

## Review Article

# Nursing Innovation, from Process to Product: A Scoping Review

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Received 30 May 2023; Revised 13 November 2023; Accepted 14 November 2023; Published 23 November 2023

Academic Editor: Meigan Robb

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**Aim.** To review the current literature on the developing role of nursing innovation, specifically, those nurses who have progressed their innovative practice into product development. **Design.** A scoping review was conducted utilising the Population, Concept, Context framework and the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews. **Data Sources.** An initial search was performed in February 2023 with a repeat search and revision to the review completed in September 2023. Electronic searches of the British Nursing Index, Current Index of Nursing Allied Health Literature, Emerald Insight, National Health Service Knowledge and Library Hub, and Google Scholar™ were undertaken using the terms Nursing AND (new product development) AND (device innovation). Two authors (LS and MS) also undertook hand searching of relevant reference lists. **Review Methods.** Two authors were involved in the screening process of available and relevant literature (LS and MS) with the third author (FH) available for decision-making in the event of any generated disagreements. **Results.** We undertook a review of seventeen papers from 274 results. The impetus of nursing innovation, defining the nurse inventor, facilitators to the nurse inventor concept, and barriers to the nurse inventor concept were all identified as themes to be explored. **Conclusion.** The nurse inventor concept requires further challenge and clarity. Nurses should aim for a consensus of definition, typology, scope of practice, and job planning. Healthcare institutions should acknowledge and explore this novel role in detail, with consideration afforded to how the role is to be specified and integrated into today's nursing practice roles. **Reporting Method.** Adherence to EQUATOR guidance was achieved through the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews.

## 1. Introduction

According to MacFadyen [1] and Smith [2], the word innovation has suffered from unjust repetition and dilution in our society, associated with mundane and sophisticated endeavours alike as an eye-catching slogan. This is no different in nursing, generating a healthy scepticism when professionals voice concepts or ideas that they attest to being innovative. One could argue that this cynicism is founded on some truth. When we contemplate nursing innovation, we often synonymize this with managerial and theoretical processes as a by-product of expected professional progression into management [3]. Nursingtimes.net [4] identified a majority cohort of nurse professionals innovating within these fields.

A concept that has been growing in interest within the nursing profession due to contemporary and significant scientific and technological advancements is that of the nurse inventor [5, 6]. According to Rowe [7], nurse inventors practice the cognitive and physical exercise of developing something radical (new) or incrementally improving upon existing equipment for the purpose of bettering a patient group, staff group, or institution.

Although historically associated with the realms of the medical physician or surgeon, the role of nurse innovator is not a new concept but rather one that requires challenge and exposure given the speculated progression into product design and development.

The nurse inventor journey is said to be a subjective experience and each journey will vary in its aims, required

resources, methods, and outputs [8], thereby limiting any generalisable evidence available for those nurses with the capacity to undertake inventive practices [9]. The purpose of this review was to explore a speculated evolving body of evidence relative to nursing innovation with a specific focus on nurses' innovation by invention.

## 2. Aim of the Review

The aim of this review was to analyse the current literature on the developing role of nursing innovation through invention. We initially speculated that this contemporary iteration of nursing innovation was in its infancy, currently void of definition and professional structure within the National Health Service (NHS) institutions. Given the postulation that nurses mainly innovate through the lenses of theory, process, or management [10], several objectives for the review were to be explored:

- (1) How has nursing innovation evolved?
- (2) How is the nurse inventor defined?
- (3) Is there guidance and facilitation for the nurse inventor concept?
- (4) Are there barriers or drawbacks for nurses who wish to invent?

## 3. Methods and Design

The scoping review framework by Arksey and O'Malley [11] was utilised to map the relevant literature within the subjects of progressive nursing innovation and the nurse inventor. This decision was taken from our speculation that currently available evidence, relative to the developing concept of nurses innovating by the invention, would be in the form of expert opinions, qualitative experiences, and descriptive manuscripts [8]. It was, therefore, supposed that our aims would unlikely drive a high volume of research focused on empirical experimentation, especially when considering the early and likely subjective aspects of a product development process [8]. Contrastingly, it was also acknowledged that those nurses further along their product journey may have published some experimental papers on their devices, also bearing relevance to this review. Given the recognised lack of evidence pertaining to the nurse inventor [9] and the envisaged breadth of appropriate evidence, a scoping review was considered the most desirable method to explore this subject.

According to the Joanna Briggs Institute (JBI), it is recommended that the Population, Concept, Context (PCC) framework tool be utilised in the scoping review design to demonstrate the boundaries of the proposed search and postulate outcomes [12, 13]. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) [14] was also utilised in the demonstration of a repeatable process of literature appraisal and selection.

## 4. Eligibility Criteria

The eligibility of potential study returns was explored and defined with the three authors (LS, MS, and FH) using the PCC [12] (Supplementary Table 1). We accepted the potential return of a wide variability in study designs and methodologies; all returned studies published in the English language were contemplated.

Our defined parameters included studies that cited a nurse as the lead or main supporting author, research exploring the progression of nursing innovation, the nurse inventor concept, a nurse product development journey, or articles exploring nursing collaboration in product development.

We excluded studies that explicitly focused on nurses innovating through theory or process, articles not specific to nursing innovation by invention, articles exploring inventions not developed by a nurse, or research exploring product development journeys not undertaken by a nurse. An additional limitation to the time of publication (2012–2023) was imposed to capture the contemporary concept of nursing innovation through invention and product development. We anticipated a potential oversaturation of purely theory or process-based nursing innovation if this was not applied.

## 5. Types of Evidence Sources

When considering our evidence source selection, we concluded that nursing databases would undoubtedly provide an appropriate yield of supporting literature on nurses' innovation by invention. Preliminary searches of the British Nursing Index and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) were variable in their yield of relevant material, leading to the addition of more medically themed evidence sources. Additionally, we also recognised the concept of the nurse-engineer collaborative in healthcare medical device development research [15, 16]. This informed the decision to further include a more technology-engineer-focused evidence source to potentially identify further relevant publications as a collaborative effort with engineers.

A search was performed in February 2023, with a repeat search completed in September 2023 of the British Nursing Index, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Emerald Insight databases, with the addition of the National Health Service Knowledge and Library Hub, and MedNar as grey literature sources.

From the lead authors' philosophical perspective of critical realism [17] and the methodology of a scoping review [11], we sought both quantitative and qualitative studies of a prospective or retrospective nature, including, but not limited to, randomised controlled trials, cross-sectional studies, experimental studies, relevant literature reviews with or without meta-analysis, qualitative context/content analysis, expert opinion, reflective, and descriptive studies. Conference abstracts, posters, and editorials were to be excluded.

## 6. Search Strategy

We performed a three-step search strategy as advised by the JBI [12, 13]:

- (1) Limited search of two databases
- (2) Analysis of keywords, titles, and abstracts
- (3) Hand searching of relevant material

Following initial scoping searches over the British Nursing Index and CINAHL using the terms “nursing innovation AND invention,” several keywords were identified from the titles and abstracts of returned articles [18–20]. Keywords were then tested with truncation and Boolean operators [21], settling upon the terms “Nursing AND (new product development) AND (device innovation)” which were applied to the British Nursing Index, Current Index of Nursing Allied Health Literature, Emerald Insight, National Health Service Knowledge and Library Hub and Google Scholar™ (Supplementary Table 2).

We affirmed that a hand search of the reference lists from studies chosen for final inclusion would be performed by LS and MS, with the third author (FH) available to discuss any generated discrepancies to a conclusion.

The collective references were imported into Microsoft™ Endnote™ software, and duplications were removed. The subsequent review of the research down to final inclusion was undertaken by two authors (LS and MS) with the third author (FH) reviewing and affirming final inclusions for the review (Figure 1).

## 7. Data Extraction

A collective of 274 results were returned across all sources. There were 12 duplicates identified, and a further two studies ( $n=2$ ) were identified as animal studies, leaving 260 titles and abstracts to be reviewed. There were 211 articles excluded through this process due to the irrelevance of the papers to the aims of the review ( $n=158$ ), an explicit focus on theoretical, management, or process innovation ( $n=51$ ), and two papers ( $n=2$ ) with unavailable abstracts.

The remaining 49 papers were assessed throughout for suitability for final inclusion in this review. There were nine ( $n=9$ ) papers that identified no nurse as an author of the work [22–30].

A further nine ( $n=9$ ) were, in fact, nurse-led studies of products they themselves did not invent [31–38]. We identified seven ( $n=7$ ) expert opinion manuscripts that we felt were not in line with the aim and objectives of this review [39–45]. There were three ( $n=3$ ) nurse-led literature reviews that were not relevant to this review [46–48].

We had to exclude two ( $n=2$ ) further studies due to their explicit focus on product performance and composition with no exploration of nursing experiences [49, 50]. Finally, we excluded two further studies, one of which explicitly focused on the ethics of artificial intelligence technology in healthcare [51], and the body of the second paper main was not written in the English language [52].

This left seventeen ( $n=17$ ) papers for final inclusion in this scoping review. The expression of this data is provided in Table 1 which provides a visual mapping of the studies identified for final inclusion. Table 2 is an expression of the defining characteristics of a nurse innovator, cited throughout the literature:

## 8. Presentation of Results

Studies ranged over our predefined timeframe, from the earliest in 2012 [53] to the most recent paper, published in 2023 [19].

Studies were undertaken in several geographical locations: USA ( $n=7$ ) Iran ( $n=3$ ), Turkey ( $n=3$ ), Brazil ( $n=1$ ), Greece ( $n=1$ ), Korea ( $n=1$ ), and Thailand ( $n=1$ ).

The yield from our search was noticeably variable, with several utilised designs and methods, reflecting the method of this review. There were seven papers ( $n=7$ ) expressing expert opinions on nursing innovation or the product development journey of the nurse inventor [15, 16, 18, 20, 53, 57, 64]. Four ( $n=4$ ) studies were literature reviews exploring nursing innovation or the product development journey of nurses [56, 58, 59, 62].

There were three ( $n=3$ ) studies of a purely qualitative design, exploring the perspectives and lived experiences of nursing innovators [19, 54, 55]. Two ( $n=2$ ) studies utilised mixed quantitative and qualitative approaches to examine a product development journey [60] and challenges to nursing innovation during a healthcare crisis [63]. A final study ( $n=1$ ) was quantitative in nature, examining the perceived barriers to innovation by nursing students [61].

As was anticipated, a large proportion of the relevant literature was focused mainly on the expert opinions and lived experiences of nursing innovation and the product design and development journey. The studies were reassessed in their entirety by LS and MS to identify overriding themes through content analysis [65].

## 9. Themes

Upon scrutinising the literature as a collective, four themes were revealed for analysis:

- (1) The impetus of nursing innovation output over time
- (2) Definition of the nurse innovation by invention
- (3) Facilitators of the nurse inventor concept
- (4) Barriers to the nurse inventor concept

## 10. The Impetus of Nursing Innovation over Time

Throughout the literature, authors often championed the nursing innovators of old, not only alluding to their achievements but, perhaps more importantly, what drove these historic individuals to become innovators [16, 20, 54–56, 64]. We considered this an important theme to explore to provide clarity on the historic and contemporary drivers of nursing innovation from process to product. When exploring individual research in our

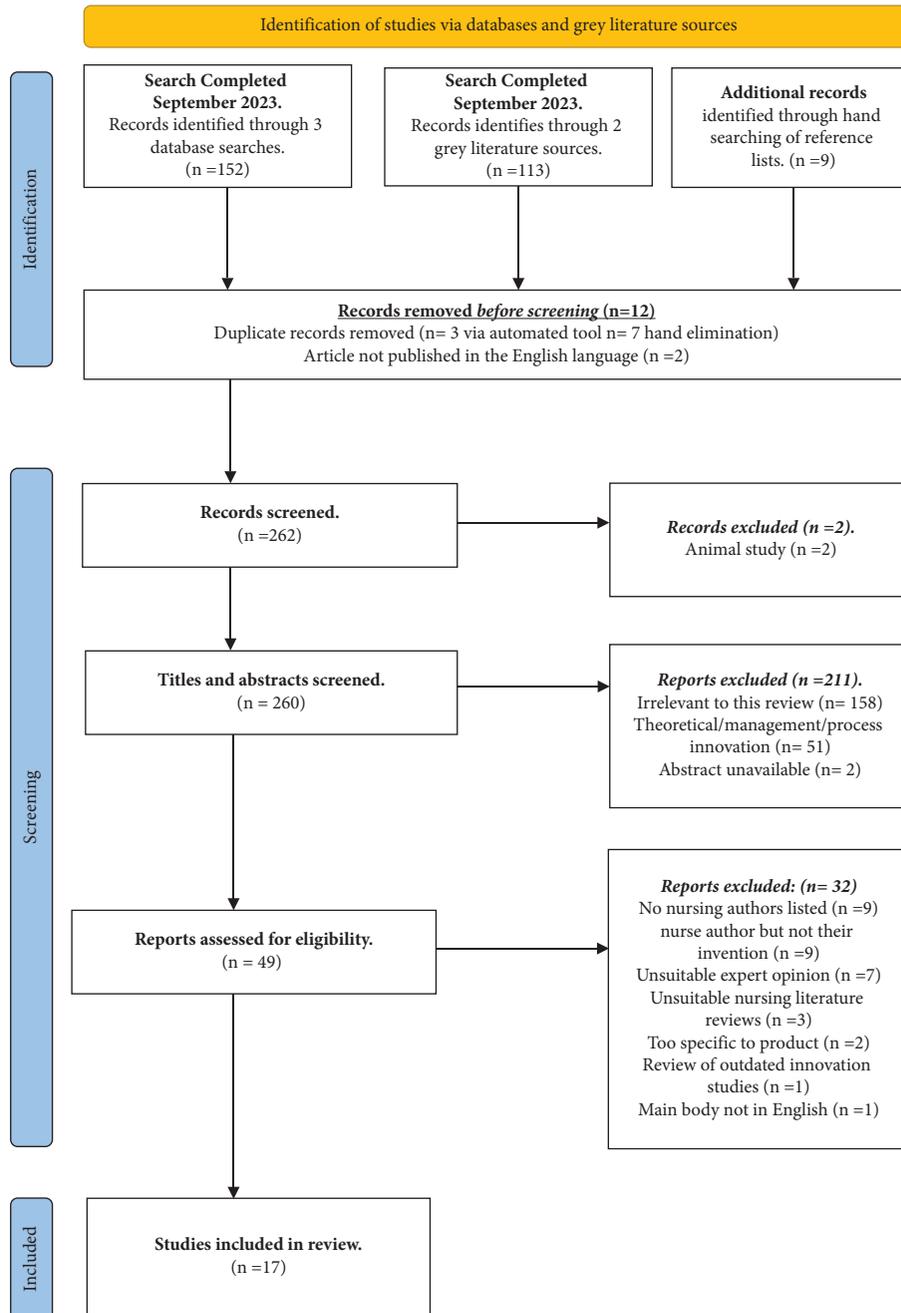


FIGURE 1: PRISMA results for innovation by invention.

returned literature, the driving forces of nursing innovation are often interpreted as a linear progression over time and space [16, 20, 54–56, 64] (Figure 2).

**10.1. Altruism.** One of the most recognised drivers of nursing innovation throughout the literature was altruism (Table 2), likely the most historic impetus for nursing innovation [54, 55, 64]. There were multiple citations throughout the literature describing how the earliest nurses innovated through a lens of spiritual or professional obligation [55, 62, 64]. One could accept that a nurse's intention to do good is at the very foundation of the profession's

philosophy, and it is no surprise that this defining characteristic has played a historic role in innovative and inventive practices.

Interestingly, altruism seems to be referred to largely within this historic context throughout the literature. This raises an important question: why is a nurse's will to do good no longer sufficient for undertaking an innovative or product development journey? One can speculate that, as the complexity of our profession and patients has evolved, so must nurse innovators, requiring multifaceted driving forces to assimilate, undertake, and progress their ideas within the contemporary technology-driven nursing profession [16, 55]. However, we argue that nurse

TABLE 1: General data extraction of product development studies.

Origin of identification	Author	Date	Location	Publication type	Design
Database/grey literature	Spencer and Odom	2012	USA	Expert opinion and 3-year review of an initiative to advance innovation in nursing education	Expert opinion/descriptive
Hand search	Isfahani et al.	2015 (a)	Iran	Exploring Iranian nurses' perceptions and experiences toward the expression of creativity in clinical settings.	QUAL content analysis ( $n = 14$ )
Hand search	Isfahani et al.	2015 (b)	Iran	Qualitative exploration into what motivates nurses to be creative	QUAL conventional content analysis approach ( $n = 16$ )
Hand search	Kaya et al.	2015	Turkey	Concept analysis of the nurse innovator	Literature review/descriptive
Hand search	Stavrou et al.	2015	Greece	Expert opinion and reflection on a personal product development journey	Expert opinion/descriptive
Hand search	Castner et al.	2016	USA	Literature review and reflection on a personal product development journey of academic road map to product development	Literature review/descriptive
Hand search	Asurakkody and Shin	2018	Korea	Literature review of innovative architects and barriers to nursing innovation	Literature review/descriptive
Database/grey literature	Bhumisirikul and Chiannilkulchai	2018	Thailand	Expert opinion on a personal product development journey Clinician experience with the product via questionnaire	QUAL/QUANT ( $n = 110$ )
Database/grey literature	Glasgow et al.	2018	USA	Expert opinion and exploration of the nurse-engineer concept	Expert opinion/descriptive
Hand search	Ceylan	2019	Turkey	Cross-sectional study of nursing students examining innovation and barriers to innovation	QUANT cross-sectional study ( $n = 279$ )
Hand search	da Silva Copelli et al.	2019	Brazil	Integrative literature review on the concept and typologies of entrepreneurship in nursing	Integrative literature review
Database/grey literature	Knoff	2019	USA	Expert opinion and reflection on a personal product development journey	Expert opinion/descriptive
Database/grey literature	Giuliano	2020	USA	Expert opinion and reflection on a personal product development career	Expert opinion/descriptive
Database/grey literature	Merih	2021	Turkey	Expert opinion on the challenges of nurse innovators during the COVID-19 pandemic	QUAL/QUANT, descriptive ( $n = 150$ )
Database/grey literature	Giuliano et al.	2022	USA	Expert opinion of the future of nursing innovation and the INNOVATE program to foster nurse innovation and collaboration	Expert opinion/descriptive
Database/grey literature	Firth	2023	USA	Expert opinion on the progression of nursing innovation	Expert opinion/descriptive
Database/grey literature	Haydari et al.	2023	Iran	Qualitative study of nursing students' perspectives on nursing innovation	QUAL ( $n = 11$ ) content analysis

TABLE 2: Cited characteristics of the nurse innovation.

Author(s)	Cited characteristics
[53]	Proactive in the increasingly complex healthcare environment, forward-thinking, higher education, good communicators, dynamic, and systematic
[54]	Creative, holistically minded, generators of novel ideas, entrepreneur, advanced knowledge, and proactive through service transformation
[55]	Creativity, motivated, active practitioners in pursuit of knowledge, learning, and service improvement, idea generator, and implementor, a passion for their profession
[56]	Active in addressing service needs, creativity, technically skilled, entrepreneurs, idea generators, design thinking mentality, and collaborator
[57]	Not defined
[58]	Novel practitioners, multidisciplinary, creators, imaginative, holistically minded, and utiliser of personal experiences
[59]	Creative, promoters of patient health and safety, good failure tolerance, opportunist, idea generator, good communicator, and champions their own ideas
[60]	Not defined
[16]	Well-informed, productive in research, design, and policy, multidisciplinary collaborator, advanced education, and technologically competent
[61]	Ready to try new things, open-minded, and the ability to adapt
[62]	Opportunistic, autonomous, independent, flexible, determined, proactive, self-confident, disciplined, communicative, responsible, holistically minded, and risk-taker
[20]	Holistically minded, idea generators, and creative
[15]	Passionate, utiliser of personal experiences, can-do attitude, challengers of the status quo, holistically minded, person-centred drive, and intradisciplinary collaboration
[63]	Creative, role model, empowered, adaptive, and active in promoting patient health
[18]	Design thinking mentality, higher education, collaborator, and entrepreneurial mindset
[64]	An architect of solutions to healthcare problems, empowered, and a creative mentality
[19]	Risk-taker, the ability to adapt, adopt, apply, and tolerate, a willingness to act, and proactive in new and diverse situations

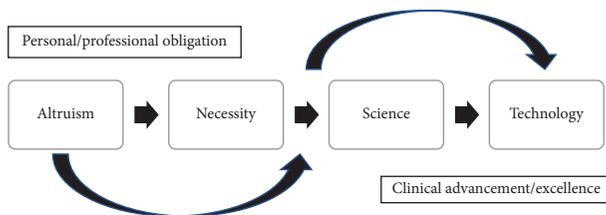


FIGURE 2: The perceived impetus of nursing innovation over time.

innovators should not substitute the altruistic impetus in favour of scientific and technological aspiration, as this would be in direct contraindication of professional philosophy. We attest that the will to do good must be a foundation to build upon with contemporary driving forces for innovation and invention.

*10.2. Economic and Institutional Necessity.* Innovation and invention driven by economic and institutional factors was another common topic of debate within the literature examined [18–20, 62, 64]. We identified two main dimensions to this theme: those nurses innovating from the perspective of economic stability [15, 16] and those nurses innovating through necessity [57, 60].

Interestingly, we found some stark geographical and economic bias reflected in the collective literature, which challenges the idea that the incentive for nursing innovation is a linear progression over time and environment. For example, much of the research conducted in the USA spoke to a contemporary time of advancing technology as an opportunity in the nursing profession and the aim to achieve clinical excellence in tandem with these progressions, including the novelty of nurses as inventors [15, 16, 20, 58]. One could postulate from this evidence alone that contemporary nurse innovation is considered a luxury in some institutions, with time and financial support in abundance to invent at will without further consideration.

In direct contrast, research from similar time periods, conducted in fluctuating economic environments around the world, still speaks to nursing innovation and invention as a critical response to patient safety needs [57, 60].

In two nursing product development studies, a lack of economic stability and institutional funding were identified as direct mechanisms towards an increasing risk to surgical patients [57, 60]. Both studies describe how the design and development of homemade medical devices have been introduced into institutions to both reduce costs and, most importantly, keep patients safe [57, 60]. We concede an obvious economic disparity and bias, even as authors from

the United Kingdom, that the idea of frugal nursing invention was not contemplated during the protocol design of this review. As opposed to some researchers' interpretation of impetus as progressive, no longer affected by predeceasing influences [16], institutional and economic drivers of innovation are not a historic concept but have, perhaps, been generally dismissed in certain institutions throughout the world. We recommend that, globally, nurse innovators would do well to keep institutional and economic factors in focus, as this is almost certainly a fluctuating mechanism, as derived from the evidence in this review [58, 60].

*10.3. A Response to Scientific Advancement.* Several of the research papers examined alluded to a time when nursing innovation blossomed in parallel with scientific knowledge and institutional resources [19, 56, 58, 62, 64].

For example, during the 1940s, Adda May Allen explored the challenges of vacuum pressure and its disruption to infant bottle feeding [64]. This innovative undertaking resulted in her design and development of disposable bottle liners, challenging, and addressing the issues of the time within her clinical practice [64]. An increased scientific understanding of clinical jaundice in children, contemplated by Sister Jean Ward in the 1950s, led to the development of modern phototherapy [64]. The life and education experiences of a nurse during World War II led her to develop a pathway innovation in the 1960s which is today known as the crash cart [64].

When considering the underlying causes of this diversification in the driving force of innovation, one might speculate that the gradual progression of the profession from the battlefield to institutions created a more stable environment, allowing innovators to focus their efforts on the advancement of clinical practices rather than the global economic crisis.

Contrastingly, Copelli et al. (2017) argue that nurses have always been driven to innovate through scientific curiosity. The earliest nursing innovators were always conscious of scientific advancements and utilised the technologies of their time in developing the foundation of the nursing profession [62]. One could conclude from this collective evidence that this notable surge in scientifically driven nursing innovation was, in fact, a by-product of global environmental and economic factors of the time, refuting any suggestion that the scientific impetus was a novel recognition within the nursing profession during this period.

Another important point to consider from the literature is that there appears to be a link between a nurse innovator's behaviour and the proclivity to utilise scientific advancements as an impetus for innovation in clinical practice [59]. A nurse's altruistic and design thinking behaviours should naturally lead them to employ scientific knowledge in their pursuit of innovation within their clinical practice [61]. Scientific advancements could, therefore, be viewed as a conducive framework within which a nurse can apply their innovative behaviours to successfully progress ideas within the nursing, medical, or surgical environment [61].

*10.4. The Pursuit of Clinical and Technological Excellence.* When exploring the most contemporary drivers of nursing innovation within the collective literature, there was a notable credence afforded to technological advancement, clinical practice excellence, engineering, nursing invention, and product development [15, 16, 18, 20, 60].

There were notable examples throughout the literature. In 2014, nurses and engineers worked together in the design and development of a telerobotic nursing assistant to reduce human contact with patients infected with the Ebola virus while maintaining a high standard of care [16]. In 2018, nurses collaborated with physicians and engineers in the undertaking of computer simulation to address patient and staff resourcing within a busy labour ward [16]. Throughout the professional careers of Guiliano [15] and Knoff [20], they attest to several product development journeys, including the design and development of medical devices.

When considering this latest guise of nursing innovation, Glasgow et al. [16] report that a surge in healthcare technology over the last decade has been the primary driving force. Technology has increased the complexity of the nursing profession, causing a paradigm shift in a nurse's educational and practice requirements to maintain high-quality care for patients [16]. The literature would suggest that nurses are now driven to innovate not only by their altruistic and scientific nature but also as a reaction to the increasing equipment and engineering knowledge required to support the patient population [15, 16, 20].

In conclusion, the collective literature suggests that one cannot consider a singular influence in isolation as a nurse's impetus for innovation. A nurse's drive to innovate cannot simply be boiled down to a consequence of time, professional, or scientific advancement.

The impetus of nursing innovation is almost certainly a multifaceted phenomenon, relying both on the knowledge of our historic peers and on how driving forces meet the contemporary challenges within the nursing profession. We, therefore, offer a revision to the assumption of impetus as a linear progression expressed in Figure 2 (Figure 3). We recommend that nurses consider their contemporary driving forces as simply another string to their innovative bow, corresponding in tandem with today's nursing and technological advancements while maintaining the driving forces at the core of the profession.

## 11. Defining the Nurse Inventor

While we identified a generic consensus of definition to encompass nursing innovation (Table 2), the nomenclature of nurses who innovate by invention has yet to be solidified and presently remains an evolving concept [16]. Though the characteristics and behaviours of the nurse inventor were expressed similarly to those of the generic nurse innovator (Table 2), there was a notable discrepancy throughout the relevant literature when defining the nurse inventor specifically as a separate entity. Interestingly, many of the nurse authors cited within the literature undertaking a product development journey failed to clarify or define how they

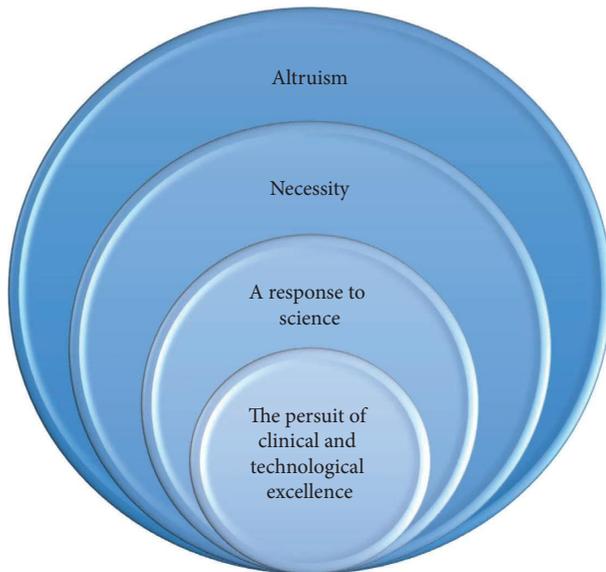


FIGURE 3: The structures of nursing innovation.

viewed themselves as nurse inventors and where their profession utilised their novel skills within their institutions [20, 57, 60].

Although this review could not identify a specific definition of the nurse inventor, several typologies were noted throughout the literature that were seemingly geographically and locally interchangeable [16, 19, 62, 64]. The research suggests that, currently, the definition of the nurse inventor is polysemic and has yet to come into its own right as a separate entity from the generic concept of nursing innovation [62]. There also appears to be a geographical disparity between the terms “nurse inventor” and “nurse entrepreneur.” For example, some of the literature used these terms interchangeably, to describe what many would consider to be a nurse inventor [62, 64]. However, research conducted in the USA and Iran also refers to the nurse entrepreneur as someone who is running their own clinical business, with no acknowledgment of a product development journey being undertaken [16, 54] (Figure 4).

While some may find the current lack of definition intriguing, proposing a limitless potential for this new novel role in the nursing profession, we speculate that many healthcare professionals find this evidence concerning. Currently, it appears researchers and nurse inventors themselves can offer no consensus on how the role should be defined, and we postulate that until this consensus is achieved, the role of a nurse inventor cannot be challenged, qualified, or utilised efficiently within the nursing profession. When considering the available evidence further, we offer the speculation that the novel role of the nurse inventor is an evolutionary process from the traditional nursing innovations of theory, process, and management. As we consider this a sensible and acceptable premise, we recommend that defining the nurse inventor concept should begin within the characteristics and behaviours of nursing innovation (Table 2). Although further research and challenges must be afforded to the concept to develop the desired

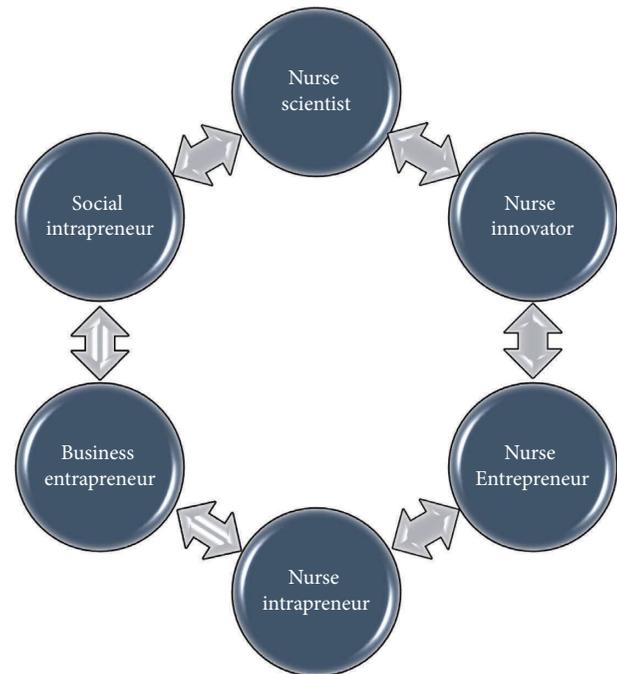


FIGURE 4: Typology of the nurse innovator throughout the literature.

consensus, we offer the following definition, generated through the themes identified in this review, as a foundation to be progressed upon by future researchers:

“The nurse inventor: an altruistic practitioner who possesses the impetus, creativity, and knowledge to collaborate in the design and development of novel products or equipment for the betterment of patients, professionals, or healthcare institutions.”

## 12. Facilitators of the Nurse Inventor Concept

Throughout the literature, there were notable facilitators of the nurse inventor concept to be themed and explored [15, 54, 55, 59]. According to Asurakkody and Shin [59], these facilitators can be divided into individual behavioural factors, sociocultural behavioural factors, and institutional behavioural factors.

As the individual factors of the nurse inventor have already been explored in detail earlier in this work (Table 2), the sociocultural and institutional factors were examined.

*Sociocultural behaviour* as a facilitator of the nurse inventor concept was found to be predominantly focused on the practice of interdisciplinary collaboration. Specifically, nurse-engineer collaboration was one of the most heavily discussed themes within the returned literature and is likely a contemporary necessity in a nurse’s product development journey [15, 16, 18, 58].

It is accepted that, as the technological advancements of the nursing profession have progressed, so has the need for a richer understanding of such technology to safely care for patients [16]. The nurse-engineer collaborative is a novel concept but has gained interest over the chronological course of the international literature reviewed [16]. The

literature attests to the generation of an institutional team of nurses and engineers for the purpose of knowledge sharing and addressing innovative challenges as a collective. When considering why this relationship has blossomed, perhaps surprisingly, nurses and engineers are astonishingly comparable in theory and application [18]. Both professions rely heavily on problem-solving, and although the profession of engineering may be associated with innovation, both utilise this practice in their exploration of professional-based challenges [18]. In fact, we suggest that the seminal differential between these two professions is the most obvious: an overriding focus on the patient or problem. While nurse-engineer collaboration was found to be the most prominent relationship examined, the evidence suggests that this relationship should not be seen as a singular behaviour to determine success for nurses undertaking product design and development. The works reviewed attest to many historic and perhaps more traditional interprofessional relationships, all of which are considered vital:

- (1) *Nurse and patient* [20, 60]
- (2) *Nurse and physician* [15, 63]
- (3) *Nurse and surgeon* [57, 60]
- (4) *Nurse and stakeholders* (Guiliano) [15]
- (5) *Nurse and academics* [18, 53]

*Institutional behaviour* as a facilitator of the nurse inventor concept was found to be multidimensional [20, 56, 59]. The literature often referred to healthcare institutions as entities, and promotional innovative behaviours by organisations were often not identified with a singular department or professional group, i.e., management. One can see from earlier evidence that the product development journey cannot be undertaken in isolation; nurse inventors must utilise likeminded and supportive institutions that will guide, support, and encourage what many may consider being a novel departure from “traditional” nursing roles [15, 19, 20, 60, 63].

The willingness of healthcare organisations to collaborate at an institutional level appears to be fundamental in how nurse inventors perceive their institutions’ responsiveness to innovative practices in nursing [15, 19, 20]. For example, research undertaken by Giuliano et al. [18] and Glasgow et al. [16] identified several healthcare institutions that were actively generating partnerships with engineering, entrepreneurial, and marketing institutions and, perhaps most importantly, providing the time, resources, and space for nurse professional collaboration.

The acceptance and promotion of nursing inventions at an organisational level were demonstrated to be highly beneficial across all levels. Improvement of patient care, improvement to the nurse inventor’s quality of work and social life, and an increased interest in the healthcare organisation itself are all recognised by products of positive industrial behaviours [15, 20, 54, 55].

Management through affective leadership was also evidently a vital component in the support and development of the nurse inventor [15, 19, 56, 58, 59]. Nurse professionals,

within management roles, who are engaged with the premise of a nurse inventor will likely foster an entrepreneurial culture [59]. By encouraging and supporting team members to freely express their thoughts and opinions, this culture in turn will often unlock the design thinking potential of the entire team and allow nurse inventors themselves to become leaders and role models [18, 62]. One could allude from this evidence that the base facilitators for nurse inventors at an institutional level are interest, positive communication, and organisational response.

### 13. Barriers of the Nurse Inventor

From the collective literature examined, one could contend that for every facilitator to the nurse inventor concept, an equally impactful barrier currently exists. Many of the reflective product development journeys of nurses cited in this review declare several barriers that they had personally experienced [15, 20, 60] (Stavrou et al., 2014). Financial support and access to resources were shown to be two of the most challenging barriers in the nurse inventor journey. This presented itself in two dimensions. First, an overall lack of funding flexibility within institutions was cited by Bhumisirikul and Chiannilkulchai [60] and Stavrou et al. (2014). On one hand, this barrier drove their innovative spirit and was their impetus, without which their output may not have come to fruition. Oppositely, we speculate that designing and developing homemade devices is arduous, encroaches on the nurse inventor’s personal time, and is potentially financially impactful for the individual and their families. This should not be seen as the ideal method for nurse inventors to innovate. The second version of this barrier was the nurse’s inability to access specific funding to turn their ideas into reality. An additional associated barrier at play is a lack of support, understanding, or interest in a nurse inventor’s idea. A poignant example of this was noted in the product development journey of Knoff [20], who attests to her own experiences, summarising that the access to financial and ancillary resources is a common confounder of nurse invention. She further stated that a lack of interest from leadership structures within the institution can halt the journey before it has even begun. There is a tangible link between interest and funding; if interest and understanding are not achieved by the nurse inventor, institutional, local, or national funding appears difficult to come by.

Professional conformity has also been cited as a barrier to nursing invention in practice [20]. Nurses are taught, from an undergraduate level, to behave as “good” employees, performing necessary tasks, and following the orders of the governing institutions (Da Silva Copelli et al., 2017). However, nurses who are inventors often speak to their affinity with challenging the status quo and often, an inability to take no for an answer [15, 20]. One may, therefore, assume that nurse inventors may habitually be seen as abrasive and perhaps troublesome practitioners within some institutions. Copelli et al. [62] support this notion, hypothesising that, at present, the current expectations of nurses are in direct contrast to the inventive and innovative logic.

Even at a sociocultural level, one could accept that nursing peers modify each other's behaviour to conform to accepted procedures and practices. Without doubt, this conformity is essential to maintaining evidenced-based care and patient safety [20]. However, it is countered that without an opportunity to safely entertain an inquisitive and rebellious spirit, innovation and invention cannot take hold [15].

Examining the literature, we found a dearth of evidence. We, therefore, make a speculation based on our themes generated through this review. It is contested that the absence of a definition to classify the nurse inventor concept is currently playing an impeding role in its acceptability within the nursing profession and organisations. Put simply, although there is evidence that innovative practices are now accepted and becoming infused with undergraduate learning [18, 53], today's nurse inventors are currently practicing in institutions where, perhaps, product design and development is considered a luxury and an expense the ward can seldom afford. The lack of understanding, definition, and integration of the practice into job plans is persistently conceptualising the concept as an oddity on the very outskirts of nursing practice. We offer the premise that, because of this, the concept remains too variable and unpredictable to become an established practice within the nursing profession.

## 14. Conclusion

Although there is discussion and research surrounding the nurse inventor concept, the practice remains underdeveloped and requires much further clarity, challenge, and integration within the nursing profession and healthcare institutions.

While individual research suggested that the impetus for nursing innovation was linear, a nurse's driving forces are in fact dynamic, generated through knowledge and reactive to economic, professional, and technological variants.

Although there were definitions available for the concept of nursing innovation, the specifics of the nurse inventor were, generally, unqualified. There is an international discrepancy relative to the typologies used to encompass the concept of the nurse inventor.

The expert opinions and reflections of nurses currently inventing allowed the authors of this review to provide a foundational definition to be further developed by future research into this phenomenon.

Interdisciplinary collaboration was identified as a foundational practice of success in the nurse inventor pathway with further recognition of more traditional collaborations within healthcare organisations, all of which are seemingly essential in the product development journey.

Behaviours of the inventor, profession, and institution are essential components to championing this novel and developing role in healthcare. The essential characteristics of the nurse inventor, support and encouragement from

management professionals, and the interest, communication, and action of the organisation are evidenced essentials.

The nurse inventor concept appears to be viewed as a disturbance to the harmony of healthcare institutions rather than a celebration of nursing excellence. There must be a radical institutional and cultural change in the understanding of what constitutes nursing care and an expansion of the current boundaries of accepted nursing practice. Many of the articles examined in this review would suggest that this has yet to be realised.

When considering future research surrounding the role of the nurse inventor, it is concluded that there needs to be a much wider exploration of the concept from both a subjective and objective standpoint.

Research should be undertaken to define and clarify the nurse inventor concept, aiming for a consensus of definition, typology, scope of practice, and job planning. A mixed-method study defining and exploring an inventive nurse device, from conceptualisation to market, coupled with the authors' reflective innovation journey and expertise would be ideal in contributing to a foundation of new knowledge.

## 15. Limitations of Study

We first acknowledge the limitations of this study generated by its methodology [11]. We made efforts to mitigate methodological biases using a systematic, clear approach, utilising the PRISMA-ScR and PPC tools [13, 14]. We also accept that potentially relevant available literature could have been absent through the search strategy and terms developed by the authors. This is evident, in that many of the expert opinions examined in this research stated that they went on to produce experimental research relative to their innovations; these papers were seemingly unavailable through our search strategy. Our initial aim and strategy of our literature review was to try and exclude any theoretical, process, or management innovations to support a yield of specific research into nursing inventions. It became apparent that this was a very difficult aim to achieve, and we acknowledge that theoretical and practical innovation is quite often conducted in tandem or as a process towards the wider product development journey.

Our search did not retrieve any research with a focus on frugal invention; however, as previously identified in this work, this was likely due to the bias of the authors, that frugal invention was not considered during the generation of the protocol for this review.

Our search did not retrieve any research with a focus on community nurse innovation or those nurses inventing outside of the hospital environment. This may have been a result of our search terms and our protocolled focus on the clinical environment; we speculate that this community research is otherwise available.

Finally, we acknowledge the wide-ranging methods, aims, and objectives of the studies retrieved. This could be seen as confounding relative to our themes, findings, and recommendations.

## Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

## Authors' Contributions

LS and MS involved in drafting the manuscript or revising it critically for important intellectual content. LS, MS, and FH provided final approval of the version to be published. Each author participated sufficiently in the work to take public responsibility for appropriate portions of the content. LS, MS, and FH agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

## Acknowledgments

Open access funding was enabled and organized by JISC.

## Supplementary Materials

Supplementary Table 1: a table representation of the Population, Concept, Context protocol which the authors generated to drive the scoping review undertaken. Supplementary Table 2: a table demonstrating the initial volume of returned literature from the search term "Nursing AND (new product development) AND (device innovation)" across each database and grey literature source. (*Supplementary Materials*)

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