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

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WORD COUNT 5829 TIME SUBMITTED 17-DEC-2020 08:48PM
PAPER ID 66943546

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Abstract

Currently, caring expression in nursing is more and more rapidly changed to include the use of sophisticated technologies. Unfortunately, the development of healthcare technologies in nursing care is very rarely created by nurses. The current study aimed to generate a theory of nursing grounded on nursing technologies creativity phenomena in nursing practice. This study used a constructivist grounded theory design. Participants of the study involved sixteen Indonesian nurses who were selected by purposive sampling technique. Data collection utilized in-depth interview and observation methods; and analyzed by constant comparative analysis through Charmaz's coding process. Results of this study generated two core conceptual categories that included technological creativity and the drivers for technological development. Besides, five theoretical statements surfaced leading to Technological Creativity as Caring Expression in Nursing (T2CEN) theory. The study concluded that T2CEN theory is a middle-range theory that focuses on technological creativity to express caring for patients in the nursing practice.

Keywords

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

Introduction

Caring is a central concept in the nursing discipline and a foundation in daily nursing practices (Smith & Parker, 2015). Previously, the concept of caring in nursing commonly has been understood as a nurse's attitude and behavior when taking care of patients such as compassion, commitment, confidence, competence, comportment, and conscience (Roach, 2002). Currently, caring expression is more and more rapidly changed to include the use of sophisticated technology for enhancing the quality of nursing care in the 4th industrial revolution era. In this era, people face a condition full of high-technologies in all aspects of human life including in healthcare industries and nursing care services.

Many sophisticated healthcare technologies have been created by healthcare technologists as efforts to improve the efficiency, effectiveness, and quality of healthcare. Unfortunately, most of the healthcare technologies in nursing practice were not designed or created by nurses. Many healthcare technologies that were used by nurses in nursing practice borrowed from the medical profession, for example, sphygmomanometer, stethoscope, blood warmer, and other healthcare technologies. Nurses as part of healthcare providers should be able to participate or to be part of the invention process for nursing technologies such as part of the team or consultant. However, few nurses' participation is seen in developing healthcare technologies. Today, most nurses are still just users or technicians of healthcare technologies (Glasgow et al., 2018). As a result, the development of nursing technology lagged behind medical technologies. A perusal of the online publications on nursing technologies showed that the number of nursing technologies created by nurses is very limited. According to Metler (2004) during 138 years from 1865 to 2003, only 42 nurses contributed to 94 patents. While the number of medical technology patents is observed thousands. O'Cearbhaill et al., (2019) reported that the number of patents in medical devices is increased rapidly, from 2005 (n = 6,603) to 2015 (n = 17,596).

Previously, Locsin (2016) in Technological Competency as Caring in Nursing theory explained that nurses who are proficient or competent in technology will be able to know patient moment-to-moment. This theory can be used as the impetus to drive developing technologies in healthcare to facilitate knowing persons as caring (Pepito & Locsin, 2018). Nevertheless, this theory did not explain in detail how to develop nursing technologies for caring for patients. Therefore, to face more complex problems in nursing practice and the need for advancing nursing technology are crucial in today's condition, Locsin's theory is not enough to answer these pressing issues. Nursing as a discipline needs a nursing theory to face the challenge that today's nurse should be a designer or creator of a nursing technology. The new role of nurses becomes more than just users of sophisticated technology, but they should also be nurse-engineers for healthcare (Glasgow et al., 2018). This new role is so important because nurses are more understand their work. Besides that, it 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 be suffered.

Meanwhile, according to the Human Caring theory, Watson (2015) stressed that a creative approach is the use of 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 explain how to demonstrate this creative approach in a clinical setting. 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 in a middle-range theory that is more concrete and narrower in scope and bridging between the grand theory and the specific nursing phenomena. Hence, the study aimed to construct a middle-range theory grounded on phenomena technological creativity in nursing practice that is very important and urgent.

Methods

Research Design

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

Participants of the Study

This study involved 16 (sixteen) Indonesian nurses clinicians who worked at Saiful Anwar Hospital in Malang City, Indonesia. Inclusion criteria of participants include 1) the nurses had experience in creating a nursing technology for the purpose to solve health problem of patients or nurses' problems in the work. 2) Nursing technologies created by nurses included techniques in the nursing interventions and nursing instruments or tools that are used to care for patients or support nurse's work. 3) The nurses were part of the Quality Control team. 4) Education level was at least a Bachelor of Science in Nursing. 5) The nurses were formally trained in making technology innovations. 6) The work experience in nursing practice was at least five years, and 7) the participants approved to participate fully in the study.

To select participants, the researcher approached participants face-to-face and selected them by a purposive sampling technique. The recruitment of participants was stopped when data saturation had been achieved. Data saturation occurs on the 16th participant which is further data collection generated similar results or the data had been collected achieving the research purpose or when nothing new in the study or the finding follows the same patterns

(Charmaz, 2006). During conducting this study, there were not participants refusing to participate or dropped out of this study.

Data collection

This study was conducted from October to December 2019 in 12 nursing wards at Saiful Anwar Hospital Malang City. Data collection used an in-depth interview guide, observation checklist and voice recorder. This triangulation method was used to make sure there would be no data left un-noted. An interview guide consisting of 10 main questions including the grand tour research questions was used to conduct in-depth individual interviews. Questions included the following:

1) How did your experiences employ technological creativity for caring patients?
2) What kinds of nursing technologies had 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 researcher interviewed participants informally in a nursing office, without pressure situation, without attending non-participants, and the participants told their experiences freely. The researcher interviewed participants for approximately 1 to 1.5 hours, without disturbing their work, and recorded their answers. 2) The researchers observed the nursing technologies created by nurses to validate and to check the availability and the use of these technologies in nursing wards. 3)

Writing verbatim transcripts carefully, and 4) Returning 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 means that the researcher compared between codes and data; between codes and codes; between codes and categories; between 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, the focused coding process identified 43 codes, and then synthesized into eight subcategories and three categories.

During the coding process, memos were written to define each code, subcategory, and category by its analytic properties and bringing raw data into the memo. Besides that, the researchers collected all codes, analyzed the data, and decided 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 emerge (theoretical saturation), sorting, diagramming, and integrating memos. Finally, the researcher constructed a nursing theory that emphasized the understanding of the meaning and showing patterns and relationships.

Trustworthiness

The criteria of trustworthiness that include credibility, dependability, conformability, transferability, and authenticity (Polit & Beck, 2018; Connelly, 2016) were fulfilled during process of the study. To establish the credibility criterion, the study used standard procedures of Constructivist Grounded Theory by Charmaz (2006), interviewed participants for 1 to 1.5 hours, and observed nursing technologies created by participants and member-checking.

Besides, evidence was presented and examined several times, and data were explored well. To fulfill the dependability, maintained an audit trail of process, and also peer-debriefings with colleagues. To establish the conformability criterion, maintained an audit trail of analysis, memos, and keep detailed notes of all the decisions and the analysis of progress. These notes were reviewed by a colleague and were discussed with a qualitative researcher, and conducted member-checking with participants. To fulfill the transferability criterion, made a rich description of location and participant of the study. Finally, to fulfill the authenticity criterion, fairly and completely showed all of the different realities and realistically told participants' experiences.

Ethical Approval and informed consent

Protocol of the study and informed consent sheet were approved by the St. Paul University Philippines Ethics Research 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 "Technological Creativity as Caring Expression in Nursing (T2CEN)" theory. The T2CEN theory is defined as the creative process in co-creating nursing technologies by nurse-innovators with 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 to achieve patient wellness. This nursing theory was built by two core categories that include technological creativity and the drivers for technological development.

Category 1: Technological Creativity.

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

Subcategory 1: Nursing Technology. Nursing technology is defined as nursing tools, machines, automata, utensils, nursing intervention procedures, health education techniques, substance, and clothes designed and used by nurses in nursing practice. For example a blanket for hypothermia patients, a corset for fixation, a warm humidifier, an infusion flow sensor, a wound care table, a method to estimate the bleeding volume post-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 of 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: Process of Technological Creativity. The process of technological creativity refers to the series of phases in creating a nursing technology that includes the following phases: 1) investigating, 2) analyzing, 3) designing, 4) prototyping, 5) testing, 6) applying, and 7) monitoring phases. This process occurs continuously until the product of nursing technology can be utilized, and then redeveloping based on the result of the 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 then determining the dominant causal factor. In the designing phase, the nurses formulated the

alternatives solutions, determined a realistic solution through brainstorming with the team members, and designing the solution. In the prototyping phase, the nurses made a design of a prototype, presenting the design to the management and other colleagues. After the design was accepted, a prototype of nursing technology was made. In the testing phase, the nurses conducted a clinical trial to test a prototype of nursing technology. After that, revising this prototype based on the result of the testing followed. Then, this nursing technology was standardized and legalized by the hospital direction before reproduced and implemented to patients. In the applying phase, the nurses disseminated the nursing technology to the colleagues for the purpose to socialize the implementation of the nursing technology in the nursing practice. The nurse-innovators collaborate with the management to commercialize and supply that nursing technology for the patient and nurses' needs. In the monitoring phase, the nurses evaluated the effectiveness and efficiency of nursing technology for the purpose to revise and develop the next nursing technology. And, the nurses proposed Intellectual Property Rights to the management. Some of these findings can be found in the following participant statement:

> *"...We assessed the patient's problems. ...We analyzed it; ...We sought an idea that 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 refers to a nurse who has specific characteristics that are different from non-nurse-innovators. Those characteristics include 1) thinking out-of-the-box, 2) positive emotional engagement, and 3) team synergy. Thinking out-of-the-box is the cognitive ability to think differently or unconventionally about something that includes visionary, inquisitive, critical, analytical, creative, imaginative thinking, innovative, logical thinking, and open insight. Positive emotional engagement is the

good attitudes or emotions of the nurses in creating nursing technologies that include enthusiasm, work hard, have fun in making creativity, never-give-up, active, initiative, hopeful, care to the patient, sensitive to patients, sensitive to the need in the work, humanize, and sacrifice; besides that, willingness, consistent, persevering, loyalty, responsibility, commitment, discipline, persistence, and seriousness on making innovations. Meanwhile, team synergy is the abilities of the nurse to collaborate with other nurses or other health or non-health professionals in creating a nursing technology that includes the ability to communicate, togetherness, loyal, synergy with the team, open-minded, able to cooperate, able to coordinate with the team, open-minded, solid teamwork, and interpersonal relationship. The following participant told about the characteristics of a nurse-innovator.

> *"We needed a disciplined person, a creative person, consistent, and persevering. Because of 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 is defined as the process of sharing information, competencies, and responsibilities to jointly create a product of nursing technology between nurse and nurse (intra-professional collaboration) or nurses and other health or non-health professionals (inter-professional collaboration). These findings can be found in one of the following participant's statement:

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

Subcategory 5: Supportive Environment. The supportive environment is defined as the conditions that can support the nurses in creating nursing technologies to encounter the problems of the patients, nurses, and management. This condition includes adequacy of management support, the existence of a quality control team, facilities in the workplace, time availability, and the colleagues' support. These findings can be found in the following participants' statements:

> *"To develop creativity ... especially related to nursing 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 facilitates us. The hospital had allocated the funding for research, for developing the hospital services; it was much facilitated.... In the hospital, the QCC (Quality Control Circle) team could motivate or encourage the development of hospital facilities. ...Every year we could make an innovation based on the actual situation." (P15)*

Category 2: The Drivers for Technological Development

The drivers for technological development are the reasons of the nurses that drive to create nursing technologies in nursing practice that include assisting patients in managing their health problems, to facilitate the need of nurses in the working, and to improve the performance of the management in healthcare services and for patients' wellness. This category is synthesized from four subcategories that include 1) caring for patients, 2) caring by nurses, and 3) caring by management, and 4) patient wellness.

Subcategory 1: Caring for Patients. Caring for the patients is defined as the meanings, the reasons, and the benefits of creating nursing technologies for the patients and nursing care process such as knowing the patient, solving health problems, maintaining patient safety, helping patient, knowing patient's problem, becoming closer with a patient, satisfying patient, comforting patient, reducing patient complaint, reducing complication, reducing cost, holistic caring, and improving quality of nursing care. The following participant revealed the meaning, reasons, and benefits of creating nursing technologies for the patient.

> *"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 by Nurses. Caring by the nurses is defined as the meanings, the reasons, and the benefits of creating nursing technologies that 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 nurse, and satisfying nurse. These findings can be found in the following participant's statement:

> *"Its meaning, actually because of 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 by Management. Caring by management is defined as the meanings, the reasons, and the benefits of creating nursing technologies that felt by the management, such as improving the quality of nursing care service, improving the efficiency, improving the effectiveness of service, increasing hospital income, improving good image to the hospital. The participants below expressed the meaning, reason, and benefits of creating nursing technologies that are 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 need a little disinfectant liquid in the tool container only. After that, the patient was transferred to the bed in clean condition. We bandaged without transferred the patient to another bed…. Reducing the duration of care, efficient personnel, material, and instrument…." (P6)*

Subcategory 4: Patient Wellness. Patient wellness is defined as a condition wherein the reduction of the health problem/morbidity or the mortality risk of the patients has occurred. This subcategory is derived from codes of reducing morbidity and reducing mortality risk. Reducing morbidity has multiple meanings such as reducing pain, preventing contracture, preventing complications, feeling better, preventing patients' accidents, promoting happiness, and preventing hypothermia. Reducing mortality risk can mean preventing airway obstruction, preventing dehydration, and other risks. This finding can be found in the following participant's 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 (Paediatric 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 the following: 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 of the nurses in nursing practice. 5) Technological creativity as a caring expression in nursing can influence patient wellness.

The Theoretical Model of Technological Creativity as Caring Expression in Nursing

To give concrete visual images of the relationships among concepts and statements in the logical order, the theoretical model of the T2CEN theory is presented in Figure 1.

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Figure 1 presents the theoretical model of T2CEN that is visually presented as "machine gears". These machine gears are used as a symbol of technology because technological creativity constitutes a central concept in this nursing theory. These gears are also symbols of the interaction or interrelation among components of the T2CEN theory. This theoretical model consists of four major components that include 1) the nurse-innovator (left side gear) who collaborate with health or non-health professionals to create nursing technologies, 2) technological creativity as caring (center gear) is as a central and essential component. The nurse-innovators create nursing technologies to express caring for patients through seven phases that include investigating, analyzing, designing, prototyping, testing, applying, and monitoring phases. 3) patient wellness (right side gear) is as the ultimate goal of the nursing care process and as feedback for the nurses to revise or develop future nursing technologies, and 4) enveloped by a supportive environment (outer ellipse) that provides the

milieu where all three major components happen and support in creating nursing 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' problems in the work, improving management performance, and for the ultimate goal to 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 in solving problems or seeking solutions for patients (Watson, 2015). Bagherian et al., (2017) claimed that there was a positive association between the use of technology and caring attributes. Caring attribute scores of nurses is increased regarding the use of technology in nursing practice. A few study concluded that technology decreased caring behavior such as Schenk et al. (2018) concluded that caring efficacy was observed a slight decreased post-Electronic Health Record implementation.

The phases of the process of technological creativity in the T2CEN theory through seven phases that included investigating, analyzing, designing, prototyping, testing, applying, and monitoring phases. These phases have some similarities to the process of bio-design (Yock et al., 2015). The similarities between those models are that the nurse's activities in the investigating and analyzing phases are similar to the identify phase in the bio-design process. The activities in the designing and testing phase are similar to the invent phase in the bio-

design process. Finally, the activities in the applying and monitoring phases are similar to the implementation phase in the bio-design.

In the process of technological creativity, the nurses attempt to know a patient's problems well; because the nurses fully investigate the patients' problems. Besides that, nurses can fully know the patient's needs, knowing nurse's and management's problems in the working. Surely, this full knowing or understanding of the nurses to the patients, nurses, and management problems can become a starting point to create a nursing technology that will be used as a solution to solve their problems. This is similar to Roach's caring attribute which through compassion the nurse attempts to understand the patient's experiences in feeling pain and discomfort (Caranto, 2015). Besides that, there is an active relationship between nurses and patients in the process of technological creativity. This relationship can inspire nurses to design and develop nursing technology to solve the patient's problem. This relationship is also similar to the concept of mutual designing in the practice process of Locsin's theory. He explained that both the nurse and one nursed together create a plan of care (Locsin, 2017).

In the nursing technologies creativity, many kinds of nursing technologies had been created by the nurses; although those technologies still had not been developed optimally that included nursing tools, machines, automata, utensils, nursing intervention procedures, health education techniques, substance, and clothes. According to Barnard (1996), the three layers of technology included 1) the physical objects such as tools, machinery, and matter, 2) technology as knowledge, through the knowledge, nurses will know how to use, repair, design, and make it, and 3) technology as a complex set of human activities is understood as the creation of a technique. Meanwhile, Locsin (2016) described that nursing techniques can include nursing therapeutic, interpersonal techniques, nursing care procedures, and educational techniques for patients. Further, Barnard (2009) defined that technology is as

machinery, equipment, tools, utensils, apparatus, automata, utilities, and structures in the practice and also organizations. Furthermore, 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 the most commonplace and ordinary technologies of nursing. Further, Locsin (2017); Locsin and Ito (2018) classified technology in healthcare into five dimensions that included 1) technology as the completer of human beings such as mechanical devices, organic or biological of human tissues/organs, 2) machine technologies to facilitate the practice of caring, 3) technology mimics human being such as robots built-in 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 nursing technologies creativity process. The nurse-innovators have three main characteristics that include thinking out-of-the-box, positive emotional engagement, and team synergy. These characters are very important and as the potency to expand the nurse role. The nurses are not just technicians or deputies of the medical profession in operating medical technologies in healthcare. However, nurses should be nurse-innovators or creators; because they hold the responsibility in discovering better quality of nursing services (Kaya et al., 2015). Through technological creativity, Lachman et al. (2006) stated that nurse-innovators can open access to create systems, to support and enhance healthcare, and emerging technologies.

In creating nursing technologies, nurse-innovators need collaboration with a health professional or non-health professional. Collaboration is very important in developing a nursing technology; because sharing information, competencies, and the involvement of each collaborator has occurred. Morley and Cashell (2017) defined that collaboration is integrating between activities and knowledge which collaborators requires a partnership to share

authority and responsibility. Further, they explained the critical elements of behaviors and attitudes in collaborative practice that included: 1) Coordination (working in achieving shared goals), 2) Cooperation (contributing, understanding, and valuing the contributions of team members), 3) Shared in making decision (involving communication, trust, openness, negotiation, and respectful), 4) Partnerships (cultivating open, respectful relationships, and all members work equitably).

A process of technological creativity needs a supportive environment. This environment includes adequacy of management support, the existence of a Quality Control Team, facilities in the workplace, time availability to create nursing technology, and the colleagues' support. This factor is an essential element in enhancing the process of technology innovations in nursing practice. Technological innovation will be very difficult to be conducted if the work environment lacks the support needed. Joseph (2015) revealed preconditions that influence innovation in an organization included: 1) values of 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).

The Drivers for Technological Development

The findings showed that the main reason of the nurses was driven to create nursing technologies in nursing practice is to assist patients in managing their health problems (caring for patient), to facilitate the need of nurses in the working (caring by nurses), and to improve the performance of the management in healthcare services (caring by management). These findings are supported by Lachman et al. (2006); 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 fulfilling the care and treatment methods. Besides, the technology can improve patient safety, one's work, and service, and achieving more time in direct contact with patients (Jelec et al., 2016), to improve nurses' communication with other healthcare providers and documentation in healthcare (Rouleau et al., 2017). Moreover, personal care robots can reduce the physical burden of caregivers such as wearable or non-wearable transfer aids, toileting aids, and monitoring systems for nursing care homes or private homes (Yamazaki et al., 2017). And, the use of the Intensive Care Information System (ICIS) reduced the time of documentation up to 30%, reduced the physical exertion of nurses, and increased productivity and communication between nurses and patients, and other health professionals, and patients' families (Jelec et al., 2016).

Another reason for the nurses in creating nursing technologies is to promote patient wellness. Patient wellness is a condition wherein the reduction of the health problem/morbidity or the mortality risk of the patients has occurred. This finding is supported by Kaya et al., (2015) who stated that a technology as a product of nurses' creativity has an advantage in improving health. Besides, Swanson (2015) claimed that the ultimate goal of caring is to enable clients to achieve well-being.

The implication of the study

The practice implication of the study in nursing practice is that the T2CEN theory can be used as a guideline to express caring for patients, nurses, and management by creating nursing technologies to solve the problems in nursing practice, to improve quality of caring, and to promote patient wellness. Besides that, this theory application can accelerate a change in nursing culture and open opportunities to change conventional caring culture to modern caring culture; as Ball et al. (2011) claimed that technology can be used to change a culture in nursing practice. Therefore, the nursing profession needs the T2CEN theory to encourage

nurses actively in expressing caring through technological creativity. As a huge impact, the nursing profession is not very dependent on the development of healthcare technologies created by other health professions. However, nurses will be independent in developing their nursing technologies, and able to participate actively to address technological dependence in nursing practice. Fasnacht (2003) revealed that creativity constitutes an essential component in daily nursing practice when nurses interact with patients, families, and other nurses. Failure to appreciate and encourage nurse's creativity will be a barrier for future innovations in nursing practice. Furthermore, Johanson (2016) explained that the use of technology in today's healthcare constitutes consideration for caring for patients of the millennial generation.

Strengths and limitations

This study has several strengths such as the generated theory is a new one in nursing theories because technological creativity in nursing had not been investigated deeply in previous nursing theories. This study also can be replicated in other nursing settings; because technological creativity is universal. Besides that, the generated nursing theory specifically the concept of "creativity" can contribute to complete a new attribute into the 6Cs attributes of caring by Roach (2002). However, this study also has a limitation that includes participants of the study is only nurses at one hospital in Indonesia. So, perhaps it has differences in work culture, qualification of nurses' education, work environment, and hospital management.

Conclusions

This grounded theory study generates Technological Creativity as Caring Expression in Nursing (T2CEN) theory. The T2CEN theory is a middle-range theory that focuses on technological creativity to express caring for patients in the nursing practice. This nursing theory is bridging between Watson's Human Caring theory and the phenomena of nursing technologies creativity in nursing practice that consists of elementary ideas stem from Watson's Human Caring theory.

Based on the substantive findings, the researchers suggest that: 1) the nurse-clinicians can use the T2CEN 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 nursing technologies. 2) The hospital management considers developing a policy that can stimulate and support an innovative culture in the hospital. 3) Nurses Association may explore opportunities in advancing a nursing practice standard and a new role being a nurse-innovator. 4) Introduce this nursing theory as part of the core curriculum in nursing education; so that the future nurse will have competence in creating nursing technologies. 5) Future researchers may test this nursing theory through researches in various settings, and use it as a direction for developing future nursing theories.

Acknowledgments

Deep appreciation is extended to the nurses who had participated to share their experiences in completing the study.

Conflict of interest

The author(s) declared the research, authorship, and/or publication of this article no potential conflicts of interest.

Funding

This study was funded by Malang State Health Polytechnic where one of the researchers works. There is no external funding supporting this study.

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