IJPS Interdisciplinary Journal of Partnership Studies
Volume 10, Issue 2
pubs.lib.umn.edu/ijps

PATIENT CARE DEVICE TECHNOLOGY TRANSFORMATION: NURSES SEEK PARTNERS TO ACHIEVE PATIENT CARE EXCELLENCE

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Abstract

Nurses make up the largest segment of the health-care workforce worldwide (World Health Organization, 2020). Nursing is fundamentally a process of innovation, where creativity and problem-solving are leveraged to co-create optimal outcomes for each patient and family. Throughout history, nurse innovators have contributed significantly to health-care research, quality, safety, and improved outcomes. Unfortunately, nursing innovation is often not well recognized, respected, or utilized, and most patient care devices and technologies currently in use were not developed by or even with direct consultation with nurses. Nurses seek transdisciplinary partners to develop devices and technologies to transform health care and achieve optimal patient outcomes. This article highlights the experience of five nurses partnering with other disciplines to bring nursing innovations into practice, introducing a vision for patient care devices and technologies developed by a committee formed through the American Nurses Association. Sharing these experiences and vision is a call to interdisciplinary colleagues to recognize nurses' needs, skills, and efforts - a call to partner with them to install devices and technologies into health care that can achieve patient care excellence.

Keywords: Nursing, Innovation, Health Care, Devices, Technology, Interdisciplinary Partnerships

BACKGROUND

In 330, BCE Plato wrote, "Our need will be the real creator" (Jowett, 1894, p. 369). Innovation begins with identifying unmet needs and developing creative solutions to address them. Nursing is a profession that requires innovation due to the constantly changing health-care environment and the changing needs of patients amid limited resources. While nursing innovations are not well-known and often not recognized, they are plentiful (Castner et al., 2016; Davis & Glasgow, 2020; Lemberger, 2023; Matinolli et al., 2020; Ram et al., 2008). Florence Nightingale, perhaps the most recognized nurse innovator and disruptor, addressed excessive mortality during the Crimean War by implementing systematic sanitization and demonstrating its impact by utilizing statistics for the first time in nursing (Storlie & Rittermeyer, 2021). Nurses invented feeding tubes, ostomy bags, color-coded IV lines, and the crash cart (Munday, 2023). Phototherapy was born from Sister Jean Ward's observation that newborns with jaundice improved after exposure to sunlight (Maisels, 2015).

It has been more than 150 years since Nightingale transformed British Army Hospitals through partnerships with multiple disciplines (Dossey et al., 2019). Despite the success of the partnership model, health care continues to need transformation. While modern technology allows information to flow freely in most spaces, health-care technology often lags behind. As inadequate health care, an aging population, and rapid evolution in health-care technology collide, nursing leadership in patient care technology is urgently needed. Nurses practice at the frontlines of patient care and are the professionals responsible for coordinating and implementing the use of patient care technology and devices; thus, patient needs must drive these innovations. Furthermore, nurses are positioned to advocate for innovations that reduce and do not exacerbate health-care disparities.

The Partnership Systems framework (Eisler & Potter, 2014) provides a theoretical model that aligns with the types of relationships needed to transform the health-care system for technology and device integration and is an appropriate framework for discussing

nursing innovation partnerships. Partnership Systems "shift health care relationships from hierarchies of domination and isolated professions to high-functioning, collaborative teams ready to be full partners with patients, families, communities, and one another" (Center for Partnership Systems, 2023). While nursing innovation is finally starting to be encouraged, supported, and celebrated, it can only be harnessed to achieve excellence by engaging in partnerships with others involved in the patient care device and technology ecosystem (Matinolli et al., 2020; Swayze & Rich, 2011; Koszalinski et al., 2021; Giuliano & Landsman, 2022; Zhou et al., 2021).

In 2022 the American Nurses Association (ANA) launched seven innovation advisory committees as part of a larger initiative to develop a strategic national framework for innovation in the nursing profession. Committees included Business, Entrepreneurship & Intrapreneurship; Data Science, AI, Augmented Intelligence; Education & Communication; New Care Delivery Models; Planetary & Global Health, Policy & Determinants of Health Equity; and Technology and Devices (Beaudet et al., 2023). The Technology and Devices Innovation Advisory Committee members embarked on an environmental scan, ecosystem mapping, and resource development, including a review of projects, publications, and publicly available resources, and a review detailing each committee member's experience with nursing innovation. Committee members collaboratively identified key actions required to ensure that patient care technologies promote excellence in patient care and developed a joint vision for nursing leadership through interdisciplinary partnerships.

FIVE STORIES OF NURSE-LED INNOVATION

Five nurse innovators from the ANA Technology and Devices Innovation Advisory Committee who are focused on patient care technology share their experiences and vision, highlighting the success of and need to form interdisciplinary partnerships with the power to transform patient care.

Rosemary Kennedy is a doctorally prepared registered nurse and a Fellow of the American Academy of Nursing; she currently serves as the Chief Health Informatics Officer for a digital health-care company. Her experience as a home care nurse led her to find ways to detect early deterioration of cancer patients in their home setting, to avoid hospital admission. Caring for patients in their homes highlighted the need to gather patient-reported symptoms using technology. Unlike in-patient clinical settings, where patients are face to face with nurses 24/7, in home care nurses rely heavily on patient-reported symptoms. Partnering with patients, business and engineering colleagues in her company, a digital oncology platform was developed, providing a patient-facing phone app for early detection of clinical deterioration. Algorithms combined collected data into a risk score that predicts deterioration and prospect of transport to the emergency department, allowing for early intervention. The first patient treated was notified in their home, through the mobile app, of a chemotherapy drug toxicity reaction within four minutes of receiving the data. The patient was quickly treated at their infusion center rather than an emergency room. Kennedy cites engineers as critical to success in this work: "Engineers listened to the requirements needed for nursing practice. They devised clever methods because they were not nurses and therefore untethered by preconceived ideas about documentation methods." She also credits ethnographers with empowering patients to become part of the design team. Kennedy acknowledges that the solution would not be affordable or available to patients without the business expertise of the team. Partnering with other disciplines enabled a co-production development model, putting patient needs first and allowing for the development of a robust solution.

Nancy Downing is a doctorally prepared forensic nurse and an Associate Professor at the Center of Excellence in Forensic Nursing at Texas A&M University. She has been caring for patients who experience interpersonal violence since 2004, and conducts research on how to improve their health outcomes. In her work with these patients, Downing learned that many who live in rural communities did not have access to high-quality care after experiencing sexual assault. Partnering with the state and federal government for funding, and with clinicians and administrators at rural hospitals,

survivor advocates, and engineers for the physical design of the solution, Downing's team developed a telehealth program, the Texas Teleforensic Remote Assistance Center (Tex-TRAC). This solution provides access to high-quality, trauma-informed, evidence-based care, connecting rural clinicians to expert sexual assault nurse examiners to provide care to patients after sexual assault (Miyamoto & Downing, 2022). The project included development of a telehealth cart for medical forensic examinations. Downing states that development of the camera portion of this solution was a key example of partnership benefits. The original camera was too heavy for the cart; survivor advocates found the mechanical arm frightening and "spider-like," and nurses found it impractical as it sometimes got in the way of using the cart and didn't hold steady on the arm. The team decided to place the camera instead on a rolling monopod so it could move more freely, look less intimidating, and hold steady. Collaborating and co-creating with engineers, forensic nurses, and survivor advocates enabled the program that is currently being implemented in 12 facilities across Texas, with additional sites planned. While Downing acknowledges that being part of an academic setting provides access to a multitude of motivated collaborators, she emphasizes the importance of finding people who are committed to equal partnerships and long-term success of the project, requiring each party to understand the others' motivations for doing the work.

Abby Winterberg Hess is a doctorally trained nurse practitioner and clinical researcher in the Department of Anesthesiology at Cincinnati Children's Hospital. Winterberg currently serves as chair of the ANA Innovation Advisory Committee for Technology and Devices. During her work with pediatric surgical patients, she saw many children struggle with anxiety and resistant behaviors when breathing anesthesia gas through a mask to fall asleep for their procedures. High anxiety before falling asleep for surgery is associated with negative postoperative outcomes (Yuki et al., 2011). Winterberg became an intrapreneur at her medical center, and developed a device that couples the anesthesia breathing mask with a video game. She assembled a team of clinicians, patients, designers, engineers, marketers, and business team members to create Ez Induction™, a device now widely used at her medical center and made available to

other hospitals through licensing to an external company, LittleSeed, Inc. (*Little Seed*, 2020; Winterberg et al., 2022). Winterberg leaned on other clinicians to gain their insights and buy-in for practice change. A design team helped develop the full set of product requirements and the app design. The engineering team identified technologies to enable product functionality and highlighted the importance of ongoing support and maintenance of the device when used in clinical practice. Winterberg cites partnership with the hospital's Innovation Ventures Department as critical for developing funding applications and for navigating the many steps to product commercialization.

Lindsey Roddy is a doctoral candidate, a registered nurse, and founder of the medical device company RoddyMedical. A patient she was caring for in the intensive care unit almost died because a piece of equipment needed to secure their vascular access device was unavailable. After reaching out to hundreds of fellow nurses and finding that she was not alone in her experience, Roddy set out to develop a device to secure medical tubes, lines, and cords, to prevent patient injuries and deaths. She credits successful development and commercialization of the SecureMove-TLC(R), a wearable securement device, to partnership with her engineering and business partners and other skilled professionals (Lardinois, 2023; Giuliano & Landsman, 2022). Roddy's experience alongside many nurses fueled the design requirements for a device that addresses a real problem clinicians have been experiencing for years. Her work with engineering and other disciplines has brought an appreciation for the skills needed to design products.

Kelly Landsman is a biomedical engineer, registered nurse, and founder of Landsman Engineering LLC. After developing patient care devices in industry, she realized that existing patient care product development efforts were not meeting the needs of nurses and patients; while technologies were accelerating and costs were decreasing, the products used at the point of care were slow to evolve. To address this need, Landsman obtained a nursing degree and spent two years providing direct patient care. She has partnered with nurses, educators, and engineers to compile a repository of information that is housed at NurseEngineer.com, contributing to a national conversation about how

nurses and engineers can collaborate to improve patient care devices and technologies, and what impact the role of dually trained nurse engineers can have on accelerating health-care transformation. Partnering with nursing exposes the complexity of developing patient care technology and devices. Landsman said, “As an engineer I worked on a single medical device category at a time, but as a nurse I am tasked with integrating a multitude of care issues into a single patient experience.” For example, providing respiratory support for a patient requires more than just putting on a mask. Care plans often involve multiple interventions and are updated frequently to meet changing patient conditions. Nurses at the bedside are the people using medical devices and delivering interventions; they must be full partners in development.

DISCUSSION

The ANA defines nursing as the “protection, promotion, and optimization of health and abilities; prevention of illness and injury; facilitation of healing; alleviation of suffering through the diagnosis and treatment of human response; and advocacy in the care of individuals, families, groups, communities, and populations” (ANA, 2021, pg.1). Nurses use patient care technologies and devices to provide care and innovate to achieve their goals. The nurses profiled in this article demonstrate that they are fierce patient advocates, not relenting until their patient needs are met. They know that when a patient's needs are not met, the consequences can be devastating and far-reaching. In processes often referred to as “workarounds,” nurses iterate and investigate using existing technology and tools until the needs are clearly identified. The design requirements for patient care technology and devices are illuminated each time nurses provide care. Therefore, nurses are best positioned to define these requirements because they co-create them with and for patients. Because patient care technology and devices are physical embodiments of care processes, they must seamlessly promote best practices. If not, the product hinders the process, compromising patient care. Thus, nurses are personally vested in patient care technology that promotes positive patient outcomes. Nurses can harness this drive to assemble and unite disciplines, working towards the common goal of patient care excellence.

The five nurse innovators identified key areas where interdisciplinary partnerships are needed in order to develop and promote patient care technology that enables care excellence. All of them successfully navigated equitable partnerships consistent with the Partnership Systems framework. All are focused on health-care solutions that respect the skills and expertise of nurses, engineers, designers, data scientists, business professionals, and patients and their families.

Multiple disciplines are needed for successful design partnerships in health-care technology and device innovation. Design expertise ensures that new products meet the needs of patients, families, and clinical staff. Science and engineering partners are essential to identify solutions that meet technical and regulatory requirements. The fast pace and complexity of practice change, coupled with the time needed to communicate a problem and coordinate the necessary skill sets to develop a solution, often limit the ability of nurses to see alternative patient care technology solutions until years after a problem is recognized in the nursing community. Manufacturing and quality expertise allow solutions to be iterated until patient risks are minimized and a commercially viable version of the solution is produced. Business, legal, and regulatory disciplines are needed to ensure that identified solutions are economically viable, scalable, and sustainable in the marketplace. Marketing, communication, and education disciplines allow patient care technologies to be disseminated, properly implemented, monitored, and improved. Each discipline can only manage part of the information required to ensure that patient care devices and technology meet user needs and endure in the marketplace. Successful patient care technology lies at the intersection of each discipline's strengths, interests, and efforts.

What is clear from each of these nurses' experiences is that partnerships across disciplines are critical to ensuring that patient care technology and devices promote care excellence. So why are not all patient care devices and technologies co-created in partnership with nursing? The Partnership Systems framework identifies multiple historical, social, and economic factors that have contributed to the low involvement of nurses in health-care innovation. Several factors, including gender and capitalism

(Eisler & Fry, 2019), may be driving the current domination system of patient care devices and technology development. For example, 75% of engineers are male (Charlesworth & Banaji, 2019), while more than 90% of nurses are female (Smiley et al., 2021). This gender disparity might create a real or perceived barrier to equitable innovation partnerships. While this article highlighted five nurses successfully engaging in the innovation space, it is important to recognize that there are still systemic barriers to nurse engagement in this work. More research is needed to understand how to reduce barriers to nursing innovation, and to influence effective and equal partnerships between nursing and other disciplines.

CONCLUSION

Because of their intimate knowledge of patients' and clinicians' needs, nurses are critical partners in health-care technology innovation. Nurses need to learn about innovation processes, embrace leadership in this work and seek out partners from professions outside health care. Nurses serve as connectors, translators, and advocates for these partnerships. Those supporting patient care technologies need to know their stakeholders. Engage nurses, give them a seat at the table, listen, and let nurses set requirements for the tools that enable optimal care delivery in their profession. Products used by nurses and patients should be co-created with nurses, and reviewed and selected by nurses to maximize positive outcomes. The future success of our health-care system depends on it.

Given our experience and a robust evaluation of the current state of the patient care technology and device ecosystem, the nurses on the ANA Innovation Advisory Committee for Technology and Devices vision statement supports the transformation of the current system to one in which "Nurses practicing in all facets of care are an integral part in the patient care technology and device ecosystem, acting as leaders in the research, design, development, implementation, and improvement of such technology and devices" (ANA, 2023). It is this vision we desire to share with our potential partners.

The work of this committee continues as we seek interdisciplinary partners who share our vision of transforming the system to achieve patient care excellence.

We look forward to partnering with you.

Acknowledgement: We thank the ANA Innovation Department for its support in bringing our committee together to envision the future of health-care technology and devices. We acknowledge our current and former committee members, Krystal Eastman and Erik Andersen, for their contributions to developing the committee's vision.

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Abby Winterberg Hess, APRN, DNP, is a nurse practitioner and clinical researcher, and an intrapreneur, at Cincinnati Children's Hospital, and an affiliate assistant professor at the University of Cincinnati. She works as a nurse practitioner in the pre-anesthesia consult clinic at the hospital. Her research and innovation work are focused on preoperative anxiety reduction. Winterberg has received multiple innovation awards, including the first Johnson & Johnson Nurses Innovate Quickfire Challenge in 2019. In partnership with Cincinnati Children's commercialization department, she has led all phases of product development, from design to partnering with a company for commercialization. Winterberg currently serves as co-chair for the American Nurses Association Innovation Advisory Committee for Technology and Devices. In collaboration with senior leadership, she recently created a new hybrid clinician-innovator role at Cincinnati Children's that focuses on growing structure and support for clinical innovation.

Kelly Landsman, MN, BME, BS, RN, PHN, is a biomedical engineer with over eighteen years of industry experience in R&D of patient care related technologies. She is also a registered nurse with experience in adult cardiology and perioperative nursing. Her passion lies in bringing nursing voices to the forefront of healthcare design processes and striving to ensure positive healthcare experiences for both patients and clinicians. Kelly endeavors to achieve this by working to bring engineering perspectives and tools into clinical care processes. Kelly has spent the past five years researching and advocating for the role of the nurse engineer. Beginning in 2018 she began hosting the website, NurseEngineer.com, which underwent an update in the fall of 2023. This website is an initiative to unite those working to bring nursing and engineering skillsets together to transform healthcare. Kelly has held multiple roles in industry from process engineer to innovation program manager. She has experience that spans the entire development spectrum, including: landscaping, need identification, business case development, patentability, design for manufacturing, product testing, device implementation, quality assurance, and product support. For the past twelve years, she has been the owner and principal engineer of Landsman Engineering LLC. She has been directly involved in the design, development and launch of at least seven medical devices and is an inventor on six issued patents.

Nancy R. Downing, PhD, RN, SANE-A, SANE-P, FAAN, is an associate professor at the Center of Excellence in Forensic Nursing at Texas A&M University in Bryan-College Station, TX. Downing has been a practicing forensic nurse since 2004, providing care to patients impacted by interpersonal violence across their

lifespan. Her teaching and research focus on the intersections of trauma, abuse, substance use, and health. She is interested in innovations with the potential to prevent or mitigate long-term adverse consequences associated with interpersonal violence. Downing enjoys working with interdisciplinary teams to design innovations that reduce disparities in patients' access to care aimed at improving health outcomes after experiencing violence.

Lindsey Roddy RN, PhD(c) Founder, CEO RoddyMedical Inc. PhD Candidate University of Wisconsin Milwaukee College of Nursing Lindsey has been a nurse for ten years in the ICU and recovery room. After starting a nursing PhD program she had an idea for a product that could prevent medical tubing dislodgement and safety issues for critically ill patients and started a company in 2018 to move the idea forward (RoddyMedical Inc.). Her journey fostered much learning around business development, product design, the FDA, IP, etc.. She and her team launched their first product (SecureMove-TLC) in 2022, and are now working with multiple hospitals with the goal of optimizing medical line management and securement, and promoting patient safety. Her experience has given her a passion for how nurses can and should be involved in product innovation from the ground up. She now mentors other nurse entrepreneurs and nurse innovators as they work to build their business models and create products. Lindsey will finish her PhD in nursing in 2024 specializing in medical device usability testing through the University of Wisconsin Milwaukee College of Nursing

Rosemary Kennedy, PhD, RN, MBA, FAAN, leads developing and implementing machine learning and AI solutions to support the management of vulnerable and underserved populations in their homes. She has over 35 years of expertise in developing and implementing health information technology solutions. She has led clinical trials using machine learning and AI, integrating biometrics and patient-reported symptoms for early detection of clinical deterioration. Dr. Kennedy has significant experience working with data scientists, AI developers, researchers, and patients to architect, train, validate, and deploy AI-based solutions while measuring value as a byproduct of solution use. As Vice President of Health Information Technology at the National Quality Forum, she was pivotal in leading electronic quality measurement for value-based programs. She led technical expert panels and spearheaded the development of quality frameworks, measures, criteria, and data standards across federal programs and public and private stakeholders. In addition to being an informatics domain expert, she holds many leadership roles through her work with the American Medical Informatics Association (AMIA) and the American Academy of Nursing. Dr. Kennedy is widely presented and published in the field of informatics. She is a fellow in the American Academy of Nursing and received the HIMSS 2009 Nursing Informatics Award and the Top 25 Women in Healthcare award for 2009. She was the Chief Nursing Informatics Officer for Siemens Healthcare Solutions for many years.

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