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ORIGINAL ARTICLE

How to Effectively Disseminate Bottom-Up Developed Nursing Technological Innovations that Enhance Job Satisfaction? The Essential Role of Collaborative Makerspaces

Thom Joosten[1], Timothy Singowikromo[2], Robert Al[1], Onno Helder[2]

[1]Department of Technology Transfer Office, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands;
[2]Department of Create4Care, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands
*Corresponding author: o.helder@erasmusmc.nl

ABSTRACT

This conceptual paper explores the dissemination challenges of bottom-up, co-created innovations developed in makerspaces, that address healthcare needs and enhance nurses' efficiency and job satisfaction. The Create4Care initiative, launched by nurses at a Dutch academic hospital, has become a national leader in this movement. A growing multidisciplinary network of makerspaces now propels the vision of Create4Care into a new phase, driven by intrinsic motivation to expand opportunities within the nursing profession. However, the dissemination of in-house innovations among hospitals faces challenges, like the Medical Device Regulation, not being a fabricant and the uncertain market opportunity. This paper takes an early step in identifying facilitators and barrier, supported by literature and lived experiences of nurses, to the national dissemination of these innovations within an emerging Dutch collaboration of hospitals and universities of applied sciences, aiming to uncover strategies to overcome these obstacles.

Keywords: Nursing staff; Innovative mindset; Medical Device Regulation; Dissemination; Makerspaces.

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INTRODUCTION

The authors, at the invitation of a guest editor, have written a conceptual and challenging piece about the innovation plans, lessons learned, and future plans of the current makerspace. This aligns with this special issue on the field of healthcare innovations and entrepreneurship. We noticed that we bounce off these very disciplinary silos in classical research organizations and journals. The classical scientific structure of an article requested by the CERN IdeaSquare Journal of Experimental Innovation fits less well with our assignment. The authors have sometimes added a subtitle to the mandatory paragraph headings to clarify the connection to the assignment.

In Europe, the demand for healthcare is rising due to factors such as an aging population, the growing prevalence of chronic conditions, and lifestyle-related illnesses (Health–Europe, 2023). At the same time, healthcare systems face capacity constraints caused by a declining share of healthcare professionals, particularly nurses, the largest workforce group. This shortage results from lower recruitment, high attrition, and dropout rates (Akselrod et al., 2023; Tamata & Mohammadnezhad, 2023). Although technological innovations such as artificial intelligence (AI) and robotics are often presented as solutions, technologies that genuinely reduce nurses' workloads remain scarce and are unlikely to substantially support nursing care in the near future (Adeyemo et al., 2025).

What are MedTech companies doing to make nursing care more efficient and improve job satisfaction? Digital innovations such as electronic patient records and information systems have advanced rapidly (Evans, 2016). However, this research study identifies that the physical care provided by nurses has changed little in recent decades. This limited progress is partly attributed to conservative attitudes toward innovation in healthcare and constrained hospital budgets, resulting in cautious adoption and few major nursing innovations from MedTech companies. One explanation is that MedTech companies often lack a clear understanding of nurses' practical needs and rely on top-down innovation approaches that may overlook effective solutions. (Rigtering et al., 2023; van Steenis et al., 2025). Second, regulatory barriers play a role. The Medical Device Regulation (MDR) (EU 2017/745) has created substantial challenges for introducing new devices to the market. Some companies have therefore reduced their EU portfolios by around 33%, potentially limiting the availability of various medical devices (MedTech Europe, 2022). As a result, the MDR may also slow the development of new nursing innovations (Garzotto et al., 2022).

Nurses face daily challenges that hinder their efficiency. They often resort to workarounds using readily available materials (Rigtering et al., 2023). In

other cases, they accept time-consuming procedures or physically demanding tasks (de Jong et al., 2023). Instead of improvised solutions, professional, safe, and efficient nursing tools are urgently needed (Rigtering et al., 2023). To address this, an increasing number of hospitals are establishing makerspaces where designers and technicians co-develop healthcare innovations (Busse et al., 2022). Equipped with tools such as 3D printers, laser cutters, and hand tools, makerspaces enable the creation of prototypes in collaboration with healthcare professionals. These innovations aim to improve efficiency and job satisfaction (Tamata & Mohammadnezhad, 2023).

One notable example is Create4Care, which was founded by nurses in 2019 at an academic hospital in partnership with a University of Applied Sciences in the Netherlands. Lecturers are part of the core team, and students are actively involved in ongoing projects (Rigtering et al., 2023). Education and innovation development progress simultaneously, which benefits healthcare professionals and patients alike. Create4Care is the first nurse-led makerspace in the Netherlands and, to the best of our knowledge, in Europe. In the United States, MIT introduced the MakerSpace® concept, but their approach differs, because healthcare professionals develop innovations themselves without the involvement of technical students (Marshall & McGrew, 2017).

From the outset, Create4Care actively promoted its activities by demonstrating implemented improvements and clarifying the design and implementation process. This visibility led several healthcare and educational institutions to request the Create4Care business case, resulting in the establishment of the Nursing Platform Healthcare Innovation Netherlands (VPZN) (Helder et al., 2023). Within this network, improvement opportunities in nursing practice are systematically collected and shared across institutions. However, the MDR restricts hospitals to developing medical devices for in-house use only, limiting dissemination to other hospitals (MedTech Europe, 2022). This barrier is problematic, as such innovations can significantly improve nurses' job satisfaction and efficiency. Therefore, this study addresses the following research question: How can makerspaces stimulate the (inter)national dissemination of successful bottom-up nursing care innovations?

THEORETICAL BACKGROUND

The given classical structure of the theoretical background does not fit well the requested topic and now covers the bottom up developing and producing innovations and its contrast with commercially entrepreneur way of thinking. We noticed that a top-down approach was ineffective among nurses as adaptation lagged (de Jong et al., 2023; van Steenis et al., 2025). Therefore, we wanted to switch to a bottom-up approach to achieve greater adaptation (Grindell et al., 2022). To structure this effectively and involve nurses, a human-centered process like design thinking was the best fit (Leary et al., 2022; Wang et al., 2025). As a starting point, Create4Care adopts the human-centered Design Thinking method (Brown, 2008). Design Thinking encompasses five phases: empathize, define, ideate, prototype, and test. Another somewhat comparable method used by designers is the double diamond approach (Zhao et al., 2023). There are also the 'co' approaches such as co-production, co-design, and co-creation, which are used in knowledge mobilization to bridge the gap between knowledge and practice with various stakeholders (Grindell et al., 2022). The similarity is that all these approaches bring together different stakeholders as active and equal partners, who contribute their collective knowledge in a creative way to solve issues. Wolstenholme describes co-design and co-production, where the focus is more on joint designing during workshops, for example with nurses (Grindell et al., 2022; Wolstenholme et al., 2020). Given the acute shortages of healthcare professionals, including nurses (Akselrod et al., 2023), it is logical to keep the deployment of nurses as efficient as possible (Rigtering et al., 2023). To maximize the impact of co-created innovations, effective dissemination is essential. The makerspace therefore explored new ways to share healthcare innovations (de Jong et al., 2023). In the next phase, makerspace staff established a network to facilitate the exchange of self-developed healthcare innovations. The details of such networks and the initial experiences of nurses are explored in this study.

Hospitals primarily provide care, while university medical centers also have educational and research missions. In the Netherlands, this includes exploring opportunities to commercialize developed knowledge and translate research outcomes into societal benefits (Netherlands Federation of University Medical Centers, 2023). The production of medical devices is not a hospital's core task. When innovations are developed for internal use, their commercialization potential is often assessed, typically with support from Technology Transfer Offices that provide legal and strategic expertise. After internal validation, broader dissemination is often desirable. However, nursing innovations frequently remain confined to the hospitals where they are developed and rarely spread (inter)nationally. Create4Care has taken a different approach by actively disseminating its innovations beyond its own institution (de Jong et al., 2023). Nevertheless, dissemination is limited by low market interest in relatively simple innovations, market uncertainty, and the costs of patent or design protection. Despite these barriers, some products, particularly injection-molded designs, have been successfully commercialized.

For production there are two commonly used options, injection molding and 3D printing. 3D printing does not

require start-up costs while injection costs requires a mold which can cost between 3.000 to 50.000 euro (Minguella-Canela et al., 2019). To get the investment back from injection molding higher productions and thus a higher market opportunity is necessary. Healthcare institutions can support commercialization by acting as launching customers and facilitating early validation across institutions. Commercial production also offers advantages: 3D-printed products are relatively expensive, difficult to clean, and unsuitable for large-scale manufacturing. While a 3D-printed product may cost around €100, the same design can be produced via injection molding for approximately €20. Outsourcing production shifts product liability and allows institutions to license designs to commercial partners, generating royalties that can support further innovation.

Medical Device Regulation and In-House Manufacturing

Under the MDR, healthcare institutions are allowed to manufacture medical devices (and accessories) in-house, but only for use within their own organization (Bretthauer et al., 2023). As soon as an institution supplies innovations to other parties, it is legally classified as a manufacturer. This entails extensive obligations, such as CE marking, a complete technical file, clinical evaluation, and structural post-market surveillance (Garzotto et al., 2022). These responsibilities are not in line with the task or risk profile of publicly funded institutions. As a result, it is not realistic for these institutions to distribute or sell internally developed devices themselves. For wider distribution, collaboration with an external commercial party is necessary, as external supply is subject to the full MDR obligations, unlike the limited requirements that apply to in-house manufacturing.

Swedish and Dutch initiatives

Svensson and Hartmann (2018) describe how six hospitals established makerspaces where healthcare professionals could develop solutions to practical problems. Over four years, these makerspaces produced innovations that would likely not otherwise have emerged and generated a return on investment estimated at fourteen times the initial costs. Create4Care in the Netherlands represents a comparable initiative.

Create4Care was founded on the premise that technological innovations can address everyday challenges faced by healthcare professionals (de Jong et al., 2023). Previously, staff encountering such problems lacked access to professional product design expertise, often resulting in improvised or inefficient solutions. By introducing professional design support, Create4Care aims to develop sustainable solutions that improve job satisfaction and efficiency, while also drawing on insights from patients and families.

The initiative began informally in 2013 and demonstrated its value through early innovations. After a positive business case, the hospital Board of Directors formally approved Create4Care, which officially opened in 2019. The team now includes product designers, quality advisors, project and business managers, instrument makers, educators, and purchasers, and focuses on developing healthcare innovations, providing education, conducting research, and collaborating with healthcare and educational institutions.

METHODS: CREATE4CARE APPROACH AND SCALING UP INITIATIVE

Create4Care combines innovation development with active visibility to ensure healthcare professionals can easily access the makerspace. Through presentations and social media, more than 90% of Erasmus MC's 2,300 nurses are familiar with its activities. Implemented solutions encourage colleagues to submit new practical challenges, and some innovations, such as the TrulyEasy clamp and KoosGuard, are named after the nurses involved in their development. Improvement ideas can be submitted via email, phone, or in person, resulting in approximately one new challenge per week (de Jong et al., 2023). Challenges are prioritized based on impact and feasibility, including a market scan for existing solutions. When appropriate, staff are advised to purchase available products, adjust procedures, or consult other departments. As a theoretical framework, Create4Care uses the design thinking during the innovation development process. For each developed innovation, a product dossier is prepared according to the hospital's quality management system for in-house device development. More than 30 innovations have been implemented at Erasmus MC. Additional data are collected on adoption barriers and facilitators, the impact of bottom-up innovation on nurses and job satisfaction, and potential labour savings. The success of Create4Care has also stimulated collaboration between healthcare and educational institutions.

Nursing Platform for Healthcare Innovation

During the COVID-19 pandemic, several academic hospitals and universities of applied sciences established the VPZN to strengthen the national impact of bottom-up healthcare innovations (Helder et al., 2023). By co-creating with healthcare professionals, VPZN ensures that innovations address end-user needs. An inventory of practical challenges revealed considerable overlap across hospitals, highlighting the need for more effective sharing of innovations to increase their impact.

To support broader dissemination, VPZN provides a network through which institutions can exchange solutions and unresolved problems, improving the use of collective innovation capacity. Because MDR legislation

restricts sharing of physical devices, a license agreement was developed to allow blueprint sharing within the network. In addition, a physical "innovation suitcase" enables the exchange of tangible innovations among hospitals. As the network grows, the potential market for innovations increases, making commercial production more attractive. However, some innovations have a clear problem–solution fit but uncertain market demand, discouraging commercial interest. For these "orphan innovations," small-batch production within the network (200–1000 units) can remain cost-effective and improve availability. To support this approach, the network could establish a small-batch manufacturing entity that outsources production and supplies innovations to members at near-cost price. If demand increases nationally or internationally, production could then be scaled up or transferred to a commercial partner.

RESULTS: FIRST EXPERIENCES AND DISSEMINATION

Internal Dissemination Create4Care

Create4Care demonstrates the dissemination of healthcare innovations through examples such as the TrulyEasy clamp, a device that allows quick and ergonomic height adjustment of the blood pressure transducer. Developed by nurse Trudi and industrial design student Lise, it replaces a non-ergonomic screw clamp. Nearly 200 units are currently in use at the academic hospital and an affiliated hospital. Another example is the KoosGuard. This device was developed by an intensive care nurse to prevent monitor cables from becoming trapped between bed rails. By guiding cables between two hooks attached to the rail, it improves patient mobility and reduces the time nurses spend untangling cables. More than 300 KoosGuards are in use locally, and the product is also available internationally, with over 1,000 units sold within three years.

Implementation and Impact-Research

Create4Care innovations that are perceived as labour-saving, intuitive, and developed bottom-up in collaboration with nurses are adopted quickly (van der Zanden et al., 2025). The qualitative study also identified key barriers to implementation by using the Theoretical Domain Framework enabling and understanding of cognitive, effective, social, and environmental influences on behavior (Atkins et al., 2017; Lawton et al., 2015): unclear logistics such as missing storage locations, negative early experiences, and a lack of ownership.

Van Steenis examined in a qualitative study the impact of Create4Care innovations on three stake holder groups in the nursing staff who can judge the innovations in the real-world setting: the nurse who identified and co-developed the solution, the nurse end user, and the department manager. The study demonstrated a strong positive impact. Bottom-up innovation increased the attractiveness of the nursing profession, and the Create4Care approach was perceived as motivating. Notably, at least two nurses who had planned to leave the profession decided to stay because of their involvement as nurse innovators. Nurses also reported both advantages and challenges when using the innovations (van Steenis et al., 2025).

An exploratory quantitative study by Puts assessed the time efficiency of the TrulyEasy clamp (unpublished data). Sixty-four intensive care nurses adjusted both a traditional screw clamp and the TrulyEasy clamp in randomized sequences of 10- and 20-cm height changes, with all actions recorded and timed via video. The TrulyEasy clamp was significantly faster (7.8 s, $p < .001$) and was rated as more ergonomic and user-friendly. Based on nurses' self-reported average of 8.9 adjustments per day, this translates to an annual saving of approximately 327 nursing hours (€18,000) and a payback period of 3.6 months.

Dissemination by Collaborative Network

The Dutch Nursing Platform for Healthcare Innovation is a growing network of over 27 healthcare institutions, including all university medical centers, major teaching hospitals, a home care organization, and six universities of applied sciences (Helder et al., 2023). The network promotes the dissemination of bottom-up innovations by first creating a digital overview of innovations and their specifications to assess interest among hospitals. To support implementation within large healthcare organizations, a traveling "innovation suitcase" has been developed containing physical prototypes, allowing nurses to explore innovations and indicate interest.

To facilitate sharing, a borrowing agreement and a license have been developed. The borrowing agreement assigns product responsibility to the receiving hospital, while the license defines how institutions may produce devices for internal use, including design adaptations in consultation with the original developer. One institution has signed a license to test an innovation with patients, and additional agreements are in progress. Standardized templates reduce legal complexity and accelerate dissemination. In the future, a digital platform will allow institutions to view and request innovations and share solutions. Commercial parties will also be able to explore innovations for potential production. This approach strengthens collaboration and market interest, increasing the impact of innovations on healthcare practice.

DISCUSSION AND CONCLUSION

Our research question was: How can makerspaces stimulate the (inter)national dissemination of successful

bottom-up nursing care innovations? By inspiring healthcare institutions to establish their own makerspaces, recognize the value of collaboration, and share bottom-up healthcare innovations, a growing innovation movement can emerge. In our opinion, sharing proven nursing innovations is essential for improving healthcare practice. To address this, a blueprint license was developed that allows institutions to produce innovations for internal use while acknowledging the original developers. If a commercial supplier later enters the market, institutions transition from in-house production to purchasing the product commercially.

The MDR as mentioned in the theoretical background has become a serious concern for hospitals, as demonstrated in an open letter signed by the European University Hospitals Association (EUHA). The letter, titled "Serious concerns about the impact of the current implementation of the MDR and the In Vitro Diagnostic Regulation (IVDR)" (April 10, 2025), warns that these regulations are reducing the availability of medical devices and slowing innovation due to increased administrative burden, delays, and costs. These requirements particularly affect start-ups and SMEs, increasing the risk of market dominance by large multinational companies. Consequently, leading European hospitals have called for adjustments to mitigate the negative effects of the MDR on innovation. Although we cannot compensate for 30% loss of medical devices due to the new regulation of the MDR, we however can contribute to upholding the current high standard of care by co-development with nurses to circumvent the loss of medical devices.

Limitations of this paper. Both the Create4Care initiative (de Jong et al., 2023) as well as the VPZN are relatively new (Helder et al., 2023), and some examples concerning how to disseminate clinical e.g. physician's innovations are described (Svensson & Hartmann, 2018), we often had to find out the way ourselves based in anecdotal best practices in nursing settings.

Lesson Learned

The Create4Care approach shows that actively involving nurses in innovation development and training innovation champions facilitates rapid adoption and internal dissemination of innovations. These engaged nurses help implement solutions efficiently within clinical practice. However, the impact and scalability of such initiatives could increase through collaboration with commercial partners and the establishment of similar makerspaces in other institutions. This would improve coordination of innovation efforts, clarify market demand, and enable innovations to be developed and tested across multiple institutions. As a result, solutions would become relevant for a broader user group and more attractive for commercial investment.

Taken together, these insights indicate that bottom-up co-creation with nurses is essential for acceptance in care processes, while effective dissemination strategies are necessary to scale innovations and maximize their impact. Combined, these elements can stimulate a broader innovation movement aimed at improving healthcare.

Conclusion: Call for Action

Disseminating bottom-up nursing innovations requires collaboration between healthcare institutions. Networks such as the Dutch VPZN illustrate how effective solutions can be shared while recognizing innovators' contributions. However, regulatory barriers, particularly the Medical Device Regulation, continue to limit innovation and dissemination. Strengthening collaboration, improving dissemination processes, and protecting intellectual contributions are therefore essential to enhance nurses' job satisfaction and efficiency. By fostering a culture of innovation, makerspaces can help ensure that valuable nursing innovations reach a wider group of healthcare professionals and patients.

CONFLICTS OF INTEREST

None to declare.

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