Original Paper

Organizational Tensions in the Implementation of Modifiable Off-the-Shelf Technologies in a University Hospital: Qualitative Multimethod Study

Alessia Nowak[1*], MSc; Carolina Gaul[1*], MSc; Elena Hinz[1]; Christine Knoll[1,2], MD, PhD; Begüm Kül[1]; Anja Wels[3], ADN; Julia C Berkmann[3], PhD; Cathrin de Pasquale[4], MSc; Gloria Kremser[5], MA; Daniel Fürstenau[1,6], Prof Dr; Akira-Sebastian Poncette[1], Prof Dr Med; Felix Balzer[1,7], Dr rer nat, Prof Dr Med; Lina Mosch[1,8,9], Dr med

[1]Charité – Universitätsmedizin Berlin, Institute of Medical Informatics, Berlin, Germany

[2]Digital Health-Non-communicable Diseases, University of Potsdam, Hasso Plattner Institute, Potsdam, Brandenburg, Germany

[3]Charité – Universitätsmedizin Berlin, Business Unit Project Management, Berlin, Germany

[4]50Hertz Transmission GmbH, IT Portfolio Management, Digitalization Transformation, Berlin, Germany

[5]Charité – Universitätsmedizin Berlin, Business Unit IT, Back Office, Berlin, Germany

[6]School of Business & Economics, Freie Universität Berlin, Berlin, Germany

[7]Charité – Universitätsmedizin Berlin, Chief Medical Information Office, Berlin, Germany

[8]Charité – Universitätsmedizin Berlin, Department of Anesthesiology and Intensive Care Medicine, Berlin, Germany

[9]Berlin Institute of Health at Charité – Universitätsmedizin Berlin, BIH Biomedical Innovation Academy, BIH Charité Digital Clinician Scientist Program, Berlin, Germany

[*]these authors contributed equally

Corresponding Author:
Lina Mosch, Dr med
Charité – Universitätsmedizin Berlin, Institute of Medical Informatics
Invalidenstraße 90, Ebene 05
Berlin, 10115
Germany
Phone: 49 30 450 5810
Email: lina.mosch@charite.de

Abstract

Background: Hospitals face increasing pressure to accelerate digital transformation. Modifiable off-the-shelf technologies (MOTs) combine standardized products with limited adaptability, offering promising opportunities for rapid digitalization. However, implementing MOTs in complex hospital settings involves multiple barriers, facilitators, and organizational dynamics that require deeper investigation.

Objective: This study identifies barriers and facilitators in the implementation of MOTs in hospitals and explores how organizational dynamics, conceptualized as tensions, emerge throughout this process.

Methods: Guided by a constructivist-interpretivist paradigm, the study followed a collaborative action research approach. A qualitative multimethod design was used, including observations, workshops, and focus groups with clinical and project management staff. Data were analyzed using deductive-inductive qualitative content analysis following Kuckartz's approach.

Results: We analyzed 12 deidentified researcher protocols from 5 observations, 3 workshops, and 4 focus groups. Across these activities, 129 individuals from various wards and departments participated. Barriers and facilitators were clustered into 6 categories representing inhibiting and enabling conditions of MOT implementation. Barriers included product limitations (22.6%, 88/390), misaligned implementation process (4.4%, 17/390), absence of available individuals (3.8%, 15/390), structural challenges (2.8%, 11/390), and resource constraints (2.8%, 11/390). Facilitators included orchestrated implementation process (13.8%, 54/390), product alignment (14.4%, 56/390), effective coordination and communication (9.2%, 36/390), presence of available individuals (6.7%, 26/390), available resources (3.1%, 12/390), and structural assets (1.8%, 7/390). These categories were conceptualized into 3 organizational tensions: limited relative advantage of generic systems, structured participation challenges in complex settings, and constrained engagement despite motivation due to limited resources.

XSL•FO
RenderX

Conclusions: Tensions in MOT implementation reflect organizational misfits that go beyond concrete barriers or facilitators and instead require systemic and agile organizational structures. The analysis introduces the concept of user:ability as an organizational capacity for enabling engagement with MOTs. We derive 3 tailored strategies to mitigate the tensions: ensuring relative advantage through IT integration and learning; empowering user participation through digital transformation and communication; and enabling clinician engagement through dedicated resources and systematic implementation. This study advances prior work by deepening the understanding of implementation determinants into organizational tensions and offering actionable strategies to address them. It also illustrates how collaborative, agile research approaches can illuminate complex organizational dynamics and support hospitals during transformative change.

(JMIR Hum Factors 2026;13:e84841) doi: 10.2196/84841

KEYWORDS

health information technology; digital health; organization; qualitative research; implementation; tensions; paradoxes; user involvement

Introduction

A growing body of literature in information systems, health services, and implementation science highlights the potential of digital health technologies (DHTs) to improve health care delivery and outcomes [1-4]. Empirical studies demonstrate that DHTs, such as electronic medication systems, can enhance patient safety, care coordination, and clinical workflow efficiency [5-10].

In Germany, this recognition has been reinforced by major political initiatives. The Krankenhauszukunftsgesetz (Hospital Future Act; KHZG) created a strong regulatory impetus by tying substantial federal and state funding to the adoption of specific digital infrastructures [11]. Intended to improve care quality and efficiency, the KHZG mandates core digital solutions for German hospitals and penalizes nonimplementation with reductions of up to 2% of inpatient reimbursement, thereby enforcing rapid adoption [12,13]. Yet, while the KHZG accelerates digital adoption, DHTs remain subject to stringent safety and performance regulations, which can inadvertently slow innovation, delay responsiveness to emerging user needs, and limit design flexibility [14,15].

In this context, we conceptualize the DHTs examined in this study as modifiable off-the-shelf technologies (MOTs), drawing on modifiable off-the-shelf software or packaged software [16,17]. MOTs are prebuilt, licensed products that allow limited customization but are not developed in-house for a specific organizational use case. In this study, MOTs encompass a range of implementations: from a completed end user–initiated development scaled into the clinic, to system-wide infrastructures, and Software-as-a-Medical-Device, such as digital medication support systems [18], to applications closely integrated with hardware components, such as mobile ward rounds with iPads (Apple Inc). While MOTs promise rapid deployment and regulatory compliance, their limited adaptability often constrains alignment with heterogeneous clinical workflows and evolving organizational needs [19,20]. These dynamics can foster resistance and undermine organizational fit [20,21], particularly in large academic hospitals, where complexity heightens the risk of “unbridled adoption” [22]. In this context, the generic design of MOTs, developed for broad markets rather than the situated needs of specific clinical practices, often reduces usability because it lacks sensitivity to local workflows and limits opportunities for contextualized, implementation-level design [23]. As a result, successful implementation requires a stronger focus on end users during and after implementation, ensuring that users can use the system safely and efficiently through adequate training and sustained support [24].

Implementation science offers structured approaches to analyze these dynamics by examining the conditions under which adoption succeeds or fails. At its core is the examination of barriers and facilitators: barriers are factors that hinder or prevent uptake, while facilitators are enabling conditions within a specific context that promote adoption [25].

Previous research has identified barriers at multiple levels, including technological barriers such as interoperability [26,27] and system complexity [27,28]; individual-level barriers such as limited digital literacy [29] and low acceptance [29,30]; organizational barriers such as the lack of integration of digital technologies into existing workflows [30,31] and limited resources [29,31]; as well as structural barriers, including the lack of stakeholder involvement [26] and insufficient funding [32].

Beyond well-documented barriers, recent research points to deeper organizational dynamics, such as tensions and paradoxes, that are not easily resolved and require ongoing management [33]. Examples include conflicts between the push for standardization and the need for clinical autonomy; the pursuit of digital efficiency and the value of hands-on care; and the promise of technology and the reality of added burden, reflecting organization-technology misfits [33-35]. Building on Strong and Volkoff [19], misfits arise when technology and organizational practices fail to align. They appear in 6 domains: functionality, data, usability, role, control, and organizational culture. Each can surface either as a deficiency (missing features or capabilities) or as an imposition (an inherent technological characteristic needed for seamless integration) [19]. If left unmanaged, organization-technology misfits can impede adoption by fostering resistance, neglect, or misuse of otherwise beneficial technologies [33-35].

To address barriers, tensions, and misfits, implementation science applies evidence-based theoretical models and frameworks [21,36-40]. However, these are often insufficiently applied in practice [41], contributing to a persistent knowledge

XSL•FO
RenderX

translation gap [42]. Action research can help bridge this gap by generating insights that are simultaneously actionable for organizations and generalizable for theory building [43]. Tailored implementation strategies [44] remain essential, as MOT implementation must account for technical and organizational factors alongside competing demands from regulations, limited resources, and staff needs.

Building on the outlined challenges and literature, we posit a set of assumptions that guide our study. As MOTs offer limited opportunities for participation in design, we expect usability and functionality misfits to emerge during implementation. Building on this premise, we suggest that effective MOT implementation requires tailored strategies to address contextual needs during implementation, as the limited modifiability of MOTs restricts contextual adaptation. We further argue that structural characteristics of hospitals can reinforce these misfits and intensify tensions during implementation.

These propositions lead to the following research question: What are the barriers and facilitators in the implementation of MOTs, and what organizational dynamics emerge during this process within complex hospital contexts?

Methods

Study Design

This study followed a qualitative, multimethod, collaborative participatory action research design within a constructivist-interpretivist paradigm. The design aimed to explore how clinical and project management staff experienced the implementation of MOTs in a complex tertiary hospital environment [45,46]. Action research was conducted in iterative Plan-Act-Observe-Reflect cycles [47,48], integrating observations, focus groups, and participatory workshops in a convergent triangulation design. Following the action research paradigm, female implementation researchers with backgrounds in clinical medicine, human factors, and information systems acted as the action researchers, whereas female members of the Chief Medical Information Office and the operational project management unit represented the client system. Participants' accounts were treated as first-order data and interpreted by the researchers to develop second-order concepts [49]. As some team members were involved in coordinating implementation activities, their dual roles not only provided valuable contextual insight but also introduced the possibility of bias. Reflexivity was supported through systematic field notes, joint data collection, and regular team discussions, and analytic distance was strengthened by involving 2 researchers (BK and DF), who had not participated in data collection, in leading the analysis. The study was reported in accordance with the Standards for Reporting Qualitative Research (SRQR; see Multimedia Appendix 1) and the Consolidated Criteria for Reporting Qualitative Research (COREQ; see Multimedia Appendix 2) [50,51].

Before data collection, participants were informed about the study's purpose, the researchers' roles, and the goals of the initiative. No formal relationships were established in advance. Researchers were introduced in line with their collaborative roles as action researchers (AN, CG, EH, and LM) and clients (AW, CdP, JCB, and GK) [47]. Professional backgrounds and interest in implementation processes were disclosed, whereas the research questions were not shared.

Setting

The study was conducted at Charité – Universitätsmedizin Berlin, a large German university hospital employing over 23,000 staff and operating more than 3000 beds across more than 100 clinics and departments [52].

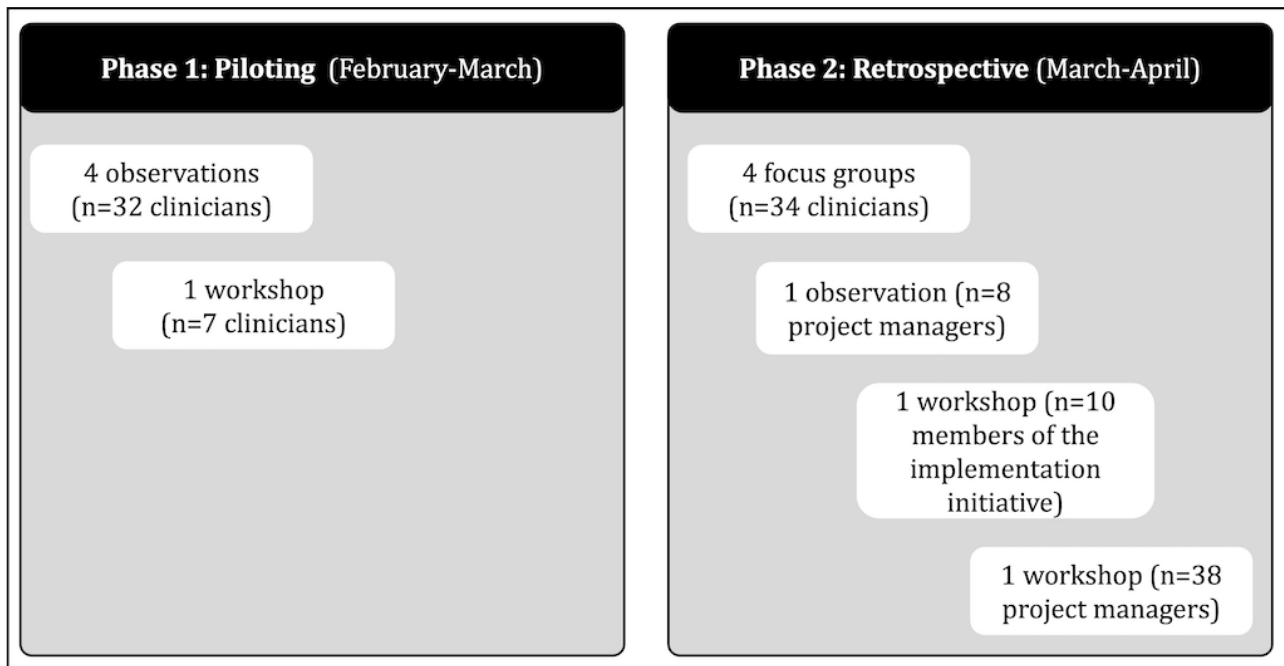
The research was embedded in the hospital's digital transformation initiative funded under the German Hospital Future Act (KHZG), which promotes the implementation of DHTs across German hospitals.

Recruitment and data collection occurred from February to April 2025 across 2 implementation phases: (1) a pilot phase observing pre- and early implementation activities and (2) an evaluation phase retrospectively assessing experiences across wards and departments. Together, these stages provided rich insights into the implementation process (Figure 1). Data were collected in inpatient wards, emergency and outpatient clinics, and administrative project management offices.

Access to the field was established by the initiative's lead via email, drawing on existing professional relationships to promote trust and encourage engagement, as well as through presentations of the initiative in various internal organizational committees. To contextualize these implementation activities, the next section describes the portfolio of digital technologies introduced under the KHZG initiative and examined in this study.

XSL•FO
RenderX

Figure 1. Data collection procedure for a qualitative study on modifiable off-the-shelf technology implementation at a large German academic hospital, illustrating a 2-stage process (pilot and evaluation phases) conducted from February to April 2025 across clinical and administrative settings.



The Implementation Portfolio

The research was conducted within the framework of the Hospital Future Act, a political mandate that allocates targeted funding to accelerate hospitals' digital transformation. Hospitals apply for these funds and must comply with national standards for DHTs to be eligible for support [11]. In line with the requirements of the KHZG and the hospital's overarching digital strategy [53], which emphasizes interoperability, user-centered design, and improved care, a dedicated implementation initiative was launched. Its objective was to introduce 10 preselected MOTs that fulfill KHZG criteria and contribute to the operationalization of the telematics infrastructure, Germany's secure and interoperable digital health network [54]. These technologies, formally approved as part of the hospital's digital transformation program, were implemented across inpatient and outpatient departments to enhance clinical documentation, resource management, device integration, and interprofessional communication. Patient-facing or consumer-oriented applications were not included because they were not part of the active implementation portfolio during the study period and thus did not constitute the exposure of interest. The study aimed to investigate the experiences, practices, and challenges of clinical personnel as active users of KHZG-funded MOTs, rather than to evaluate patient experiences or patient-technology interactions. The portfolio comprised both mandatory and optional solutions (see Table 1). Aligning with the action research approach [47], the initiative was iteratively refined in response to contextual factors, including high workloads and limited resources, as well as ongoing adjustments to evolving KHZG regulations.

XSL•FO
RenderX

Table 1. Overview of mandatory and optional modifiable off-the-shelf technologies included in the implementation portfolio of a digital transformation initiative at a large German university hospital (February-April 2025). Technologies were implemented in inpatient and outpatient clinical areas as part of the KHZG[a]-funded program and represent the digital tools to which clinical staff were exposed during the study.

Technology	Description	Requirement type
Electronic Sick Leave Certificate [55]	Online transmission of sick leave certificates via the telematics infrastructure.	Mandatory
Nationwide electronic health record (elektronische Patientenakte) [56]	Integration and implementation of a unified IT system for medical report writing across the hospital.	Mandatory
ePrescription Implementation [57]	Digital creation and transmission of prescriptions via the telematics infrastructure.	Mandatory
Digital Medication Management (inpatient) [58]	Digital documentation of medication on regular wards and some outpatient clinics; work on emergency and intensive care units in progress.	Mandatory
KIM (Communication in Medicine) – KIM Email [59]	Secure, encrypted email service within the telematics infrastructure for medical communication.	Optional
Operating Room Solutions (Digital Implant Passport) [60][b]	Clinical information system–integrated software module for implant documentation.	Optional
Mobile Ward Round [61]	An iPad app allowing access to critical clinical systems/features to support clinical ward rounds for doctors, nurses, and other staff (Wi-Fi dependent).	Optional
Admission Planning Tool [62][b]	Standardized planning for inpatient admissions.	Optional
Fluid Balance Module [63][b]	Digital documentation of access points, drains, and fluid balances in the clinical information system.	Optional
Digital Whiteboard for Ward Management [64][c]	Digital workflow organization tool for inpatient services in hospital wards and intensive care units.	Optional

[a]KHZG: Krankenhauszukunftsgesetz (Hospital Future Act).

[b]SAP modules were modified by the local IT department.

[c]End user–initiated development.

Participants

Participants were clinical staff (physicians, nurses, and patient coordinators) and nonclinical project management personnel involved in or affected by the digitalization initiative.

Eligibility criteria were (1) employment at Charité in a clinical or project management role and (2) involvement in or exposure to at least one MOT implementation. Recruitment followed a multistage purposeful sampling strategy to ensure maximum variation across disciplines and hierarchical levels [65]:

- Stage 1 (maximum variation sampling): selection of diverse departments (regular ward, emergency, and outpatient settings).
- Stage 2 (emergent purposive sampling): inclusion of additional participants expressing interest during project meetings and presentations.
- Stage 3 (criterion sampling): targeted recruitment of project managers due to their pivotal role in planning and coordination.

Elements of convenience sampling were used when data collection was integrated into existing meeting schedules.

A total of 129 participants were included: 73 clinicians, 46 project managers, and 10 members of the implementation initiative. While participation was generally high, a small number of invited nurses and physicians declined due to time constraints. Exact numbers of refusals and dropouts were not systematically recorded, as participation was integrated into routine clinical and project management activities. Sampling decisions across all stages aimed to capture diverse perspectives from frontline users and institutional implementers. Units of study were 12 researcher protocols: 5 from observations, 4 from focus groups, and 3 from workshops (see Multimedia Appendix 3). While 129 individuals contributed to data collection activities, analytic inferences were drawn from these protocols rather than from individual participants.

Demographic data were not collected because, following Rapoport's [43] view of action research as a collaborative, context-bound process focused on collective practice change, roles and functions in implementation were considered more relevant than individual characteristics, and statistical generalizability was not sought.

Assessments

Primary outcomes were perceived barriers and facilitators to MOT implementation, as well as underlying organizational dynamics that became evident during the process.

Exposures of interest included the characteristics of MOTs (usability, adaptability, and interoperability) and organizational factors (resources, infrastructure, and communication structures).

Potential contextual influences considered during interpretation included differences in departmental resources, professional hierarchies, and workload variation.

All outcomes were derived from qualitative accounts rather than standardized instruments, reflecting participants' lived experiences and professional perspectives.

XSL•FO
RenderX

Data Sources

Overview

An emergent qualitative design [66] guided data collection. Outcomes were assessed using 3 qualitative data sources: focus groups [67], workshops [68], and field observations [69] (see Multimedia Appendix 3). Data collection was conducted across 2 implementation phases and combined real-time engagement with retrospective reflection to capture both situated practices and reflective accounts of barriers, facilitators, and organizational dynamics. Each method contributed distinct perspectives on implementation processes and context-specific determinants.

Field Observations (n=5 Protocols)

Field observations were conducted on-site or online to capture real-time implementation practices, clinical routines, and interactional dynamics within the organizational environment. In phase 1, researchers (AN, CG, LM, AW, JCB, GK, and CdP) conducted 4 departmental observations (each 60-90 minutes; protocols [P] 9-12), focusing on implementation workflows and situated engagement with available MOTs, including how interest in specific solutions emerged or failed to emerge. In phase 2, a 90-minute online observation with project managers provided broader perspectives on cross-departmental coordination processes (P2). Researchers adopted a participant-observer stance, with varying levels of engagement depending on the activity. Observational field notes documented contextual factors, actor interactions, emergent issues, and workflow characteristics [69]. Field observations focused on capturing situated practices and real-time interactions as they occurred in the clinical and organizational context, rather than participants' retrospective accounts or evaluative judgments.

Workshops (n=3 Protocols)

Workshops served as participatory formats to support collective reflection and cocreate implementation strategies. In phase 1, following a ward's expressed interest in an MOT, AN and EH conducted a 2-hour back-casting workshop [70] with senior and assistant physicians, nursing staff, and patient coordinators to envision future workflows and articulate required process changes, starting from a desired future state (P4). In phase 2, a 30-minute workshop with project managers (P6), conducted by CG, AN, and EH, focused on evaluating implementation steps ("do," "don't," "must") and strategies for resource-constrained contexts. A 1-hour internal workshop with implementation initiative members (P7), led by CG and AN, supported reflexive examination of the overall approach. Workshops followed a semistructured but flexible facilitation style to allow participant-led exploration of barriers, facilitators, and implementation needs. They were explicitly future-oriented and designed to support joint sense-making, cocreation, and the development of shared implementation strategies.

Focus Groups (n=4 Protocols)

In phase 2, CG, AN, JCB, CdP, and AW conducted 4 one-hour focus groups with clinicians across diverse professional and hierarchical levels (P1, P3, P5, and P8). Focus groups explored implementation experiences, communication preferences, perceived determinants of adoption, and emergent best practices. Sessions were held on-site or digitally and were researcher-moderated. Focus groups elicited retrospective reflections, complementing the observational insights generated in phase 1. In contrast to workshops and observations, focus groups emphasized retrospective reflection on implementation experiences and facilitated comparison of perspectives across professional roles.

Across all methods, manual note-taking (without audio or video recordings) ensured participant comfort, protected confidentiality, and supported candid dialogue. A structured field note template (see Multimedia Appendix 4) was developed specifically for the study to document setting characteristics, actor interactions, contextual influences, and emerging themes consistently across methods. Only study participants and researchers were present during data collection; no nonparticipating individuals attended. Field notes were primarily compiled by AN and CG and supplemented by LM, CdP, AW, and JCB, enabling iterative refinement of prompts and observational foci in response to field engagement [66].

Study Size

The final study size (n=129 participants across 12 protocols) was determined pragmatically, based on data sufficiency, diversity of perspectives, and information power. This approach aligns with qualitative research conventions rather than statistical power considerations [71]. Breadth and representativeness across roles and departments were prioritized over saturation, given the multimethod, organizational scope of the research.

Data Analysis

All analyses were conducted at the protocol level, with the 12 researcher protocols forming the analytic corpus. Coding frequencies indicate patterns across activities rather than individual-level quantification, consistent with the study's action research design [47].

All protocols were transcribed and analyzed in MAXQDA 2022 (VERBI GmbH) [72] using deductive-inductive qualitative content analysis following Kuckartz and Rädiker [73].

To ensure analytic rigor, all coding activities were conducted by product-independent action researchers who were not part of the client system. AN and CG defined a priori codes from the Consolidated Framework for Implementation Research [21,36], guided by prior knowledge of barriers and facilitators. An independent researcher (BK), who was not involved in data collection, then coded the material in MAXQDA, applying these codes and developing inductive ones specific to the MOT context. BK subsequently assigned these codes to either the first-order category MOT implementation barrier or MOT implementation facilitator, with regular review by AN and CG. AN grouped related codes into 12 second-order categories (6 barriers and 6 facilitators), which were validated in 3 team meetings (AN, CG, and LM). To prevent "data overload," we decided to report only codes with 4 or more coded segments [74]. As Kuckartz and Rädiker [73] do not provide numerical thresholds, these cutoffs were established through analytical reflection to manage data complexity and ensure transparent reporting. This approach aligns with qualitative standards that emphasize conceptual significance over statistical

XSL•FO
RenderX

representativeness. A detailed overview of coding frequencies is provided in Multimedia Appendix 5.

Building on preliminary qualitative findings from the different data collection steps, MOT implementation barriers and facilitators also served as a basis for analyzing organizational tensions and deep-seated dynamics. Together, the 3 data sources provided complementary perspectives on the implementation of MOTs. Field observations captured how available MOTs were encountered in practice and how reasons for adoption or nonadoption emerged in everyday clinical and organizational workflows. Workshops contributed to the structured, future-oriented articulation of implementation pathways, including required process changes and strategies for resource-constrained contexts. Focus groups supported retrospective reflection on individual implementation experiences, preferences, and perceived determinants of adoption. Additionally, findings from the different data collection steps were triangulated to inform the interpretation of recurring patterns and contradictions. Based on access to the coded material, LM and DF, who were not involved in data collection and therefore contributed additional analytical distance, independently examined codes for contradictory demands or competing logics (eg, complexity vs participation, resource constraints vs engagement). Findings were discussed in 3 team meetings with AN and CG.

Integrating findings across methods, perspectives, and study phases, the analysis served as the basis for identifying higher-order organizational tensions. As a result, the final conceptual interpretations and tailored implementation strategies were derived from this integrated, triangulated analytical process.

Triangulation of methods (observations, workshops, and focus groups) and perspectives (clinicians, project managers, and implementation staff) enhanced trustworthiness [75]. Reflexivity was maintained through analytic memos and peer debriefing sessions. Quantitative counting of coded segments (frequencies and percentages) was used descriptively to illustrate emphasis, not to infer significance.

Ethical Considerations

Ethics Approval

The study protocol was reviewed and approved by the Charité – Universitätsmedizin Berlin Ethics Committee (approval number EA4/031/23). As the study involved human participants in the form of clinical and project management staff, institutional ethics oversight was required and obtained.

Informed Consent

Before participation, all individuals received verbal information about the study's aims, procedures, voluntary nature, and their right to withdraw at any time without consequences. Verbal informed consent was obtained before all data collection activities. The ethics committee confirmed that verbal consent was appropriate given the minimal risk, nonclinical nature of the study, and the absence of patient-related data.

Privacy and Confidentiality

To protect participant confidentiality, all field notes and workshop and focus group documentation were deidentified at the point of data collection. No names, professional identification numbers, or other personal identifiers were recorded. Data were stored on secure, password-protected institutional servers accessible only to the research team. Findings are presented exclusively in aggregated or anonymized form.

Compensation

Participants did not receive any financial or material compensation for their involvement. Participation was voluntary and occurred during or adjacent to routine professional activities.

Identifiability in Images or Multimedia Appendices

No identifiable individuals are presented in the manuscript or its multimedia appendices. All illustrative figures and multimedia appendices contain only anonymized documents and deidentified field note excerpts. No visual materials include recognizable individuals; therefore, no individual image-based consent forms were required.

Results

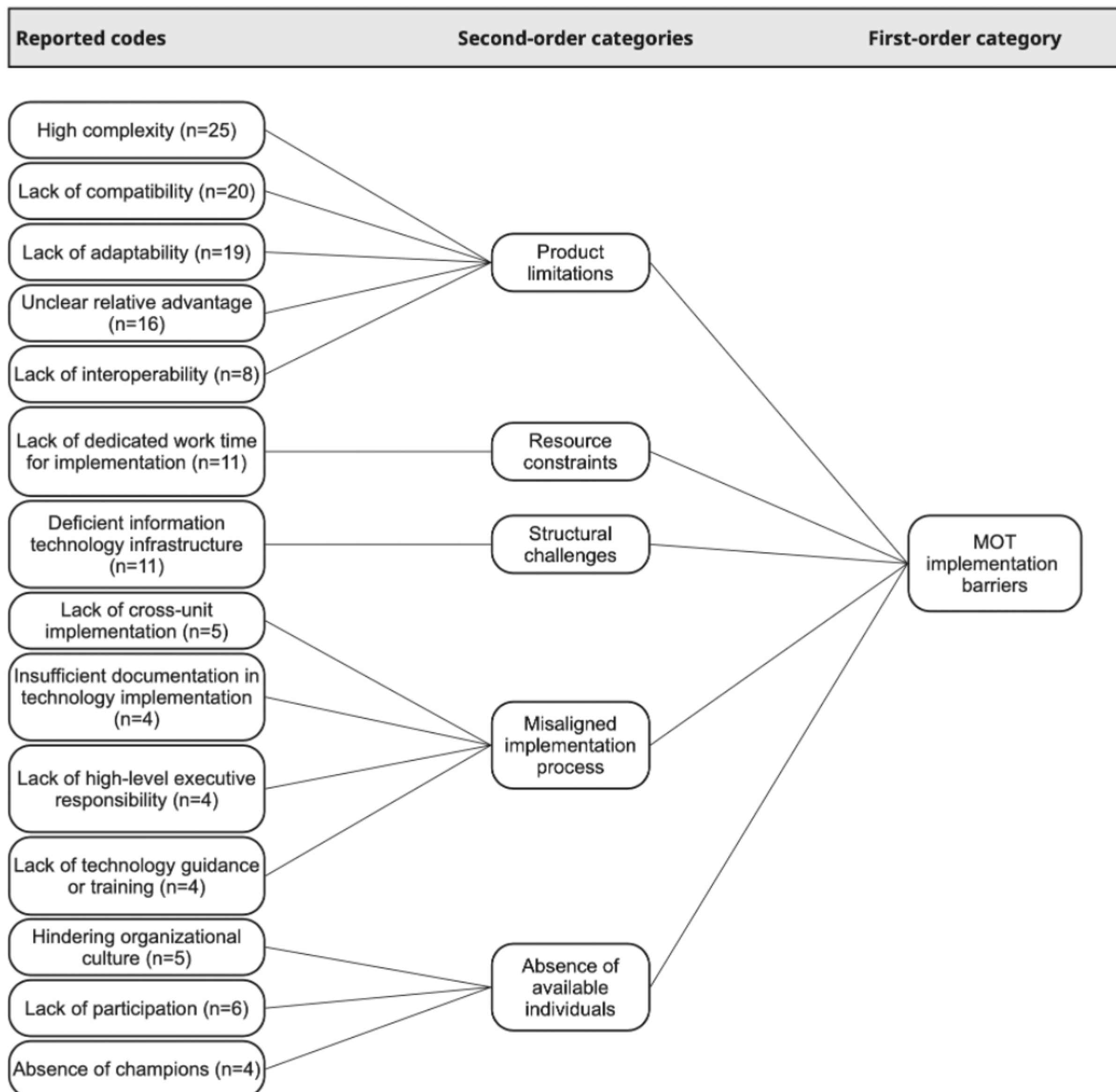
Overview and Analytical Structure

Results are presented in 2 sections: (1) 6 integrated second-order categories combining barriers and facilitators within shared aspects of MOT implementation (see Figures 2 and 3) and (2) organizational dynamics conceptualized as 3 tensions. We defined barriers as factors that hinder or prevent uptake and facilitators as enabling conditions that support uptake [25]. Codes and second-order categories were labeled according to participants' perceptions and our interpretation: barriers were typically described using terms such as lack of, limited, or deficient, whereas facilitators were usually characterized by the perceived presence or availability of a factor.

In total, the coding process identified 390 data segments, comprising 172 barriers and 218 facilitators across the 12 researcher protocols. Frequencies indicate how often themes occurred across protocols and are not intended to represent participant-level prevalence. Multimedia Appendix 5 provides an overview of the distribution of reported and unreported codes, as well as all code frequencies. Representative quotes for all codes can be found in Multimedia Appendix 6. The following sections elaborate on each second-order category, beginning with those related to product characteristics.

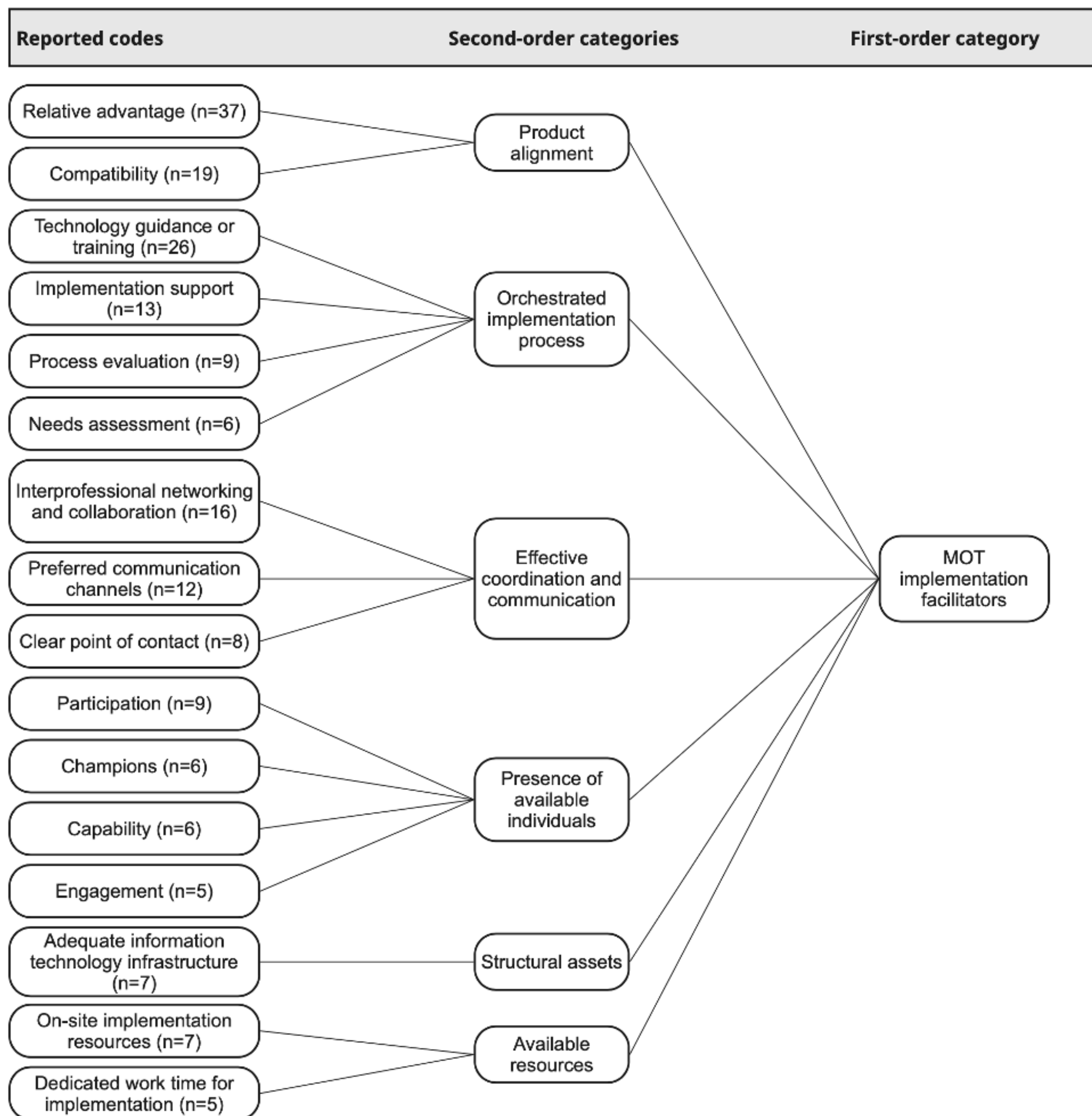
XSL•FO
RenderX

Figure 2. Coding scheme of modifiable off-the-shelf technology (MOT) implementation barriers. Reported codes were aggregated into 5 second-order categories—product limitations, resource constraints, structural challenges, misaligned implementation processes, and absence of available individuals—which together constitute the overarching category of MOT implementation barriers.



XSL•FO
RenderX

Figure 3. Coding scheme of modifiable off-the-shelf technology (MOT) implementation facilitators. Reported codes were grouped into 6 second-order categories—product alignment, available resources, structural assets, an orchestrated implementation process, the presence of available individuals, and effective coordination and communication—which together constitute the overarching category of MOT implementation facilitators.



Product Limitations and Product Alignment

This category captures how the functional, technical, and workflow-related characteristics of MOTs shaped users' experiences.

Barriers arose when MOTs were difficult to operate, poorly aligned with existing routines, or technically constrained. These challenges were reflected in the lack of compatibility (20/172, 11.6%, barriers; 20/390, 5.1%, coded segments), such as when duplicate documentation or parallel paper processes were required. Lack of adaptability (19/172, 11%, barriers; 19/390, 4.9%, coded segments) captured the limited flexibility of MOTs to accommodate diverse wards, workflows, or professional roles. The added value of MOTs was not always evident, as reflected in unclear relative advantage (16/172, 9.3%, barriers; 16/390, 4.1%, coded segments). Difficulties were further reinforced by missing interfaces and fragmented data flows, represented by a lack of interoperability (8/172, 4.7%, barriers; 8/390, 2.1%, coded segments), which required manual bridging and complicated coordination across units. High complexity (25/172, 14.5%, barriers; 25/390, 6.4%, coded segments) referred to multistep logins, unstable Wi-Fi, and slow system responses that conflicted with fast-paced clinical work, as exemplified by a participant describing the mobile ward round:

> *[Mobile Ward Round] You go into the room to see the first patient, document everything, then go to the second patient, then the iPad is off, you have to enter a code and unlock it again, then log back into the HIS – by the time you've logged in, 3-5 minutes have passed and the others are already with the next patient. Then you want to look at the MRI image*

XSL•FO
RenderX

again, but the Wi-Fi cuts out. So, the idea is great, but the application isn’t [P9]

Facilitators emerged when MOTs aligned with clinical routines and offered clear benefits. Relative advantage was the most frequently reported facilitator (37/218, 17%, facilitators; 37/390, 9.5%, coded segments), emphasizing efficiency gains and reduced communication effort. Compatibility (19/218, 8.7%, facilitators; 19/390, 4.9%, coded segments) supported adoption when system functions fit existing workflows or professional expectations.

Together, these patterns indicate that MOT uptake depended on the extent to which technical design, usability, and workflow integration cohered with everyday clinical practice.

Resource Constraints and Available Resources

This category captures how staffing levels, protected time, and available support shaped clinicians’ ability to engage in MOT implementation activities.

The most prominent barrier was a lack of dedicated work time for implementation, which accounted for 11 out of 172 (6.4%) barriers and 11 out of 390 (2.8%) coded segments. Participants reported that implementation-related tasks had to be completed alongside routine clinical duties, leaving little opportunity for training, experimentation, or supporting colleagues. As P7 noted: “Enthusiasm is there, but the time resource is missing.”

Facilitators emerged when additional resources or protected time were available. On-site implementation resources represented 7 out of 218 (3.2%) facilitators and 7 out of 390 (1.8%) coded segments, and dedicated work time for implementation accounted for 5 out of 218 (2.3%) facilitators and 5 out of 390 (1.3%) coded segments. Participants described that responsive local support and focused time windows enabled them to engage in implementation activities without competing clinical responsibilities and to incorporate MOTs more consistently into everyday practice.

Structural Challenges and Structural Assets

This category reflects how participants experienced the adequacy and reliability of the hospital’s technical infrastructure during MOT use and implementation.

Barriers were primarily captured in the code-deficient IT infrastructure, which accounted for 11 out of 172 (6.4%) barriers and 11 out of 390 (2.8%) coded segments. Participants described limited device availability, unstable Wi-Fi, slow system performance, and outdated hardware, all of which interfered with routine work and discouraged sustained use of MOT functions. Furthermore, these gaps sometimes prevented MOTs from being implemented in the first place, as required equipment was delayed or unavailable. As one participant noted: “Procurement of technical infrastructure unclear or very slow and bureaucratic via procurement platform” [P3].

By contrast, facilitators emerged when the infrastructure functioned reliably. Adequate IT infrastructure accounted for 7 out of 218 (3.2%) facilitators and 7 out of 390 (1.8%) coded segments. Participants reported smoother logins, stable network access, and consistent availability of clinical information; these conditions supported the routine use of MOTs and reduced the need for workaround practices.

Misaligned Implementation Process and Orchestrated Implementation Process

This category captures how the structure, coordination, and support of implementation activities influenced clinicians’ experiences.

Barriers reflected fragmented processes, unclear responsibilities, and insufficient preparation. Lack of cross-unit implementation (5/172, 2.9%, barriers; 5/390, 1.3%, coded segments) and insufficient documentation in technology implementation (4/172, 2.3%, barriers; 4/390, 1.0%, coded segments) highlighted difficulties in understanding which technologies were already in use and how previous rollouts had unfolded. Several participants reported that oversight for implementation had been delegated to local clinical leaders who, due to existing clinical demands, had limited capacity to take on additional coordination tasks, as reflected in the lack of high-level executive responsibility (4/172, 2.3%, barriers; 4/390, 1.0%, coded segments). Reports of lack of technology guidance or training (4/172, 2.3%, barriers; 4/390, 1.0%, coded segments) further contributed to inconsistent processes and limited practical support.

Facilitators emerged when implementation was structured and actively supported. Technology guidance or training was a frequent facilitator in this domain (26/218, 11.9%, facilitators; 26/390, 6.7%, coded segments), alongside implementation support (13/218, 6.0%, facilitators; 13/390, 3.3%, coded segments), process evaluation (9/218, 4.1%, facilitators; 9/390, 2.3%, coded segments), and needs assessment (6/218, 2.8%, facilitators; 6/390, 1.5%, coded segments). Participants emphasized that accessible, context-specific training formats, visible support from the implementation team, and iterative feedback loops helped align expectations and adapt strategies to local workflows: “Planned iterative approach from the start—reminding people, asking about further interaction” [P7].

Absence of Available Individuals and Presence of Available Individuals

This category reflects how the availability, engagement, and roles of clinical staff and members of the implementation team were experienced by participants during MOT adoption.

Barriers were reported when individuals lacked time, recognition, or opportunity to participate meaningfully. Lack of participation accounted for 6 out of 172 (3.5%) barriers and 6 out of 390 (1.5%) coded segments. Participants described that, although interest often existed, competing clinical duties limited involvement. Hindering organizational culture represented 5 out of 172 (2.9%) barriers and 5 out of 390 (1.3%) coded segments, referring to hierarchical structures and strained working climates that reduced openness to change. The absence of champions accounted for 4 out of 172 (2.3%) barriers and 4 out of 390 (1.0%) coded segments, indicating missing local multipliers who could support peers or coordinate with the project team.

XSL•FO
RenderX

By contrast, facilitators emerged when individuals—whether clinicians or implementation team members—were available and engaged. Participation accounted for 9 out of 218 (4.1%) facilitators and 9 out of 390 (2.3%) coded segments, with staff actively initiating or supporting MOT rollout activities. Presence of champions represented 6 out of 218 (2.8%) facilitators and 6 out of 390 (1.5%) coded segments, capturing designated or informal multipliers who guided colleagues, tested functions, or liaised with the implementation team. Capability accounted for 6 out of 218 (2.8%) facilitators and 6 out of 390 (1.5%) coded segments, with participants highlighting digital competence and willingness to learn. Engagement accounted for 5 out of 218 (2.3%) facilitators and 5 out of 390 (1.3%) coded segments, reflected in proactive contributions to problem solving or workflow adaptation. A participant summarized the importance of identifiable and engaged individuals: "What else do we need from the clinics? Clear, consistent contacts who can serve as multipliers" [P6].

Effective Coordination and Communication

This category captures how interprofessional coordination and communication practices shaped the implementation of MOTs.

Although participants occasionally referred to coordination challenges, no communication-related barrier reached the minimum reporting threshold of 4 coded segments used in this study. Facilitators, however, were more frequently described and were reflected in interprofessional networking and collaboration, preferred communication channels, and a clear point of contact.

Interprofessional networking and collaboration accounted for 16 out of 218 (7.3%) facilitators and 16 out of 390 (4.1%) coded segments. Participants emphasized that structured collaboration between clinical professions and the project team supported implementation activities, as illustrated by one clinician who noted the value of "bringing different professional groups together to plan the implementation" [P6]. Preferred communication channels represented 12 out of 218 (5.5%) facilitators and 12 out of 390 (3.1%) coded segments, highlighting the importance of using familiar and accessible communication formats, such as in-person briefings, emails, or departmental meetings. A clear point of contact accounted for 8 out of 218 (3.7%) facilitators and 8 out of 390 (2.1%) coded segments, emphasizing the role of identifiable, reliable contacts for resolving questions and maintaining continuity during implementation.

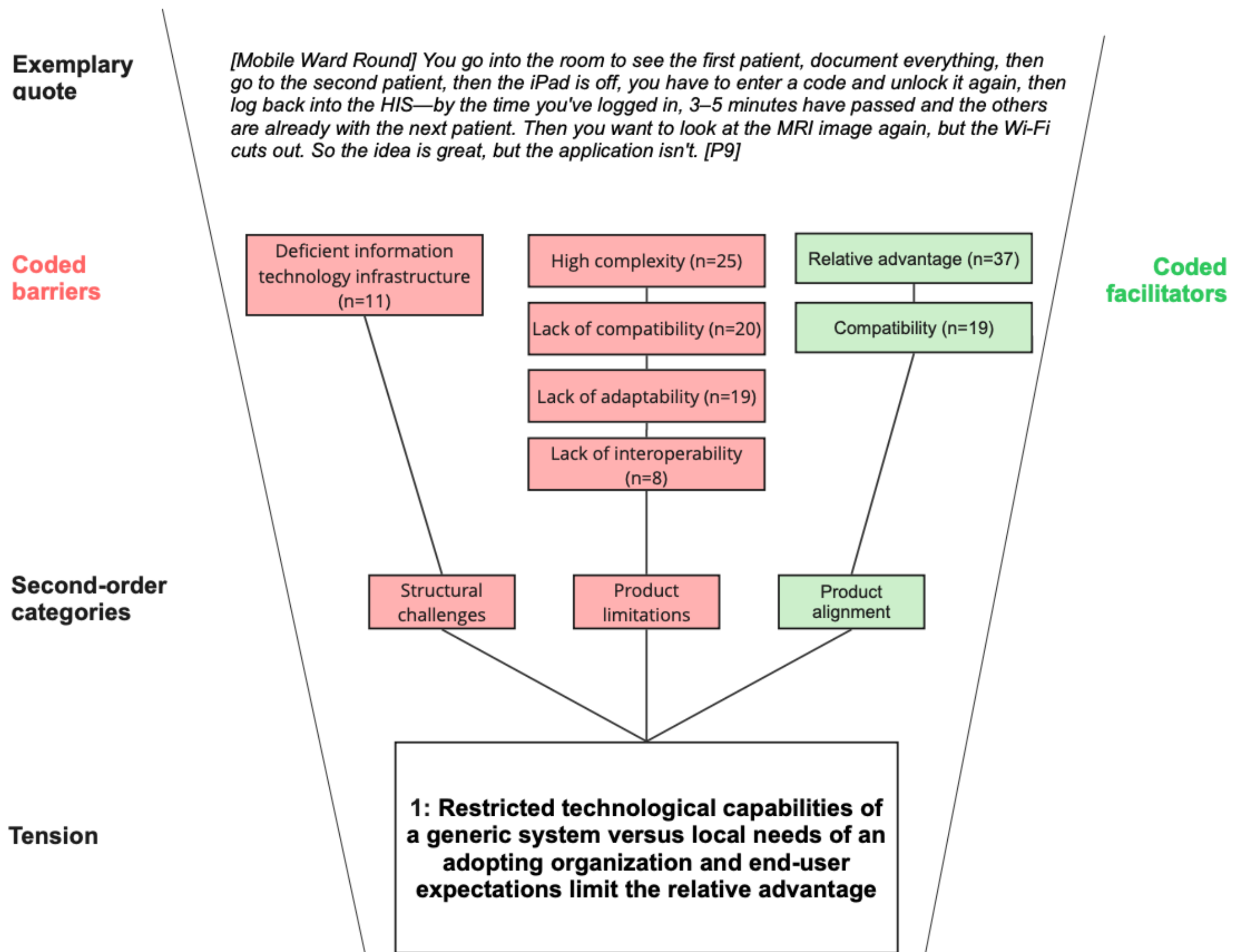
Tensions in MOT Implementation Resulting From Existent and Perceived Barriers and Facilitators

Organizational Tensions in MOT Implementation

Across all categories, our analysis revealed deeper, interrelated patterns beyond isolated barriers or facilitators, pointing to underlying organizational tensions that become apparent during MOT implementation and use. We identified 3 organizational tensions that characterize MOT implementation in complex academic hospital settings (see Figures 4-6).

XSL•FO
RenderX

Figure 4. Coding structure illustrating barriers and facilitators associated with tension 1 (generic system capabilities vs local clinical needs) in the implementation of modifiable off-the-shelf technologies at a large German academic hospital. Reported codes were aggregated into second-order categories that together capture the tension between standardized system design and the requirements of local clinical workflows. Exemplary quotes illustrate the underlying dynamics.



XSL•FO
RenderX

Figure 5. Coding structure illustrating barriers and facilitators associated with tension 2 (organizational complexity vs structured user participation) in the implementation of modifiable off-the-shelf technologies at a large German academic hospital. Reported codes were aggregated into second-order categories that together capture the tension between organizational oversight structures and desired user participation. Exemplary quotes illustrate the underlying dynamics.

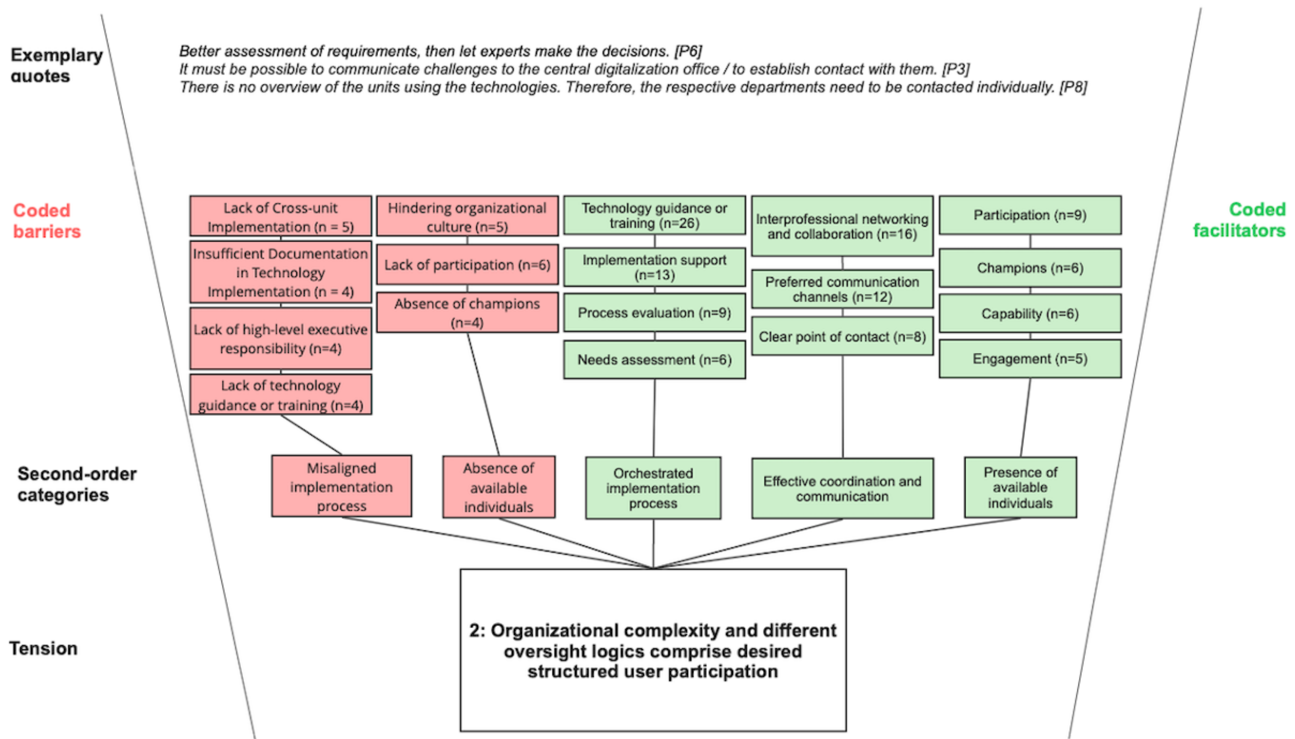
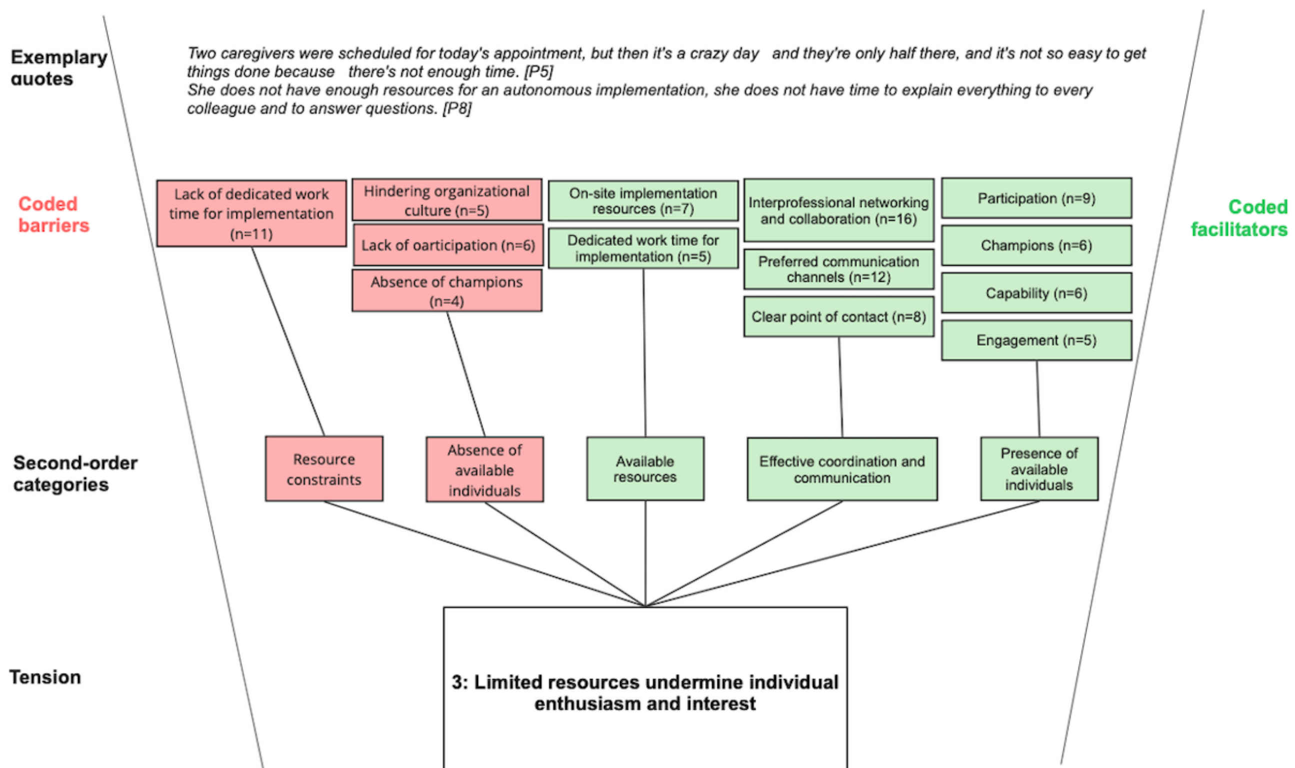


Figure 6. Coding structure illustrating barriers and facilitators associated with tension 3 (limited resources vs individual enthusiasm) in the implementation of modifiable off-the-shelf technologies at a large German academic hospital. Reported codes were aggregated into second-order categories that together capture the tension between constrained organizational resources and the motivation of clinicians and project teams to support implementation. Exemplary quotes illustrate the underlying dynamics.



XSL•FO
RenderX

Tension 1: Restricted Technological Capabilities of a Generic System Versus Local Needs of an Adopting Organization and End User Expectations Limit The Relative Advantage

While users expected a relative advantage from MOT use, product limitations emerged as a major barrier. Lack of interoperability and lack of compatibility led to fragmented data flows and incomplete functional integration, as vendor-driven system designs using preconfigured, standardized interfaces conflicted with the locally required data exchange in everyday care, which is often based on organization-specific terminology and interfaces. This created a tension because standardized system logics prioritized general applicability across diverse settings, whereas local care practices required flexible, context-specific integration of data flows. As a result, users were confronted with constant translation and alignment work to bridge the gap between the generic system architecture and their actual needs.

Closely related, the lack of adaptability and high complexity of MOTs produced usability constraints, forcing workaround practices as MOT use collided with the temporal, relational, and situational logics of clinical practice. This stood in tension with the expectation that digital systems should simplify and streamline clinical work, as MOTs instead introduced additional layers of cognitive and procedural effort. In practice, clinicians had to spend more time navigating complex interfaces or bypassing rigid functions, which diverted attention from patient care.

The emerging technological tension was further exacerbated by structural challenges, another major barrier category, particularly the hospital's deficient IT infrastructure. Ultimately, MOTs were not adopted when their potential efficiency and performance gains were outweighed by these barriers. These included high complexity, limited adaptability, and IT-infrastructural constraints, particularly a lack of interoperability and compatibility. Under such conditions, the relative advantage of MOTs was not apparent to users, which hindered their uptake.

Tension 2: Organizational Complexity and Different Oversight Logics Compromise Desired Structured User Participation

Clinicians emphasized the importance of active involvement before and during MOT implementation through preimplementation needs assessment, implementation support, process evaluation, and the use of preferred communication channels to share information effectively. Likewise, project managers highlighted their need for clear points of contact and designated champions for MOT implementation within departments. While participation was valued and desired by both groups, a hindering organizational culture was reported by clinicians and the implementation team. Clinicians, for example, felt that too much responsibility for MOT implementation was shifted to local clinical leaders, indicating a mismatch between assigned responsibilities and their perceived roles.

Participants perceived misaligned implementation processes—such as lack of technology guidance or training, insufficient documentation in technology implementation, and lack of cross-unit implementation—as barriers to their participation. These challenges may reflect differing oversight logics and governance structures shaped by managerial, economic, and regulatory requirements, such as the KHZG and data protection regulations, which had to be implemented within a short time frame, leaving limited opportunity for thorough planning and preparation. Specifically, rigid, project-bound management, hierarchical structures, and strained working climates reduced openness to participatory formats (eg, needs assessment) and hindered effective coordination and communication. This created a tension between the participatory processes that clinicians valued and the formal structures guiding implementation.

Tension 3: Limited Resources Undermine Individual Enthusiasm and Interest

While some participants expressed enthusiasm and willingness to participate, a major barrier to MOT implementation was resource constraints. Clinicians criticized the lack of dedicated work time they could allocate to implementation and highlighted their need for intensive on-site implementation support from project managers. Project managers, in turn, lacked champions in clinical departments for rollout processes and faced IT staff shortages and tight rollout schedules. This tension arises when clinicians are assigned responsibility as implementation leaders without having the necessary resources or identifying with that role. As a result, hospital managers experience tensions because they must operate under resource constraints while facing a persistent need for dedicated implementation resources.

Furthermore, interprofessional collaboration was recognized as a facilitator of MOT implementation because it was perceived to help align perspectives and create shared ownership. However, in practice, training and support were often organized in monoprofessional silos, meaning that doctors and nurses were trained separately. This reduced opportunities for joint learning and undermined the collaborative momentum required for sustained adoption. These structural and organizational barriers not only slowed implementation processes but also gradually weakened the initial enthusiasm of both clinicians and project managers. This reflects tensions between the demand to be innovative and collaborative and the lack of structures and resources needed to facilitate such collaboration.

Discussion

Principal Findings

This study identified 3 tensions during the implementation of MOTs.

Tension 1 concerned restricted technological capabilities that did not meet local needs and reduced the perceived relative advantage of the MOTs. Key barriers included product limitations, such as limited interoperability, low compatibility, low adaptability, and high complexity, as well as structural challenges that hindered smooth use. Product alignment acted as a facilitator when MOTs fit existing workflows.

XSL•FO
RenderX

Tension 2 arose from organizational complexity and differing oversight logics that compromised structured user participation. Barriers included a misaligned implementation process and the absence of available individuals to coordinate or support activities. Facilitators included an orchestrated implementation process, effective coordination and communication, and the presence of available individuals who could enable cross-unit participation.

Tension 3 reflected limited resources that undermined individual enthusiasm and interest in implementation. Barriers included resource constraints and a recurring absence of available individuals. Facilitators involved available resources, effective coordination and communication, and the presence of available individuals who could help maintain engagement.

The remainder of the "Discussion" section links these tensions and their respective barriers to misfit theory, introduces the concept of user:ability, and examines how 3 tailored strategies that integrate the observed facilitators respond to the organizational tensions in MOT implementation.

Misfits and the Role of User:Ability

Across all 3 tensions, the findings reveal that hospitals operate in a policy environment that seeks to accelerate digitalization while imposing strict timelines and compliance demands. Examples include Germany's KHZG and telematics infrastructure requirements [11,54], EU regulations such as General Data Protection Regulation (GDPR) [76] and the upcoming European Health Data Space [77], and US initiatives like HITECH [78] and the 21st Century Cures Act [79]. In this environment, hospitals often rely on MOTs, even though their standardized architecture restricts adjustments to functions, interfaces, or data flows. Limited involvement of end users during early procurement also contributes to systems that later need upgrades or expensive adjustments, as seen with the electronic health record in Germany [80-82]. These dynamics create fertile ground for organization-technology misfits as described by Strong and Volkoff [19]. Such misfits manifest in fragmented tools, disrupted workflows, higher error risk, and increased resource demands for both clinicians and IT teams [83]. In this study, multiple misfits are reflected in, and help explain, the tensions observed.

Tension 1 is characterized by functionality misfits, data misfits, and usability misfits when systems fail to reflect local workflows or information needs. Consistent with prior research, complex authentication [84], complicated user interface navigation [26], misalignment between systems and workflows [29,85], and limited interoperability [86] contributed to usability, data, and functionality misfits. Together, these factors limited the perceived usefulness of the technologies and thus discouraged adoption while also creating workarounds that made the misfits persistent [29,32,33,87,88]. Structural challenges, such as unreliable Wi-Fi, lack of functional devices [31,84], and difficulties complying with interoperability standards, reinforced these limitations.

Tension 2 reflected role and control misfits. Organizational complexity, unclear responsibilities, and inconsistent oversight made structured participation difficult [35,89]. These patterns mirror earlier studies showing that rigid governance structures and unclear responsibilities impede participation [19,90,91]. In our data, clinicians valued early involvement, whereas project managers emphasized clear contact points and department champions.

Tension 3 reflected role and organizational culture misfits. Clinicians were motivated but lacked time, recognition, and resources to take on implementation responsibilities. Resource constraints limited dedicated work time for both clinicians and project managers, a pattern consistent with the comparatively low IT investment levels in German hospitals [92]. Prior evidence supports that high workload and competing priorities force clinicians to prioritize patient care, limiting their capacity to meaningfully evaluate and adopt MOTs [93-95].

Taken together, these misfit patterns allow a focused reflection on the 3 assumptions from the "Introduction" section. The first assumption, that MOT implementation is shaped by functional and usability misfits, is confirmed but should be broadened. Functionality and usability mattered, but their effects were strengthened by role, control, and cultural misfits, showing that challenges arise from clusters of misfits rather than from product issues alone. The second assumption, that MOT implementation requires capacity-building conditions, is supported but needs refinement. Training, participation opportunities, and protected time are not optional but essential to counteract misfits caused by the limited modifiability of MOTs. However, capacity building alone cannot address structural or cultural misfits when organizations lack available individuals or coordination mechanisms. The third assumption, that structural characteristics intensify misfits, is also supported. Structural conditions not only amplified existing misfits; they also created new roles and cultural misfits by limiting participation, creating inconsistent responsibilities, and reducing available time. Overall, successful MOT implementation requires managing technological, organizational, and cultural misfits together, not only improving product alignment or increasing training.

Based on these findings, we introduce the concept of user:ability. User:ability describes the organizational conditions that enable users to adapt to MOTs effectively. It includes targeted training to clarify relative advantage, structured participation supported by clear communication, and protected time that allows users to engage in implementation tasks. Unlike related concepts such as user participation and user involvement, user:ability does not rely on early co-design, which is usually not possible with MOTs. Instead, it focuses on empowering users during implementation. Strengthening user:ability can help address the 3 tensions by improving perceived relative advantage (resolving tension 1), enabling participation in complex settings (resolving tension 2), and sustaining engagement despite limited resources (resolving tension 3). To operationalize user:ability, the following 3 strategies describe mechanisms to mitigate the tensions identified above, drawing on the facilitators observed in this study and integrating prior evidence.

XSL•FO
RenderX

Strategy 1: Ensuring Relative Advantage Through IT Integration, Product Alignment, and Targeted Learning

Strategy 1 focuses on reducing functionality, data, and usability misfits by strengthening the perceived relative advantage of the technologies through product alignment, IT integration, and targeted learning.

In this study, relative advantage and compatibility emerged as decisive factors for technology adoption, consistent with diffusion of innovations theory and the Consolidated Framework for Implementation Research [21,36,40]. Tailored learning approaches, including training, local implementation support, process evaluation, and microlearning formats, such as short instructional videos and question-and-answer sessions, helped clarify the benefits of MOT adoption and strengthened user confidence and acceptance [31,85,87,96-103]. As MOTs often require repeated upgrades and costly customizations even after rollout, organizations should integrate MOTs into the IT ecosystem with sufficient in-house IT expertise, enabling real-time access and workflow alignment [104].

Strategy 2: Empowering User Participation Through Digital Transformation and Structured Communication

Strategy 2 focuses on reducing role and control misfits by creating structures that enable meaningful participation through clear responsibilities, coordination mechanisms, and consistent communication.

Facilitators such as interprofessional networking and collaboration, clear points of contact, and preferred communication channels promoted knowledge-sharing, joint problem-solving, and shared ownership [31,97,100,101,103]. To strengthen these facilitators, hospitals can align IT and organizational goals through a digital business strategy and improve decision-making and coordination through a participatory process model that promotes aligned leadership, adaptive culture, and effective communication [105,106].

Structured and multimodal communication, including intranet resources, structured training, hybrid meetings, and targeted phone calls, can provide tailored support, clarification, and feedback [107]. These measures help align diverse stakeholders, foster trust, and enable coordination across units, thereby reducing role and control misfits.

Strategy 3: Enabling Clinician Engagement Through Resource Allocation and Systematic Implementation

Strategy 3 focuses on reducing role and cultural misfits by ensuring that individual enthusiasm can translate into sustained engagement through adequate time, support, and recognition.

Hospitals can address these constraints by allocating dedicated resources; providing clear points of contact for clinicians, project teams, and IT support; and structurally embedding clinicians across all phases of implementation [7]. By establishing structured roles such as clinical champions with protected time, for example, 4 hours per week [108], and clear cross-functional points of contact, organizations can sustain engagement, foster ownership, and enhance job satisfaction, supporting effective MOT adoption and evaluation [109-111].

This study contributes to implementation science by moving beyond the common focus on isolated barriers and facilitators. Instead of producing another descriptive list, the analysis integrates the findings into overarching misfits and organizational tensions. This perspective highlights how implementation challenges emerge from structural and relational dynamics rather than from single determinants. The study also introduces the concept of user:ability as an additional contribution. User:ability offers a way to understand how organizations can empower users in settings where technologies allow little adaptation. It shifts the focus from usability to organizational enablement and shows how targeted learning, structured participation, and protected time can help resolve core tensions. This conceptual addition extends existing implementation models by emphasizing the active role organizations play in enabling users to work effectively with MOTs.

While this study focused on barriers to implementing MOTs, the findings should not be interpreted as favoring in-house software development. In-house solutions can involve high development and maintenance costs, limited scalability, and long-term dependence on internal technical expertise and resource commitments [112]. By contrast, off-the-shelf systems benefit from vendor support, regulatory readiness, and standardized functionality, yet implementing them in complex clinical environments frequently requires extensive organizational adaptation to achieve local fit [22,113]. The findings, therefore, do not suggest the superiority of one technological strategy over the other but highlight the need for robust, participatory implementation processes and organizational alignment so that any technology, commercial or locally developed, can be meaningfully integrated into clinical practice.

Limitations

This study has several limitations that may influence interpretation and transferability. First, researchers held dual roles as implementers and evaluators, which is common in action research but may introduce observer bias. This was mitigated through reflexive practices, independent coding, and triangulation. Second, the analysis relies on frequency-based thresholds to structure qualitative data. Although the thresholds were transparently documented and grounded in established guidance for managing data overload, they may restrict the visibility of less frequent but potentially meaningful insights. As the analysis was conducted at the level of researcher protocols, the findings do not allow conclusions about participant-level prevalence or individual differences.

No demographic data were collected, which limits conclusions about individual differences. While this is methodologically acceptable in action research, where the focus is on collective learning and context-specific change [43], it constrains the ability to examine how individual characteristics may have shaped experiences. The findings, therefore, reflect shared group perspectives within the specific organizational context. Participation was voluntary and may have attracted digitally

XSL•FO
RenderX

engaged staff. However, even digitally motivated participants reported substantial barriers, suggesting that the identified tensions reflect systemic conditions rather than the views of a single subgroup. Still, less confident users may be underrepresented.

Some data relied on retrospective accounts, and the short data collection period limited insights into long-term adoption. Moreover, the focus on ready-made solutions may not fully capture upstream influences such as procurement procedures or funding structures. One included technology originated as a local initiative, which only partly aligns with the definition of MOTs but highlights the role of early user involvement.

The study did not include patient-facing technologies and did not collect patient perspectives, limiting insights into how digital transformation affects the care experience. Finally, the study took place in a single, highly resourced university hospital. Transferability is therefore limited, especially to smaller or less digitalized hospitals. Nonetheless, several observed tensions likely resonate across large and complex health care organizations. Future studies should examine these dynamics across hospitals with different structures and digital maturity levels.

Conclusions

This study demonstrates that, in the context of a German university hospital, the successful implementation of MOTs in hospitals depends less on improving usability and more on strengthening user:ability. This reframes digital transformation as an organizational challenge that requires structures that support learning, participation, and engagement when technologies cannot be adapted to local needs.

The 3 strategies derived from the findings provide context-specific guidance for creating such supportive conditions. Their relevance may extend to other large and complex health care institutions, although the implications should be interpreted in light of the single-site setting and the KHZG-funded implementation environment.

More broadly, hospitals must invest in conditions that enable users to work effectively with digital tools. This includes visible benefits for clinicians, coordinated implementation processes for project teams, and strategic resource allocation from hospital leadership.

These insights also extend beyond MOTs. Any digital technology requires alignment between structures, roles, and resources, so the choice between in-house or off-the-shelf solutions is secondary to an organization’s capacity to implement them effectively. Future research should examine how user:ability can be supported across diverse hospital settings to strengthen digital transformation efforts.

Acknowledgments

We gratefully acknowledge the valuable support of Hannah and Lynn during this study. We also extend our sincere thanks to the wards, units, and staff who contributed to data collection, with special appreciation to the nursing management and teams for their commitment and cooperation. GPT-4o (OpenAI) supported improvements to text fluency and grammar. All tool outputs were reviewed and revised by the authors, who take full responsibility for the submitted work.

Data Availability

The datasets generated and analyzed during this study are not publicly available because of data privacy; however, they are available from the corresponding author (LM) upon reasonable request. The qualitative data (field notes, workshop summaries, and focus group materials) generated and analyzed during this study are not publicly available because they contain sensitive information that could compromise participant confidentiality and institutional privacy. This paper includes selected anonymized participant quotations (anchor quotes) that illustrate key themes reported in the findings. No additional data are available for sharing.

Funding

Projects that made the evaluated technologies available for implementation were funded by the European Union through the Hospital Future Act (Krankenhauszukunftsgesetz), by financial support for the provision and maintenance of the telematics infrastructure negotiated between the National Association of Statutory Health Insurance Funds (GKV Spitzenverband) and the German Hospital Federation (Deutsche Krankenhausgesellschaft), and by internal digitalization budgets (regular institutional budgetary resources). Authors from the business units project management and CMIO were funded through the administrative budgets of their respective business units or by the European Union through the Hospital Future Act (Krankenhauszukunftsgesetz). No funder or funding body had any role in the study design, data collection, analysis, interpretation of results, or writing of the manuscript.

Authors' Contributions

Conceptualization: LM, FB, AN, CG
Data curation: BK, AN, CG
Formal analysis: BK, AN, CG, LM
Funding acquisition: FB, JCB
Investigation: AN, CG, AW, CdP, LM, EH, JCB, GK

XSL•FO
RenderX

Methodology: LM, AN, CG
Project administration: LM, CG, AN
Resources: AN, CG, GK, JCB
Supervision: LM, FB, ASP
Validation: AN, CG, BK, LM, EH, FB, CdP, AW, JCB, GK, DF, CK
Visualization: GK, BK, AN, CG, LM, DF
Writing – original draft: AN, CG, CK, EH, JCB, CdP, DF, ASP, GK, LM
Writing – review & editing: All authors

Conflicts of Interest

CG, AN, CK, and EH are researchers at the organization that launched and piloted the evaluated initiative, with no financial interests, no role on the JMIR editorial board, and no involvement in developing the technologies. LM is a participant in the BIH Charité Digital Clinician Scientist Program funded by Charité – Universitätsmedizin Berlin and the Berlin Institute of Health at Charité (BIH), and has received research funding from Masimo Inc and Philips. These contributions are independent of this project. DF is employed as a part-time researcher at the organization that launched and piloted the implementation initiative evaluated in this study; has received research funding from the European Commission, the German Federal Ministry of Research, Technology and Space, the German Federal Ministry of Health, the Berlin University Alliance, and the Einstein Foundation; has received support for attending meetings or travel from the German Academic Exchange Service. These contributions are independent of this project; and has no financial interests in the initiative or related products, has not served on the JMIR editorial board, and was not involved in the development of the evaluated technologies. FB has received research funding from the Hans Böckler Foundation, Berlin University Alliance, Charité Foundation, Joint Federal Committee, European Commission, Fresenius Foundation, the German Federal Ministry of Research, Technology and Space, the German Federal Ministry of Health, the German Research Foundation, Honda Research Foundation, and Philips; and has received honoraria from Pfizer and support for attending meetings or travel from the Association of German Anesthetists, DGAI, the German Society of Anesthesiology and Intensive Care Medicine, Masimo, and the Bavarian Academy of Sciences and Humanities. ASP has received research funding from the German Federal Ministry of Education and Research (BMBF), the European Society of Intensive Care Medicine, and the medical technology companies Masimo and Dräger; serves in an advisory capacity to Philips; and is a co-founder and managing director of INCH Health GmbH. BK declares no financial interests, no involvement in JMIR editorial activities, and no role in developing the evaluated technologies. JCB is employed as a project manager at the organization that launched and piloted the implementation initiative evaluated in this study and has no competing financial interests in the initiative or related products. GK is a digitalization manager within the CMIO at the organization that launched and piloted the initiative and declares no competing financial interests. CdP is a digital manager at the organization that launched and piloted the initiative and declares no competing financial interests. AW is employed as a digital manager and nurse at the organization that launched and piloted the initiative and declares no competing financial interests.

Multimedia Appendix 1

Standards for Reporting Qualitative Research (SRQR) checklist.
[DOCX File , 38 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist.
[DOCX File , 24 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Units of study.
[DOCX File , 24 KB-Multimedia Appendix 3]

Multimedia Appendix 4

Observation guide.
[DOCX File , 32 KB-Multimedia Appendix 4]

Multimedia Appendix 5

Table of code frequencies.
[DOCX File , 55 KB-Multimedia Appendix 5]

XSL•FO
RenderX

Multimedia Appendix 6

Codebook.
[DOCX File , 61 KB-Multimedia Appendix 6]

References

1. Bardhan I, Chen H, Karahanna E. Connecting systems, data, and people: a multidisciplinary research roadmap for chronic disease management. MIS Quarterly: Management Information Systems. Mar 01, 2020;44(1):185-200. [doi: 10.25300/misq/2020/14644]
2. Sunyaev A, Fürstenau D, Davidson E. Reimagining digital health. Bus Inf Syst Eng. May 27, 2024;66(3):249-260. [doi: 10.1007/s12599-024-00870-x]
3. Borges do Nascimento IJ, Abdulazeem HM, Vasanthan LT, Martinez EZ, Zucoloto ML, Østengaard L, et al. The global effect of digital health technologies on health workers' competencies and health workplace: an umbrella review of systematic reviews and lexical-based and sentence-based meta-analysis. Lancet Digit Health. Aug 2023;5(8):e534-e544. [FREE Full text] [doi: 10.1016/S2589-7500(23)00092-4] [Medline: 37507197]
4. Endalamaw A, Zewdie A, Wolka E, Assefa Y. A scoping review of digital health technologies in multimorbidity management: mechanisms, outcomes, challenges, and strategies. BMC Health Serv Res. Mar 15, 2025;25(1):382. [FREE Full text] [doi: 10.1186/s12913-025-12548-5] [Medline: 40089752]
5. Campanella P, Lovato E, Marone C, Fallacara L, Mancuso A, Ricciardi W, et al. The impact of electronic health records on healthcare quality: a systematic review and meta-analysis. Eur J Public Health. Feb 30, 2016;26(1):60-64. [doi: 10.1093/eurpub/ckv122] [Medline: 26136462]
6. Thompson S, Whitaker J, Kohli R, Jones C. Chronic disease management: how IT and analytics create healthcare value through the temporal displacement of care. MISQ. Jan 01, 2020;44(1):227-256. [doi: 10.25300/misq/2020/15085]
7. Kraus S, Schiavone F, Pluzhnikova A, Invernizzi AC. Digital transformation in healthcare: analyzing the current state-of-research. Journal of Business Research. Feb 2021;123:557-567. [doi: 10.1016/j.jbusres.2020.10.030]
8. Insani WN, Zakiyah N, Puspitasari IM, Permana MY, Parmikanti K, Rusyaman E, et al. Digital health technology interventions for improving medication safety: systematic review of economic evaluations. J Med Internet Res. Feb 05, 2025;27:e65546. [FREE Full text] [doi: 10.2196/65546] [Medline: 39909404]
9. Woods L, Eden R, Green D, Pearce A, Donovan R, McNeil K, et al. Impact of digital health on the quadruple aims of healthcare: a correlational and longitudinal study (Digimat Study). Int J Med Inform. Sep 2024;189:105528. [FREE Full text] [doi: 10.1016/j.ijmedinf.2024.105528] [Medline: 38935999]
10. Gates P, Hardie R, Raban M, Li L, Westbrook J. How effective are electronic medication systems in reducing medication error rates and associated harm among hospital inpatients? A systematic review and meta-analysis. J Am Med Inform Assoc. Jan 15, 2021;28(1):167-176. [FREE Full text] [doi: 10.1093/jamia/ocaa230] [Medline: 33164058]
11. Gesetz für ein Zukunftsprogramm Krankenhäuser (KHZG). Bundesgesundheitsministerium. Oct 23, 2020. URL: https://www.bundesgesundheitsministerium.de/fileadmin/Dateien/3_Downloads/Gesetze_und_Verordnungen/GuV/K/bgbl1_S.2208_KHZG_28.10.20.pdf [accessed 2026-02-16]
12. Doelfs G. Streit um enge fristen: kliniken im wettlauf gegen KHZG-Strafzahlungen. kma-online. May 23, 2023. URL: https://www.kma-online.de/aktuelles/it-digital-health/detail/kliniken-im-wettlauf-gegen-khzg-strafzahlungen-49902 [accessed 2025-08-23]
13. Heeser A. Krankenhauszukunftsgesetz: das KHZG und der Hürdenlauf. Wie geht es 2025 weiter? kma-online. May 17, 2024. URL: https://www.kma-online.de/aktuelles/it-digital-health/detail/das-khzg-und-der-huerdenlauf-wie-geht-es-2025-weiter-51987 [accessed 2025-08-23]
14. Svempe L. Exploring impediments imposed by the Medical Device Regulation EU 2017/745 on software as a medical device. JMIR Med Inform. Sep 05, 2024;12(1):e58080. [FREE Full text] [doi: 10.2196/58080] [Medline: 39235850]
15. Miclăuş T, Valla V, Koukoura A, Nielsen AA, Dahlerup B, Tsianos G, et al. Impact of design on medical device safety. Ther Innov Regul Sci. Jul 9, 2020;54(4):839-849. [FREE Full text] [doi: 10.1007/s43441-019-00022-4] [Medline: 32557299]
16. Mousavidin E, Silva L. Theorizing the configuration of modifiable off-the-shelf software. ITP. Nov 06, 2017;30(4):887-909. [doi: 10.1108/itp-07-2014-0140]
17. Lucas H, Walton E, Ginzberg M. Implementing packaged software. MIS Quarterly. 1988;12(4):537-549. [doi: 10.2307/249129]
18. Fürstenau D, Gersch M, Schreiter S. Digital therapeutics (DTx). Bus Inf Syst Eng. Apr 06, 2023;65(3):349-360. [doi: 10.1007/s12599-023-00804-z]
19. Strong, Volkoff. Understanding organization—enterprise system fit: a path to theorizing the information technology artifact. MIS Quarterly. Dec 2010;34(4):731-756. [doi: 10.2307/25750703]
20. Safi S, Thiessen T, Schmailzl KJ. Acceptance and resistance of new digital technologies in medicine: qualitative study. JMIR Res Protoc. Dec 04, 2018;7(12):e11072. [FREE Full text] [doi: 10.2196/11072] [Medline: 30514693]

XSL•FO
RenderX

21. Damschroder LJ, Reardon CM, Widerquist MAO, Lowery J. The updated Consolidated Framework for Implementation Research based on user feedback. Implement Sci. Oct 29, 2022;17(1):75. [FREE Full text] [doi: 10.1186/s13012-022-01245-0] [Medline: 36309746]
22. Marwaha JS, Landman AB, Brat GA, Dunn T, Gordon WJ. Deploying digital health tools within large, complex health systems: key considerations for adoption and implementation. NPJ Digit Med. Jan 27, 2022;5(1):13. [FREE Full text] [doi: 10.1038/s41746-022-00557-1] [Medline: 35087160]
23. Li M. An approach to addressing the usability and local relevance of generic enterprise software. Association for Information Systems (eLibrary). 2019. URL: https://aisel.aisnet.org/iris2019/3 [accessed 2026-02-25]
24. Kaipio J, Lääveri T, Hyppönen H, Vainiomäki S, Reponen J, Kushniruk A, et al. Usability problems do not heal by themselves: national survey on physicians' experiences with EHRs in Finland. Int J Med Inform. Jan 2017;97:266-281. [FREE Full text] [doi: 10.1016/j.ijmedinf.2016.10.010] [Medline: 27919385]
25. Garcia L, Mendonça G, Benedetti TRB, Borges LJ, Streit IA, Christofoletti M, et al. Barriers and facilitators of domain-specific physical activity: a systematic review of reviews. BMC Public Health. Oct 26, 2022;22(1):1964. [FREE Full text] [doi: 10.1186/s12889-022-14385-1] [Medline: 36289461]
26. Zhai Y, Yu Z, Zhang Q, Zhang Y. Barriers and facilitators to implementing a nursing clinical decision support system in a tertiary hospital setting: a qualitative study using the FITT framework. Int J Med Inform. Oct 2022;166:104841. [doi: 10.1016/j.ijmedinf.2022.104841] [Medline: 36027798]
27. Jacob C, Sanchez-Vazquez A, Ivory C. Clinicians' role in the adoption of an oncology decision support app in Europe and its implications for organizational practices: qualitative case study. JMIR mHealth and uHealth. May 03, 2019;7(5):e13555. [FREE Full text] [doi: 10.2196/13555] [Medline: 31066710]
28. Giraldo L, Schachner B, Luna D, Benítez S. Exploring nurses' perceptions and expectations toward a BCMA implementation using a mobile app and workstations as a change management strategy. Stud Health Technol Inform. 2018;250:134-138. [Medline: 29857405]
29. Seibert K, Domhoff D, Huter K, Krick T, Rothgang H, Wolf-Ostermann K. Application of digital technologies in nursing practice: results of a mixed methods study on nurses' experiences, needs and perspectives. Z Evid Fortbild Qual Gesundhwes. Dec 19, 2020;158-159:94-106. [FREE Full text] [doi: 10.1016/j.zefq.2020.10.010] [Medline: 33223491]
30. Kleinpell R, Barden C, Rincon T, McCarthy M, Zapatochny Rufo RJ. Assessing the impact of telemedicine on nursing care in intensive care units. Am J Crit Care. Jan 31, 2016;25(1):e14-e20. [doi: 10.4037/ajcc2016808] [Medline: 26724303]
31. Delaforce A, Li J, Grujovski M, Parkinson J, Richards P, Fahy M, et al. Creating an implementation enhancement plan for a digital patient fall prevention platform using the CFIR-ERIC approach: a qualitative study. Int J Environ Res Public Health. Feb 21, 2023;20(5):3794. [FREE Full text] [doi: 10.3390/ijerph20053794] [Medline: 36900804]
32. Jacob C, Sanchez-Vazquez A, Ivory C. Factors impacting clinicians' adoption of a clinical photo documentation app and its implications for clinical workflows and quality of care: qualitative case study. JMIR Mhealth Uhealth. Sep 23, 2020;8(9):e20203. [FREE Full text] [doi: 10.2196/20203] [Medline: 32965232]
33. Wosny M, Strasser LM, Hastings J. The paradoxes of digital tools in hospitals: qualitative interview study. J Med Internet Res. Jul 15, 2024;26:e56095. [doi: 10.2196/56095]
34. Miron-Spektor E, Ingram A, Keller J, Smith WK, Lewis MW. Microfoundations of organizational paradox: the problem is how we think about the problem. AMJ. Feb 2018;61(1):26-45. [doi: 10.5465/amj.2016.0594]
35. Haring M, Freigang F, Amelung V, Gersch M. What can healthcare systems learn from looking at tensions in innovation processes? A systematic literature review. BMC Health Serv Res. Oct 28, 2022;22(1):1299. [FREE Full text] [doi: 10.1186/s12913-022-08626-7] [Medline: 36307839]
36. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implement Sci. Aug 07, 2009;4:50. [FREE Full text] [doi: 10.1186/1748-5908-4-50] [Medline: 19664226]
37. Greenhalgh T, Wherton J, Papoutsi C, Lynch J, Hughes G, A'Court C, et al. Beyond adoption: a new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies. Journal of Medical Internet Research. Nov 01, 2017;19(11):e8775. [FREE Full text] [doi: 10.2196/jmir.8775] [Medline: 29092808]
38. Glasgow RE, Harden SM, Gaglio B, Rabin B, Smith ML, Porter GC, et al. RE-AIM planning and evaluation framework: adapting to new science and practice with a 20-year review. Front Public Health. Mar 29, 2019;7:64. [FREE Full text] [doi: 10.3389/fpubh.2019.00064] [Medline: 30984733]
39. Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. Am J Public Health. Sep 1999;89(9):1322-1327. [doi: 10.2105/ajph.89.9.1322] [Medline: 10474547]
40. Rogers E, Singhal A, Quinlan M. Diffusion of Innovations. In: An Integrated Approach to Communication Theory and Research. New York, NY. Routledge; 2014:432-448.
41. Moullin JC, Dickson KS, Stadnick NA, Albers B, Nilsen P, Broder-Fingert S, et al. Ten recommendations for using implementation frameworks in research and practice. Implement Sci Commun. Apr 30, 2020;1(1):42. [FREE Full text] [doi: 10.1186/s43058-020-00023-7] [Medline: 32885199]

XSL•FO
RenderX

42. Graham ID, Logan J, Harrison MB, Straus SE, Tetroe J, Caswell W, et al. Lost in knowledge translation: time for a map? Journal of Continuing Education in the Health Professions. 2006;26(1):13-24. [doi: 10.1002/chp.47] [Medline: 16557505]
43. Rapoport R. Three dilemmas in action research: with special reference to the Tavistock experience. Human Relations. Dec 01, 1970;23(6):499-513. [doi: 10.1177/001872677002300601]
44. Köberlein-Neu J, Söling S. Implementierung von digitalen technologien in der patientenversorgungine frage der passenden strategie(n). In: Technologien und Technologiemanagement im Gesundheitswesen. Wiesbaden, Germany. Springer Fachmedien Wiesbaden; 2024:431-454.
45. Schwandt T. Constructivist, interpretivist approaches to human inquiry. In: Handbook of Qualitative Research: Theories and Issues. Thousand Oaks, CA. Sage; Jan 01, 1994:221-259.
46. Ponterotto JG. Qualitative research in counseling psychology: a primer on research paradigms and philosophy of science. Journal of Counseling Psychology. Apr 2005;52(2):126-136. [doi: 10.1037/0022-0167.52.2.126]
47. Hult M, Lennung S. Towards a definition of action research: a note and bibliography. J Management Studies. May 1980;17(2):241-250. [doi: 10.1111/j.1467-6486.1980.tb00087.x]
48. Kemmis S, McTaggart R, Nixon R. The Action Research Planner: Doing Critical Participatory Action Research. Singapore. Springer Singapore; Nov 12, 2013.
49. Walsham G. Interpretive case studies in IS research: nature and method. European Journal of Information Systems. Dec 19, 2017;4(2):74-81. [doi: 10.1057/ejis.1995.9]
50. Tong A, Sainsbury P, Craig J. Consolidated Criteria for Reporting Qualitative Research (COREQ): a 32-item checklist for interviews and focus groups. International Journal for Quality in Health Care. Sep 16, 2007;19(6):349-357. [FREE Full text] [doi: 10.1093/intqhc/mzm042] [Medline: 17872937]
51. O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: a synthesis of recommendations. Acad Med. Sep 2014;89(9):1245-1251. [doi: 10.1097/ACM.0000000000000388] [Medline: 24979285]
52. Charité. 2024. URL: https://www.charite.de/die_charite/profil/zahlen_fakten [accessed 2025-08-07]
53. Charité strategie 2030. Charité. URL: https://www.charite.de/die_charite/profil/charite_strategie_2030 [accessed 2025-06-10]
54. Bundesamt für Justiz. Sozialgesetzbuch (SGB V) § 306 – telematikinfrastruktur. sozialgesetzbuch SGB. URL: https://www.sozialgesetzbuch-sgb.de/sgbv/306.html [accessed 2025-09-23]
55. eAU. Gematik GmbH. URL: https://www.gematik.de/anwendungen/kim/faq?faqc=47 [accessed 2025-08-29]
56. Nation-wide electronic health record. Gematik GmbH. 2025. URL: https://www.gematik.de/anwendungen/epa-fuer-alle [accessed 2025-08-29]
57. ePrescription. e-Rezept. 2025. URL: https://www.das-e-rezept-fuer-deutschland.de/en [accessed 2025-08-29]
58. ID MEDICS – closed loop: medication support from the hospital information system. ID Berlin. 2025. URL: https://www.id-berlin.de/en/products/emedikation/id-medics/ [accessed 2025-08-29]
59. Kommunikation im medizinwesen. Gematik GmBH. 2025. URL: https://www.gematik.de/anwendungen/kim [accessed 2025-08-29]
60. SAP help portal – SAP for healthcare documentation. SAP. URL: https://help.sap.com/docs/SAP_FOR_HEALTHCARE/7d223867a0ad462a8665d1f9531eb5e9/4dd3306d81a60b63e10000000a42189b.html?version=618.26&q=implantatpass [accessed 2025-08-27]
61. Common MS. eMed: die perfekte mobile Lösung für Cerner i.s.h.med®. Common MS. 2022. URL: https://commonms.com/de/gesundheit/interoperabilitat/ [accessed 2025-08-27]
62. SAP help portal – SAP for healthcare. SA. URL: https://help.sap.com/docs/SAP_FOR_HEALTHCARE/f3a8c1fd3c8748df9bdaeb1736b387f1/4d958010d1b83c46e10000000a42189e-846.html?version=604.74 [accessed 2025-08-27]
63. Flüssigkeitsbilanz – SAP help portal. SAP. URL: https://help.sap.com/docs/SAP_FOR_HEALTHCARE/7d223867a0ad462a8665d1f9531eb5e9/14ecbd1891064031a331e23f5904ac6f.html?version=618.26 [accessed 2025-08-27]
64. Wenn idee auf initiative trifft: der stationsbuddy: Charité. Charité. 2025. URL: https://karriere.charite.de/karrieremagazin/stationsbuddy [accessed 2025-08-27]
65. Palinkas LA, Horwitz SM, Green CA, Wisdom JP, Duan N, Hoagwood K. Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. Administration and Policy in Mental Health. Sep 2015;42(5):533-544. [FREE Full text] [doi: 10.1007/s10488-013-0528-y] [Medline: 24193818]
66. Pailthorpe B. Emergent design. In: Matthes J, Davis C, Potter R, editors. The International Encyclopedia of Communication Research Methods. Hoboken, NJ. Wiley; Nov 07, 2017:1-2.
67. Morgan DL. Focus groups. Annu Rev Sociol. Aug 01, 1996;22(1):129-152. [doi: 10.1146/annurev.soc.22.1.129]
68. Storvang P, Mortensen B, Clarke A. Using workshops in business research: a framework to diagnose, plan, facilitate and analyze workshops. In: Freytag P, Young L, editors. Collaborative Research Design: Working with Business for Meaningful Findings. Singapore. Springer; 2018:155-174.
69. Mulhall A. In the field: notes on observation in qualitative research. J Adv Nurs. Feb 04, 2003;41(3):306-313. [doi: 10.1046/j.1365-2648.2003.02514.x] [Medline: 12581118]
70. Dreborg KH. Essence of backcasting. Futures. Nov 1996;28(9):813-828. [doi: 10.1016/s0016-3287(96)00044-4]

XSL•FO
RenderX

71. Malterud K, Siersma VD, Guassora AD. Sample size in qualitative interview studies: guided by information power. Qualitative Health Research. Nov 27, 2015;26(13):1753-1760. [doi: 10.1177/1049732315617444] [Medline: 26613970]
72. MAXQDA 2022. VERBI GmbH. URL: https://www.maxqda.com/de/about [accessed 2025-08-07]
73. Kuckartz U, Rädiker S. Qualitative Inhaltsanalyse. Methoden, Praxis, Umsetzung mit Software und künstlicher Intelligenz. 6. Auflage. Weinheim, Germany. Beltz Juventa; 2024.
74. Miles M, Huberman A. Qualitative Data Analysis: An Expanded Sourcebook. Thousand Oaks, CA. Sage Publications; 1994.
75. Carter N, Bryant-Lukosius D, DiCenso A, Blythe J, Neville AJ. The use of triangulation in qualitative research. Oncology Nursing Forum. Sep 01, 2014;41(5):545-547. [doi: 10.1188/14.ONF.545-547] [Medline: 25158659]
76. Datenschutz-Grundverordnung (General Data Protection Regulation). European Parliament and of the Council. Brussels, Belgium. European Union; 2016. URL: https://dsgvo-gesetz.de/ [accessed 2025-09-23]
77. European Parliament and of the Council. Regulation (EU) 2025/327 on the European Health Data Space (EHDS). EUR-Lex. Brussels, Belgium. European Union; 2025. URL: https://eur-lex.europa.eu/eli/reg/2025/327/oj/eng [accessed 2025-09-23]
78. Public Law 111-5. Senate and House of Representatives of the United States of America. Washington, DC. US Government Publishing Office; 2009. URL: https://www.govinfo.gov/content/pkg/PLAW-111publ5/pdf/PLAW-111publ5.pdf [accessed 2025-09-23]
79. Public Law-114-255. Senate and House of Representatives of the United States of America. Dec 13, 2016. URL: https://www.congress.gov/114/plaws/publ255/PLAW-114publ255.pdf [accessed 2025-09-23]
80. Tsai CH, Eghdam A, Davoody N, Wright G, Flowerday S, Koch S. Effects of electronic health record implementation and barriers to adoption and use: a scoping review and qualitative analysis of the content. Life (Basel). Dec 04, 2020;10(12):327. [FREE Full text] [doi: 10.3390/life10120327] [Medline: 33291615]
81. Uncertainty surrounds electronic patient record rollout in Germany. The Munich Eye. Apr 03, 2025. URL: https://themunicheye.com/delay-in-electronic-patient-record-rollout-germany-15435 [accessed 2025-08-28]
82. Elektronische patientenakte: ePA für alle. Bundesministerium für Gesundheit. 2025. URL: https://www.bundesgesundheitsministerium.de/epa-vorteile/ [accessed 2025-08-18]
83. Carlos Ferreira J, Elvas LB, Correia R, Mascarenhas M. Enhancing EHR interoperability and security through distributed ledger technology: a review. Healthcare (Basel). Oct 02, 2024;12(19):1967. [FREE Full text] [doi: 10.3390/healthcare12191967] [Medline: 39408147]
84. Duhm J, Fleischmann R, Schmidt S, Hupperts H, Brandt SA. Mobile electronic medical records promote workflow: physicians' perspective from a survey. JMIR Mhealth Uhealth. Jun 06, 2016;4(2):e70. [FREE Full text] [doi: 10.2196/mhealth.5464] [Medline: 27268720]
85. Leenen JPL, Rasing HJM, Kalkman CJ, Schoonhoven L, Patijn GA. Process evaluation of a wireless wearable continuous vital signs monitoring intervention in 2 general hospital wards: mixed methods study. JMIR Nurs. May 04, 2023;6:e44061. [FREE Full text] [doi: 10.2196/44061] [Medline: 37140977]
86. Torab-Miandoab A, Samad-Soltani T, Jodati A, Rezaei-Hachesu P. Interoperability of heterogeneous health information systems: a systematic literature review. BMC Medical Informatics and Decision Making. Jan 24, 2023;23(1):18. [FREE Full text] [doi: 10.1186/s12911-023-02115-5] [Medline: 36694161]
87. Mosch LK, Poncette A, Spies C, Weber-Carstens S, Schieler M, Krampe H, et al. Creation of an evidence-based implementation framework for digital health technology in the intensive care unit: qualitative study. JMIR Form Res. Apr 08, 2022;6(4):e22866. [FREE Full text] [doi: 10.2196/22866] [Medline: 35394445]
88. van Offenbeek MAG, Vos JFJ, van den Hooff B, Boonstra A. When workarounds aggravate misfits in the use of electronic health record systems. Information Systems Journal. Oct 13, 2023;34(2):293-326. [doi: 10.1111/isj.12478]
89. Hansen S, Baroody AJ. Electronic health records and the logics of care: complementarity and conflict in the U.S. healthcare system. Information Systems Research. Mar 01, 2020;31(1):57-75. [doi: 10.1287/isre.2019.0875]
90. Shahzad K, Imran F, Butt A. Digital transformation and changes in organizational structure. Research-Technology Management. Apr 09, 2025;68(3):25-40. [doi: 10.1080/08956308.2025.2465706]
91. Verhoef PC, Broekhuizen T, Bart Y, Bhattacharya A, Qi Dong J, Fabian N, et al. Digital transformation: a multidisciplinary reflection and research agenda. Journal of Business Research. Jan 01, 2021;122:889-901. [doi: 10.1016/j.jbusres.2019.09.022]
92. Liebe J, Reincke L, Buddrus U. IT-ausgaben in krankenhäusern im internationalen vergleich: Deutschland, Dänemark und die Niederlande. Science to Business GmbH – Hochschule Osnabrück. Osnabrück, Germany. Science to Business GmbH – Hochschule Osnabrück; 2025. URL: https://www.dkgev.de/fileadmin/default/Mediapool/1_DKG/1.7_Presse/1.7.1_Pressemitteilungen/2025/2025-07-30_Anlage_Studie_int._Vergleich_von_IT-Ausgaben_in_Krankenhaeusern.pdf [accessed 2025-08-23]
93. Borges do Nascimento IJ, Abdulazeem H, Vasanthan LT, Martinez EZ, Zucoloto ML, Østengaard L, et al. Barriers and facilitators to utilizing digital health technologies by healthcare professionals. npj Digital Medicine. Sep 18, 2023;6(1):161. [doi: 10.1038/s41746-023-00899-4]
94. Zharima C, Mhlanga S, Abdulla S, Goudge J, Griffiths F. What engagement strategies are useful in facilitating the implementation of electronic health records in health care settings? A rapid review of qualitative evidence synthesis using

XSL•FO
RenderX

the normalization process theory. Digit Health. 2024;10:1-28. [FREE Full text] [doi: 10.1177/20552076241291286] [Medline: 39497787]
95. Grignoli N, Manoni G, Gianini J, Schulz P, Gabutti L, Petrocchi S. Clinical decision fatigue: a systematic and scoping review with meta-synthesis. Fam Med Community Health. Feb 08, 2025;13(1):e003033. [FREE Full text] [doi: 10.1136/fmch-2024-003033] [Medline: 39922690]
96. Powell BJ, Waltz TJ, Chinman MJ, Damschroder LJ, Smith JL, Matthieu MM, et al. A refined compilation of implementation strategies: results from the Expert Recommendations for Implementing Change (ERIC) project. Implement Sci. Feb 2015;10(1):21. [FREE Full text] [doi: 10.1186/s13012-015-0209-1] [Medline: 25889199]
97. Barchielli C, Marullo C, Bonciani M, Vainieri M. Nurses and the acceptance of innovations in technology-intensive contexts: the need for tailored management strategies. BMC Health Serv Res. Jul 03, 2021;21(1):639. [doi: 10.1186/s12913-021-06628-5]
98. Connolly SL, Kuhn E, Possemato K, Torous J. Digital clinics and mobile technology implementation for mental health care. Curr Psychiatry Rep. May 07, 2021;23(7):38. [doi: 10.1007/s11920-021-01254-8]
99. Verma N, Mamlin B, Flowers J, Acharya S, Labrique A, Cullen T. OpenMRS as a global good: impact, opportunities, challenges, and lessons learned from fifteen years of implementation. International Journal of Medical Informatics. May 2021;149:104405. [doi: 10.1016/j.ijmedinf.2021.104405]
100. Olesen ML, Rossen S, Jørgensen R, Langballe Udbjørg L, Hansson H. Usefulness of a digitally assisted person-centered care intervention: qualitative study of patients' and nurses' experiences in a long-term perspective. JMIR Nurs. May 18, 2023;6:e46673. [FREE Full text] [doi: 10.2196/46673] [Medline: 37200076]
101. Hofstetter S, Zilezinski M, Behr D, Kraft B, Buhtz C, Paulicke D, et al. Integrating digital assistive technologies into care processes: mixed methods study. JMIR Med Educ. Oct 09, 2024;10:e54083. [FREE Full text] [doi: 10.2196/54083] [Medline: 39383526]
102. Alotaibi N, Wilson CB, Traynor M. Enhancing digital readiness and capability in healthcare: a systematic review of interventions, barriers, and facilitators. BMC Health Serv Res. Apr 04, 2025;25(1):500. [FREE Full text] [doi: 10.1186/s12913-025-12663-3] [Medline: 40186200]
103. Claessens D, Boudewijns EA, Vervloet M, Keijsers LCEM, Gidding-Slok AHM, van Schayck OCP, et al. Barriers and facilitators to the implementation of the Assessment of Burden of Chronic Conditions tool in Dutch primary care: a context analysis. BMJ Open. Jan 20, 2025;15(1):e087197. [FREE Full text] [doi: 10.1136/bmjopen-2024-087197] [Medline: 39833000]
104. Mathias R, McCulloch P, Chalkidou A, Gilbert S. Digital health technologies need regulation and reimbursement that enable flexible interactions and groupings. NPJ Digit Med. Jun 18, 2024;7(1):148. [FREE Full text] [doi: 10.1038/s41746-024-01147-z] [Medline: 38890404]
105. Hess T, Matt C, Benlian A, Wiesböck F. Options for formulating a digital transformation strategy. In: Strategic Information Management. New York, NY. Routledge; 2020:151-173.
106. Bharadwaj A, El Sawy OA, Pavlou PA, Venkatraman N. Digital business strategy: toward a next generation of insights. MISQ. Feb 2, 2013;37(2):471-482. [doi: 10.25300/misq/2013/37:2.3]
107. Adjekum A, Blasimme A, Vayena E. Elements of trust in digital health systems: scoping review. J Med Internet Res. Dec 13, 2018;20(12):e11254. [FREE Full text] [doi: 10.2196/11254] [Medline: 30545807]
108. Bunce AE, Gruß I, Davis JV, Cowburn S, Cohen D, Oakley J, et al. Lessons learned about the effective operationalization of champions as an implementation strategy: results from a qualitative process evaluation of a pragmatic trial. Implement Sci. Oct 01, 2020;15(1):87. [FREE Full text] [doi: 10.1186/s13012-020-01048-1] [Medline: 32998750]
109. Wieslander L, Bäckström I, Häggström M. Participation in the digital transformation of healthcare: a review of qualitative studies. Int J Health Care Qual Assur. Nov 15, 2024;37(3-4):68-84. [doi: 10.1108/IJHCQA-03-2024-0021] [Medline: 39541252]
110. Galazzi A, Fonda F, Chiappinotto S, Justi L, Sønderskov Frydensberg M, Lehmann Boesen R, et al. Recommendations to promote the digital healthcare transformation in the clinical practice: findings from an international consensus development method. BMC Health Serv Res. Jul 04, 2025;25(1):929. [FREE Full text] [doi: 10.1186/s12913-025-13079-9] [Medline: 40616118]
111. Hansen A. Rapid adaptation in digital tRansfoRmation: a paRticipatoRy pRocess foR engaging is and Business leadeRs. MIS Quarterly Executive. Dec 4, 2011;10(4):175-185. [FREE Full text]
112. Amlung J, Huth H, Cullen T, Sequist T. Modernizing health information technology: lessons from healthcare delivery systems. JAMIA Open. Oct 01, 2020;3(3):369-377. [doi: 10.1093/jamiaopen/ooaa027]
113. Takian A, Sheikh A, Barber N. Organizational learning in the implementation and adoption of national electronic health records: case studies of two hospitals participating in the National Programme for Information Technology in England. Health Informatics J. Sep 02, 2014;20(3):199-212. [FREE Full text] [doi: 10.1177/1460458213493196] [Medline: 25183608]

Abbreviations

COREQ: Consolidated Criteria for Reporting Qualitative Research

XSL•FO
RenderX

DHT: digital health technology
GDPR: General Data Protection Regulation
KHZG: Krankenhauszukunftsgesetz (Hospital Future Act)
MOT: modifiable off-the-shelf technology
P: protocol
SRQR: Standards for Reporting Qualitative Research

Edited by C LeRouge; submitted 25.Sep.2025; peer-reviewed by R Reid, C Yi; comments to author 30.Oct.2025; accepted 21.Feb.2026; published 13.May.2026

Please cite as:
Nowak A, Gaul C, Hinz E, Knoll C, Kül B, Wels A, Berkmann JC, de Pasquale C, Kremser G, Fürstenau D, Poncette A-S, Balzer F, Mosch L
Organizational Tensions in the Implementation of Modifiable Off-the-Shelf Technologies in a University Hospital: Qualitative Multimethod Study
JMIR Hum Factors 2026;13:e84841
URL: https://humanfactors.jmir.org/2026/1/e84841
doi: 10.2196/84841
PMID:

©Alessia Nowak, Carolina Gaul, Elena Hinz, Christine Knoll, Begüm Kül, Anja Wels, Julia C Berkmann, Cathrin de Pasquale, Gloria Kremser, Daniel Fürstenau, Akira-Sebastian Poncette, Felix Balzer, Lina Mosch. Originally published in JMIR Human Factors (https://humanfactors.jmir.org), 13.May.2026. This is an open-access article distributed under the terms of the Creative Commons Attribution License (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work, first published in JMIR Human Factors, is properly cited. The complete bibliographic information, a link to the original publication on https://humanfactors.jmir.org, as well as this copyright and license information must be included.

XSL•FO
RenderX