point of view: either a workaround exists, or it does not, regardless of whether a single worker uses the workaround or if most of them do. They also state a clear start and end point of a workaround's life cycle. It starts with an initial learning phase, usually initiated through an incident, and ends with the system being changed based on the workaround. In this organizational view, multiple workers are considered to change as a unit, following a dialectic view in terms of Van de Ven and Poole (1995).

Between the emergence and the system change, we find two options in existing theories: Either workarounds are adopted by groups (Alter, 2014; Weinzierl et al., 2021) or individuals share a workaround they know with peers (Safadi & Faraj, 2010). However, neither view fits with our data. If workarounds were consciously adopted by groups conform Alter (2014) and Weinzierl et al. (2021), we would expect large jumps in the ratio of workarounds to normative processes every time it is shared with a new group of colleagues. While ER7 shows some jumps during the growth phase, it overlaps with a period where the general process was not applied often, making the jaggedness in the line more likely related to this limited data availability. As the alternative adoption option, any individual with the workaround knowledge could share it conform the diffusion phase of Safadi and Faraj (2010). In that case, we would expect an exponential growth in the ratio, as a workaround could be shared more quickly every time a new actor uses it. This also does not fit as ER5 and ER6 show consistent linear growth, implying that the learning of the workaround is initiated through workers running into the obstacle before choosing the workaround. Both options follow a dialectic view: An obstacle to the normal procedure starts the development of an alternative variant, which is then adopted by multiple entities. While this view makes sense from an organizational point of view, the continuous growth we observe shows that the workaround is adopted more according to an individualistic, teleological model change (Van de Ven & Poole, 1995); Workers experience an obstacle individually and then adopt workarounds they may learn through colleagues.

Limitations

In this section, we reflect on the limitations of our study and how they may have influenced results. We first discuss the potential bias due to our case study with a single organization. Then we investigate the fit of the general indicators to specific workarounds. Finally, we explain why we did not identify any start and end points of the workarounds.

All workarounds we investigate originate from the same institution, which leads to a potential bias in our results. To mitigate this issue, we used an embedded case study with ten workaround types. All these types were discovered in previous work with a data-driven method where people, and potentially subjective bias, only were involved after the discovery. In addition, the workarounds originate from two very different wards. This makes it likely our results can be extended to other hospitals, although workarounds will likely evolve differently in smaller healthcare institutions or other domains.

If we view a workaround as a specific version of how a process can be executed, our expert-defined indicators may cover more than one version of non-prescribed behavior. As such, the general overview of the process does not paint the full picture of how processes change. We see this with indicator ER1. While the general overview indicates that the process is stable overall with a single temporary increase, if we examine it in more detail, we see that it consists of two distinct workarounds. We can place similar questions around indicators ER2 (Orders before Physician Visit), where the type of order may indicate alternative processes. The expert did include a general exception around this rule capturing emergency-related, normative variants. Any further investigation into this would require specialized domain knowledge, which would be a clear direction for future work. Note that we are more confident in the remaining indicators. While ER3 and ER7 also concern the sequential order of events like ER1, they are very specific events. ER4, ER5, and CCU3 do compare a specific event to a group of general event types, but in these cases the workaround is clearly placed on the specific event, using the events as a general indication. Finally, ER6, CCU1, and CCU2 describe more specific workarounds. In all cases, the motivation of a specific workaround instance may differ, but the execution would be similar enough to consider them the same workaround.

According to current theories concerning the temporality of workarounds, a workaround has a clear starting point, after which its application grows over time before it may be adopted into the organization (Safadi & Faraj, 2010; Alter, 2014). While we find various incidents that increase the application of workarounds, we never find a very clear starting point. Despite our scope of 13 years, all workarounds have been present in some form since the start of the current information system. In addition, we also see no workarounds that were adopted as standard practice. This makes sense since we selected them during interviews with experts where we specifically asked for workarounds. Any official process that used to be a workaround before, would now be considered normative, so it would not come up during the interview. Future work could investigate this further by either specifically asking for adopted workarounds or by examining the current state of workarounds discovered in older studies. As an alternative route, we could shift the focus from workarounds within the full organization to workarounds performed by individual actors. This would allow us to determine when an individual first uses the workaround and examine the start and end in more detail.

Conclusion

In this study, we have examined how ten different types of workarounds in one large hospital evolved over 13 years using HIS data. Although most research into workarounds assumes they do not change much over time, we find that for most workarounds the occurrence of an incident drastically changes their application. Furthermore, even after the initial change, the use of a workaround may continue to grow for years instead of stabilizing. In addition, our data does not fit with current theories regarding how workarounds get shared in an organization. Instead of groups adopting a workaround or users sharing them with others, we find that the workarounds are adopted on a more individual level.

These new theoretical insights have direct implications for practice. First, workarounds need to be monitored and addressed continuously. Even if the frequency of workaround use is acceptable, this may change over time with or without incidents. Second, if workers decide to start using a workaround individually, prevention should also be targeted there. While informing about the dangers of a workaround may help, the individual need may be more important.

Future work

Repeating this study with different workarounds, preferably in a non-healthcare domain, should allow new insights. While the current study can contribute to existing theories into workarounds, taking a broader view would likely fill in even more gaps. For example, we do not know why some workarounds remain stable for a long time without any apparent control, while others continue to be used more and more.

A more detailed analysis of how workarounds evolve close to the incidents can further explain the initial changes in a process. While we can find specific incidents with a somewhat broad view of one month, this cannot further explain what is happening on a day-to-day basis.

In this work we split the evolution of workarounds into four categories and identify moments of interest based on a visual inspection, matching our observation to the dominant ideal types. Although this approach makes sense as a first step for investigating how workarounds evolve over long periods, the resulting categorization is somewhat subjective, especially since most workarounds show multiple categories in practice. In the future, this can be improved using more objective methods such as changepoint detection (Killick et al., 2012) for a more objective categorization.

Instead of our current focus on the ratio of workarounds to normative behavior, we can also switch our lens to include actors or even actor types. Instead of finding that workarounds spread according to certain patterns, this could further detail who instigates workarounds, potentially allowing insights into how people learn workarounds.

Acknowledgements

We would like to thank M.C.H. de Groot, PhD for his help during data extraction and for pointing us towards the right historical documents, as well as B. Vrijsen, MD and G.H.J.M. Ellenbroek MD, PhD for their time in finding workarounds and set up indicator rules.

This publication is part of the WorkAround Mining (WAM!) project with project number 18490 which is (partly) financed by the Dutch Research Council (NWO).

References

Alter, S. (2014). Theory of Workarounds. *Communications of the Association for Information Systems (CAIS), 34*.

Alvarez, R. (2008). Examining technology, structure and identity during an enterprise system implementation. *Information Systems Journal, 18*, 203–224.

Azad, B., & King, N. (2012). Institutionalized computer workaround practices in a Mediterranean country: an examination of two organizations. *European Journal of Information Systems, 21*, 358–372.

Barley, S. R. (1990). Images of Imaging: Notes on Doing Longitudinal Field Work. *Organization Science, 1*, 220–247.

Bartelheimer, C., Wolf, V., & Beverungen, D. (2023, April). Workarounds as generative mechanisms for bottom-up process innovation—Insights from a multiple case study. *Information Systems Journal, 33*, 1085–1150.

Becker, M. C. (2004). Organizational routines: a review of the literature. *Industrial and Corporate Change, 13*, 643–678.

Beerepoot, I., & van de Weerd, I. (2018). Prevent, Redesign, Adopt or Ignore: Improving Healthcare using Knowledge of Workarounds. *Proceedings of the 26th European Conference on Information Systems (ECIS).*

Berente, N., Seidel, S., & Safadi, H. (2019). Research Commentary—Data-Driven Computationally Intensive Theory Development. *Information Systems Research, 30*, 50–64.

Boudreau, M. C., & Robey, D. (2005). Enacting Integrated Information Technology: A Human Agency Perspective. *Organization Science, 16*, 3–18.

Choudrie, J., & Zamani, E. D. (2016). Understanding Individual User Resistance and Workarounds of Enterprise Social Networks: The Case of Service Ltd. *Journal of Information Technology, 31*, 130–151.

Cloutier, C., & Langley, A. (2020). What Makes a Process Theoretical Contribution? *Organization Theory, 1*, 1–32.

Cresswell, K. M., Mozaffar, H., Lee, L., Williams, R., & Sheikh, A. (2016). Workarounds to hospital electronic prescribing systems: a qualitative study in English hospitals. *BMJ Quality & Safety, 26*, 542–551.

Davison, R. M., Wong, L. H., Alter, S., & Ou, C. (2019). Adopted Globally but unusable Locally: What Workarounds Reveal about Adoption, Resistance, Compliance and non-Compliance. *ECIS 2019 Proceedings*.

Davison, R. M., Wong, L. H., Ou, C. X., & Alter, S. (2021). The coordination of workarounds: Insights from responses to misfits between local realities and a mandated global enterprise system. *Information & Management, 58*, 103530.

Debono, D. S., Greenfield, D., Travaglia, J. F., Long, J. C., Black, D., Johnson, J., & Braithwaite, J. (2013). Nurses' workarounds in acute healthcare settings: a scoping review. *BMC Health Services Research, 13*.

Ejnefjäll, T., & Ågerfalk, P. J. (2019). Conceptualizing Workarounds: Meanings and Manifestations in Information Systems Research. *Communications of the Association for Information Systems (CAIS)*, 340–363.

Ejnefjäll, T., Ågerfalk, & Andreas, H. (2023). WORKAROUNDS IN INFORMATION SYSTEMS RESEARCH: A FIVE-YEAR UPDATE. *ECIS 2023 Research Papers*, (p. 211).

Goff, M., Hodgson, D., Bailey, S., Bresnen, M., Elvey, R., & Checkland, K. (2021). Ambiguous workarounds in policy piloting in the NHS: Tensions, trade-offs and legacies of organisational change projects. *New Technology, Work and Employment, 36*, 17–43.

Grisold, T., & Schneider, J. (2023). Dynamics of Human-AI Delegation in Organizational Routines. *International Conference of Information Systems 2023*.

Hansson, M., Hærem, T., & Pentland, B. T. (2022). The effect of repertoire, routinization and enacted complexity: Explaining task performance through patterns of action. *Organization Studies, 44*, 473–496.

Killick, R., Fearnhead, P., & Eckley, I. A. (2012). Optimal Detection of Changepoints With a Linear Computational Cost. *Journal of the American Statistical Association, 107*(500), 1590-1598.

Kobayashi, M., Fussell, S. R., Xiao, Y., & Seagull, F. J. (2005). Work coordination, workflow, and workarounds in a medical context. *CHI '05 Extended Abstracts on Human Factors in Computing Systems*.

Koppel, R., Wetterneck, T., Telles, J. L., & Karsh, B.-T. (2008). Workarounds to Barcode Medication Administration Systems: Their Occurrences, Causes, and Threats to Patient Safety. *Journal of the American Medical Informatics Association, 15*, 408–423.

Malaurent, J., & Karanasios, S. (2020). Learning from workaround practices: The challenge of enterprise system implementationsin multinational companies. *Information Systems Journal, 30*, 639–663.

Outmazgin, N., & Soffer, P. (2014). A process mining-based analysis of business process work-arounds. *Software & Systems Modeling (SoSyM), 15*, 309–323.

Pentland, B. T., & Feldman, M. S. (2008). Designing routines: On the folly of designing artifacts, while hoping for patterns of action. *Information and Organization, 18*, 235–250.

Pentland, B. T., Recker, J., & Wyner, G. (2017). Rediscovering handoffs. *Academy of Management Discoveries, 3*, 284–301.

Pentland, B., Vaast, E., & Wolf, J. R. (2021). Theorizing Process Dynamics with Directed Graphs: A Diachronic Analysis of Digital Trace Data. *MIS Quarterly, 45*, 967–984.

Safadi, H., & Faraj, S. (2010). The role of workarounds during an opensource electronic medical record system implementation. *Thirty First International Conference on Information Systems ICIS*.

Van de Ven, A. H., & Poole, M. S. (1995). Explaining development and change in organizations. *The Academy of Management Review, 20*, 510–540.

van der Aalst, W. M., Reijers, H. A., Weijters, A. J., van Dongen, B. F., de Medeiros, A. K., Song, M., & Verbeek, H. M. (2007). Business process mining: An industrial application. *Information Systems, 32*, 713–732.

van der Waal, W., van de Weerd, I., Beerepoot, I., Lu, X., Kappen, T., Haitjema, S., & Reijers, H. A. (2024a). Putting the SWORD to the Test: Finding Workarounds with Process Mining. *Business & Information Systems Engineering (BISE)*.

van der Waal, W., van de Weerd, I., Haitjema, S., Kappen, T., & Reijers, H. A. (2024b). Whetting the SWORD: Detecting Workarounds by Using Active Learning and Logistic Regression. *Hawaiian International Conference on System Sciences (HICSS)*, (pp. 3687--3696).

Weinzierl, S., Wolf, V., Pauli, T., Beverungen, D., & Matzner, M. (2021). Detecting temporal workarounds in business processes – A deep-learning-based method for analysing event log data. *Journal of Business Analytics (JBA), 5*, 76-100.

Wijnhoven, F., Hoffmann, P., Bemthuis, R., & Boksebeld, J. (2023). Using process mining for workarounds analysis in context: Learning from a small and medium-sized company case. *International Journal of Information Management Data Insights (IJIM Data Insights), 3*, 100163.

Wong, L. H., Hurbean, L., Davison, R. M., Ou, C. X., & Muntean, M. (2022). Working around inadequate information systems in the workplace: An empirical study in Romania. *International Journal of Information Management, 64*, 102471.

Yin, R. K. (2013). *Case Study Research. Design and Methods (5th ed.)*. SAGE Publications.

Zhou, X., Ackerman, M., & Zheng, K. (2011). CPOE Workarounds, Boundary Objects, and Assemblages. *Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems*, (pp. 3353–3362).