



Nurses as Innovators: Inventing Solutions in Medical Device Technology

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Abstract

Nurses play a pivotal role in healthcare delivery, often acting as the bridge between patients and technology. Their direct engagement with medical devices in real-world clinical settings provides unique insights into functionality, usability, and patient safety. This article explores how nurses, leveraging their practical experience and problem-solving skills, contribute to medical device innovation. It highlights case studies of nurse-led innovations, the challenges they face, and the potential for collaborative development with engineers and manufacturers. The discussion emphasizes the importance of equipping nurses with the necessary resources



and fostering a culture that encourages innovation, ultimately improving patient care and operational efficiency.

Keywords-Nurse innovation, medical devices, healthcare technology, patient safety, clinical usability, nurse-led solutions, interdisciplinary collaboration, medical device development.

Introduction

Innovation in healthcare is not solely the domain of engineers, researchers, or technology firms; it also emerges from the frontline professionals who interact with patients and devices daily—nurses. With their firsthand experience in addressing clinical challenges, nurses are uniquely positioned to identify gaps in existing medical devices and propose practical, impactful solutions.

The dynamic environment of healthcare presents nurses with a myriad of challenges, from managing complex equipment to ensuring patient comfort and safety. These challenges often inspire creative solutions that have the potential to transform healthcare delivery. Historically, nurses have contributed to innovations like the crash cart and IV catheter stabilization devices, demonstrating their ability to bridge clinical needs with technological advancements.

However, despite their contributions, nurses' role in medical device innovation often remains underrecognized. This article delves into the significance of empowering nurses as innovators in the medical device industry. It examines the factors that enable or hinder their ability to contribute, discusses examples of successful nurse-led innovations, and provides a roadmap for fostering a culture of innovation within nursing practice. By recognizing and supporting nurses' potential in medical device development, healthcare systems can unlock new pathways to enhanced patient care and operational efficiency.

Nurses and Medical Device Innovation: A Unique Perspective

Nurses occupy a unique position in the healthcare ecosystem, acting as both frontline caregivers and pivotal operators of medical devices. This dual role equips them with a deep understanding of the practical challenges and unmet needs within clinical settings. Their perspective as direct users of medical devices and advocates for patients gives them a distinctive edge in identifying opportunities for innovation.

Why Nurses are Well-Positioned for Innovation

- Hands-On Experience with Medical Devices**
Nurses use a wide range of medical devices daily, from simple thermometers to complex ventilators and infusion pumps. This close interaction provides them with an intimate understanding of what works, what doesn't, and how devices can be improved to better suit clinical workflows.



- 2. Real-Time Problem Identification**
Working in fast-paced environments, nurses often encounter situations where existing devices fail to meet the demands of patient care. These experiences drive their ability to pinpoint inefficiencies and areas for improvement that may not be apparent to designers or engineers.
- 3. Patient-Centered Approach**
Nurses are advocates for patients' well-being, balancing clinical needs with comfort and safety. This perspective enables them to propose innovations that are not only functional but also enhance the patient experience. For instance, nurses have driven the development of devices with reduced noise levels in neonatal intensive care units to minimize stress for premature infants.
- 4. Adaptability in Diverse Environments**
Nurses work in varied settings, from hospitals to community clinics and home care. This adaptability gives them insights into how devices perform across different environments, informing the design of versatile and robust solutions.

Examples of Nurse-Led Innovations in Medical Devices

- 1. Improved IV Stabilization Devices**
Nurses observed that traditional IV stabilization methods often caused discomfort and were prone to dislodgement. In response, some nurses designed better stabilization devices that improve securement while minimizing irritation for patients.
- 2. Wearable Health Monitors**
Recognizing the need for continuous monitoring of patients with chronic conditions, nurses have contributed to the development of wearable devices that track vital signs and alert caregivers to abnormalities in real-time.
- 3. Simplified Emergency Tools**
The invention of the crash cart by nurse Anita Dorr exemplifies how a nurse's ingenuity can address critical needs. Her design made life-saving equipment more accessible during emergencies, saving countless lives since its introduction.

Bridging the Gap Between Clinical Practice and Technology

Nurses' insights can significantly improve the design, usability, and effectiveness of medical devices. However, to maximize their contributions, healthcare organizations must bridge the gap between clinical practice and technology development. Encouraging interdisciplinary collaboration between nurses, engineers, and designers can foster the creation of devices that better meet clinical demands.



A Vision for the Future

To truly harness the innovative potential of nurses, healthcare systems must:

- **Recognize their expertise as end-users and innovators.**
- **Provide platforms for nurses to share ideas and collaborate with industry professionals.**
- **Invest in education programs that teach nurses the fundamentals of innovation, intellectual property, and prototyping.**

By empowering nurses in this way, the healthcare industry can ensure that medical devices are not only technologically advanced but also practical, user-friendly, and aligned with the realities of patient care.

Notable Nurse-Led Innovations

Nurses have been instrumental in driving healthcare innovations that address critical needs in patient care, workflow efficiency, and device usability. These innovations often stem from their firsthand experiences with medical devices and their constant interaction with patients. Below are some notable examples of nurse-led innovations that have left a significant mark on healthcare.

1. The Crash Cart

Inventor: Anita Dorr, RN
Impact: Revolutionizing emergency care

The crash cart, invented by nurse Anita Dorr in 1968, is one of the most iconic contributions by a nurse to medical technology. While working in a hospital, Anita observed how time was wasted searching for necessary emergency equipment during critical situations. She designed a portable cart that organized all life-saving tools and medications in a single unit, making them easily accessible in emergencies.

Key Features:

- Compact, mobile design for rapid deployment
- Organized compartments for medications, defibrillators, and tools
- Reduced response times in critical care settings

This innovation became a standard feature in hospitals worldwide, saving countless lives and setting the precedent for nurse-led problem-solving in device design.



2. Neonatal IV Armboards

Inventor: Betty Lank, RN

Impact: Improving IV stability for infants

Recognizing the difficulty of stabilizing intravenous (IV) lines in fragile neonatal patients, Betty Lank designed specialized IV armboards to keep needles in place without harming the baby. These devices not only improved the safety and reliability of IV therapy but also minimized discomfort for newborns.

Key Benefits:

- Secure IV placement in neonates
- Soft, flexible materials to enhance patient comfort
- Reduced risk of IV dislodgement

This innovation addressed a critical challenge in pediatric care and became a valuable tool in neonatal intensive care units (NICUs).

3. Intravenous (IV) Catheter Stabilization Devices

Inventors: Various nurses across institutions

Impact: Reducing complications in IV therapy

Nurses frequently observed that traditional taping methods for securing IV catheters were prone to failure, leading to discomfort and dislodgement. To address this, several nurse innovators collaborated with manufacturers to develop catheter stabilization devices that keep IV lines secure while allowing patients to move freely.

Key Features:

- Adjustable designs for different patient sizes
- Improved adhesive technologies to prevent skin irritation
- Enhanced stability, reducing the risk of complications such as phlebitis

These devices have become standard in hospitals, significantly improving the patient experience and safety during IV therapy.

4. Wearable Health Monitors

Collaborators: Nurse innovators in partnership with engineers

Impact: Enhancing remote patient monitoring

With the rise of chronic conditions and the need for continuous health monitoring, nurses have contributed to the development of wearable devices that track vital signs, such as heart rate,



oxygen saturation, and glucose levels. Their feedback on usability and patient comfort helped refine these devices for practical, everyday use.

Applications:

- Diabetes management (continuous glucose monitors)
- Cardiac care (wearable ECG monitors)
- General health tracking for remote or at-risk patients

These monitors have empowered patients to manage their health proactively while enabling nurses to monitor conditions remotely and intervene early when abnormalities are detected.

5. Pressure Ulcer Prevention Cushions

Inventor: Innovated by various wound care nurses

Impact: Preventing pressure injuries in bedridden patients

Nurses specializing in wound care identified the need for better tools to prevent pressure ulcers in immobile patients. They designed cushions and overlays with specialized materials that distribute pressure evenly, reduce friction, and improve airflow to the skin.

Key Benefits:

- Reduced incidence of pressure ulcers
- Enhanced comfort for patients with limited mobility
- Customizable designs for different body types and medical needs

These devices have improved the quality of life for patients in long-term care facilities and hospitals while reducing healthcare costs associated with treating pressure ulcers.

6. Post-Surgical Drainage Systems

Inventors: Nurse teams collaborating with manufacturers

Impact: Streamlining post-operative care

Nurses noticed inefficiencies in managing drainage tubes for post-surgical patients, which often caused discomfort and infections. They worked with medical device companies to design better drainage systems that are easier to use, more hygienic, and less invasive.

Innovative Features:

- Closed-system designs to reduce infection risk
- User-friendly mechanisms for patients and caregivers



- Compact and discreet designs for enhanced mobility

These systems have transformed post-operative care, making recovery more comfortable and safe for patients.

7. Pediatric Distraction Devices

Inventor: Nurse teams in pediatric care

Impact: Reducing anxiety in young patients

Pediatric nurses identified that medical procedures often caused significant anxiety in children. To address this, they developed distraction tools such as light-up devices and wearable gadgets that engage children's attention during procedures like blood draws or vaccinations.

Examples:

- Devices that play calming music or display visual patterns
- Interactive toys integrated into medical tools
- VR headsets designed to distract children during painful procedures

These innovations have made pediatric care less intimidating for young patients, improving compliance and outcomes.

8. Smart Bedside Monitors

Collaborators: Nurses and medical technology firms

Impact: Improving safety and workflow efficiency

Nurses provided critical input on bedside monitors to ensure they were user-friendly and effective in tracking vital signs. They contributed ideas for alarm customization, data integration, and ergonomic design.

Key Advancements:

- Intuitive interfaces for faster interpretation
- Automated alerts for critical changes in patient status
- Integration with electronic health records for streamlined documentation

These features have helped nurses manage patient care more effectively in high-pressure environments.

Conclusion

These notable innovations underscore the critical role nurses play in advancing medical device technology. By combining their practical expertise with a deep understanding of patient needs,



nurses continue to shape tools and solutions that transform healthcare delivery. Empowering nurses through education, collaboration, and access to innovation resources can unlock even more groundbreaking contributions in the future.

Challenges Faced by Nurse Innovators

Despite their immense potential and valuable insights, nurse innovators often encounter significant barriers when attempting to bring their ideas to fruition. These challenges stem from systemic, educational, and institutional factors that hinder their ability to contribute fully to medical device innovation. Below, these challenges are explored in detail:

1. Limited Access to Resources

Nurses often lack access to the resources necessary for innovation, including funding, technical support, and materials for prototyping.

- **Funding Constraints:** Innovation requires financial investment for research, development, and testing. Nurses may find it difficult to secure grants or other funding sources, as these are often directed toward physicians, researchers, or larger institutional projects.
- **Technical Support:** Nurses may not have the engineering or design expertise needed to create functional prototypes or refine their ideas into viable products.
- **Time and Workload:** Nurses frequently work long hours, leaving little time for brainstorming or pursuing creative projects.

Potential Solutions:

- Establish innovation grants specifically for nurse-led projects.
- Create interdisciplinary innovation labs within healthcare institutions where nurses can collaborate with engineers and designers.
- Provide protected time for innovation as part of nurses' roles.

2. Organizational Hierarchies and Cultural Barriers

Healthcare organizations often operate with rigid hierarchies where nurses' contributions to innovation may not be valued or prioritized.

- **Perception of Roles:** Nurses are traditionally viewed as caregivers rather than inventors, leading to underestimation of their creative potential.



- **Decision-Making Exclusion:** Nurses may not be included in conversations about technology development or procurement, despite their critical role as end-users of medical devices.
- **Resistance to Change:** Healthcare organizations may resist adopting new ideas, especially if they challenge established workflows or require significant investment.

Potential Solutions:

- Foster a culture that values and rewards innovation across all professional levels.
- Include nurses in decision-making committees for technology procurement and development.
- Provide platforms for nurses to present and pitch their ideas to leadership.

3. Lack of Formal Training in Innovation

While nurses are highly skilled in clinical care, they may not have formal training in areas critical to innovation, such as:

- **Intellectual Property:** Nurses may not understand how to protect their ideas through patents or trademarks.
- **Design Thinking:** Many nurses are unfamiliar with systematic approaches to problem-solving, such as prototyping, testing, and iteration.
- **Commercialization:** Bringing a medical device to market requires knowledge of regulatory approvals, marketing, and manufacturing processes.

Potential Solutions:

- Offer training programs or workshops focused on innovation, intellectual property, and medical device development.
- Partner with academic institutions to integrate innovation curricula into nursing education.
- Establish mentorship programs where experienced innovators guide nurses through the innovation process.

4. Regulatory and Legal Challenges

The healthcare industry is heavily regulated, and navigating these regulations can be daunting for nurse innovators.



- **Complex Approval Processes:** Medical devices must undergo rigorous testing and approval by regulatory bodies like the FDA or EMA, which can be costly and time-consuming.
- **Liability Concerns:** Nurses may fear legal repercussions if their inventions fail to meet safety standards or if complications arise during use.
- **Intellectual Property Issues:** Nurses employed by healthcare institutions may face challenges asserting ownership of their innovations, as many organizations claim intellectual property rights for ideas developed on their premises.

Potential Solutions:

- Provide access to legal advisors who specialize in medical device regulation and intellectual property.
- Simplify and streamline internal processes for innovation within healthcare organizations.
- Develop frameworks that allow nurses to share ownership of their innovations with their employers.

5. Limited Recognition and Support

Nurse innovators often face a lack of recognition for their contributions, which can be discouraging and limit their motivation to pursue new ideas.

- **Underrepresentation in Innovation:** Nurses are often excluded from innovation-focused events, panels, or conferences that highlight advancements in healthcare.
- **Inadequate Incentives:** Many healthcare institutions do not have formal mechanisms for recognizing or rewarding innovative contributions from nurses.

Potential Solutions:

- Highlight nurse-led innovations in organizational newsletters, media, and industry events.
- Establish innovation awards specifically for nursing professionals.
- Promote nurse innovators as role models to inspire others within the profession.

6. Balancing Clinical Responsibilities with Innovation

The demanding nature of nursing, characterized by long shifts and high-stress environments, leaves little room for innovation.



- **Burnout and Fatigue:** The physical and emotional toll of nursing can reduce creativity and motivation to pursue projects outside of clinical responsibilities.
- **Conflict of Priorities:** Nurses may feel pressured to focus solely on patient care, perceiving innovation as secondary to their primary duties.

Potential Solutions:

- Integrate innovation into nursing roles, allowing nurses to dedicate time to creative problem-solving as part of their job descriptions.
- Offer flexible schedules or innovation sabbaticals to nurses interested in pursuing projects.
- Provide mental health and wellness support to address burnout and create space for creative thinking.

Overcoming Challenges: A Call to Action

To empower nurse innovators, healthcare systems must:

1. **Invest in Innovation Infrastructure:** Create resources, spaces, and programs that support nurse-led innovation.
2. **Encourage Interdisciplinary Collaboration:** Foster partnerships between nurses, engineers, designers, and manufacturers to bring ideas to life.
3. **Cultivate an Innovation-Friendly Culture:** Recognize and reward creative contributions from nurses, integrating innovation into the fabric of healthcare organizations.
4. **Advocate for Policy Changes:** Push for regulatory and institutional reforms that make it easier for nurses to innovate without fear of liability or intellectual property disputes.

By addressing these challenges, the healthcare industry can unlock the untapped potential of nurses, driving meaningful advancements in medical device technology and patient care.

Fostering a Culture of Innovation

Creating an environment that nurtures and supports nurse-led innovation is essential to unlocking the potential of frontline healthcare providers. A culture of innovation enables nurses to identify challenges, generate solutions, and collaborate on advancements that improve patient care and clinical workflows. This section explores strategies and frameworks to foster such a culture within healthcare organizations.



1. Establishing Dedicated Innovation Programs

Healthcare organizations can set up structured programs that empower nurses to innovate.

- **Innovation Labs:** Create physical and virtual spaces where nurses can brainstorm, prototype, and test new ideas in collaboration with engineers and other healthcare professionals.
- **Innovation Grants:** Allocate funding specifically for nurse-led projects to cover the costs of research, prototyping, and development.
- **Pilot Programs:** Allow nurses to trial their innovations in controlled environments, gathering feedback and refining their solutions before broader implementation.

Example: Some hospitals have introduced "Innovation Units," where nurses are encouraged to experiment with new ideas and are given access to resources like 3D printers, funding, and mentorship.

2. Encouraging Interdisciplinary Collaboration

Innovation often flourishes at the intersection of different disciplines. By fostering collaboration between nurses, engineers, designers, and business experts, healthcare organizations can enhance the development of practical and scalable solutions.

- **Cross-Disciplinary Teams:** Form teams that include nurses, product designers, and biomedical engineers to co-create medical devices.
- **Hackathons and Design Challenges:** Organize events where nurses work with professionals from other fields to solve specific healthcare problems within a set timeframe.
- **Partnerships with Universities and Startups:** Collaborate with academic institutions and tech startups to provide nurses with access to technical expertise and resources.

Example: Hackathons like "Nurse Maker" events have successfully brought together nurses and technologists to develop innovative solutions for pressing healthcare challenges.

3. Providing Education and Training

Equipping nurses with the knowledge and skills to innovate is crucial for fostering a culture of creativity and problem-solving.

- **Workshops and Seminars:** Offer training on design thinking, prototyping, intellectual property, and commercialization.



- **Innovation Courses:** Include modules on innovation and entrepreneurship in nursing education programs.
- **Mentorship Opportunities:** Pair nurses with experienced innovators or entrepreneurs who can guide them through the process of developing and implementing their ideas.

Example: Programs like "The Johnson & Johnson Nurse Innovation Fellowship" provide nurses with training, mentorship, and resources to advance their innovative ideas.

4. Recognizing and Rewarding Innovation

Acknowledging the contributions of nurse innovators boosts morale and motivates others to contribute.

- **Awards and Recognition Programs:** Create awards for nurse-led innovations and highlight these achievements in organizational newsletters and events.
- **Career Advancement Opportunities:** Reward nurses who contribute innovative ideas with promotions, leadership roles, or additional funding for their projects.
- **Public Showcases:** Host events where nurses can present their innovations to stakeholders, including administrators, investors, and peers.

Example: Organizations like the American Nurses Association (ANA) have established awards to celebrate outstanding nurse innovators and their contributions to healthcare.

5. Building Supportive Leadership

Leadership plays a critical role in cultivating a culture of innovation. Administrators and managers must actively encourage and support nurse-led initiatives.

- **Open-Door Policies:** Leaders should create an environment where nurses feel comfortable sharing their ideas without fear of dismissal or criticism.
- **Innovation Champions:** Appoint dedicated leaders who advocate for and guide nurse-led innovation projects.
- **Integration into Organizational Strategy:** Include innovation as a core pillar of the institution's mission and values, emphasizing its importance in improving patient care.

Example: Forward-thinking hospitals have established Chief Innovation Officer roles to ensure innovation remains a strategic priority.



6. Allocating Time for Innovation

Nurses often face demanding workloads, leaving little room for creative thinking and experimentation. Allocating protected time for innovation can address this challenge.

- **Innovation Hours:** Dedicate specific hours or shifts for nurses to work on their ideas without clinical responsibilities.
- **Flexible Scheduling:** Provide flexibility in scheduling to allow nurses to participate in innovation-related activities, such as workshops or hackathons.
- **Innovation Sabbaticals:** Offer short-term leaves for nurses to focus on developing and implementing their ideas.

Example: Some healthcare organizations allow nurses to dedicate a portion of their work hours to projects aimed at improving processes or patient care.

7. Leveraging Technology to Support Innovation

Technology can act as a catalyst for nurse-led innovation by providing tools for idea generation, collaboration, and implementation.

- **Idea Management Platforms:** Implement digital platforms where nurses can submit, discuss, and refine their ideas with colleagues and leadership.
- **Prototyping Tools:** Provide access to 3D printers, simulation software, and other tools that allow nurses to bring their concepts to life.
- **Data Analytics:** Use data-driven insights to identify trends and areas for improvement, guiding innovation efforts.

Example: Hospitals with dedicated innovation hubs often include prototyping labs equipped with advanced technologies like 3D printing and augmented reality.

8. Promoting a Fail-Forward Mindset

Innovation involves trial and error, and fostering a mindset that embraces failure as part of the learning process is crucial.

- **Normalize Risk-Taking:** Encourage nurses to experiment without fear of judgment or repercussions for failed attempts.
- **Celebrate Lessons Learned:** Highlight examples where failure led to valuable insights or subsequent successes.



- **Iterative Processes:** Emphasize the importance of refining ideas through repeated testing and feedback.

Example: Innovation-focused organizations often host "Failure Forums," where staff can share lessons from unsuccessful projects and discuss how to improve.

9. Measuring and Evaluating Innovation Outcomes

To sustain a culture of innovation, organizations must track and measure the impact of nurse-led initiatives.

- **Metrics for Success:** Develop key performance indicators (KPIs) to evaluate the effectiveness of innovations, such as patient outcomes, cost savings, or workflow improvements.
- **Regular Feedback Loops:** Collect feedback from nurses, patients, and other stakeholders to assess the practicality and impact of new devices or processes.
- **Continuous Improvement:** Use evaluation results to refine and scale successful innovations.

Example: Hospitals that implement nurse-led innovations often conduct pilot studies to assess their effectiveness before scaling them across the organization.

Conclusion

Nurses are uniquely positioned to drive innovation in medical device technology due to their deep understanding of patient needs, clinical workflows, and the challenges of healthcare delivery. However, to fully leverage their potential, it is imperative to foster a culture of innovation that empowers nurses to ideate, collaborate, and implement solutions. By addressing barriers such as limited resources, lack of formal training, and organizational hierarchies, and by providing platforms for education, recognition, and interdisciplinary collaboration, healthcare organizations can unlock the creative potential of their nursing workforce.

Investing in nurse-led innovation is not just about improving devices; it's about enhancing patient outcomes, optimizing healthcare processes, and ensuring that the future of medical technology is driven by those who understand its end users best. With the right support, nurses can continue to make transformative contributions to healthcare, shaping a more effective, efficient, and empathetic medical landscape.



References

1. American Nurses Association. (2020). *Innovation in Nursing: Empowering Nurses to Transform Healthcare*.
2. Institute of Medicine. (2011). *The Future of Nursing: Leading Change, Advancing Health*. National Academies Press.
3. Johnson & Johnson. (2021). *Nurses Leading Innovation in Healthcare*.
4. National Academy of Medicine. (2021). *Taking Action Against Clinician Burnout: A Systems Approach to Professional Well-Being*. National Academies Press.
5. The Henry Ford Innovation Institute. (2022). *Creating a Culture of Innovation in Healthcare*.
6. World Health Organization. (2020). *State of the World's Nursing Report*.
7. Yeh, V., & Smith, R. (2018). *Design Thinking in Healthcare: A Nurse's Perspective*. *Journal of Nursing Innovation*, 10(3), 45-52.
8. Zimmerman, B., & Snow, R. (2020). *Fostering Interdisciplinary Collaboration in Healthcare Innovation*. *Healthcare Management Review*, 45(4), 67-76.