Original Paper

Using a Living Lab to Refine an Electronic Prescribing Workflow: Insights From the eRIKA Project

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Abstract

Background: The integration of eHealth solutions into routine health care remains challenging despite their potential to improve care quality and efficiency. Living labs (LLs) have emerged as an approach to addressing these challenges by enabling co-design and iterative testing of eHealth tools. LLs promote collaboration among patients, health care professionals, developers, and policy makers. However, systematic insights into their practical implementation remain limited.

Objective: This study explores the use of an LL approach to dynamically create and adapt project workflows, as well as its potential as a methodological framework for developing an implementation plan for a digital prescribing workflow (eRIKA [eRezept als Element Interprofessioneller Versorgungspfade für Kontinuierliche Arzneimitteltherapiesicherheit]). The analysis focuses on intervention-level insights identified throughout the LL process. The study also reflects on the limitations of the approach.

Methods: The co-design process was structured into 4 thematic sprints conducted across 3 regions in Germany (Saarland, Berlin, and Westphalia-Lippe) between November 2022 and September 2024. Workshops were held with general practitioners (GPs), pharmacists (PHs), medical assistants, and pharmacy technicians recruited from 6 GP practices, 6 pharmacies, and 1 hospital (n=17). Audio-recorded workshop data were analyzed using reflexive thematic analysis.

Results: Three themes were identified: (1) Workflow Efficiency, encompassing demands for filtering and prioritization mechanisms to manage information volume, direct digital communication channels, and concerns about workload; (2) Technical Implementation, addressing the need for seamless system integration, data integrity of the medication history, and interoperability with existing practice management systems; and (3) A New Way of Working, reflecting interprofessional negotiations around roles and responsibilities and regulatory requirements, including data privacy. Notably, strongly divergent views emerged between GPs and PHs regarding what data PHs require to conduct effective medication safety reviews.

Conclusions: Consistent with previous research, the results highlight concerns about workload, system interoperability, roles and responsibilities, and regulatory barriers to implementation. Beyond these established challenges, the results also reveal interprofessional tensions between GPs and PHs regarding the extent of data sharing required for effective pharmaceutical counseling. These findings inform the subsequent phase 1 and phase 2 evaluation studies and contribute to the growing evidence base on LL methodology in digital health implementation.

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KEYWORDS

living labs; eHealth; medication safety; digital prescriptions

Introduction

In Germany, the integration of eHealth solutions into health care remains a complex challenge despite their potential to enhance care quality, efficiency, and patient outcomes [1,2]. This includes digital tools and workflows for managing medication prescriptions and associated processes, such as medication safety checks for patients with polypharmacy. The reasons for these challenges are well understood, both for eHealth in general and for specific use cases. A major barrier is the transition from successful pilot projects to large-scale, sustainable implementation. Many digital health interventions fail at this stage due to misalignment with interest-holder needs and structural barriers within health care systems [1]. Ensuring that eHealth solutions align with health care workflows and user needs is essential for adoption. Swinkels and colleagues [3] emphasize that sustainable eHealth integration requires collaboration among patients, health care professionals, small- and medium-sized enterprises, and policy makers. Because of the fragmented nature of the health care system in Germany, interoperability issues, communication gaps between health care providers, and resistance to change among medical professionals hamper the wider uptake of health IT [4,5].

Starting in October 2022, Germany's innovation fund for the health care system funded an implementation project to develop and test a combined pathway for ePrescription and medication safety checks, called the eRIKA (*eRezept als Element Interprofessioneller Versorgungspfade für Kontinuierliche Arzneimitteltherapiesicherheit* or ePrescription as an Element of Interprofessional Care Pathways for Continuous Medication Safety, grant ID 01NVF21110) project. eRIKA comprises a clinical decision support system (CDSS), ePrescriptions, a medical record using the national health IT infrastructure, and digital communication to enhance medication safety in prescription handling between general practitioner (GP) practices and pharmacies. The project took place during a critical stage in the wider adoption of ePrescribing in Germany. Until 2023, ePrescribing had seen only limited uptake [6] but became legally mandated for both prescribers and pharmacies beginning in January 2024. Like most European Union member states, Germany operates a single national ePrescription system built around a central IT infrastructure, through which any licensed pharmacist (PH) can retrieve a patient's prescription at the point of dispensing.

The eRIKA process was planned to interface with these national-level developments and specifically to make use of Germany's health telematics infrastructure (TI) for the delivery of ePrescriptions and the use of a medication record. At the same time, the intervention was intended to deliver additional functionalities (based on additional data) that are not a regular part of the TI. One project aim was to demonstrate the general feasibility of such an extended process and develop strategies for its full integration with the national infrastructure. To facilitate the design and implementation of the more comprehensive eRIKA process, comprising ePrescribing and medication safety checks, the project used a co-design approach in its first stage to collect and integrate user feedback into the development of the process and the digital tools being applied. This was carried out using a living lab (LL) methodology between November 2022 and September 2024. By the end of data collection, ePrescriptions had been implemented nationwide and were mandatory, meaning that participating health professionals showed increasing levels of awareness of and initial practical experience with ePrescribing during the co-design process.

The involvement of interest-holders is commonly regarded as an effective way to address the aforementioned implementation challenges [5,7]. According to the Medical Research Council (MRC) Framework [8], successful implementation requires coordinated collaboration at the micro (patient and clinician), meso (organizational), and macro (policy and system) levels to address the complexity of health care environments and promote sustainable digital transformation. To address this need, LLs have emerged as an approach for developing and testing eHealth solutions in real-world settings. The *Living Lab Methodology Handbook* [9] defines 5 core elements of the approach: (1) multimethod approaches, (2) user engagement, (3) involvement of multiple interest-holders, (4) real-world settings, and (5) cocreated innovation environments. By applying these elements, LLs enable the early identification and resolution of adoption challenges, such as usability issues, workflow misalignment, and digital literacy barriers [10,11]. Furthermore, the participatory process may help bridge the gap between experimental projects and their successful integration into routine care [12].

This paper describes the results of the LL methodology applied in the eRIKA project and how these were incorporated into the design process for the eRIKA process and digital tools. The paper also reflects on practical experiences gained during the application of the methodology.

Methods

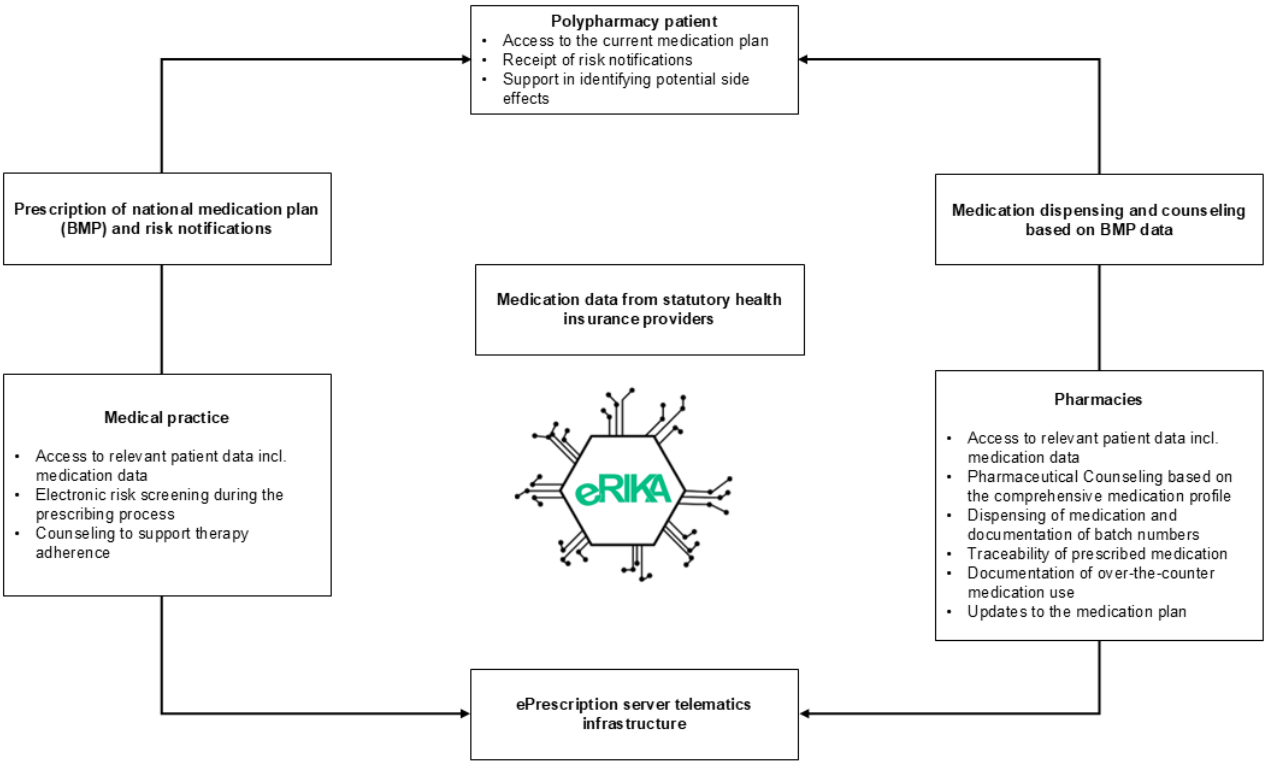
The eRIKA Process

Figure 1 depicts the eRIKA process for ePrescribing and medication safety checks as originally designed and served as the basis for the LL activities. It is based on centrally stored, individual electronic medication plans accessible to health care providers and patients. Each plan is intended to be continuously updated using ePrescriptions; prescription and dispensation data from statutory health insurance claims data; and information on over-the-counter (OTC) drugs provided by PHs and patients.

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This eRIKA medication plan differs from the national TI medication plan in 2 ways: it draws on additional data sources (claims data and OTC information) and is potentially available to a wider audience, as the TI medication plan is limited to patients receiving at least three prescribed medications.

Figure 1. Planned care process for electronic prescribing and medication safety checks for patients with polypharmacy in the eRIKA (eRezept als Element Interprofessioneller Versorgungspfade für Kontinuierliche Arzneimitteltherapiesicherheit) project before iterative refinement through the living lab co-design process, Germany, 2022.



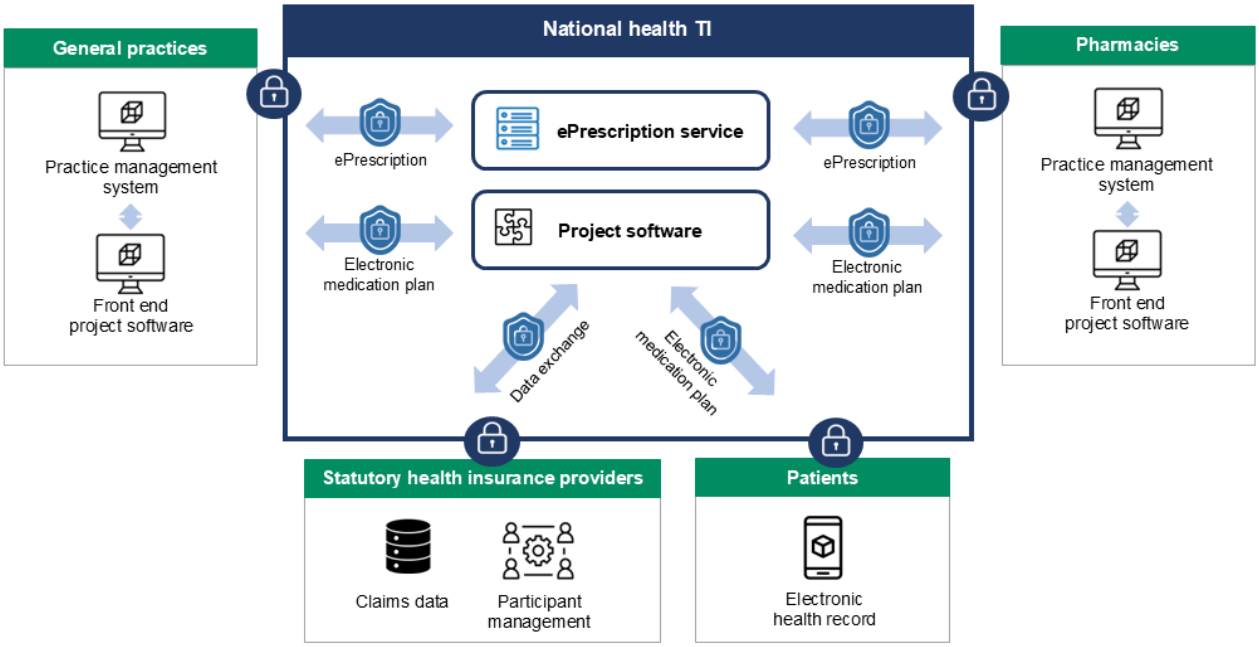
The eRIKA system contains patient data provided by statutory health insurance providers and supports the electronic review of prescriptions to detect preventable risks. It also provides PHs with detailed information to support effective pharmaceutical counseling. CDSS functions, such as medication interaction alerts and dosage checks, are integrated to enhance prescribing safety. Additionally, the system includes digitally assisted communication between physicians and PHs, as well as drug traceability to enable the prompt identification and resolution of safety issues.

The system comprised components at different stages of technical maturity when the LL co-design process began. The CDSS was implemented as a functional prototype: it was technically operable within the project environment, but its functionalities and interface design were subject to iterative refinement through the co-design process. The communication functions, which would enable structured digital exchange between general practices and community pharmacies, were planned for future implementation. The ePrescription and electronic medication plan were operational prototypes. Both were fully implemented and operational by January 2024 as part of the federal rollout of ePrescriptions. The intervention as a whole depends on the national TI as its underlying infrastructure.

Figure 2 shows the planned technical integration of the software as an independent software component within the existing national TI operated by gematik. Key actors depicted are the GP, community pharmacy, patient, and statutory health insurance. Security-relevant components of the national health TI shown are the ePrescription, the Health ID (Gesundheits-ID), the TI authenticator, and the interface connecting eRIKA to the broader TI ecosystem. Figure 2 reflects the status of the operational prototype at the time of the LL co-design process. Not all depicted components were fully implemented during the study period, and certain functions represent planned integrations that depended on external systems within the national health TI.

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Figure 2. Architecture of the eRIKA software prototype and its integration into Germany's national telematics infrastructure (TI) during the study period (2022-2024).



To develop, implement, and evaluate the new form of care, the project was divided into 3 stages. The first stage, reported in this manuscript, was the LL [13]. The LL was conducted between November 2022 and September 2024, during which the software interface and the processes between GP practices and pharmacies were iteratively developed and refined. This stage was followed by 2 implementation and evaluation phases. In phase 1, the intervention was initially tested on a smaller scale in a cluster-randomized controlled trial [14]. Data collection for phase 1 has been completed, and analysis is ongoing. In phase 2, the intervention was expanded and implemented on a broader scale in a quasi-experimental study [14]. Data collection for phase 2 has likewise been completed, and analysis is ongoing. The overall project ran from October 2022 to September 2026.

Ethical Considerations

The LL conducted as part of the eRIKA study was approved by the Ethics Committee of the University of Wuppertal (approval number SK/AE 220906). Before participating, all participants provided written informed consent covering both their participation in the workshop sessions and the audio recording of these sessions. Participation was voluntary, and participants were informed of their right to withdraw at any time without consequence. Participants received financial compensation for their time and travel (€276 [US $310] net per practice/pharmacy team per sprint or €212 [US $238] net if only 1 person participated per sprint).

To protect participants' privacy and confidentiality, transcripts were anonymized using codes. Data were handled in accordance with applicable data protection regulations, including the GDPR (General Data Protection Regulation).

LL Approach

LLs can be used as a tool within the co-design process, providing a collaborative platform for active discussion and iterative refinement of the planned intervention with potential users. In this context, co-design refers to the active involvement of end users, such as GPs, PHs, and patients, together with developers and researchers throughout the development or implementation process. The specific goal of this project was to collaboratively refine the details of the care processes to align them closely with user needs, expectations, and real-world practices and to define concrete, practical steps for effective implementation within participating practices and pharmacies.

The methodology applied in this project followed a structured, iterative co-design process divided into 4 consecutive development "sprints" following an onboarding meeting. A sprint refers to a defined development cycle consisting of several sequential steps: (1) preparation and presentation, (2) interest-holder workshops, (3) documentation and ranking of change requests, and (4) negotiation meetings (for sprints 1 and 2).

The onboarding meeting served to introduce the LL concept and prepare participants for the co-design process. Before sprint 1, a 1-hour meeting was held for participants from 2 of the 3 regions: Westphalia-Lippe (region 1) and Berlin (region 2). The third region, Saarland, joined the study at a later stage, and a separate onboarding meeting was held for its participants.

The interest-holder workshops took place at the premises of KVWL (Kassenärztliche Vereinigung Westfalen-Lippe; region 1), AOK Nordost (region 2), and the software provider based in Saarland (region 3). Each sprint addressed a different topic, as described below. All participating organizations were directly involved in the project, which may have discouraged the open expression of critical or dissenting views. This environmental framing represents a form of contextual bias that cannot be retrospectively controlled for.

Online negotiation meetings were held during sprints 1 and 2 to discuss change requests arising from the workshops. These

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meetings involved workshop participants and members of the core project team. Members of the core project team first ranked the requests according to 3 feasibility dimensions: temporal feasibility (realizable within the project timeline), technical feasibility (within the IT architecture), and financial feasibility (within the project budget). Each dimension was rated on a scale from 0 to 3, with 3 indicating full feasibility and 0 indicating no feasibility, yielding a composite score for each change request. The resulting scores indicated whether the core team considered a request immediately implementable, potentially implementable at a later stage, or not implementable. The rationale for each assessment was discussed during the negotiation meeting, during which workshop participants could argue for a change in the assessment.

No negotiation meetings were held after sprints 3 and 4. This decision was deliberate rather than incidental. Given the nature of these sprints, which centered on live software demonstrations and hands-on system walkthroughs, representatives of the software development team were present throughout each session. This enabled real-time documentation and direct discussion of requirements identified by participants within the workshops themselves, making separate post hoc negotiation meetings unnecessary.

Recruitment

The LL participants comprised 4 professional groups working within the German primary care and community pharmacy system: GPs and medical assistants (MAs; Medizinische Fachangestellte) working in GP practices, as well as PHs and pharmacy technicians (PTs; Pharmazeutisch-technische Angestellte). All 4 professional groups are directly involved in the prescribing or dispensing workflows addressed by the project. Patients were not included in the LL because the focus was on the design and optimization of the electronic prescribing workflow and the associated software interfaces within GP practices and pharmacies, which are system components with which patients do not interact directly. Overall, 6 general practices, 6 pharmacies, and 1 hospital were represented across the 3 regions. Recruitment followed a convenience sampling strategy, drawing on existing professional networks and prior project collaborations in each region. In Saarland, the Saarland Association of Statutory Health Insurance Physicians (*Kassenärztliche Vereinigung Saarland*) recruited 2 general practices affiliated with the association as pharmacotherapy advisors. These practices, in turn, identified 1 interested community pharmacy within their professional networks. In Berlin, a regional statutory health insurance company (*AOK Nordost*) recruited 2 general practices with prior experience in a related project and 2 pharmacies, with support from the Berlin Pharmacists' Association (*Apothekerverband Berlin*). In Westphalia-Lippe, the *KVWL* recruited 2 GPs who had previously participated in a project. These physicians subsequently approached pharmacies with which they had established working relationships. The participating hospital was approached by the project team based on its participation in a previous project.

The study included micro-level actors (GPs, MAs, PHs, and PTs) as LL participants. Meso-level actors were represented in the negotiation meetings and included the software provider, statutory health insurance companies (BARMER and AOK Nordost), and the KVWL. Macro-level interest-holders were not involved, reflecting both the study's focus and the contextual realities of the German health care system. Consistent with the MRC Framework's [8] guidance on interest-holder engagement in complex intervention development, involvement was prioritized according to relevance to the intervention's core objectives. This study focused on end-user experience and organizational workflow integration. Additionally, in Germany's highly fragmented health care system, the perspectives of macro-level organizations are inherently shaped by their institutional and political positions and may not reflect the diversity of views across the system.

Sprints, Topics, and Data Collection

Workshops were conducted between November 2022 and September 2024 as structured, 2-hour sessions. To ensure accurate data collection, written notes were supplemented by audio recordings. Each workshop addressed a specific component of the intervention or its current state, which was presented as a description, mock-up, or functional prototype. The "thinking aloud" technique [15] was used to elicit participants' perceptions and identify workflow-related challenges and areas for improvement, particularly at the interface between general practices and pharmacies. The LL sessions were conducted in German and moderated by trained members of the research group (AP, IM, and BM). Other members of the research group recorded the sessions and took field notes. Data collection was organized into sprints with predefined themes and development steps, as described below. These themes and subsequent development steps were adapted iteratively in response to findings from previous sprints. Triangulation was achieved by comparing data across the 3 regions. These methods were selected to support a comprehensive process evaluation of the LL and capture participants' experiences and perspectives throughout the co-design process.

Sprint 1: Formative Feedback and Priority Setting

Sprint 1 was conducted in 2 regions (regions 1 and 2) as individual 2-hour workshops (n=4 and n=7, respectively), which were audio-recorded in full. The sessions focused on generating broad, formative feedback on all components of the eRIKA system and the processes developed for physician practices and pharmacies, as well as identifying priority topics for further development. The outputs of sprint 1 directly informed a revision of the eRIKA process design, which formed the basis for sprint 2.

Sprint 2: Specific Feedback on Revised Process Design

Sprint 2 was conducted across all 3 regions, with each session lasting 2 hours, for a total of 4 workshop sessions. In region 1, separate sessions were held for physician practices (n=2) and pharmacies, as originally planned for all regions. In regions 2 and 3, scheduling constraints required joint sessions for both settings (n=7 and n=6, respectively). The sessions addressed specific feedback on the revised version of the eRIKA process developed after sprint 1, with particular attention to practice-

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and pharmacy-specific workflow aspects. All sessions were audio-recorded. In region 3, content from sprint 1 was also revisited at the beginning of the session. Feedback from sprint 2 was documented in the change log and informed further software refinements before sprint 3.

Sprint 3: Software Interface, Usability, and Acceptance

Sprint 3 was conducted across all 3 regions as individual 2-hour workshops (region 1: n=3; region 2: n=5; and region 3: n=5), all of which were audio-recorded in full. The focus shifted from process design to the eRIKA software interface, including its design, usability, and acceptance, and the collection of specific improvement requests. In each session, the software provider gave a live demonstration of the practice software (remotely in 2 regions, with the project team and participants on-site, and fully on-site in 1 region). No printed or digital materials were distributed; the live demonstration served as the sole basis for discussion.

Sprint 4: Collaborative Workflow Testing

Sprint 4 was conducted 3 times across 2 regions (region 2: 2 sessions, n=4 each; and region 3: 1 session, n=3), with each session lasting 2 hours and audio-recorded in full. Sprint 4 could not be conducted in region 1 because of technical and scheduling challenges. The sessions focused on challenges in collaborative workflows between physician practices and pharmacies. Participants conducted a hands-on walkthrough of all eRIKA process steps in a live test environment, providing direct experiential feedback on interactions between the 2 settings. No additional materials were used beyond the live system.

Notes from meetings with GPs, MAs, PHs, and pharmacist assistants were analyzed to identify recurring themes and practice-relevant insights. Data collection was therefore iterative, capturing evolving user needs and adaptations to local workflows over time.

Data Analysis

All LL sessions were audio-recorded, transcribed, anonymized, and analyzed in German. For anonymization, participants were assigned acronyms (GP, MA, PT, and PH). Participants were then assigned numerical identifiers based on the order in which they spoke. After the analysis, the results and selected quotes were translated into English for publication by native German speakers with a high level of English proficiency. The translation was assisted by the AI system Claude (Anthropic) and subsequently independently reviewed and finalized following the four-eyes principle.

This study is grounded in an interpretivist research paradigm, which assumes that knowledge is socially constructed through participants' lived experiences, perspectives, and interactions. Data were analyzed using reflexive thematic analysis within an interpretative (Big Q) spectrum, as outlined by Braun and Clarke [16,17]. Consistent with Braun and Clarke's [17] emphasis on methodological coherence and reflexive openness, reflexive thematic analysis was chosen over more structured approaches, such as qualitative content analysis (eg, Mayring) or codebook thematic analysis, because it offers the flexibility required to capture the dynamic, iterative nature of interest-holder feedback within an evolving co-design process. Given the exploratory character of the LL process, the diversity of data sources (eg, observational notes and negotiation meetings), and the heterogeneity of participants, an open and adaptive coding strategy was considered more appropriate than the application of a predefined category system. Furthermore, because the care process itself evolved across the 4 sprints, codes were continuously adapted to accommodate emerging topics, a process that would be constrained by a fixed codebook. Coding was carried out independently by multiple researchers (AP, EG, and CB) and subsequently discussed and refined collaboratively. Divergences were resolved through iterative discussion, consistent with the reflexive rather than reliability-oriented tradition of this approach.

In accordance with this approach, the thematic analysis was divided into 6 steps: (1) data familiarization, (2) generation of initial codes, (3) search for themes, (4) review of themes, (5) definition and naming of themes, and (6) reporting of results. The initial analysis was carried out by researchers with expertise in implementation science, qualitative methods, and eHealth interventions, ensuring methodological rigor and contextual sensitivity throughout the analytic process. The researchers who facilitated and analyzed the LL sessions had academic backgrounds in sociology and psychology. As members of the project team, they had prior knowledge of the study and its development, which may have introduced assumptions about which aspects of the co-design process were particularly salient or problematic. The researchers' dual role as both session facilitators and data analysts created a degree of relational familiarity with participants, which may have encouraged more open disclosure but could also have influenced workshop dynamics.

After initial data familiarization and code generation (steps 1 and 2), codes and preliminary themes were compared and discussed. Where interpretations differed, the differences were discussed until consensus was reached, and code definitions were adjusted. Following steps 1 and 2, the initial codes were refined and expanded to reflect nuances in the material, particularly in response to the thematic focus of each development sprint. Coding was performed in Microsoft Excel, with regular reflexive review to ensure analytic rigor and depth. This process resulted in the following list of preliminary categories, which was used to structure all relevant data:

- User-friendliness: Intuitive interfaces, standardized input fields, and customizable alert systems tailored to the needs of different users.
- Practical utility: Inclusion of features such as medication checks, electronic signature batching, and efficient communication pathways to enhance workflow efficiency.
- Implementation barriers: Addressing training needs, minimizing duplicate documentation, and ensuring sustainable integration into routine care.
- Concerns and gaps: Prioritization of alerts, maintenance of comprehensive medication records, and resolution of data accuracy concerns regarding patient-provided information (such as OTC medication).

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Based on these initial codes, data were then iteratively clustered into preliminary themes and subthemes (steps 3 and 4), aiming to reflect interest-holder needs as articulated during the LL sprints. Given the varying methodological emphasis and content across the 4 sprints, not all codes were applicable in every case, and additional codes were introduced as needed to capture emerging requirements and process adjustments. Through iterative discussion and reflexive analysis across the research team, the initial codes were progressively consolidated into 3 overarching themes—Workflow Efficiency, Technical Implementation, and A New Way of Working—each integrating multiple initial codes that shared a common conceptual focus (step 5). These themes were subsequently reported (step 6). This study was reported in accordance with the SRQR (Standards for Reporting Qualitative Research) checklist (see Multimedia Appendix 1).

Results

Overview

The sample comprised 17 participants, including 10 from medical practices (GPs and MAs) and 7 from pharmacies (PHs and PTs; see Table 1). The same participants were invited to attend all sprints throughout the co-design process to ensure continuity of involvement. Due to scheduling constraints, not all participants were able to attend every session, but continuity was maintained at the practice and pharmacy levels.

Table 1. Professional background and gender distribution of living lab participants by region and sprint in the eRIKA[a] co-design study, Germany (Saarland, Berlin, and Westphalia-Lippe), November 2022-September 2024.

Participants by sprint, gender, and professional group	General practitioners, n	Medical assistants, n	Pharmacists, n	Pharmacy technicians, n	Total, n
Sprint 1					
Region 1	2	0	2	0	4
Region 2	2	1	3	1	7
Region 3	3	2	1	0	6
Sprint 2					
Region 1	2	0	0	0	2
Region 2	2	0	4	1	7
Region 3	3	2	1	0	6
Sprint 3					
Region 1	2	0	1	0	3
Region 2	2	0	2	1	5
Region 3	3	2	0	0	5
Sprint 4					
Region 1	0	0	0	0	0
Region 2	2	0	2	0	4
Region 3	1	1	1	0	3
Gender					
Male	6	0	0	0	6
Female	1	3	6	1	11

[a]eRIKA: eRezept als Element Interprofessioneller Versorgungspfade für Kontinuierliche Arzneimitteltherapiesicherheit.

The adequacy of the sample was assessed based on information richness rather than numerical sufficiency. The sample was considered appropriate given the depth and breadth of professional experience represented, the multiregional composition, and the iterative nature of the data collection process, which allowed emerging themes to be revisited and elaborated across successive sprints.

Theme 1: Workflow Efficiency

Subtheme 1: Utility and Cognitive Load Management

The issue of alert abundance was discussed in various areas: “One must not forget that there is little time for individual patients, which is why interruptions from queries are disruptive. It is also a matter of concentration. Every interruption prevents you from properly treating the patient sitting in front of you. That is when errors occur. Interruptions are the biggest source of errors.” [R1, S2, GP2]. Physicians reported that the numerous medication interaction warnings that pop up when using the

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software are too time-consuming to address in everyday clinical practice.

Another debated topic was PHs' information needs. As pharmacies, like medical practices, can access data on prescribed medications and diagnoses, the necessary level of detail was discussed: "What does the patient want? E.g. transmitting lab data to the pharmacy." [R2, S1, MA1]. Physicians argued that diagnoses are not always necessary for PHs. One suggestion was that PHs compile a core dataset comprising the information needed for medication reviews covering 80%-90% of side effects and that they should only have access to this subset of data: "For lab tests, a set would need to be defined that is relevant for the pharmacy: potassium, liver function values, for example." [R2, S2, GP1]. PHs argued that diagnoses play a relevant role in assessing medication risks. Physicians generally expressed concern about information overload: "I would remove everything. As a patient, I cannot assume that the pharmacist understands it." [R1, S2, GP1].

Subtheme 2: Direct Digital Communication

LL participants requested brief but efficient means of communication other than phone calls or faxing: "A uniform communication structure between the parties, where such cases [interactions] can be coordinated. No phone!" [S1, R2, GP1]; "It is also a time saver; the topic of fax is catastrophically outdated, often does not work. It would also be nice to have everything in one system, it spares the faxing." [S2, R2, PT1]. Overall, the intervention would be perceived as useful only if it enabled shorter and faster communication. The software should ensure targeted exchanges within a standardized communication structure: "There is a coexistence and confusion in every practice. Therefore, it would be important to use the medication identifiers and find a uniform language." [R2, S3, GP1]. Prioritizing push messages should enable physicians and pharmacies to exchange information at short notice, especially in urgent cases when patients are waiting for their medication: "Then it also becomes a care team, if the pharmacy can prioritize that. Then it also has added value for us." [R2, S2, GP1]. At the same time, targeted risk analysis and the inclusion of relevant information, such as the overall medication regimen and dosages, should prevent inefficient communication and information overload: "The chat function is not bad at first, but has no added value for me, because the communication between doctor and pharmacist is asynchronous." [R1, S3, GP1]. Therefore, participants suggested that notification settings should remain configurable at the individual practice level: "Then everyone can decide that for their own practice — a button where one can decide whether to be alerted at the computer, or a mute function that can be applied to individual devices." [R2, S3, GP1]

However, concerns were also raised about the communication system. Physicians expressed concern that push messages could create an expectation of immediate responses, which is not always feasible in everyday practice: "Push notifications could not be answered in real time by physicians, as they would be disruptive during other patient consultations. I would not look at that." [R1, S2, GP2]. Second, prioritization could result in important messages going unnoticed.

Subtheme 3: Concerns About Workload

Overall, LL participants expressed concerns about the workload associated with using the software. They criticized the lack of a simple solution to avoid duplicating workflows when documenting prescriptions in both the project software and the practice management software: "it is too complicated that there are two parallel programs." [R2, S4, GP1]. There were concerns about the additional workload caused by duplicate documentation of prescriptions, which could lead to inefficient use of working time: "A prescription created with the eRIKA software is otherwise not included in the statistics and billing of the practice. So, everything would have to be entered twice." [R2, S4, GP1]. This was considered particularly important because the overall workload was reported to be very high. Physicians' time was considered very limited and therefore needed to be used effectively. In addition, some participants noted that nondigital approaches could sometimes be preferable: "To avoid losing information or notes in the digital system, sticky notes are used on prescriptions. In the system, such notes should not 'move up' and disappear before the next appointment. We use sticky notes because the system is no longer opened for a follow-up prescription." [R2, S2, GP2]. Overall, it was considered important that using the software should not create additional work but should be integrated into existing practice workflows. PHs also noted that using additional software at the point of sale would not be practical, as it would otherwise increase customer waiting times: "It has to go quickly, also in the interest of the customer." [R2, S2, PT1].

Analytical Interpretation of the Theme

The results revealed a core tension between prescription safety mechanisms and workflow efficiency. While the former were considered necessary, efficiency concerns acted as a strong barrier to their use. Participants expressed a desire for efficient, modern communication. The intervention was considered likely to reduce workflow efficiency and thus lead to rejection of the new technology. If too many warnings are displayed, the risk to patients may increase, as the warnings may no longer be heeded in everyday practice.

Theme 2: Technical Implementation

Subtheme 1: Additionality of the Intervention

According to LL participants, automatic contraindication checks were not available in their practice management systems: "not standard. Has to be purchased additionally." [R2, S1, GP1]. As the project software includes this feature, it was considered a valuable addition to the existing system. Other patient information, such as prescriptions and diagnoses from other physicians, was also considered useful for supporting treatment. The integration of a function for quickly creating repeat prescriptions was also suggested: "Do the same thing again should be available as a button." [R2, S2, GP2]. To reduce physicians' workload, patients should be able to enter their OTC purchases into the system themselves via an online platform. However, the function should be designed so that patients can create entries but not delete them: "If patients bring their OTC preparations to the practice for entry, there will be a lot to enter. Self-reporting by patients should be enabled and relieve doctors

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of the data entry burden — allowing patients to write but not delete." [R1, S2, GP2].

Direct integration of information on the availability of certain medications was considered very useful, especially during drug shortages, as suggested by physicians: "At our headquarters there is currently a notice hanging up showing which medications are currently available. If one could see that in the program, it would be optimal. Currently we receive the information through patients who come back when they were unable to obtain a medication and need a new one prescribed." [R2, S3, GP1]. This information could be sourced from pharmacies' merchandise management systems. However, the participating PHs noted that this would be difficult to implement because patients' preferred or most conveniently located pharmacies could vary and might be quite far from the practice: "I would tend to say that it would be good to know the availability. It is probably due to the two contracted supply companies, and patients often then go to a different pharmacy." [R3, S3, GP1]. Nevertheless, participants emphasized that it was essential for the project not to slow down or disrupt existing daily workflows and procedures.

Subtheme 2: Integrity Concerning Medication History

PHs and PTs stated that information on discontinued medications was needed: "If [a medication] is discontinued and something new is taken, the old one still pops up — you would see that on the medication plan." [R2, S2, PH1]; "I also find it very helpful that changes can be traced, i.e. the history." [R2, S2, PH2]. Similarly, participants noted a lack of information on patients' actual adherence to the medication plan. The discrepancy between documented prescriptions and patients' actual medication use was raised as a distinct and problematic scenario, highlighting the need for physicians to have editing rights: "When something is documented in the system that the patient does not take at all — the level of documents and the real-life level. Then I would want to remove the prescription." [R3, S1, GP2]. Both issues were seen as factors that could result in the medication plan not reflecting the actual medication regimen followed by the patient: "The medication plan is often not up to date and cannot always be used as a basis for decisions." [R2, S1, GP1]. In this context, participants also considered it important to include medications obtained from online pharmacies, whether prescription or OTC medications: "Online-ordered preparations would be missing if patients could not enter them themselves." [R1, S2, GP1].

Participants also emphasized the need to ensure that the medication history or prescription overview contained no gaps. A 3-month history was considered sufficient: "A three-month history of medication changes is sufficient. A quarter is realistic — changes from nine months ago are not of interest as a general practitioner." [R1, S2, GP1].

Subtheme 3: System Interoperability and Integration

To ensure successful integration of the software into everyday practice, the connection between the eRIKA software and the practice management system was considered particularly important. Physicians and PHs emphasized that the software must run without delays and be integrated into existing software systems: "One should not have to enter everything twice. eRIKA should of course run automatically in the background." [R1, S1, PH1]. Participants also stated that different statutory health insurance providers should not offer separate software apps: "The killer would be having to open different programs for different insurance providers." [R2, S2, GP2]. Instead, a single software application should be available for all patients.

Physicians stated that data documented in the eRIKA software should be transferred back to their regular practice management system, as it also needed to be documented there for completeness and to comply with legal documentation requirements: "Information must not only be stored in an external system — you would no longer be able to access it if the project is not continued." [R2, S2, GP1]. Based on legal requirements, standardized documentation of prescription data was also considered essential. Frequent outages of the underlying IT infrastructure for the German health system (TI) were seen as another significant barrier to the prescription process, affecting the use and usefulness of the eRIKA software: "There are recurring technical failures, including general TI outages." [R1, S2, GP2]; "You need an 'emergency exit' in case of failures, for example a button 'old system' — without having to overwrite it via the new route." [R1, S2, GP1].

Analytical Interpretation of the Theme

The results under this theme reveal a series of specific functionalities and functional improvements to existing software systems that both physicians and PHs would like to have available. These improvements relate to the anticipated effectiveness and efficiency of medication prescribing and medication regimen monitoring. Participants were aware of the fragmentation of the required underlying information, which is held across different practices, pharmacies, online pharmacies, and patients themselves, as well as the fact that this fragmentation cannot be easily overcome at the technical level.

Deep integration of the software with existing systems in medical practices and pharmacies was not part of the system shown to participants in the LL. Participants clearly considered this a critical issue that would seriously hamper the use of eRIKA at the point of care, not least because of the additional workload it would create for staff. This finding also relates to those presented under theme 1.

Theme 3: A New Way of Working

Subtheme 1: Roles and Responsibilities

The implementation of the eRIKA care process was seen as likely to involve a redistribution of roles compared with current care practices. New functions, such as patients' self-reporting of OTC purchases, were considered to necessitate adaptations to existing workflows. This would also require appropriate training for care staff.

Delegating alert management to MAs or pharmacies would expand their professional responsibilities, raising questions about role boundaries and accountability within the practice: "Error messages would need to be categorized by urgency — the highest urgency message should reach the doctor directly. Could also be handled this way with medical assistants." [R1,

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S2, GP1]. To safeguard this redistribution of tasks, participants emphasized the need for transparency regarding actions taken: “Traceability of the person processing the push notification would be sensible.” [R1, S2, GP1]. Moreover, participants underscored the importance of clearly defined professional responsibilities, noting that ambiguity in role boundaries could lead not only to clinical errors but also to a loss of patient confidence: “Division of tasks is sensible. The competencies for reviewing laboratory values clearly lie with physicians. Otherwise, patients will also be unsettled.” [R1, S2, GP1].

In this context, the assignment of clear roles and permissions within the software was discussed. One example was that MAs could prepare prescriptions for physicians to sign. Participants suggested that alert management should be embedded within clearly defined team workflows: “Warning messages should only be dismissed by medical assistants if it has been previously agreed with the physician. Regular workflow coordination — agreeing on standard cases, for example prescribing active ingredients individually if a combination preparation is not available. Otherwise, the warning message should be forwarded so that the physician can deal with it when they have time — not in parallel with a patient consultation.” [R1, S2, GP1]. Moreover, a cascading notification model was suggested to ensure that alerts were escalated through the care team until formally acknowledged by the responsible clinician: “It should appear at multiple stages — everyone who handles the prescription. It is always good when several people receive notifications. The notification should go to the medical assistant and then be forwarded to the treating physician, so that the treating physician finally 'clicks away' the notification.” [R1, S1, GP2].

A concern was raised that sharing medication data across different practices and pharmacies might reveal omissions by individual parties. Participants considered it important that the system not be used to assign blame to specific actors: “If it comes down to the doctor/pharmacist getting blamed, then that is of course not pleasant — for example, attributions of blame due to prescribing cascades.” [R2, S1, PH1].

Subtheme 2: Regulatory Requirements, Including Data Privacy

While integrating eRIKA software data into the practice management software was considered important for workflow efficiency (see above), it was also discussed in the context of regulatory documentation requirements. Participants voiced concerns that information requiring documentation might suddenly become unavailable: “This is critical for us, because it would mean double work, as we ourselves have the documentation obligation and cannot note there that it has been recorded in another system. This creates a significant additional workload and discrepancy.” [R2, S3, GP1].

In the context of compiling data on a given patient from different sources and sharing them among GP practices and pharmacies, participants considered data privacy essential: “The question of data protection is important. It was already a huge topic with the ePrescription. If data were to fall into the wrong hands, that would be the ‘worst-case scenario’.” [R1, S1, GP2]. This concern related not only to ensuring that only those who needed the information for their specific tasks could access it but also to determining exactly which data were needed, as discussed in relation to diagnoses: “Even with the emergency core dataset, a selection is made — depending on what I think is relevant for emergency physicians. Noting the diagnoses in the software also takes effort. It is not feasible with every prescription.” [R1, S2, GP2].

Analytical Interpretation of the Theme

The findings under this theme relate more to the implementation of eRIKA care processes as a sociotechnical system in day-to-day practice than to the work processes themselves or to specific technical issues.

Interest-Holder Representation Across Themes

To illustrate the breadth of interest-holder involvement and the saturation of qualitative data across professional groups, Table 2 maps the 3 themes and 8 subthemes generated through thematic analysis to the 4 participating interest-holder groups (GP, MA, PH, and PT). All 3 themes were informed by contributions from at least three interest-holder groups, with theme 2 (Technical Implementation), specifically subtheme 2.3 (System Interoperability and Integration), being the only subtheme to which all 4 professional groups contributed. GPs provided input across all 3 themes and all 8 subthemes, reflecting their central role in the prescribing workflow and their broad engagement with both technical and organizational aspects. PHs contributed substantially to themes related to workflow efficiency and technical implementation, while their input was less prominent in discussions of roles, responsibilities, and regulatory requirements—areas predominantly raised by GPs and MAs. MAs and PTs contributed more selectively, with MAs focusing primarily on workload-related and regulatory concerns within the practice setting, and PTs focusing on communication and interoperability issues at the pharmacy counter. The distribution of contributions across groups reflects the complementary perspectives inherent in the collaborative prescribing process and supports the thematic saturation of the dataset within the scope of the LL co-design approach.

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Table 2. Interest-holder finding matrix mapping themes and subthemes generated through reflexive thematic analysis [16] to 4 professional groups participating in the living lab co-design process across 3 regional sites in Germany (Saarland, Berlin, and Westphalia-Lippe), November 2022 to September 2024.

Theme and subtheme	GP[a]	MA[b]	PH[c]	PT[d]	Key findings by interest-holder group
Theme 1: Workflow Efficiency					
Subtheme 1.1: Utility and Cognitive Load Management	✓	✓	—[e]	—	GPs raised concerns about information overload (eg, too many alerts flagged as "red") and the need for risk-stratified alerts. MAs highlighted the risk of data overflow and uncertainty about which information is relevant for pharmacies.
Subtheme 1.2: Direct Digital Communication	✓	—	✓	✓	GPs and PHs requested a unified, structured communication channel replacing telephone contact. PTs and PHs highlighted the need for prioritized push notifications (eg, color-coded urgency levels) to enable faster responses.
Subtheme 1.3: Concerns About Workload	✓	—	✓	✓	GPs emphasized that the intervention must not slow down existing workflows. PHs and PTs raised concerns about additional administrative burden, particularly around blister packaging and inventory management integration.
Theme 2: Technical Implementation					
Subtheme 2.1: Additionality of the Intervention	✓	—	✓	—	GPs stressed that eRIKA[f] should run automatically in the background without requiring duplicate data entry. PHs noted that the system should add value beyond existing processes rather than duplicating them.
Subtheme 2.2: Integrity Concerning Medication History	✓	—	✓	✓	GPs reported that medication plans are frequently outdated and cannot serve as a reliable basis for decision-making. PHs and PTs highlighted that patients often do not take medications as prescribed and that online pharmacy orders are not integrated, creating gaps.
Subtheme 2.3: System Interoperability and Integration	✓	✓	✓	✓	All interest-holder groups raised concerns about compatibility between the new and existing systems. GPs and MAs noted the risk of heterogeneous system landscapes across practices; PTs and PHs flagged issues with standardized entry of allergies and medication data across different systems.
Theme 3: A New Way of Working					
Subtheme 3.1: Roles and Responsibilities	✓	✓	✓	—	GPs expressed concern that too much responsibility might be shifted onto MAs or PHs, particularly regarding the processing of alerts and task prioritization. MAs highlighted the need for clear role definitions and training requirements if new functions (eg, over-the-counter self-reporting by patients) were introduced.
Subtheme 3.2: Regulatory Requirements Including Data Privacy	✓	✓	—	—	GPs raised questions about documentation obligations and the legality of current workarounds (eg, sending ePrescriptions via PDF by email). MAs noted the importance of restricting deletion rights for patient-entered data to protect data integrity. PH pointed out the issue of liability in the event of prescription cascades.

[a]GP: general practitioner.

[b]MA: medical assistant.

[c]PH: pharmacist.

[d]PT: pharmacy technician.

[e]—: the group did not inform on the subtheme.

[f]eRIKA: eRezept als Element Interprofessioneller Versorgungspfade für Kontinuierliche Arzneimitteltherapiesicherheit.

Normalization Process Theory

The themes identified through reflexive thematic analysis were interpreted through the lens of Normalization Process Theory (NPT) [18]. NPT provides a framework for understanding how new practices and technologies become embedded, or fail to become embedded, by focusing on 4 generative mechanisms: coherence (sense-making), cognitive participation (engagement and commitment), collective action (the work of implementation), and reflexive monitoring (appraisal of outcomes). Applied to our findings, all 4 mechanisms are reflected across the 3 themes, although with varying prominence.

The sense-making work (*coherence*) through which participants understand the purpose and value of a new practice is most prominently reflected in theme 2 (Technical Implementation), where participants repeatedly questioned the added value of the intervention relative to existing tools, the reliability of the medication history as a basis for clinical decisions, and the system's interoperability with their existing software

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environments. However, coherence concerns also permeate theme 1, where participants' skepticism about alert overload and system complexity suggests that the value proposition had not yet been fully established across all professional groups.

The relational work through which key actors are enrolled and committed to the new practice (*cognitive participation*) is evident in the structural decisions made throughout the LL process itself: the deliberate inclusion of all 4 professional groups across 3 regions, the involvement of the software provider as an active participant in sprints 3 and 4, and the separate facilitation of practice and pharmacy sessions in region 1 to enable setting-specific engagement. Theme 3 further reflects cognitive participation in participants' negotiation of new roles and responsibilities.

The operational work of enacting the new practice in context (*collective action*) is captured primarily in theme 1 (Workflow Efficiency), where participants across all professional groups identified practical barriers, including cognitive load, communication inefficiencies, and the risk of workflow disruption. The sprint structure of the LL was itself a form of structured collective action, enabling participants to progressively engage with and refine the intervention across cycles.

The appraisal work through which participants assess the effects of a new practice and adjust their engagement accordingly (*reflexive monitoring*) is reflected across all 3 themes but is most explicit in theme 3, where participants evaluated regulatory implications, data privacy risks, and the long-term sustainability of proposed workflow changes. The LL format inherently supports reflexive monitoring, as each sprint provided a structured opportunity for participants to evaluate the revised intervention and feed their assessments back into the next development cycle.

Discussion

Empirical Findings From the LLs

This study examined the application of an LL methodology to iteratively co-design and refine a collaborative electronic prescribing intervention (eRIKA) for patients with polypharmacy in German primary care and community pharmacy settings. Three themes emerged from the thematic analysis: Workflow Efficiency, Technical Implementation, and A New Way of Working. The study also reflects on the practical challenges encountered in applying the LL methodology within a project plan. Interest-holder–derived insights gathered across 4 sprints were fed back into the design process through a collection of change requests, followed by a negotiation procedure. The LL aimed to facilitate the stepwise refinement of the intervention in preparation for 2 implementation studies on a small scale (10 practices and 10 pharmacies) and a medium scale (116-233 practices and corresponding pharmacies).

The LL findings encompassed both expected and unexpected subthemes. Concerns about workload, system interoperability, roles and responsibilities, and regulatory barriers to implementation are not specific to the intervention but have been reported for a wide variety of health IT implementations [1,19]. Alert fatigue and information overload, in particular, have been discussed previously in CDSS interventions [20]. The LL findings suggest that participants wanted filtering mechanisms or prioritization strategies to manage the volume of available information and messages. This aligns with the notion that new information technologies perpetuate a self-reinforcing cycle of information overload, underscoring the critical need to develop and refine effective filtering strategies to support better decision-making [21].

Moreover, regarding interprofessional cooperation between physicians and PHs, the findings align with previous research indicating a shared desire for a predefined, clear, and straightforward method of communication between the 2 professions [22].

Less anticipated were the substantial differences in views between GPs and PHs regarding the data PHs would need to conduct effective medication safety reviews. These differences reflect deeper interprofessional asymmetries in the understanding of the PH's role in collaborative medication management workflows.

The LL discussions also revealed certain double binds. One concerned the use of direct digital communication (see subtheme 1.2), which was considered useful if implemented as a push messaging service, preferably accessible at the point of sale in the pharmacy when the patient is present. By contrast, clear concerns were raised about information overload and the risk of creating unrealistic expectations of immediate responses. Another study focusing on nurses and physicians highlighted the need for institutional guidance on appropriate text messaging between professions, attributing this need to fundamentally differing perspectives and expectations between the 2 groups [23]. Based on the available results, some form of guidance would also be necessary in this case, although it should be developed at the national level.

Another double bind relates to the role of patients in the process (see subthemes 2.1 and 2.2). Both GPs and PHs supported an active role for patients in which they could add information, particularly on OTC medications, including those purchased from online pharmacies. At the same time, this possibility raised concerns about the reliability and integrity of such data. By their nature, these double binds cannot be readily resolved at a purely functional level but require a more in-depth design of the process elements concerned.

Methodological Lessons on Using the LL Approach

While eRIKA did not aim to systematically evaluate the LL methodology itself, the experiences gained allow for selected methodological reflections. LLs offer insights into the refinement and contextual adaptation of complex interventions. This study illustrates how such a participatory approach can support iterative development and reveal barriers to the planned intervention. The structured co-design process enabled the identification of practical barriers and the direct translation of interest-holder feedback into requirements for software modifications. The LL also allowed workflow issues to be identified at an appropriate stage of the intervention

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development cycle, underscoring the importance of timing in co-design efforts.

Additionally, integrating workshops, negotiation meetings, and prototype testing contributed to a multidimensional understanding of user needs that would have been difficult to capture through other evaluation approaches, such as post hoc interviews, standardized surveys, or 1-time usability tests. The project also aligns with key elements of the MRC Framework for the development and evaluation of complex interventions, including interest-holder engagement, identification of uncertainties, and iterative refinement of the intervention within its real-world context [8].

Regarding interest-holder integration, the MRC Framework recommends including representatives at the micro, meso, and macro levels. This study covered the micro level (users in medical practices and pharmacies) and the meso level (IT company). However, the macro level could not be included due to recruitment difficulties. Relevant macro-level actors would have included pharmacy associations, medical associations, vendors of practice software systems, gematik (the operator of the German health TI), and political decision makers. These actors were only loosely affiliated with the project or not affiliated at all, limiting opportunities for their effective inclusion. This lack of macro-level involvement is reflected in the results. For example, participants often expressed a desire to integrate the new software into legacy practice software systems. However, this could not be implemented because of a lack of open interfaces, which are not strongly mandated by regulation.

Additionally, participant feedback indicated that the LL concept itself was not always well understood. Unfamiliar terminology and a lack of clarity about the purpose of their involvement occasionally led to confusion or resistance. After follow-up conversations and clearer explanations of the co-design process, participants reported feeling better informed and more motivated to contribute, which reinforced the participatory value of the LL format and its potential to promote engagement throughout the development cycle. This suggests that LL co-design processes should prioritize clear communication of expectations and the link between participation and tangible outcomes.

Despite various strengths, the application of the LL approach in the eRIKA project also revealed challenges. While the process facilitated rapid iteration, it lacked standardized indicators for evaluating implementation success. This aligns with existing criticism of LLs, which often rely on qualitative feedback but rarely provide quantifiable outcome data. Although one could argue that this is a goal of the approach, Zipfel et al [24] and Kim et al [25] have also noted that the field still lacks validated frameworks to systematically assess the impact of LLs beyond narrative or anecdotal results.

Limitations

Despite the insights gained, this study has several limitations.

First, it reports on the formative stage of the eRIKA project and should be interpreted accordingly. The findings reflect participant-generated feedback, preferences, and perceived barriers within the specific co-design process rather than a broader, systematic view of the topics under study.

Second, the sampling strategy relied on convenience sampling through professional networks and prior project collaborations, which may have introduced selection bias by overrepresenting digitally engaged and organizationally well-connected participants. This limits the transferability of the findings to care settings with lower levels of digital maturity or weaker interprofessional ties.

Third, the study was limited to 4 thematic sprints conducted over a defined project period, restricting the ability to observe long-term adoption patterns or assess the sustainability of implemented changes beyond the co-design phase. Therefore, participant engagement and system acceptance under routine conditions remain unknown.

Fourth, the LL sessions focused primarily on intervention-level optimization, while implementation strategies to support sustained maintenance were only marginally addressed. This may limit the practical applicability of the findings to sites seeking to scale the intervention beyond the project context.

Fifth, the researchers who facilitated and analyzed the sessions were members of the project team, and their prior knowledge of the intervention's development history may have influenced the interpretation of the results based on their personal experiences, potentially leading to an underemphasis of critical or contradictory findings.

Finally, the co-design process engaged primarily micro-level interest-holders who are directly involved in the day-to-day prescribing and dispensing workflow. Macro-level interest-holders, including health care policy makers, regulatory authorities, and representatives of the TI, were not systematically integrated into the LLs. This absence has relevant implications for interpreting the study as a comprehensive LL implementation.

Conclusions

By applying the LL approach, barriers, obstacles, and user requirements regarding the planned intervention could be collected systematically. These findings relate not only to technical implementation but also to challenges in interprofessional collaboration, such as communication between medical practices and pharmacies, as well as questions of responsibilities and areas of accountability. The results highlight the critical importance of involving end users in the design of health care solutions. Future research on eHealth involving multiple professions must take these findings into account and incorporate them into the research process so that potential barriers to implementation can be addressed at an early stage.

Beyond the descriptive findings, this study makes several contributions to the literature on digital health co-design and eHealth implementation. The interprofessional tensions surrounding the sharing of patient data with PHs represent a substantive finding that goes beyond usability concerns. GPs and PHs held divergent expectations regarding what data should be shared and at what level of detail, reflecting deeper professional boundaries. These tensions are not merely technical

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interoperability problems but also reflect boundaries between professional groups whose responsibilities are being redefined. This finding aligns with NPT's concept of coherence: the intervention cannot be normalized until a shared understanding of its purpose and the appropriate scope of data sharing is negotiated across professional groups. Second, the double bind around push communication constitutes a theoretically relevant paradox for eHealth design. Participants simultaneously requested proactive push notifications to improve responsiveness and expressed concern that such notifications would add to an already unsustainable workload. Additionally, this study offers transferable lessons about the application of the LL methodology within a fragmented national health IT environment. Germany's decentralized health care system, characterized by heterogeneous practice management systems, regionally variable digital maturity, and a nationally mandated but recently introduced TI, created structural constraints that shaped the co-design process at every stage. Variation in system landscapes across practices and the dual dependency on both local practice software and national TI components meant that participant feedback could not always be translated into universally applicable design solutions. This experience highlights a fundamental challenge for LLs in fragmented health IT environments: co-design processes that work well at the level of individual workflows may encounter systemic barriers at the infrastructure level that lie outside the scope of participatory design. Future LL implementations in comparable contexts should consider explicitly mapping national infrastructure dependencies at the outset and involving macro-level IT governance interest-holders, such as gematik or national interoperability bodies, alongside end users.

This study demonstrates that LLs can support the refinement of digital health interventions under everyday conditions. To fully realize this potential, several improvements are necessary. Future implementations should aim for broader participant inclusion across varying levels of digital literacy and levels of routine practice with digital tools to reduce selection bias. Linking LL activities to established methodological frameworks, such as the MRC Framework, could enhance consistency and comparability across projects. In the context of the MRC Framework, particular consideration should be given to involving interest-holders at all levels, including the political (macro) level. The LL showed that, given the particular challenges surrounding digitalization in Germany, user involvement alone is insufficient. Successful development and integration of eHealth solutions into care delivery also require the active participation of policy makers and decision makers. Future research should therefore account for this broader context and ensure that the micro, meso, and macro levels are all considered during development and implementation.

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Data Availability

The data supporting the findings of this study are available from the corresponding author (AP) upon reasonable request. Due to confidentiality considerations, access to the data may be subject to institutional approval and data-sharing agreements.

Authors' Contributions

Conceptualization: IM
Data curation: CB (lead), EG (equal), AP (supporting)
Formal analysis: AP (lead), EG (equal), BM (equal)
Funding acquisition: IM (lead), JKN (equal), WG (equal)
Investigation: AP (lead), IM (equal), BM (equal)

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Methodology: IM (lead), AP (equal)
Project administration: IM (lead), JKN (equal), WG (equal)
Resources: AP (lead), BM (supporting), eRIKA Study Group (supporting)
Supervision: IM (lead)
Validation: AP (lead), BM (equal), IM (equal)
Visualization: AP, eRIKA Study Group (supporting)
Writing – original draft: AP (lead), EG (supporting), CB (supporting), BM (supporting), DL (supporting), JS (supporting), IM (supporting)
Writing – review & editing: AP (lead), BM (supporting)

Conflicts of Interest

None declared.

Multimedia Appendix 1

The SRQR checklist.
[DOCX File , 23 KB-Multimedia Appendix 1]

References

1. Tossaint-Schoenmakers R, Versluis A, Chavannes N, Talboom-Kamp E, Kasteleyn M. The challenge of integrating eHealth into health care: systematic literature review of the Donabedian model of structure, process, and outcome. J Med Internet Res. May 10, 2021;23(5):e27180. [FREE Full text] [doi: 10.2196/27180] [Medline: 33970123]
2. Archibald MM, Wittmeier K, Gale M, Ricci F, Russell K, Woodgate RL. Living labs for patient engagement and knowledge exchange: an exploratory sequential mixed methods study to develop a living lab in paediatric rehabilitation. BMJ Open. 2021;11:e041530. [FREE Full text] [doi: 10.1136/bmjopen-2020-041530] [Medline: 33947723]
3. Swinkels ICS, Huygens MWJ, Schoenmakers TM, Oude Nijeweme-D'Hollosy W, van Velsen L, Vermeulen J, et al. Lessons learned from a living lab on the broad adoption of eHealth in primary health care. J Med Internet Res. Mar 29, 2018;20(3):e83. [FREE Full text] [doi: 10.2196/jmir.9110] [Medline: 29599108]
4. Schmitt T. New governance of the digital health agency: a way out of the joint decision trap to implement electronic health records in Germany? Health Econ Policy Law. Apr 2024;19(2):269-288. [doi: 10.1017/S1744133123000142] [Medline: 37694342]
5. Hennemann S, Beutel ME, Zwerenz R. Ready for eHealth? Health professionals' acceptance and adoption of eHealth interventions in inpatient routine care. J Health Commun. Mar 2017;22(3):274-284. [doi: 10.1080/10810730.2017.1284286] [Medline: 28248626]
6. Bruthans J, Duftschmid G, Hammar T, Kardas P, Bertalan L, Hug MJ, et al. Comparison of electronic prescription systems in the European Union: benchmarking development, use, and future trends. IEEE J Biomed Health Inform. May 2025;29(5):3712-3722. [doi: 10.1109/JBHI.2025.3531317] [Medline: 40036418]
7. Nilsen ER, Stendal K, Gullslett MK. Implementation of eHealth technology in community health care: the complexity of stakeholder involvement. BMC Health Serv Res. May 11, 2020;20(1):395. [FREE Full text] [doi: 10.1186/s12913-020-05287-2] [Medline: 32393265]
8. Skivington K, Matthews L, Simpson SA, Craig P, Baird J, Blazeby JM, et al. A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. BMJ. Sep 30, 2021;374:n2061. [FREE Full text] [doi: 10.1136/bmj.n2061] [Medline: 34593508]
9. Ståhlbröst A, Holst M. The Living Lab Methodology Handbook. Luleå University of Technology. 2012. URL: https://www.nmi.is/static/files/Vefverslun/Stjornun_og_rekstur/livinglabsmethodologybook_web.pdf [accessed 2026-10-19]
10. Eysenbach G. What is e-health? J Med Internet Res. 2001;3(2):E20. [FREE Full text] [doi: 10.2196/jmir.3.2.e20] [Medline: 11720962]
11. Leminen S, Westerlund M, Nyström A-G. Living labs as open-innovation networks. Technology innovation management review. Technology Innovation Management Review. Sep 2012;2(9):6-11. [doi: 10.22215/timreview/602]
12. Russo-Spena T, Salvatore C, Fairfield B, Giordano A, De Simone S, Illario M. Living labs in digital health: a collaborative ecosystem approach for continuum of care. Front Public Health. 2025;13:1728904. [FREE Full text] [doi: 10.3389/fpubh.2025.1728904] [Medline: 41567766]
13. Poppe A, Schmidt J, Lampe D, Greiner W, Köberlein-Neu J, Söling S, et al. ePresciption as an Element of Interprofessional Pathways for continuous medication safety management (eRIKA) – a living lab as an iterative co-design process for a participative intervention development. Open Science Framework (OSF). 2023. URL: https://osf.io/xhj8m [accessed 2026-10-19]
14. Schmidt J, Lampe D, Poppe A, Meyer I, Söling S, Köberlein-Neu J, et al. eRIKA Study Group. Enhancing continuous medication safety through e-prescription and clinical decision support systems in outpatient practices and pharmacies:

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protocol for a Multiperspective Study (eRIKA Study). JMIR Res Protoc. Apr 07, 2026;15:e87277. [FREE Full text] [doi: 10.2196/87277] [Medline: 41945652]
15. Van den Haak M, de Jong M, Schellens P. Employing think-aloud protocols and constructive interaction to test the usability of online library catalogues: a methodological comparison. Interacting with Computers. Dec 2004;16(6):1153-1170. [doi: 10.1016/j.intcom.2004.07.007]
16. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. Jan 2006;3(2):77-101. [doi: 10.1191/1478088706qp063oa]
17. Braun V, Clarke V. Toward good practice in thematic analysis: avoiding common problems and be(com)ing a researcher. Int J Transgend Health. 2023;24(1):1-6. [FREE Full text] [doi: 10.1080/26895269.2022.2129597] [Medline: 36713144]
18. May CR, Mair F, Finch T, MacFarlane A, Dowrick C, Treweek S, et al. Development of a theory of implementation and integration: normalization process theory. Implement Sci. May 21, 2009;4:29. [FREE Full text] [doi: 10.1186/1748-5908-4-29] [Medline: 19460163]
19. 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):e10120327. [FREE Full text] [doi: 10.3390/life10120327] [Medline: 33291615]
20. Ancker JS, Edwards A, Nosal S, Hauser D, Mauer E, Kaushal R, et al. with the HITEC Investigators. Effects of workload, work complexity, and repeated alerts on alert fatigue in a clinical decision support system. BMC Med Inform Decis Mak. Apr 10, 2017;17(1):36. [FREE Full text] [doi: 10.1186/s12911-017-0430-8] [Medline: 28395667]
21. Klerings I, Weinhandl AS, Thaler KJ. Information overload in healthcare: too much of a good thing? Z Evid Fortbild Qual Gesundhwes. 2015;109(4-5):285-290. [doi: 10.1016/j.zefq.2015.06.005] [Medline: 26354128]
22. Löffler C, Koudmani C, Böhmer F, Paschka SD, Höck J, Drewelow E, et al. Perceptions of interprofessional collaboration of general practitioners and community pharmacists - a qualitative study. BMC Health Serv Res. Mar 21, 2017;17(1):224. [FREE Full text] [doi: 10.1186/s12913-017-2157-8] [Medline: 28327136]
23. Lee JL, Kara A, Huffman M, Matthias MS, Radecki B, Savoy A, et al. Qualitative analysis of team communication with a clinical texting system at a midwestern academic hospital. Appl Clin Inform. Mar 2022;13(2):391-397. [FREE Full text] [doi: 10.1055/s-0042-1744389] [Medline: 35294986]
24. Zipfel N, Horreh B, Hulshof CTJ, de Boer AGEM, van der Burg-Vermeulen SJ. The relationship between the living lab approach and successful implementation of healthcare innovations: an integrative review. BMJ Open. Jun 28, 2022;12(6):e058630. [FREE Full text] [doi: 10.1136/bmjopen-2021-058630] [Medline: 35768105]
25. Kim J, Kim YL, Jang H, Cho M, Lee M, Kim J, et al. Living labs for health: an integrative literature review. Eur J Public Health. Feb 01, 2020;30(1):55-63. [FREE Full text] [doi: 10.1093/eurpub/ckz105] [Medline: 31169898]

Abbreviations

CDSS: clinical decision support system
eRIKA: eRezept als Element Interprofessioneller Versorgungspfade für Kontinuierliche Arzneimitteltherapiesicherheit
GDPR: General Data Protection Regulation
GP: general practitioner
KVWL: Kassenärztliche Vereinigung Westfalen-Lippe
LL: living lab
MA: medical assistant
MRC: Medical Research Council
NPT: Normalization Process Theory
OTC: over-the-counter
PH: pharmacist
PT: pharmacy technician
SRQR: Standards for Reporting Qualitative Research
TI: telematics infrastructure

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