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***ORIGINAL ARTICLE***

# De-implementation as a Missing Link in Digital Health Innovation Dynamics: The Example of Remote Patient Monitoring Services

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***ABSTRACT***

Research and practice in digital health innovation have largely focused on the processes underlying the development, implementation, and scaling of new digital services. Meanwhile, comparatively little attention has been paid to the processes underlying the removal - or de-implementation - of ineffective, inefficient, or obsolete digital tools. Drawing on evolutionary perspectives of innovation dynamics, this conceptual paper argues that a lack of clear responsibilities in de-implementation decision-making may undermine the contemporary digital health innovation arena by impeding the development, implementation, and scaling of superior solutions. On this basis, initial ideas are offered for innovation policy directions that could better support the systematic integration of de-implementation processes into digital health innovation ecosystems.

*Keywords: Digital Health Innovation; Evolutionary Economics; De-implementation.*

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## INTRODUCTION

Digital health innovation has long been heralded as a transformative force in healthcare systems. From the early days of health telematics to contemporary applications in mobile health services, personalized medicine, and artificial intelligence-powered solutions, consecutive waves of digital health technologies have promised enhanced efficiency, patient empowerment, and improved clinical outcomes (see e.g. World Health Organisation, 2025). Despite unprecedented levels of investment and enthusiasm, however, the impact of digital transformation in the healthcare domain is occasionally reported as underwhelming or ambiguous (Wachter, 2017; Lupton, 2017; Ziebland et al., 2021).

A notable example is represented by Electronic Medical Records (EMRs/EHRs), whose widespread adoption was projected to result in major savings for healthcare systems through improvements in efficiency and safety (Hillestad et al., 2005). Later studies have noted that, while EMRs may improve the efficiency of secondary clinical work (e.g. administrative tasks), they may also negatively affect the efficiency of primary clinical work (Greenhalgh et al., 2009). Indeed, time and motion studies in American ambulatory practices have found that, for every hour physicians spend on face-to-face patient care, almost two additional hours are spent on EMRs and desk work (Sinsky et al., 2016). In a global context of increasingly strained healthcare systems, facing unprecedented challenges (including aging populations, pandemics, supply chain disruptions, climate change, and armed conflicts) while sustaining severe and worsening workforce shortages (Liu et al., 2017), novel ideas on the reasons for the mixed success of contemporary digital health innovation processes are sorely needed.

Innovation diffusion mechanisms in digital health differ from the processes observed in other healthcare sectors, such as pharmaceutical products and non-digital medical devices. New drugs typically demonstrate superiority through controlled trials, and reimbursement frameworks actively facilitate their introduction and the replacement of previous standards of care. On the other hand, non-digital products are governed through well-established standards, and their selection and purchase are typically managed by dedicated institutional functions such as hospital procurement departments. In both domains, clear responsibilities are assigned for both purchasing and discontinuation decisions, which are guided by regulatory, clinical, and market incentives. New digital health interventions, by contrast, often constitute complex product-service systems (combining software, hardware, data infrastructure, and care pathway redesign), and their evaluation and adoption follow different logics, incentives, processes, and methods (Guo et al., 2020).

Drawing on evolutionary models of innovation dynamics in the healthcare sector (Consoli and Mina, 2009), this paper conceptualizes *de-implementation* as a possibly underestimated and underutilized, yet vital, component of the digital health innovation lifecycle.

More in detail, we suggest that a blind spot in contemporary digital health innovation ecosystems might be represented by the absence of structural, institutionalized mechanisms for de-implementation, intended as the systematic discontinuation of low-value care practices through removal, replacement, reduction, or restriction (Kien et al., 2024). In contrast to disinvestment (the withdrawal of financial resources), obsolescence (the passive fading out of outdated tools), or non-adoption, non-adherence and abandonment (the lack of engagement of intended users), de-implementation implies an active, evidence-informed process. We propose that this active process could be based on clearly defined responsibilities, continuous real-world monitoring of digital health services, engagement of stakeholders in the decision-making process, and structured exit strategies.

Next, we set the stage by offering a brief overview of the theoretical background underpinning evolutionary perspectives in health innovation. Following, we characterize the lack of clearly defined de-implementation responsibilities as a possible contributor to evolutionary dysfunctions in the current digital health innovation landscape. To explore this possibility, we build on a model of health services innovation from Windrum and García-Goñi (2008) to examine current roles of key stakeholders in de-implementation decision-making. Based on this analysis, we note that none of the examined actors appear to have a clear mandate for digital health de-implementation. Finally, we propose initial ideas for the construction and embedding of de-implementation capacities within digital health ecosystems.

## DIGITAL HEALTH INNOVATION AS VARIATION AND SELECTION

Innovation dynamics, intended as the mechanisms of emergence and diffusion of novelty across domains and markets, can be described through a large variety of models and disciplinary perspectives, ranging from empirical studies (Cohen & Levin, 1989) to theoretical modelling (Loreto et al., 2016). Some perspectives on innovation dynamics are grounded on an understanding of the innovation arena as a complex system shaped by continuous mechanisms of adaptation and competition. While several have warned against too-literal comparisons with the biological world (see e.g. Hodgson, 1997; Louçã & Cabral, 2021), these perspectives are often referred to as *evolutionary*.

An important tradition within evolutionary perspectives on innovation dynamics consists in the vast body of research influenced by the scholarship of Joseph Schumpeter - and especially by his seminal Theory of Economic Development (1912). Schumpeterian views on innovation dynamics stem from a recognition of development as a *variation cum selection* process, intended as a dynamic framework relying, at a macro level, both on the provision of variations in offerings and propositions and on a responsive system able to displace 'inferior' offerings and propositions with 'superior' ones (Metcalfe, 2012).

Although the healthcare context has long been recognized as unique in terms of competition forces (Arrow, 1963), evolutionary perspectives on innovation dynamics have been successfully applied in this domain (see e.g., Consoli & Mina, 2009; Lehoux et al., 2016; Pannunzio et al., 2020). In the specific case of digital health, variation – intended, broadly, as 'the doing of new things or the doing of things that are already being done in a new way' (Schumpeter, 1947) - can be recognized in any element of novelty in digital health offerings, including technical breakthroughs in health informatics, updates on existing software and hardware, novel business models for digital health provision, improved digital interfaces, integrated health data platforms, and much more. In this domain, selection – intended, broadly, as the set of functions involved in determining the adoption and retention of novelties –is mediated by an intricate network of decision-making actors and organizations, including hospital managers, IT specialists, healthcare providers, researchers, patients, insurers, policymakers, and regulators, often following highly regulated protocols and upholding rigorous standards of scrutiny.

## THE POTENTIAL ROLE OF DE-IMPLEMENTATION

Evolutionary perspectives on innovation dynamics allow for the identification of systemic dysfunction across innovation ecosystems. Notably, these perspectives are well-suited to describe circumstances in which path dependencies might lead to established technologies persisting even when they are inferior to new competitors (Nill & Kemp, 2009), a phenomenon described by Arthur (1989) as 'lock-in'. Such circumstances may indeed characterise current digital health innovation ecosystems: when 'inferior' offerings become locked in and resistant to de-implementation, 'superior' alternatives are locked out, creating a downstream bottleneck in innovation dynamics. This phenomenon has been recently observed in several European contexts: notably, in platform-based innovation in Dutch first-line healthcare (Van der Wielen et al., 2024) and in the Swedish digital health ecosystem (Saenyi et al., 2025).

As contemporary digital health ecosystems are often characterised by high degrees of complexity, fragmentation, specialisation, and path-dependency (Lim et al., 2016), it might be hard for any one set of stakeholders to have the interest and decision-making power needed to effectively dispose of obsolete offerings once they are integrated within routine care pathways.

This could either lead to excessive market consolidation, as observed in the case of EHRs (see e.g. Wanderer et al., 2014; Koppel et al., 2015); or, on the contrary, to excessive market fragmentation, as observed in the phenomenon of digital health *pilotitis*. This is the tendency of promising digital health initiatives to remain locally implemented in small pilot settings, rather than scaled up across contexts (see e.g. Huang et al, 2017 and Egermark et al., 2022).

To explore this hypothesis, we build on the foundational theoretical contribution provided by Windrum and García-Goñi (2008), who formalise a neo-Schumpeterian model of health services innovation. This model articulates the interacting roles of three types of actors in evolutionary innovation dynamics in the health domain, namely **service users** (e.g. patients, healthcare staff), **policymakers** (e.g. governments, supranational regulatory bodies), and **service providers** (e.g. hospitals, GP practices, MedTech companies). Particularly, Windrum and García-Goñi highlight the influence of each type of stakeholder on key decisions related to the *development and adoption* of health service innovations. In the next section, we build on this model to consider the influence of each type of stakeholders in digital health *de-implementation*, which we argue to be an equally important innovation step from an evolutionary perspective.

To do so, we use the example of Remote Patient Monitoring (RPM) services, a subset of digital health applications aimed at improving patient care through digitally transmitted, health-related patient data, usually collected through sensors (Farias et al., 2020). Because of its emblematic nature both in terms of challenges and opportunities, RPM is presented as a frontier of digital health at large (see e.g. Gandy et al., 2021). In terms of challenges, RPM poses a broad mix of issues common in the broader digital health domain, including risk of increased workload, patient anxiety, data inaccuracy, disorienting technology, financial issues, privacy concerns, and lack of standardisation and interoperability (Sagahyroon et al., 2017; Serrano et al., 2023). At the same time, deploying effective RPM services holds considerable potential to reduce healthcare resources utilization while maintaining or improving care quality (Holtz et al., 2024). Yet, evidence regarding RPM effectiveness at scale is mixed (Noah et al., 2018; Mecklai et al., 2021; Tan et al., 2024), and the development and scaling of RPM is known to be affected by widespread difficulties (Ruyobeza et al., 2020).

## WHO IS RESPONSIBLE FOR DE-IMPLEMENTING REMOTE PATIENT MONITORING?

We begin by examining the role of **service users** in de-implementation decision-making. In the case of RPM, service users can be best characterized as patients and staff, as RPM services require active participation from both. RPM services are often introduced with the promise of empowering patients, enhancing self-management, and alleviating the workload of healthcare staff. However, patients and staff alike might have little power to initiate or influence the removal of such services from healthcare systems once these are implemented. Even when patients and staff experience burden, frustration, or disengagement (e.g. due to frequent technical glitches, low perceived usefulness, or alert fatigue), structural feedback mechanisms in RPM are often limited to research settings rather than post-implementation quality monitoring (Pannunzio et al., 2024; León et al., 2023). Patients may stop using the devices or apps personally, but this rarely translates into broader de-implementation. Indeed, patient discontinuation tends to be framed in the literature as a problem of 'non-compliance', rather than as a useful signal that the care technology itself may be suboptimal (Burgess et al., 2022).

Secondly, we consider the de-implementation decision-making power of RPM **policymakers**. Policy bodies, national, and supranational health authorities often play a central role in funding, legitimizing, and scaling RPM services, especially through innovation funds, tailored reimbursement strategies, digital transformation initiatives, or pandemic-era emergency measures (see e.g. Ubl, 2007 and Peek et al., 2020). However, they appear to be currently ill-positioned to promote de-implementation efforts. Innovation grants and procurement mechanisms typically reward scale-up and diffusion; few include requirements for post-implementation audit or criteria for removal. As a result, policymaking actors typically don't have a clear mandate to evaluate whether individual RPM services continue to deliver value across diverse populations and contexts, let alone coordinate their phase-out.

Finally, we consider the de-implementation decision-making power of RPM **service providers**. Healthcare providers (including hospitals, clinical teams, and health administrators) are at the frontline of deploying and maintaining RPM services. They are also in the best position to observe challenges in real-world service delivery: low patient engagement, high false-positive alert rates, uncertain clinical relevance of collected data, and impact on staff workload. Yet, providers may face substantial barriers to initiating de-implementation. On one side, a prominent challenge is represented by operational inertia. RPM services require significant up-front investment: procurement of devices, integration with electronic health records, staff training, workflow redesign, and patient onboarding protocols (Miranda et al., 2023). Once implemented, these systems become deeply embedded in clinical practice. Removing them would often mean undoing months (or years) of work, including negotiations with vendors, reassigning of staff responsibilities, training, and reconfiguring IT systems. On the other side, there is still a lack of institutional

capacity and established methods for post-implementation evaluation and monitoring of digital health services. While established auditing and care quality monitoring protocols and practices exist for more traditional treatments and care pathways, many RPM service providing organisations may have no formal procedures yet for regular reassessment or withdrawal of services.

Overall, the case of Remote Patient Monitoring exemplifies a possible systemic difficulty in de-implementing digital health services. While all these stakeholders are key decision-makers in the development, implementation, and scaling of digital health services, none might be effectively positioned to lead de-implementation efforts; patients lack the power and visibility to trigger meaningful reviews, policymakers are structurally incentivized to promote innovation rather than manage its failures, and providers may be hampered by operational entrenchment and lack of mature auditing and quality improvement practices for these relatively new technologies.

In these terms, moving beyond ad-hoc or reactive approaches to de-implementation might have a beneficial systemic effect in supporting more adaptive digital health innovation ecosystems. Following, a set of initial ideas is outlined for enabling more effective removal of ineffective or misaligned digital health technologies, using the case of Germany's DiGA framework.

## TOWARD A DE-IMPLEMENTATION INFRASTRUCTURE

Germany's DiGA (Digitale Gesundheitsanwendungen) framework offers a useful model for the formal (re)assessment of digital health services. Under this system, digital health apps can be provisionally listed in the DiGA Directory and made reimbursable by statutory health insurance for 12 months while real-world evidence is collected (Mäder et al., 2023). If sufficient evidence of positive effects is not produced within that time, the app is delisted. Importantly, this policy establishes de-implementation as a *default* outcome in the absence of confirmatory evidence, in contrast to systems where continued use is the default. Another key lesson from the DiGA model is the importance of centralized, independent assessment bodies with the mandate and expertise to review digital health products over time. This is instrumental in mitigating the influence of commercial lobbying or institutional sunk costs and in facilitating evidence-based decisions. For RPM services, this could mean establishing dedicated, independent evaluation units (perhaps embedded within digital health agencies or health technology assessment bodies) that can oversee post-market surveillance, patient feedback integration, and long-term value audits. These bodies should be resourced to maintain longitudinal registries and assess real-world performance, especially in diverse populations. Rather than assuming permanence once implemented, new digital health services could be granted a time-limited "conditional adoption" status, with renewal contingent on a positive evaluation including key outcome metrics (e.g., patient adherence, clinical outcomes, cost-effectiveness). These metrics and quality indicators should reflect both system-level goals and patient-reported experiences, acknowledging the multidimensional nature of value in digital health innovation. At the same time, de-implementation should not be perceived a top-down punitive act, but as a participatory practice that is part of a learning health system. Clinicians, patients, developers, and administrators should be engaged not only in the design, evaluation, implementation, and scaling of digital health services, but also in decisions about their de-implementation.

Next to health insurance reimbursement mechanisms, another direction for de-implementation capacity building might be represented by new procurement models for healthcare organisations (e.g., hospitals or integrated care networks) acquiring digital health technologies.

These procurement models might be designed to include structured exit pathways, specifying outcome thresholds tied to renewal, data-sharing obligations to enable independent evaluation, terms for phased withdrawal if clinical or economic benchmarks are not met, and rights to reallocate funds to more effective alternatives. Such contractual structures may be instrumental in introducing accountability and reversibility into the innovation process, aligning digital health procurement with adaptive governance principles. Inspiration could come from health innovation domains that already have established performance monitoring and de-implementation mechanisms. For instance, learnings from medical equipment replacement planning in hospitals (see e.g. Clark, 2020) could be leveraged in terms of key factors to include in digital health services de-implementation decision-making. Similarly, learnings from pharmacovigilance and drug safety could be leveraged in terms of data sharing obligations and direct patient feedback integration (see e.g. Matos et al., 2019).

Rather than stifling innovation, we argue that the proposed oversight mechanisms might benefit digital health entrepreneurship. As in the DiGA case, they might be coupled with relatively low thresholds for market entry and explicit incentives for initial adoption and scaling. At the same time, the embedding of structural de-implementation mechanisms might stimulate a more dynamic and transparent playing field in digital health markets, opening new opportunities for digital health innovators and service providers.

However, current knowledge on mechanisms of de-implementation decision-making in digital health and their potential systemic effects appears to be scarce.

While valuable work on de-implementation has been recently produced in the field of implementation science (see e.g. Walsh-Bailey et al., 2021; Leigh et al., 2022; Kien et al., 2024), this tends to concern the management of de-implementation processes *after* the decision of de-implementing a health service or practice has already been made. Instead, an opportunity exists to conduct novel research shedding light on who currently takes de-implementation decisions in digital health, how these decisions are taken, how they affect the broader innovation ecosystem, and how de-implementation responsibilities could be better assigned. This last goal appears to be particularly challenging, as it would require an alignment, on an ecosystem level, of the diverse range of organisations and stakeholders involved in digital health variation and selection.

Examples of research questions to prioritise for preliminary inquiry in this domain could be formulated as follows:

a) Which health system actors would be best positioned to assume responsibility for digital health de-implementation?
b) How to best integrate incentives across the digital health innovation ecosystem?
c) What performance thresholds could be used to grant reimbursement of digital health services, and how could these best be calculated, evaluated, and updated?
d) What regulatory instruments could be used to manage digital health de-implementation mechanisms?

Beyond the primary learnings from the proposed research objectives, which could be applied to inform policy and managerial recommendations on de-implementation mechanisms, we expect that these research directions would result in valuable secondary learnings on digital health innovation ecosystems at large. This is because, in order to determine meaningful baseline measures and thresholds, considerable research progress would be required in terms of assessing real-world performances of digital health services. These secondary learnings could, in turn, inform new and improved processes for digital health development, implementation, and scaling.

Such a research agenda would need to draw from a mix of disciplines, including implementation science but also innovation management, systems engineering, systemic design, health technology assessment, health informatics, health service research, health economics, and entrepreneurship and management studies. These varied perspectives could illuminate different aspects of the digital health innovation ecosystem and its complex networks of incentives, leading to initial proposals for system-level intervention. We suggest that this research should mainly be practice-oriented to facilitate interdisciplinary alignment through a shared, tangible goal.

However, we contend that this research direction would also constitute a precious opportunity for advancing our theoretical understanding of digital health innovation mechanisms. In particular, we argue that further exploring de-implementation processes could unlock unexplored theoretical potential both in terms of how we evaluate digital health and in terms of how we understand digital health innovation dynamics at large.

## DISCUSSION AND CONCLUSIONS

In this paper, we have put forward the hypothesis that de-implementation might represent an underused, but potentially powerful capacity in the governance of digital health innovation. By applying evolutionary models of innovation dynamics to the example of RPM, we have described the lack of clearly defined roles for de-implementation decision-making across the main actors involved in health service innovation. Contextually, we have explored initial directions for integrating structural de-implementation capacities in digital health ecosystems, building on the real-life example of Germany's DiGA framework.

While coherent with evolutionary perspectives on health service innovation, the presented hypotheses are at this stage purely speculative, and empirical research would be required to investigate the merits of this direction. In this sense, we characterize this contribution as an invite for further debate and investigation on this research angle, which might offer a novel perspective on the severe and resistant issues observed in the digital innovation arena. Previous discourse on digital health innovation has largely been driven by a narrative centered around embracing novelty and adding new services, interventions, or features. Yet, for health systems to truly benefit from digital transformation, complementary attention must be given to the processes of undoing and removing. In this sense, we wish to characterize de-implementation not as a sign of failure, but rather as a mark of maturity in health innovation systems. In a context of urgent need for improved health systems performance worldwide, especially in terms of healthcare staff shortages and health systems resilience to a vast array of rapidly changing threats, such a direction might offer a new avenue for achieving more consistent and sustainable benefits from digital health technologies as whole.

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## CONFLICTS OF INTEREST

None to disclose.

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