

The Development of the Transactive Relationship Theory of Nursing (TRETON): A Nursing Engagement Model for Persons and Humanoid Nursing Robots

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Abstract

Background: Precise nursing actions assure quality human health care. However, such actions are often identified as low-level health care work thereby delegated as tasks that only need completion. With the Japanese elderly population increasing at a phenomenal rate, these types of nursing actions are critically demanded. As a health care practice problem leading to labor shortages in health care settings specifically among nurses and direct health caregivers, Japan has made a national commitment focused on developing healthcare robots to respond to the nursing care demands of the older adult population. Transactive relationships are necessary in human and robot nurse-patient interactions. How will human persons and humanoid nursing robots (HNRs) relate with each other? Research on robots assisting patient care is needed to reduce human-dependent activities thereby sanctioning human nurses' focus on direct human caring relationships.

Aim: The purpose of this paper is to describe the development of the Transactive Relationship Theory of Nursing (TRETON) for nursing engagements between HNRs and human persons.

Methods: Theory development and Systematic Review of Literature focused on the phenomenon of healthcare engagements, humanoid robots, and nursing practice. Specifically, the metaparadigms of Nursing provided the procedural theoretical structures.

Results/Findings: The TRETON is the product of theory development. Nursing encounters between humanoid nursing robots and human persons in transactive interactions were described within the metaparadigms of person, nursing, environment, and health.

Conclusion: The TRETON is a middle-range theory of nursing guiding nursing practice focused on the relationship between human persons and humanoid nursing robots. It endorses two critical nursing questions, i.e., if the nature of HNRs is to assume human caring practices to promote human health and well-being, will this nature matter to nursing care of human persons? What will engender the nature of the transaction between human persons and HNRs in 21st century ontology of nursing?

Introduction

The aging population in Japan has increased and continues to increase at a phenomenal rate unequalled in any other country [1]. This phenomenon signifies that the population of older persons and in particular those with dementia are also continually increasing. It is predicted that by the year 2025, one out of every ten older adults will suffer from dementia [2]. In addition, the declining birth rate associated with the aging society has similarly contributed to this changing population demographic structure [3].

Also, while the aging population is increasing, the working-age group has not caught up with the trend. This situation has expectedly become a serious social problem, leading to labor shortages, particularly within health care settings. Reacting to this phenomenon, Japan has made a national commitment focused on the development of healthcare robots especially for the older adult population [4].

Research on robots that assist patients in physically transporting themselves [5], or that perform simple tasks like taking vital signs or delivery [6, 7] is critically needed. Reducing these types of human-dependent activities will, more importantly, allow human nurses to focus on direct human caring relationships and nursing care for these patients. Furthermore, healthcare robot research is urgently needed to focus on developing new computational algorithms for determining accurate patient emotional state classification in interactions between human and intelligent machine relations with healthcare robots during health care services [8].

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In response to these identified needs and demands, studies have been conducted which focused on topics such as “what is a healthcare robot?” and “what nursing tasks physically performed by human nurses can be performed efficiently by healthcare robots?” or “what are the possibilities that HNRs play in stereotypical human nurse behaviors?” Because nursing care is more than the completion of tasks that HNRs can perform, it is not appropriate to define nursing care as the performance of tasks that HNRs can do. It is now a reality that technical capabilities possessed by HNRs are dramatically evolving, answering some or most of the aforementioned questions.

Moreover, some extant studies currently inform the topic of healthcare robots' functionalities [6, 9-16]. The findings of these studies direct the futuristic consideration of perfecting a ‘real’ HNR that can assist with the demands of human caring in nursing.

As the health status of patients change, it will be necessary to verify the extent of the needs and demands for health care, and to explore

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whether or not robots can actually share in the fullness of nursing care, such as in situations requiring competent assessments and timely judgments or whether or not caring or the functionality of HNRs is a major assistance to the tasks of nursing. Ethical and moral issues have challenged experts of nursing and engineering in Japan and in the broader global community. However, while there exists a need to address the functionalities of healthcare or caring robots, little discussion were made for the most part on the introduction of these robots into health care settings.

Nevertheless, what is important to understand is the apparent apathy that nursing professionals have shown towards nurses, healthcare or caring robots, and similarly, as Ito et al. [17, 18] have found, the lack of interest from nursing experts on the existence and use of intelligent machines in healthcare settings and their lack of current information about them.

The purpose of this paper is to describe the development of the Transactive Relationship Theory of Nursing (TRETON) for nursing engagements between humanoid nursing robots and human persons.

Computerization and Artificial Intelligence (AI)

Computerization and nursing

The overwhelming development of personal computers, the intranet and the Internet is transforming the work methods of nurses, physicians, and other healthcare staff members who work in hospital settings. Two of the most distinctive technologies available and used in current health care settings are the ordering systems and the use of electric care cards [19].

The functionalities of these technologies are irreplaceable. For example, when a patient undergoing an examination at an internal medicine clinic is given an order for a prescription, the ordering system makes it possible to send that data to each department instantly. By using electric cards, clinical data and nursing data are recorded and shared with multiple professionals.

The introduction of AI has reliably increased the speed of healthcare operations particularly in hospital settings, supporting the anticipation and realization that AI has a more expansive future. HNRs would change human relationships, particularly between human persons as patients and nurses. In view of this, what is most important is that nurses actively participate the HNRs' development, and in order to introduce it into resource-poor settings, help design and test their functionality. Also important is the concern regarding the relationship between nursing judgment and the use of databases. By using nursing judgment in thirteen areas of NANDA (North American Nursing Diagnosis Association), NOC (Nursing Outcome Classification), and NIC (Nursing Intervention Classification), a description of the manner and kind of observations and care given is accounted for, so that a necessary nursing plan can be made. However, as a technological system, it is possible that technical problems will occur.

There are two common possible problems identified. First, in the case that a nurse uses NANDA just as if it were a simple manual, the healthcare robot with AI capabilities will inevitably function only as an old-fashioned robot. This means that the impersonal aspect of technology is perceived to de-emphasize the need to know the patient and act as a distraction from the nurse-patient relationship. In situations such as these, nurses are torn between the human caring model of nursing and the robot-like attitudes perceived to be created by technology [20] or other prescriptive data bases such as NANDA, NOC and NIC.

The other possible problem is that if a nursing plan of care is made automatically without any information derived from conversations/discussions between patients and nurses, knowledge about the patients will not be current, and nursing care will become mechanical – without actually knowing and understanding the patient as human person and his/her unique needs or hopes. It is useful to take advantage of this situation and understand that with these databases, technological systems as nursing diagnosis are recognized as empirical ways of knowing the person.

However, it is most important to note that to be functional, competency with this technology ought to be understood and appreciated as an expression of caring in nursing. The expression of nursing, caring and technology is advanced by Locsin [21] in the middle range theory of *Technological Competency as Caring in Nursing*.

Evolution of HNRs as intelligent machines

Fundamental questions exist that challenge the development of HNRs. These include: (1) What is healthcare and nursing? (2) Should nursing robots be humanoids? (3) What necessary functions are required for these robots so that their performance of delegated healthcare tasks can be enhanced? (4) What level of intelligence should healthcare robots and HNRs have so that it can function effectively as a responsive 'assistant' to human persons as patients? (5) Up to which levels of decision-making should HNRs have to be dependable partner assisting in solving patient-care problems? (6) What ethical issues for HNRs exist as it is introduced to medical institutions or hospitals? These questions warrant answers that help foster understanding of human-to-intelligent-machine interrelationships.

The transaction that occurs between intelligent machine technologies and human beings originate from the perceived desire of assuring the quality of patient care now and in the future. In so doing, a guide for practicing nursing from the perspective of HNRs and caring in nursing is presented as integral to ensuring the quality of patient care, with intelligent machines as primary characters within the transactive relationship.

Persons, therefore can be understood as patients and their families, healthcare providers, nurses, or in the future, those intelligent humanoid nursing robots. Human caring practice is an excellent intervention for nurses to use, in which both nurses and HNRs will be involved in an intra-disciplinary health team care. Health, therefore can be understood as the appreciation of human-robot transactive processes for human health caring encounters between human persons and HNRs. This transactive process facilitates the attainment of quality health and well-being.

Furthermore, the health care environment will depend on the dynamic social development in which technology, as within the environmental milieu is used to make people healthy and well. Therefore, the end focus of nursing expressions of caring is health and well-being in which the nurse enhances the living of the person who is being nursed.

In addition, nurses must have a deep understanding of the code of ethical nursing practice to guide the introduction of new technologies, especially intelligent machines, and their usefulness in health care in perpetuity. There are no common conceptions of ethico-moral practices within all cultures and so the ethics of care in one country may or may not be accepted in another country.

Today, care for patients following AI as instructed activities based on human-made programs require that all robot-programming ought to be accomplished with expert human being management. However, this may change in the future, when robot technologies and AI will surpass human intelligence and ingenuity.

Concerns about HNRs characteristics

There are two possible problems with the introduction of HNRs. First, there is an ethical problem. Human nurses are licensed to provide nursing care, the license guaranteeing the nurse's competence to provide nursing care including assessments, decision-making, and the competent use of technologies. However, for the moment, there is no similar standard for HNRs. Nurses must consider how the qualities of the robots' performance of their specific tasks are ensured. Secondly, if nurses are not included in decisions about the appropriate use of HNRs, then engineers or business giants will make the crucial decisions. If these issues are solved and the government bestows nursing licenses to HNRs, then the robots will become assistive colleagues of nurses and be able to work at hospitals.

As HNRs are actually 'personalized' AI, their capabilities may be below the level of humans, and it is natural that nurses should consider them as assistants. However, today, some robots with AIs have the ability to improve themselves through activity encounters just like humans do [22]. Looking to the future, one can see the possibility that robots with AI will exceed human intelligence, i.e., when scientific advancement brings to existence robots with super AI and with high functions of learning [23]. Furthermore, what is important is the possibility of robots with AI creating their own AI.

However, it is now possible that AI with the intelligence and information-processing skills of human nurses will soon be available in health care institutions. Is it then possible that HNRs will exceed nurses' capacity to provide professional care and perhaps assume their roles?

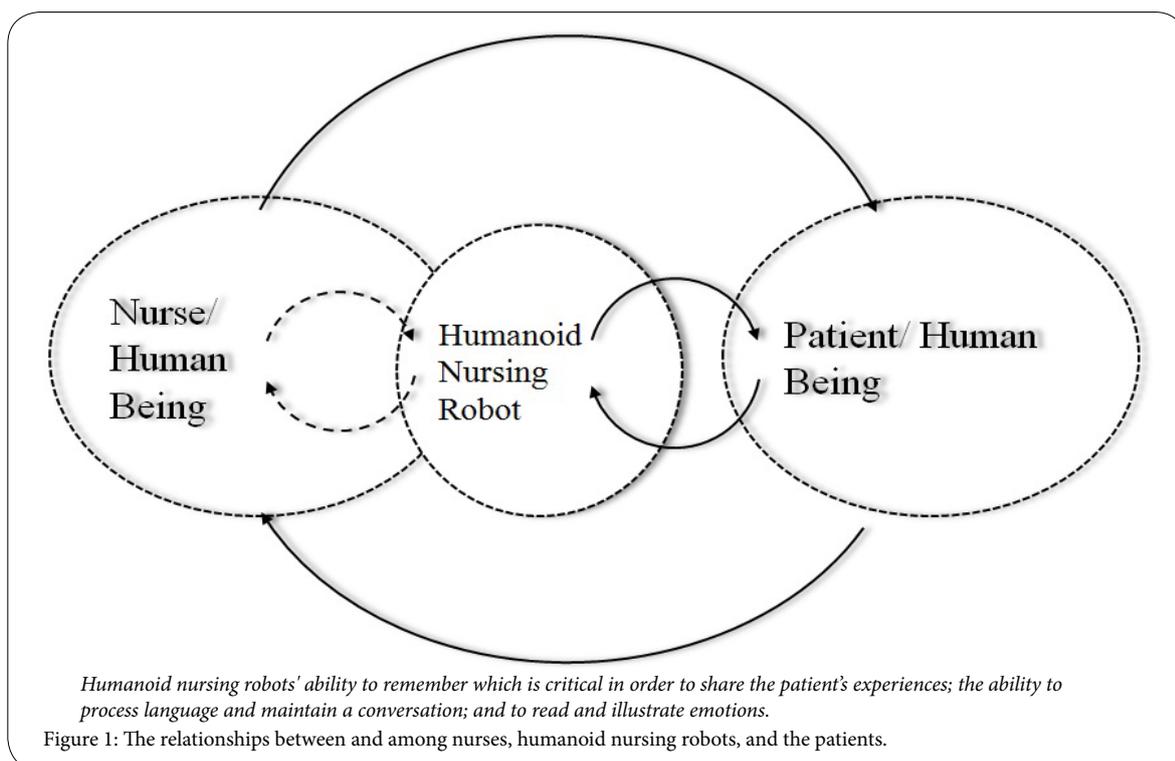
Theory Development Process

Theory development processes were conducted through a Systematic Review of Literature focused on the phenomenon of healthcare engagements in nursing with humanoid nursing robots (HNRs) and nursing practice. The metaparadigms of Nursing [24-26] engendered the structure of the theory in which the concepts of nursing, persons, environment and health organized the ontological and epistemological descriptions expressly elucidated in the practice of nursing engagements of human persons and HNRs.

The Transactive Relationship Theory of Nursing (TRETON)

Revealed in this theory is a practical process of relationship advanced as the transactive engagement between human persons (patients) and caring or HNRs as intelligent machines. As such, the theory illustrates a unique and emerging practice of nursing. The realization of human and intelligent machine transactions in human health care has been the impetus for the development of the Transactive Relationship Theory of Nursing. As the demands and needs for quality health care rise, particularly in environments poor in human resources and among the older adult population, the use of human-machine process requirements is intensified, and the realities and consequences of transactive relationships have become integral to assuring quality human health care.

"Transactive" is a term that focuses on the transactional nature of things. As an active process, it illuminates the main feature of the relationship between human-to-human and human-to-intelligent machines which is that it is always a transaction. The term delineates as well as illuminates the relationship between HNRs and human persons (patients). The TRETON is a theoretical transactive engagement, and as such, the process of nursing is an 'active' engagement between the nurse and person being nursed (Figure 1).



Some of the concerns, demands, and needs which have influenced the development of this theory include:

- The functionality of HNRs as a requirement for assisting in human caring.
- The possibility that patients, especially older adults and those with dementia can gain well-being from dialogues and conversations with HNRs.
- The need for theories guiding nursing practice with HNRs.
- Accordingly, the following questions are posited:
- If HNRs are developed and introduced into healthcare facilities for older adults, should not the ethical issue of robotic practice engagements be prioritized and fully discussed and addressed for realizable solutions?
- What functionalities may be required of HNRs to engage in a compassionate, nurturing relationship within the demands of robot performance?
- Should nurses and other key health care personnel still provide the required health care tasks and practices considering human-to-human relationships, and between humans and HNRs?
- These questions advance the transactive relationship theory of nursing (TRETON) as focused on the constant and “active” transactional engagement between the nurse, the HNR, and patient triad.

Theoretical assumptions

The Transactive Relationship Theory of Nursing (TRETON) is a middle-range theory grounded in the general theory of Nursing as Caring [27], and the Technological Competency as Caring in Nursing [21] middle-range theory. It is a critical and much-needed theory from which is derived a practical process of nursing as a transactive engagement expressed as nursing transpiring between the nurse and nursed - the shared engagement between human persons (patients) and intelligent machines (HNRs). This engagement is an active interaction between the nurse and nursed co-existing in a transactive relationship. How will this process of transactive engagement guide the practice of nurses in human person-HNR nursing encounters? The theory acknowledges ways in which human-to-human and human-to-intelligent machine nursing encounters are expressed in nursing.

- **Nursing is a relationship between and among human beings (human persons) and intelligent machines (HNRs)**

AI influences HNR functionality. AI is necessary in HNRs. In order to express caring in nursing, HNRs are used to enhance the quality of nursing care by the “delegation” of healthcare tasks to the robots—not to solve the nursing care problem, nor meet the demands of task completion because of shortage of nurses or other health caregivers.

- **Nurses use technologies of care for practice**

Nurses are adept at technologies that aid the practice of nursing. However, an understanding of and intentionality with the code of ethical practice for nurses guides the suitable use of AI in hospitals and in other healthcare arenas. Nurses must always exercise sensibility with AI-capable equipment. Transactive relationships are guided by ethical use of AI in nursing.

- **Intelligent machines possess AI that can mimic human interactions**

Various levels of AI provide ‘intelligent’ versions of humanoid robots capability of interactive discourse and seamless physico-mechanical movements. Today, robots abound in health care institutions: From guided delivery of ‘containers’ of medications, to automated security systems, surgical instrumentations, and interactive telemachines. The AI of HNRs gives them the ability to engage in practical relationships, to possess high-level AI programming, and to extend interactive discourse with human persons.

- **Human-to-intelligent machine relationships are technology dependent**

From mobility to physical capabilities, robots depend on sophisticated technologies – from enhanced robotic performance to ‘super-intelligent’ discursive abilities.

- **Transactive relationships are guided by ethics in nursing**

Regardless of the level of sophistication in physico-mechanical functions and intelligence, HNRs are expected to have a programmed response system that is guided by ethico-moral sensibilities. The possible problem that may arise in possible contradictory situations is the dependency that robots may encounter in relationship situations, simply because it is dependent on human coded programs.

Enhancing nursing and caring with HNRs

If HNRs are to be developed and introduced into hospitals and other healthcare facilities then ethical issues for practice engagements must be discussed and addressed with realizable co-created solutions. Its basic function is to support nurses and enhance patient healthcare. It will become necessary for these intelligent machines to be equipped with the functionality to recognize and respond to the emotional expressions of persons [9]. Caring is an intentional expression of Nursing thereby generating the expectation that in the future HNRs will be able to facilitate human caring. HNRs may be delegated to “be with”, to “listen to”, to “gently touch”, and support other caring behaviors programmed into its system.

Caring is a concept central to professional nursing practice and discipline [28]. Since the time of Florence Nightingale, the goal of nursing has remained unchanged, i.e. to provide a safe and caring environment that promotes patient health and well-being [29]. Mayeroff [30] in his book *On Caring* provided a detailed description and explanation of the encounters of caring by and being cared for. Since then nursing theorists grounded in caring have been studying the relationships between nursing and caring. Mayeroff [30] has expressed that there are basic ingredients of caring expressed between a parent who is caring for a child, a teacher who is caring for a pupil, a psychotherapist caring for a patient, or a husband caring for his wife. They all exhibit a common pattern of caring even though such caring may be uniquely expressed.

Other ingredients of caring by Mayeroff [30] include: honesty, courage, hope, knowing, patience, trust, humility, and alternating rhythms. These ingredients are useful in helping one to understand the ambiguous concept of caring, as one is called to reflect on how each of these ingredients is lived uniquely every day. This understanding of living, caring, and knowing the self as caring is the basis for knowing the other as caring.

Similarly, Boykin and Schoenhofer [31] offered that caring in nursing must be a lived experience of caring between the nurse and the person being nursed, communicated intentionally, and in authentic presence and interconnectedness, express a sense of oneness with oneself and other. They [31] declared that the knowing of nursing is embedded within the nursing situation, defined as a shared lived experience in which the caring between the nurse and nursed enhances personhood. Thoughtful reflection upon practical nursing situations provides exquisite opportunities for uncovering the knowledge and essence of caring in nursing.

Moreover, Locsin [21] explained the connection between technology and caring in nursing. Specifically, technological competency as caring in nursing is the effective use of technologies which allow nurses to understand patients more fully as whole persons and in doing so, understand patients' "calls for nursing" and respond accurately and appropriately to their hopes, dreams, and aspirations for living and growing in caring. The complementary system of "calls for nursing" and "response" builds up trusting relationships between human persons as patients and nurses.

The nursing encounter: where all nursing occurs

The nursing encounter is what Boykin and Schoenhofer [27] describes as a 'nursing situation,' the shared lived experience in which the caring between the nurse and nursed enhances personhood. Similarly, it is also what Locsin [32] has called the technological encounter of a co-created moment in which the nursed and nurse, through technologies of care, come to know each other more fully as caring persons.

The occurrence of a nursing relationship exists between and among human-to-human and human-to-intelligent machines. The nursing

encounter is the focal point of engagement between the nurse and nursed. Two distinctive features of this engagement are the human-to-human relationship between the human nurse and human patient, and the technological engagement between the humanoid robot - the intelligent machine - and the patient in "its" care. As technological engagements occur, the nursing encounter is illuminated as the shared experience fostering human caring. In order to acknowledge the value of understanding these encounters, the necessary element of "knowing" the patient is initiated.

As one of the central characters in this nursing encounter is a highly evolved intelligent machine, technological knowing [32] becomes an essential dimension, an initial stage of knowing. The occasion in which the transactive relationship through technological knowing occurs is *mutual engagement*. Such a relationship is much like Locsin's [33] mutual designing, an elemental dimension in the practice process of the Technological Competency as Caring in Nursing theory. If the HNR and the human person assume the participants-in-their-care role, the patient may passively or actively participate in creating a plan of care addressing the desire towards well-being or more-being [34] or of enhanced personhood [27], i.e. living the meaning of one's own life (Figure 2).

Moreover, in the healthcare setting a variety of technology is introduced; the ultimate form of providing care through the use of AI technology is considered humanoid robot activities. These activities are expressed as tenderness or caring within the human - technology interactions, practices which are much like those that human beings do, thereby easily appreciated as similar to human-to-human caring. This is the ultimate form of the human-to-intelligent-machine transactive relationship. It is the rationale following the dual features of the theory-based practice in human-to-human, and human-to-intelligent machine engagements.

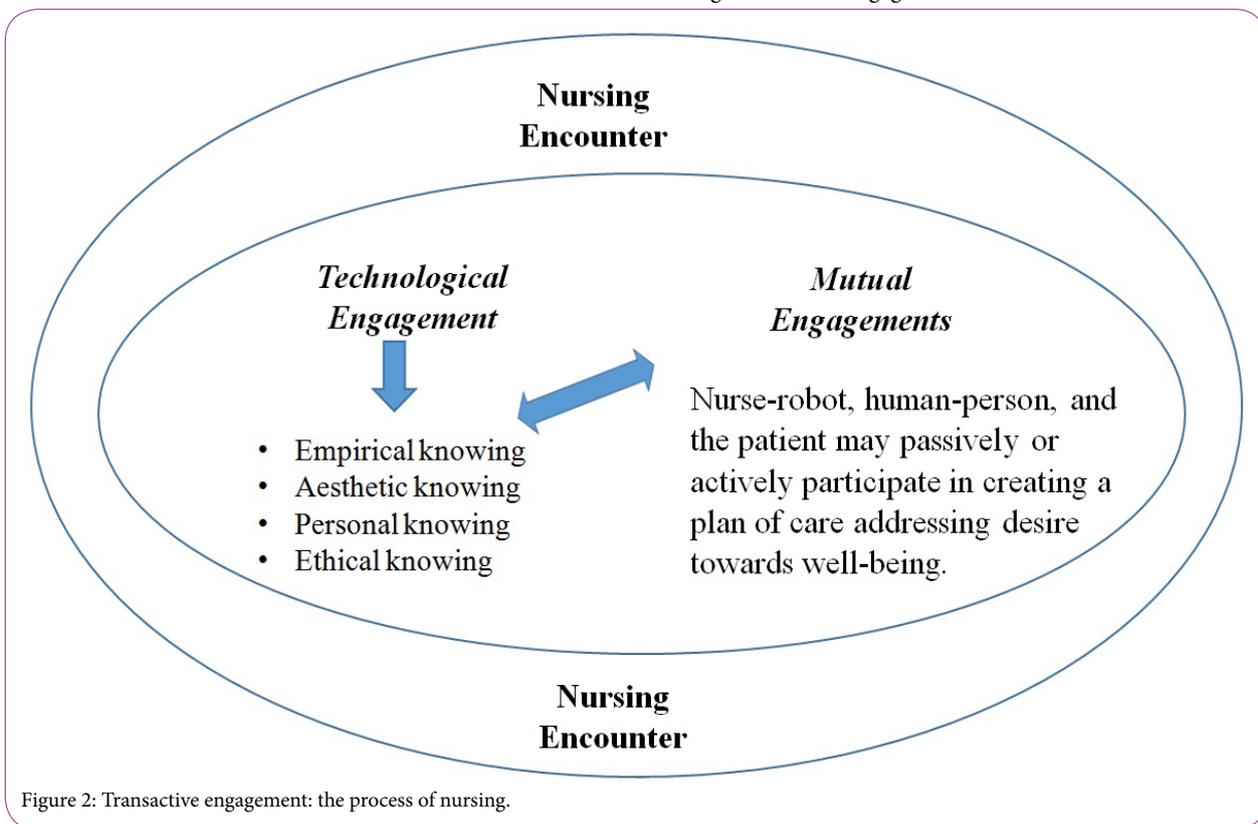


Figure 2: Transactive engagement: the process of nursing.

Today, the usefulness of Humanoid Nursing Robots may be about the functionalities of physical care for patients - for example those requiring change of patient clothing - and continuous monitoring of vital signs, to name a few. In order for HNRs to recognize humans, they have to exist in the world of the patients, to be in the world of those receiving nursing care, and secure consent from the patients and other healthcare staff. Patients have a right to decide whether or not to allow nurses and HNRs to collect and store their personal information and medical histories. This consent for nursing care and the acquisition of health information should be sought upon admission.

It is necessary for professional nurses and patients to fully understand the usefulness of these intelligent machines and the elements of their delegated care. Patient cooperation and patient safety are assured when an understanding among all participants is reached, in that the patient understands that the professional nurse has delegated certain healthcare tasks to the robots, but also that the nurse remains responsible for the tasks performed by the robot. It is also crucial to obtain permission from the patient because they need to check whether nurses are suited to care for them so that they could build a relationship of confidence. However, in their case, it is critical that patients - as well as human - nurses see to it that these intelligent machines are indeed trustworthy. This is an element of delegation in which the nurse gives healthcare tasks to the delegatee, which in this instance is the HNR, although the nurse continues to retain responsibility for the care provided.

Performance of humanoid nursing robots in a transactive relationship

What abilities may be required of HNRs to 'practice' nursing as human caring within the demands of robot performance? Anthropomorphic machines are embodied mechanical entities interacting with humans [35]. The performance of these machines ought to focus on their ability to remember, which is critical in order to share the patient's experiences; the ability to process language and maintain a conversation; and the ability to read and illustrate emotions from facial expressions - these will all become necessary functions. Essentially, in various healthcare settings, it will be necessary to facilitate and encourage conversations centering on the relationship between "human persons" as well as the conversations between "human persons and human persons", and eventually among "human persons and HNRs".

The practice of nursing requires the ability of nurses to understand patients. Therefore robots should also possess this ability, so that they may be able to practice similar to humans or better. The robots may also be required to possess high-level thinking properties/processes, such as empathy, confidence, and conscience. The five human senses will all become their requisite characteristics [36]. In order to function like human nurses, these HNRs must show an understanding of patients based on some level of expertise and conscience, and the ability to express themselves humanely, including being empathic and kind.

Moreover, in nursing relationships, the nurses also need to grow alongside the patients. What does it mean when human nurses grow in their caring [30]? Nurses learn from the patients through encounters, and grow with their experiences which can influence future practice. For this reason, it may be necessary to develop HNRs equipped with

self-enhancing AI, assuming that these intelligent machines can record empirical knowledge onto their specific databases - an AI system equivalent to a human brain. In this situation, the HNR can share experiences with other human nurses, HNRs, and other similar technologies as legally sanctioned by law.

Furthermore, while Travelbee's [37] interpersonal model of nursing focused on human-to-human relationships, it is also important to understand the specific concept of human relationships - a feature of engagement of a HNR with a sophisticated AI.

HNRs and knowing in nursing

Knowing a person is a central feature of human caring and HNR caring practice if it is to be significantly valuable to nursing and human health care must be able to sanction such activities as knowing persons. Nurses are required to make good use of these HNRs and thereby help them understand human persons (patients) more fully. Nursing does not only require technical skillfulness, which HNRs can excel at, but also the ability to communicate to patients with compassion, an understanding of humans getting better, and the ability to make ethical judgments accurately and appropriately. In the practice of nursing, knowing is the essential process that initiates the relationship between the nurse and nursed. While Carper [38] has described four fundamental patterns of knowing in nursing, knowing the other person continually and intentionally leads to the understanding of persons more fully as persons. All persons have aspects of self that they can change from moment to moment; therefore, HNRs have to use a process of "knowing" in order to understand the person from moment to moment.

Guided by Carper's [38] fundamental patterns of knowing in nursing, the technological engagement in the transactive relationship between human persons and intelligent machines is best expressed through patterns of knowing.

Personal knowing: In nursing, nurses make efforts to share experiences with care participants (human persons as patients) through human connections. In doing so, nurses know and understand the other person. Personal knowing is to recognize images, fingerprints, and the individual persons. They record information regarding conversations with their patients and record these in databases such as the electronic medical/health care record. These recorded data can be shared by those authorized to access these data, and sharing these with the patients and other health care personnel enables them to know and understand their patients more fully as persons.

Similarly, HNRs have databases. Through programmed technological capabilities, they are able to collect and store data, and at appropriate times interpret these data, somewhat understanding them at the robots' level of intelligence. HNRs can measure vital signs electronically and assess a patient's physical condition and emotions by recognizing facial expressions and through interactive engagements. Moreover, they can conduct recordings necessary for nursing care through sound recognition, particularly when they are paired with human nurses. In order to provide sufficient care by using scientific information such as anatomical, physiological, and pharmacological data, HNRs strive to analyze and interpret the whole image of care of the human person (patient) by considering their anxieties and their psychological responses to their prospective health care treatments. Sensory data are not lacking with HNRs. Their capacities continually increase exponentially.

Empirical Knowing: Nurses should consider the participants' biological, psychological, sociological, cultural, medical, and spiritual conditions - including their psychological state - in order to create appropriate and accurate nursing care activities. In nursing care institutions, nursing skills mean technological expertise such as measuring blood pressure, heart rate, and body temperature, and also observing the patient's physical situation. The data collected from these processes are automatically transferred from the measuring equipment to the database. HNRs can also do the same provided its programming includes certain parameters that measure certain conditions. For one, it can confirm the remaining amount of intravenous drip and instantly provide this information to nurses.

HNRs can obtain the latest information regarding the patients' medical treatment, rehabilitation, and other care methods necessary in conducting appropriate and accurate nursing care. Similarly, for various illnesses, HNRs can gain access to databases and from the internet so that human nurses and HNRs can jointly judge the patient's situation. If HNRs gain access to the internet and provide the most appropriate information to nurses as well as patients through AI, HNRs can help them make a well-informed decision.

Ethical Knowing: In order to care, nurses should practice nursing within the viewpoint of what is good, right, and best for the patients. However, in addition to common sense and ethical judgment, it would be very difficult to introduce personal judgment between right or wrong into HNRs because there are no strict standards, even for humans. Nevertheless, this functionality can be added in rudimentary form and then enhanced exponentially given the current degree of technological sophistication.

Aesthetic knowing: In order to communicate what the nurse knows about the patient through this or her knowing, the nurse needs to express this knowledge in ways that others can appreciate. So that nurses realize the care recipient's wishes, or help them grow as caring persons as they meander through the maze of human health care, they need to reflect on the caring process and consider how to provide even better, more convenient, and more responsive care.

For example, for his purpose, the nurse asks the patient's latest wish or current desire, and the patient takes time deciding his desires, hopes, dreams and aspirations. Human nurses may be able to capture these essences and the accumulated data can be stored in databases. Moreover, personal effects such as photographs, and laboratory information can be stored and made available to family members when appropriate. Information related to past experiences including those of their parents are inserted into the database as accessible information. In this sense, it is important to program into the robots such an interactive relationship. Therefore, in order to have HNRs function within the Transactive Relationship Model, it is necessary to develop a computerized interface communication process between HNRs and healthcare practitioners.

Concluding Statements Emphasizing Nursing Practice Applications

A theory-guided nursing practice is integral to meet healthcare demands. Attaining good quality healthcare particularly in situations in which human beings, robots, and patients are involved may be the common healthcare practice in the very near future. Nursing caring practices involving intelligent machines with highly sophisticated robotic functions such as interactive capabilities may be the best option for the increasing demand of health care labor. Engaging in

activities that assure good health within the changing and evolving world of human caring is essential for human healthcare.

The AI-equipped HNRs will be programmed to appreciate the meanings of the nursing experience. When these are able to express themselves through human-like emotive behaviors, they will be able to convey empathic understanding to the patients and their families. Therefore, within the Transactive Relationship Theory of Nursing, a nursing encounter where all nursing occurs encompasses the process of nursing as technological engagement and mutual knowing. These aspects of a transactive relationship between the HNR and the person being nursed essentially prepare future nursing practitioners in a highly technological world, to practice appropriate and accurate nursing activities through theory-based nursing practice.

In essence, the occurrence of nursing encounters involving human persons and HNRs can advance the practice of transactive engagement, but when the human person can feel to have been healed with the help of a HNR, or when a human patient can equate the HNRs to a human person practicing nursing, will these prompt the human healthcare team to possibly accept the HNRs as a legitimate member? If HNRs can demonstrate technological competency in nursing care, what will make 'them' different from the competency in nursing as displayed by current human nurses?

Although it may be a contemporary reality that intelligent machine technologies may not be able to care for human persons as human nurses can, HNRs are being developed to assume such activity. Are these machines developed with contributions by nurses or others who think they know what a nurse is and what a nurse does? Regardless, the main question still remains: Do nursing activities and their subsequent completion make nursing care, nursing care? If so, what does nursing practice headlined by HNRs mean as for its ontology? If the nature of HNRs is their supposition of human caring practices for the promotion of human health and well-being, will this nature matter, and how different will nursing be with this nature engendered within the current 21st century ontology of nursing?

Competing Interests

The author declares that he has no competing interests.

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References

1. Muramatsu N, Akiyama H (2011) Japan: super-aging society preparing for the future. *Gerontologist* 51: 425-432.
2. Japanese Nursing Association (2013) Nursing for the older people in Japan.
3. Bongaarts J (2009) Human population growth and the demographic transition. *Philos Trans R Soc Lond B Biol Sci* 364: 2985-2990.

4. The Japan Times News: Development of care robots growing in aging Japan, By Masui A, KYODO.
5. TOYOTA: TMC Shows New Nursing and Healthcare Robots in Tokyo.
6. Huang S, Tanioka T, Locsin R, Parker M, Masory O (2011) Functions of a caring robot in nursing. *Proceeding of 7th International Conference on Natural Language Processing and Knowledge Engineering (NLP-KE)*, pp.425-429.
7. Hirata Y, Sugiyama Y, Kosuge K (2015) Control architecture of delivery robot for supporting nursing staff. *Proceedings of 2015 IEEE/SICE International Symposium on System Integration (SII)*.
8. Swangnetr M, David B, Kaber D (2013) Emotional State Classification in Patient-Robot Interaction Using Wavelet Analysis and Statistics-Based Feature Selection. *Proceeding of 2013 IEEE Transactions on Human-Machine Systems* 43: 63-75.
9. Tanioka T, Yasuhara Y, Osaka K, Ito H, Kato K, et al. (2015) Performance Requisites for Compassionate Nursing Robots, With Communication Competency. *Proceeding of the Seventh International Conference on Information, Taipei, Taiwan*, pp. 77-80.
10. Osaka K, Tanioka T, Yasuhara Y, Locsin R (2016) Empathic understanding in human-robot communication: Influences on caring in nursing. *GSTF Conference Proceedings on WNC* 233-239.
11. Osaka K, Tsuchiya S, Ren F, Tanioka T (2008) Analysis of Empathetic Understanding Using Relationship between Electrode and Frequency. *Proceeding of ICAI 2008, Beijing, China*, pp. 116-121.
12. Yasuhara Y, Osaka K, Tanioka T, Locsin R (2016) Artificiality in intelligence of human caring machines: Towards its effective functioning in human patient care demands. *GSTF Conference Proceedings on WNC* 2016, pp. 240-245.
13. Fuji S, Ito H, Yasuhara Y, Shihong H, Tanioka T, Locsin R (2014) Discussion of Nursing Robot's Capability and Ethical Issues. *Information* 17: 349-354.
14. Tanioka T, Locsin R (2012) Feasibility of developing nursing care robots. *Proceeding of 8th International Conference on Natural Language Processing and Knowledge Engineering (NLP-KE'12)*, China, pp. 567-570.
15. Ito H, Yasuhara Y, Tanioka T, Locsin R (2012) Adoption of medical/welfare robots in medical environments and its ethical issues. *Proceeding of 8th International Conference on Natural Language Processing and Knowledge Engineering (NLP-KE'12)*, China, pp. 560-562.
16. Yasuhara Y, Tamayama C, Kikukawa K, Osaka K, Tanioka T, et al. (2012) Required Function of the Caring Robot with Dialogue Ability for Patients with Dementia. *AIA International Advanced Information Institute* 4: 31-42.
17. Ito H, Miyagawa M, Kuwamura Y, Yasuhara Y, Tanioka T, et al. (2015) Professional Nurses' Attitudes towards the introduction of Humanoid Nursing Robots (HNRs) in Health Care Settings. *Journal of Nursing and Health Sciences* 9: 73-81.
18. Ito H, Yasuhara Y, Tanioka T, Osaka K, Locsin R (2016) Intelligent machines and ethical dilemmas concerning fidelity in human caring activities. *GSTF Conference Proceedings on WNC* 2016, pp. 228-232.
19. Oida T, Okuyama T, Finley M (2005) A Security Gateway System for Medical Communication Networks Inter-Hospital Use of the Secure Socket Layer, *Joint International Conference on Autonomic and Autonomous Systems and International Conference on Networking and Services - (icas-isns'05)*, pp. 35-35.
20. Radhakrishnan K (2008) Technology and caring: Finding common ground for nursing practice. *The International Journal of Technology, Knowledge and Society* 4: 27-32.
21. Locsin R (2005) *Technological Competency as Caring in nursing*. Sigma Theta Tau International Press, Indianapolis, IN, USA.
22. Barrat J (2013) *Our Final Invention*. Thomas Dunne Books, St. Martin's Griffin Press, New York, pp. 9-31.
23. Kurzweill R: *Singularity is Near*. Penguin Book, New York, 2006.
24. Fawcett J (1985) Theory: basis for the study and practice of nursing education. *J Nurs Educ* 24: 226-229.
25. Fawcett J (1996) On the requirements for a metaparadigm: an invitation to dialogue. *Nurs Sci Q* 9: 94-97.
26. Fawcett J (1984) The Metaparadigm of Nursing: Present Status and Future Refinements. *The Journal of Nursing Scholarship* 16: 84-87.
27. Boykin A, Schoenhofer S (2001) *Nursing as Caring: A Model for Transforming Practice*. Sudbury, MA: Jones Bartlett, p. 13.
28. Smith MC, Turkell M, Wolf Z (2013) *Caring in Nursing Classics*. New York: NY, Springer.
29. Nightingale F (1954) Notes on Nursing: What It Is and What It Is Not. In Seymer, LR. *Selected Writings of Florence Nightingale*, (Ed). MacMillan Book Co., New York.
30. Mayeroff M (1971) *On Caring*. The Harper Perennial, New York, NY.
31. Boykin A, Schoenhofer S (1993) *Nursing as Caring, A Model for Transforming Practice*. Jones and Bartlett Publishers, p. 25.
32. Locsin R, Purnell M (2015) Advancing the Theory of Technological Competency as Caring in Nursing: The Universal Technological Domain. *International Journal for Human Caring* 19: 50-54.
33. Locsin R (2016) Technological Competency as Caring in Nursing: Co-creating Moments in Nursing Occurring Within the Universal Technological Domain. *The Journal of Theory Construction and Testing* 20: 5-11.
34. Paterson JG, Zderad LT (1976) *Humanistic Nursing*. New York, John Wiley & Sons.
35. Locsin R, Tanioka T, Kawanishi C (2005) Anthropomorphic machines and the practice of nursing: knowing persons as whole in the moment, *Proceedings of 2005 IEEE International Conference on Natural Language Processing and Knowledge Engineering, IEEE NLP-KE'05*.
36. Miwa H, Okuchi T, Takanobu H, Takanishi A (2002) Development of a new human-like head robot WE-4. *International Conference on Intelligent Robots and Systems, IEEE/RSJ*, 2002.
37. Travelbee J (1971) *Interpersonal Aspects of Nursing*, (2nd ed.), Philadelphia. F.A. Davis, 1971.
38. Carper B (1978) Fundamental patterns of knowing in nursing. *Advances in Nursing Science* 1: 13-24.