

# Nursing Technologies Creativity as an Expression of Caring: A Grounded Theory Study

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## Abstract

Caring expression in nursing is rapidly changing to include the use of sophisticated healthcare technologies. Unfortunately, few nurses participate in developing healthcare technologies. The current study aimed to generate a theory of nursing grounded in the phenomenon of nursing technologies creativity in nursing practice. The study design used a constructivist grounded theory. Sixteen Indonesian nurses selected by purposive sampling were interviewed in-depth. Data analysis used constant comparative analysis through Charmaz's coding process. This study generated two core conceptual categories that included technological creativity and drivers for technological development. Five theoretical statements were developed leading to the Technological Creativity as Caring in Nursing Theory. This theory is a middle-range theory that focuses on technological creativity to express caring for patients, nurses, and management in nursing practice.

## Keywords

caring, grounded theory, nursing technology, nursing theory, technological creativity, Indonesia

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## Introduction

Caring as a central concept in the nursing discipline needs to be deeply investigated in today's era. Previously, the concept of caring in nursing has been understood as a nurse's attitudes and behaviors when taking care of patients, such as compassion, commitment, confidence, competence, comportment, and conscience (Roach, 2002). Currently, the expression of caring is rapidly changing to include the use of sophisticated healthcare technologies for enhancing the quality of nursing care. In this era, people face a world full of advanced technologies in all aspects of human life, including in nursing care services.

Many sophisticated technologies have been created by healthcare technologists in efforts to improve the efficiency, effectiveness, and quality of healthcare service. Unfortunately, most of the technologies in nursing practice were not designed or created by nurses. Many healthcare technologies used in nursing practice have been borrowed from the medical profession, such as sphygmomanometers, stethoscopes, blood warmers, and other devices. As healthcare providers, nurses should be team members or consultants in the invention process for nursing technologies; however, few nurses do so. Today, most nurses are still just users or technicians of healthcare technologies (Glasgow et al., 2018). As a result,

the development of nursing technologies lags behind medical technologies. A perusal of the online publications on nursing technologies showed that the number of technologies created by nurses is very limited. According to Metler (2004), between 1865 and 2003, only 42 nurses contributed to 94 patents, while the number of medical-technology patents is in the thousands. O'Cearbhaill et al. (2019) reported that the number of patents for medical devices increased rapidly from 2005 ( $n = 6,603$ ) to 2015 ( $n = 17,596$ ).

In the Technological Competency as Caring in Nursing Theory, Locsin (2016) explained that nurses who are proficient or competent in technology would be able to know about patients, moment-to-moment. This theory can be used as the impetus to drive developing technologies in healthcare to facilitate knowing patients as an act of caring (Pepito & Locsin, 2018). Nevertheless, this theory did not offer a detailed explanation of how to develop nursing

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technologies for caring for patients. Therefore, the need for advancing nursing technologies is crucial to face the more complex problems in nursing practice. Locsin's theory is not enough to answer these pressing issues. Nursing, as a discipline, needs a theory to address the challenge that today's nurses should be designers or creators of nursing technology. Nurses' new role is more than just as users of sophisticated technology; they should also be nurse-engineers for healthcare (Glasgow et al., 2018). This new role is vital because nurses understand their own needs better than those from other professions. Additionally, they can improve the quality of patient care through innovative ideas. Glauser (2017) stated that if nurses do not start to understand and participate in the development and implementation of technology, the nursing profession, and the patients' interest will suffer.

Meanwhile, according to the Human Caring theory, Watson (2015) stressed that a creative approach uses all ways of knowing, being, and doing to engage nurses in clinical caring. This theory showed the many ways to know, to be, and to do in caring for patients; however, this theory did not offer a detailed explanation on how to demonstrate this creative approach in a clinical setting, either. Therefore, to encounter the phenomena of technological dependence and the demand to develop nursing technologies in today's nursing practice, Watson's theory needs to be expanded into a middle-range theory that is more concrete and narrower in scope, bridging grand theory and specific nursing phenomena. Hence, this study aimed to construct a nursing theory grounded in the phenomenon of nursing technologies creativity in nursing practice.

## Methods

### Research Design

The philosophical underpinning of this study used constructivism philosophy in which the researcher generated a theory through the interpreting and understanding of lived reality or phenomena based on symbolic interaction (Kenny & Fourie, 2015). Therefore, the research design used Charmaz's (2006) constructivist grounded theory approach. This approach is used to generate the theory through interpreting and understanding of lived reality or phenomena in which both researcher and participants interpreted and shared their experiences (Charmaz, 2006).

### Participants of the Study

This study involved 16 (sixteen) Indonesian nurse-clinicians who worked at Saiful Anwar Hospital in Malang City, Indonesia. Inclusion criteria for participants included (1) the nurses had experience in creating a nursing technology designed to solve some patient health problem or nurses' problems at work. (2) Nursing technologies creativity

included techniques or procedures in nursing interventions, nursing instruments or tools, and machines that are used to care for patients or support nurse's work. (3) The nurses were members of a quality control team who are responsible for improving the quality of care. (4) Education level was at least a Bachelor of Science in Nursing. (5) The nurses were formally trained in making technological innovations organized by Quality Assurance Unit. (6) All participants had at least 5 years of nursing experience, and (7) the participants agreed to participate fully in the study.

To select participants, the researcher approached the nurses face-to-face and selected them by a purposive sampling technique. Recruitment stopped when data saturation had been achieved. Data saturation occurred on the 16th participant, which was when the collected data or the findings followed the same patterns (Charmaz, 2006).

### Data Collection

Data collection was conducted from October to December 2019 in 12 units at the Saiful Anwar Hospital, Malang City. Data were collected using an in-depth interview guide and an observation checklist. Individual interviews were conducted using open-ended questions, including grand tour questions, and were audio-recorded. The questions included the following:

- (1) How did your experiences employ technological creativity in caring for patients?
- (2) What kinds of nursing technologies have you created?
- (3) How did you create nursing technologies?
- (4) How the process of creating nursing technologies did you do?
- (5) What nurse's characteristics did you need in the process of creating nursing technologies?
- (6) When did you create nursing technologies?
- (7) Where did you create nursing technologies?
- (8) Why did you create nursing technologies?
- (9) What were the benefits of those nursing technologies for patients, nurses, and management?
- (10) As a nurse, what does creating nursing technologies for caring mean to you?

Data collection was conducted with the following steps: (1) the researchers interviewed participants informally in nursing wards, without any pressure or the presence of any non-participants, and the participants spoke freely about their experiences. The researcher interviewed each participant for between 1 and 1.5 hours, without disturbing their work, and recorded the interview. (2) The researchers observed the nursing technologies created by the nurses to validate them and to check the availability and the use of the technologies in nursing wards. (3) We wrote verbatim transcripts carefully based on the recorded interview, and (4)

returned the transcripts to the participants for correction (participant checking).

### Data Analysis

Data were analyzed by a constant comparative analysis through Charmaz's coding process (initial, focused, axial, and theoretical coding). The constant comparative analysis allowed the researcher to compare codes and data, codes and codes, codes and categories, categories and other categories, and between the generated theory and literature (Kenny & Fourie, 2015). During data analysis, Open Code 4.02 software was utilized in developing codes, categories, and the relationship among codes and categories. The process of initial coding identified 180 codes, and the focused coding process identified 43 codes; then codes were synthesized into nine subcategories and two core categories.

During the coding process, memos were written to define each code, subcategory, and category by its analytic properties and bring raw data into the memo. Furthermore, the researchers collected all codes, analyzed the data, and determined the next data that would be collected and where would find those data (theoretical sampling). After that, the researchers developed the properties of categories until no new properties emerged (theoretical saturation), sorting, diagramming, and integrating memos. Finally, the researchers constructed a nursing theory that emphasized understanding of the meaning and showing patterns and relationships.

### Trustworthiness

The criteria of trustworthiness, including credibility, dependability, confirmability, transferability, and authenticity (Connelly, 2016; Polit & Beck, 2018), were fulfilled during the process of the study. The credibility of study findings was supported by using multiple sources of data (interviews and observations), member checking, and re-examining the data on multiple occasions to verify the analysis. To fulfill the criterion of dependability, we maintained an audit trail of process logs and performed peer-debriefings with colleagues. An audit trail of analysis and memos were maintained to establish the confirmability criterion, and we kept detailed notes of all the decisions and the analysis of progress. These notes were reviewed by a colleague and discussed with a qualitative researcher, and we conducted member-checking with participants. We created a rich description of the location and participants of the study to fulfill the transferability criterion. Finally, to fulfill the authenticity criterion, we fairly and completely showed all the different realities and realistically reported participants' experiences.

### Ethical Approval and Informed Consent

The study protocol and informed consent sheet were approved by the St. Paul University Philippines Ethics

Review Committee (ERC), with the protocol code 2019-03-PhDNS-95 on September 3rd, 2019, and Dr. Saiful Anwar Hospital ERC No: 400/207/K.3/302/2019 on October 7th, 2019.

## Results

This constructivist grounded theory study generated the Technological Creativity as Caring in Nursing (T2CN) theory. The T2CN theory was defined as the creative process of co-creating nursing technologies with nurse-innovators and a network of collaborators in a supportive environment, to express caring for patients, to improve the quality of nurse's caring, and for the ultimate goal of achieving patient wellness. This nursing theory was built with two core categories that included technological creativity and the drivers for technological development.

### Category 1: Technological Creativity

Technological creativity was defined as a creative process that involved the nurse-innovators in co-creating nursing technologies with network collaborators, in a supportive environment. The concept of technological creativity was synthesized from five subcategories that included (1) nursing technology, (2) process of technological creativity, (3) nurse-innovators, (4) collaboration, and (5) supportive environment.

*Subcategory 1: nursing technology.* Nursing technology was defined as nursing tools, machines, automata, utensils, nursing intervention procedures, health education techniques, substance, and clothes designed and used by nurses in nursing practice. There were 53 kinds of nursing technologies created by participants, including a blanket for hypothermia patients, a mattress for mobilization, prominent protective bone, a corset for patient's fixation, a warm humidifier, an infusion flow sensor, a wound-care table, a method to estimate the bleeding volume post-Trans Ureteral Resection-Prostate (TUR-P), and other nursing technologies. Some of these findings can be found in the following participant's statement.

*Our team made a blanket for hypothermia patients in the intensive room, because the intensive room was very cold; for preventing hypothermia, we made a blanket for a patient in 2013. . . . In 2017, we made a mattress for mobilization and prominent protective bone (PPB). (P9)*

*Subcategory 2: the process of technological creativity.* The process of technological creativity referred to the series of phases in creating a nursing technology that included the (1) investigating, (2) analyzing, (3) designing, (4) prototyping, (5) testing, (6) applying, and (7) monitoring phases. This process occurred cyclically until the product could be utilized well, and then redeveloped based on the results of evaluation.

In the investigating phase, the nurses assessed the problem of patient and nurse in the nursing care process, prioritizing the problems and collecting the data. In the analyzing phase, the nurses analyzed possible factors that cause emerging problems and determined the dominant causal factor. In the designing phase, the nurses formulated alternatives solution and determined a realistic solution through brainstorming with team members, then designed the solution. In the prototyping phase, the nurses designed a prototype, presenting the design to management and other colleagues. After the design was accepted, a prototype of the technology was made. In the testing phase, the nurses conducted a clinical trial to test the prototype. After that, the prototype was revised based on the result of the testing. Finally, the technology was standardized and legalized by the hospital before being reproduced and implemented. In the applying phase, the nurses disseminated the technology to their colleagues to facilitate the implementation of the technology in nursing practice. The nurse-innovators collaborated with management to commercialize and supply the technology. In the monitoring phase, the nurses evaluated the effectiveness and efficiency of the technology to revise and develop the next nursing technology. Additionally, the nurses proposed Intellectual Property Rights to the management. These findings can be found in the following participant statement:

*We assessed the patient's problems. . . . We analyzed it; . . . We sought an idea that was similar to the physiologic function of respiration. We had given cold oxygen; therefore, it causes respiratory obstruction. After that, we had an idea to make a solution to treat this problem. That idea emerged through a discussion in the team. After that, we made a tool design that could be modified with a humidifier; and then, we tested that tool. After testing that tool, we required legalization to the hospital management created SOP (Standard Operating Procedure) also. After that, we implemented it for the patients. Finally, we evaluated it. (P4)*

**Subcategory 3: nurse-innovator.** A nurse-innovator is a nurse who has specific characteristics that are different from non-nurse-innovators. Those characteristics include (1) thinking outside the box, (2) positive emotional engagement, and (3) team synergy. Thinking outside the box is the cognitive ability to think differently or unconventionally about something, and includes being visionary, inquisitive, critical, analytical, creative, thinking imaginatively, being innovative, logical thinking, and being insightful. Positive emotional engagement refers to the positive attitudes or emotions of the nurses regarding creating nursing technologies. Those attitudes and emotions included enthusiasm, working hard, having fun being creative, never giving up, being active, taking initiative, hopefulness, caring about and being sensitive to patients, being sensitive to work needs, being humane, and making sacrifices. Other important qualities included willingness, being consistent,

loyalty, responsibility, commitment, discipline, and seriousness about being innovative.

Meanwhile, team synergy refers to nurses' ability to collaborate with each other or other health or non-health professionals in creating nursing technology. Synergy relies on the ability to communicate, togetherness, loyalty, open-mindedness, cooperation, ability to coordinate with the team, solid teamwork, and interpersonal relationships. One participant talked about the characteristics of a nurse-innovator.

*We needed a disciplined person, a creative person, consistent, and persevering. Because we tried to make a tool; we were straight to try, we were not hopeless, open-minded from colleagues' suggestion, believe to the team leader; so, collaboration would be better. (P4)*

**Subcategory 4: collaboration.** Collaboration was the process of sharing information, competencies, and responsibilities between nurses (intra-professional collaboration) or nurses and other health or non-health professionals (inter-professional collaboration), to jointly create nursing technology. These findings can be seen in this participant's statement:

*We collaborated with other professions, we had an idea. Those tools were made together with a third party. For example, anti-rotation was made together with the craftsman; corset for fixation was made together with medical rehabilitation employees. (P2)*

**Subcategory 5: supportive environment.** The supportive environment was defined as the conditions that support the nurses in creating nursing technologies to address the problems of patients, nurses, and management. This condition included adequate management support, the existence of a quality control team, facilities in the workplace, time availability, and colleague support. This is described in the following participant's statement:

*To develop creativity, especially related to nursing care, was a challenge for nurses. . . . The nurses needed big support from the management and the other parties. In the hospital, there was an organization that facilitated us. The hospital had allocated funding for research, for developing the hospital services; it was much facilitated. . . . In the hospital, the quality control team could motivate or encourage the development of hospital facilities. . . . Every year we make an innovation based on the actual situation. (P15)*

## Category 2: The Drivers for Technological Development

The drivers for technological development were what drove the nurses to create new technologies for nursing practice that included assisting patients in managing their health problems, facilitating the nurses' needs in their work, and improving the performance of management of healthcare

services and the patients' wellness. This category was synthesized from four subcategories that included (1) caring for patients, (2) caring for nurses, (3) caring for management, and (4) patient wellness.

*Subcategory 1: caring for patients.* Caring for the patients was defined as the meanings, reasons, and benefits of creating nursing technologies for patients and nursing care process. This included knowing the patient, solving health problems, maintaining patient safety, helping patients, knowing patients' problems, becoming closer with a patient, satisfying and comforting patients, reducing patient complaints, reducing complications, reducing costs, holistic caring, and improving the quality of nursing care. The following participant revealed the meaning, reasons, and benefits of creating nursing technologies for patients.

*Creating nursing technology could help patients. For example, airway obstruction due to thick mucus in the throat is high among ICU (Intensive Care Unit) patients. Mortality could be higher without that technology (warm humidifier). Besides that, I was more aware of patient problems. . . . patients would be safer; because the airway obstruction cases would be decreased, the risk of respiratory distress would be decreased. . . , we reduced risk factors. (P4)*

*Subcategory 2: caring for nurses.* Caring for nurses was defined as the meanings, reasons, and benefits of creating nursing technologies that are felt by the nurses, such as facilitating the nurse's work, facilitating the nursing process, improving the quality of nursing care, improving the dignity of the nurse, and satisfying nurse. These findings are explained in the following participant's statement:

*It's meaningful because I felt happy; I wanted to make something new. I felt happy, my friends (other nurses) felt happy, too. I would be happy, if my friends worked happily, gratifying and facilitating the team in the working. Thus, at least this tool could reduce exhaustion, perhaps physically and mentally. . . (P6)*

*Subcategory 3: caring for management.* Caring for management was defined as the meanings, reasons, and benefits of creating nursing technologies that are felt by management, such as improving the quality of nursing care services, improving efficiency and the effectiveness of service, increasing hospital income, and improving the hospital's image. The participant below expresses the benefits of creating a nursing technology that is felt by the management:

*. . . That tool was more efficient, almost 100%, or at least 95%, we needed it only 5% to work. We only needed one person to clean that tool, and we only need a little disinfectant liquid in the tool container. After that, the patient was transferred to the bed in a clean condition. We bandaged without transferring the patient to another bed. . . . Reducing the duration of care, efficient personnel, material, and instrument. . . (P6)*

*Subcategory 4: patient wellness.* Patient wellness was defined as a condition wherein there was a reduction of patients' health problems/morbidity or mortality risk. This subcategory was derived from codes of reducing morbidity and reducing mortality risk. Reducing morbidity had multiple meanings, such as reducing pain, preventing contracture, preventing complications, patients feeling better, preventing patient accidents, promoting happiness, and preventing hypothermia. Reducing mortality risk meant preventing airway obstruction, preventing dehydration, and reducing other risks. These findings can be seen in the following participant statement:

*Many foot drop cases in the ICU (Intensive Care Unit); . . . in my mind, how to solve that foot drop. So, that case did not affect the high morbidity. . . . Previously, in the PICU (Pediatric Intensive Care Unit), I saw high mortality of infants and children. We found many causes. . . then we found its solutions; for instance, the fluid management and nutrition. . . so now, we can reduce the mortality of infant. (P14)*

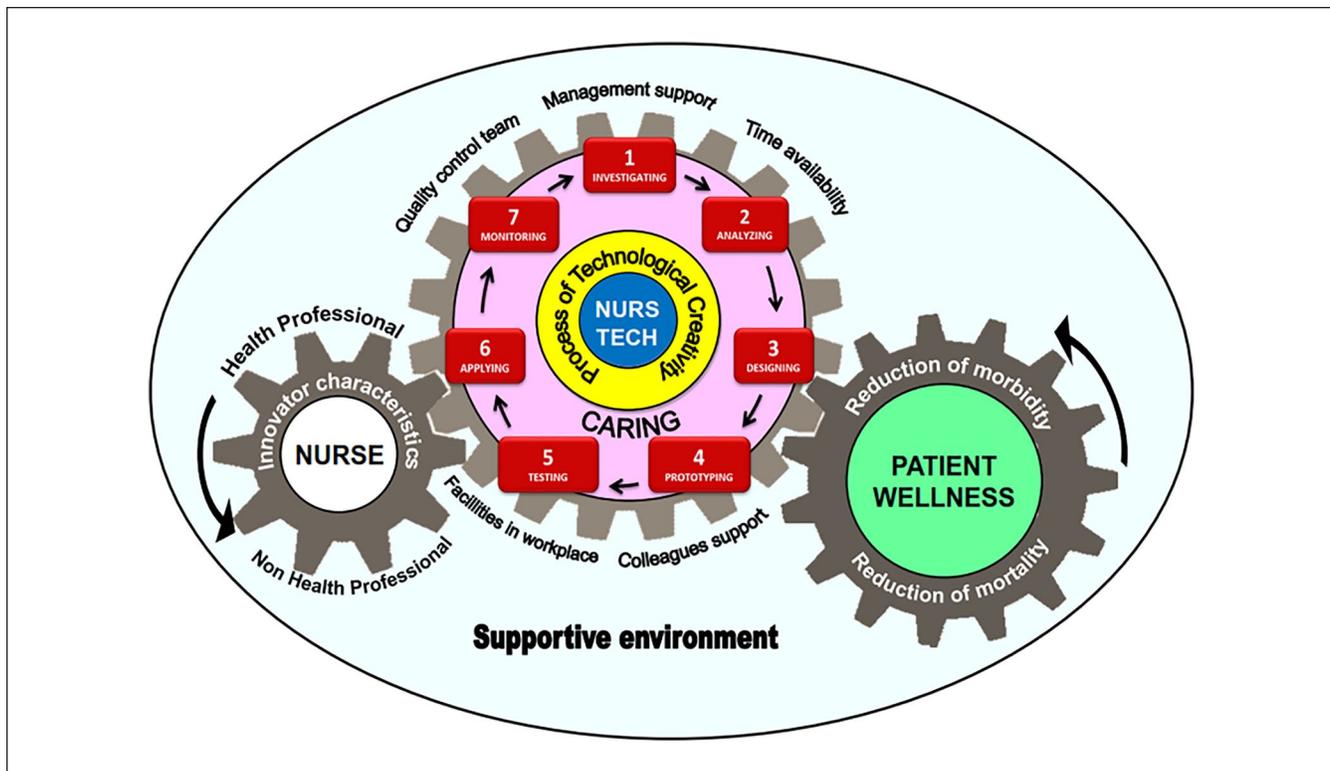
## Theoretical Statements

The theoretical statements of the generated theory are as follows: (1) Nurse-innovators, collaboration, and a supportive environment are needed in the process of technological creativity. (2) The process of technological creativity can influence the production of nursing technologies. (3) Technological creativity in nursing practice can influence the quality of nurse's caring. (4) Technological creativity is a caring expression in nursing practice. (5) Technological creativity as a caring expression in nursing can influence patient wellness.

## Theoretical Model of Technological Creativity as Caring in Nursing

To give concrete visual images of the relationships among concepts and statements in the logical order, the theoretical model of the T2CN theory is presented in Figure 1.

Figure 1 illustrates the theoretical model of T2CN as "machine gears." These gears are used as a symbol of technology, because technological creativity constitutes a central concept in this nursing theory. These gears also symbolize the interaction or interrelation among components of the T2CN theory. This theoretical model consists of four major components that include (1) the nurse-innovator (the left gear) who collaborates with health or non-health professionals to create nursing technologies. (2) Technological creativity as caring (the middle gear) is a central and essential component. The nurse-innovators create technologies to express caring for patients through seven phases that include investigating, analyzing, designing, prototyping, testing, applying, and monitoring phases. (3) Patient wellness (the right gear) is the ultimate goal of the nursing care process,



**Figure 1.** The theoretical model of technological creativity as caring in nursing.

providing feedback for the nurses to revise or develop future nursing technologies. (4) The gears are enveloped by a supportive environment (the outer ellipse) that provides the milieu where all three major components happen, and supports creating technologies.

## Discussion

### Technological Creativity

Technological creativity in nursing is a creative process that involves the nurse-innovators in co-creating nursing technologies with network collaborators in a supportive environment. Through technological creativity, nurses attempt to solve the health problems of patients, nurses' challenges with their work, improve management performance, and achieve patient wellness. This definition sharpens Watson's statement that a creative approach is using all ways of knowing/being/doing to engage in caring-healing practice. The creative use of all ways of knowing patients and doing something for the patient is an integral part of the caring process of solving problems or seeking solutions for patients (Watson, 2015). Furthermore, Bagherian et al. (2017) claimed that there was a positive association between the use of technology and caring attributes; caring attribute scores of nurses were increased regarding the use of technology in nursing practice. A few studies that claimed a technology decreased

caring behavior, such as Schenk et al. (2018), who claimed that caring efficacy was observed to decrease slightly post-Electronic Health Record implementation.

The process of technological creativity in the T2CN theory uses the seven phases of investigating, analyzing, designing, prototyping, testing, applying, and monitoring. These phases have some similarities to the process of bio-design (Yock et al., 2015). The similarities between the models are that the nurse's activities in the investigating and analyzing phases are similar to the identifying phase in the bio-design process. Further, the activities in the designing and testing phase are similar to the invention phase in the bio-design process. Finally, the activities in the applying and monitoring phases are similar to the implementation phase in bio-design. In the process of technological creativity, the nurses attempt to fully understand patients' problems or needs and nurses' and management's challenges at work. Nurses' deep understanding of the needs of the patients, nurses, and management can become a starting point to create technologies that will be used to solve their problems. This understanding is similar to Roach's caring attribute, in which nurses attempt to understand patients' experiences of feeling pain and discomfort through compassion (Caranto, 2015). Moreover, nurses and patients have an active relationship in the process of technological creativity. This relationship can inspire nurses to design and develop nursing technologies to solve patients' problems. The relationship is similar to the concept

of mutual designing in the practice process from Locsin's theory, in which the nurse and patient co-create a plan of care (Locsin, 2017).

Nurses have created many types of technologies, including nursing tools, machines, automata, utensils, nursing intervention procedures, health education techniques, substance, and clothes. Examples include a blanket for hypothermia patients, a mattress for mobilization, a prominent protective bone, a corset for patient fixation, a warm humidifier, an infusion flow sensor, a wound-care table, a method to estimate the volume of bleeding post-TUR-P, and other technologies. These nursing technologies are appropriated with the categories of technology by Barnard (1996). He categorized technology in three layers that include (1) physical objects, such as tools, machinery, and matter; (2) technology as knowledge; and (3) technology as a complex set of human activities or a technique. Locsin (2016) stated that nursing techniques could include therapeutic interpersonal techniques, nursing care procedures, and educational techniques for patients. Furthermore, Barnard (2009) explained that technology included machinery, equipment, tools, utensils, apparatus, automata, utilities, and structures used in practice and organizations. Locsin (2016) classified nursing technologies into eight types that include clothes, utensils, structures, apparatus, utilities, tools, machines, and automata. Nursing technologies do not only associate with modern electronics, diagnostics, and treatment but also with the most commonplace and ordinary needs of nursing. Further, Locsin (2017) and Locsin and Ito (2018) classified technology in healthcare into five dimensions, which are (1) technology as the completer of human beings, such as mechanical devices, organic/biological of human tissues or organs; (2) machine technologies to facilitate the practice of caring; (3) technology that mimics human beings, such as robots with Artificial Intelligence (AI); (4) technology as an enhancer of human qualities, such as cyborgs; and (5) technology to facilitate human-like organisms' advancement.

Nurse-innovators have an important role in the process of technological creativity. They have three main characteristics that include thinking out-of-the-box, positive emotional engagement, and team synergy. These characteristics provide the drive to expand nurses' roles such that nurses are not just technicians or deputies of the medical profession in operating medical technologies in healthcare. Nurses should be nurse-innovators or creators, because they hold the responsibility for discovering a better quality of nursing services (Kaya et al., 2015). Through technological creativity, Lachman et al. (2009) stated that nurse-innovators could open access to create systems to support and enhance healthcare and emerging technologies.

In creating nursing technologies, nurse-innovators must collaborate with health professionals or non-health professionals. Collaboration is vital to the development of nursing technologies because it leads to sharing information, competencies, and the involvement of each collaborator.

Similar to the findings in the current study, the literature suggests that nurse-innovators need to collaborate with other professionals because collaboration produces activities that include: (1) coordination (working in achieving shared goals); (2) cooperation (contributing, understanding, and valuing the contributions of team members); (3) shared decision-making (involving communication, trust, openness, negotiation, and respectful); and (4) partnerships (cultivating open, respectful relationships where all members work equitably) (Morley & Cashell, 2017).

The process of technological creativity needs a supportive environment. This includes adequate management support, a quality control team, facilities in the workplace, time to create, and colleague support. Adequate management support, such as a management policy, financial support, and rewards, encourages nurse-innovators to create technological innovations. The quality control team plays an important role in improving the quality of care by creating technological innovations in nursing practice. Facilities in the workplace that facilitate creativity constitute an important element because they can motivate nurse-innovators in creating many innovations. Time to develop innovations during the workday can stimulate nurses to create nursing technologies. Thus, nurses are not only very busy in their daily routine activities. Lastly, colleagues support can motivate nurse-innovators to be more creative and encourage collaboration. Conversely, technological innovation would be difficult to develop if the work environment lacks the necessary support. Joseph (2015) revealed preconditions that influenced innovation in an organization: (1) values of the organization (the vision and mission), (2) workplace relationships (building relationships), (3) organizational identification (how the organization members define themselves), (4) organizational support (the value of organization care for the employees), and (5) relational leadership (the role and leadership style). These preconditions are essential elements in enhancing the process of technological innovations in nursing practice.

### *The Drivers for Technological Development*

The findings showed that the main reasons the nurses were driven to create nursing practice technologies were to assist patients in managing their health problems (caring for patient), to facilitate nurses' needs in the workplace (caring for nurses), to improve management in healthcare services (caring for management), and to achieve patient wellness. These findings are supported by Lachman et al. (2009) and Bowles et al. (2015) who revealed that technological creativity or innovation is for quality improvement, cost-effectiveness, and efficiency. Moreover, Kaya et al. (2015) contended that innovation of nursing applications is to improve health, prevent diseases, avoid risk factors, develop standard attitudes of a healthy life, and for fulfilling care and treatment methods as well as to improve nurses' communication with other healthcare providers

and documentation in healthcare (Rouleau et al., 2017). Moreover, personal care robots can reduce caregivers' physical burden in nursing care homes or private homes (Yamazaki et al., 2017). The use of technology can improve patient safety, work, service, and the achievement of more contact time with patients. Intensive Care Information System (ICIS) reduced the time of needed for documentation up to 30% and nurses' physical exertion, increased productivity and communication between nurses and patients, other health professionals, and patients' families (Jelec et al., 2016). Kaya et al. (2015) who stated that technology, as a product of nurses' creativity, was driven by improving health, also support this finding.

Essentially, nursing technologies created by nurses themselves were an expression of caring for patients and achieving patient wellness. This finding is congruent with Swanson (2015), who suggested that the ultimate goal of caring is to enable clients to achieve well-being. In today's healthcare, the use of technology constitutes consideration for caring for patients of the millennial generation (Johanson, 2016). Besides, most of today's nurses are part of this millennial generation.

### *The Implications of the Study*

This study's implication for nursing practice is that the T2CN theory can be used as a guideline to express caring for patients, nurses, and management, to solve the problems in nursing practice, to improve the quality of nurse's caring, and to achieve patient wellness. Moreover, this theory can encourage nurses in accelerating a change in nursing culture, offering opportunities to change conventional caring culture to a modern caring culture in which nurses are expressing caring by utilizing and developing healthcare technologies, as Ball et al. (2011) claimed. As result, the nursing profession would be less dependent on the healthcare technologies created by other health professions. Nurses will be independent in developing their own technologies, and be able to participate actively in addressing technological needs in nursing practice through their technological innovation. Creativity constitutes an essential component in daily nursing practice when nurses interact with patients, families, and other nurses. Failure to appreciate and encourage nurses' creativity will be a barrier for future innovations in nursing practice (Fasnacht, 2003). Moreover, Bartos (2020) stated that encouraging developing nurses to think creatively would inspire future innovation and advancements in nursing. Furthermore, Shahsavari et al. (2015) revealed that nurse's creativity could improve quality of care, quality of work, personal and social life, and promote an organization. Another implication of the T2CN theory is that the concept of "technological creativity" also can help complete Roach's (2002) caring attributes and act as one of the nursing arts for patient care.

### *Strengths and Limitations*

This study has several strengths; the generated nursing theory is new among nursing theories because technological creativity has not been investigated deeply in previous nursing theories. These findings can also be transformed and applied to similar situations in various nursing settings. However, this study also has some limitations. The study was only conducted at one hospital in Indonesia, so it cannot describe the process of technological creativity in different work cultures, environments, and hospital management styles. Only nurses participated, so there is no information from the perspective of patients. Additionally, this study cannot explain the degree of relationship among concepts, because according to McEwen and Wills (2014), a grounded theory study only generates a descriptive theory that purposes to identify, describe, and interpret lived reality or phenomena.

### **Conclusions**

This grounded theory study generated the theory of Technological Creativity as Caring in Nursing (T2CN). This theory is a middle-range theory that focuses on technological creativity to express caring in the nursing practice, with the ultimate goal of the patient's wellness. This theory bridges between Watson's Human Caring theory and the phenomena of nursing technologies creativity in nursing practice that consists of the elementary ideas stemming from Watson's Human Caring theory.

Based on these substantive findings, the researchers suggest that: (1) nurse-clinicians can use the T2CN theory as a guide to express caring for patients, nurses, and management through the process of investigating problems, analyzing, designing, prototyping, testing, applying, and monitoring created nursing technologies. (2) Hospital management considers developing a policy that can stimulate and support an innovative culture in the hospital. (3) Nurses associations may explore opportunities to advance a nursing practice standard and the new role of being a nurse-innovator. (4) This theory can be advanced as part of the core curriculum in nursing education, so that future nurses will have competence in creating nursing technologies. (5) Future researchers may test this nursing theory through research in various settings and use it as a direction for developing future nursing theories.

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### **Author Contributions**

KISSA BAHARI: Study conception and design, data collection, data analysis and interpretation, drafting of the article, and critical

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