Chapter

Artificial Brain for the Humanoid-Nurse Robots of the Future: Integrating PsyNACS© and Artificial Intelligence

Hirokazu Ito, Tetsuya Tanioka, Michael Joseph S. Diño, Irvin L. Ong and Rozzano C. Locsin

Abstract

Robots in healthcare are being developed rapidly, as they offer wide-ranging medical applications and care solutions. However, it is quite challenging to develop high-quality, patient-centered, communication-efficient robots. This can be attributed to a multitude of barriers such as technology maturity, diverse healthcare practices, and humanizing innovations. In order to engineer an ideal Humanoid-Nurse Robots (HNRs), a profound integration of artificial intelligence (AI) and information system like nursing assessment databases for a better nursing care delivery model is required. As a specialized nursing database in psychiatric hospitals, the Psychiatric Nursing Assessment Classification System and Care Planning System (PsyNACS©) has been developed by Ito et al., to augment quality and safe nursing care delivery of psychiatric health services. This chapter describes the nursing landscape in Japan, PsyNACS© as a specialized nursing database, the HNRs of the future, and the future artificial brain for HNRs linking PsyNACS© with AI through deep learning and Natural Language Processing (NLP).

Keywords: PsyNACS©, artificial brain, humanoid-nurse robot, artificial intelligence, communication, nursing

1. Introduction

The nursing shortage in Japan has significantly increased in years [1]. Population aging coupled with a declining birthrate has greatly steered the upward demand for nursing professionals [2, 3]. In response, the Government of Japan has called for the adoption of the Internet of Things (IoT) and robots in healthcare [4, 5]. Japan's Act for the Mental Health and Welfare of Persons with Mental Disorders has been undertaken reducing chronic psychiatric hospital stay as much as possible and providing home care services. However, the nursing shortage has created can be more pressing healthcare issues in psychiatric hospitals where the length of average hospital stay is much longer in contrast with other countries [6, 7].

Psychiatric signs and symptoms provide dysfunctional evidence and pose as healthcare disadvantage to patients with mental illness [8–10]. These dysfunctions and disadvantages characterized by repeated exacerbations and remissions for patients with mental illness often follow a chronic course [11] wherein they maintain their lives in the community while being repeatedly admitted to and discharged from psychiatric hospitals [12, 13]. In addition, psychiatric nursing care situations have become more challenging as the number of people with dementia continues to increase with the population getting older.

Caring for patients with dementia is complex and requires specialized interventions [14]. In Japan, these situations influence psychiatric healthcare services therefore, psychiatric nursing practice requires early assessment during the acute phase, and effective health maintenance in the chronic phase to provide optimal nursing care for patients.

Access to health data is essential in clinical decision making. This can considerably improve interdisciplinary care and health outcomes of patients with psychiatric conditions, preventing unnecessary readmissions and unsafe discharges in psychiatric hospitals. In the absence of a functioning database, psychiatric nursing care becomes inefficient and fragmented, further creating an inadequate environment for IoT and robots in healthcare to thrive. On the whole, the current nursing landscape remains to exhibit countless unstructured challenges in attaining and sustaining quality psychiatric nursing care.

2. The PsyNACS© database

The need for a specialized nursing database for psychiatric hospitals in Japan prompted the development of the Psychiatric Nursing Assessment Classification System and Care planning System (PsyNACS©) to improve psychiatric nursing care services (Ito et al.) [15, 16]. This was a data-driven classification system of nursing assessment data for Japanese psychiatric healthcare which can be used in various patient care situations in psychiatric units.

In developing the system, a select group of experienced nurses (N = 664) working in psychiatric hospitals evaluated 211 assessment items for psychiatric nursing care derived from contemporary nursing theoretical models and frameworks. The results of the factor analysis of the final 209 assessment items generated 9 Patient Assessment Data (PAD) and 31 Cluster Assessment Data (CAD). Each PAD consisted of 2 to 5 CADs.

The PADs are simple categories for each corresponding CADs. The PADs include (a) psychological symptom and stress, (b) information about treatment, (c) function of eating and balance of water, (d) life and value, (e) vital signs and health assessment, (f) self-care, (g) social support, (h) activity, sleeping and mobility capability, and (i) Sexual function and sexual behavior.

PsyNACS© is designed to assist nurses to provide timely, effective and appropriate care for patients with mental illness. It can be a server-type, laptop-type, or web-type system. A server-type PsyNACS© installs a server in a psychiatric hospital and the laptop-type PsyNACS© can be used without an internet connection. Of interest, the web-type PsyNACS© is connected to a cloud server that enables online nursing care planning. These pathways address access to design care plans to meet the needs of the patient with mental illnesses for individualized care, including treatment, rehabilitation, and post-discharge welfare services. Since the PsyNACS© database deals with big data, it has a secure mechanism to gather healthcare information and other assessment data.

As a result, the completed database (**Figure 1**) was digitized so that nursing care plans can be accessed using a computer or laptop system.

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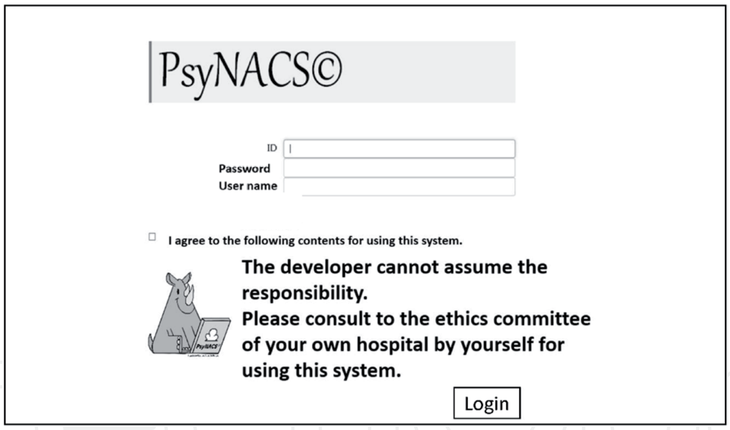

Figure 1.
PsyNACS© login page.

PysNACS© works at a lower cost as compared to hospital systems where expensive electronic medical records may not be feasible. The web-type PsyNACS© deals with aggregate patient information and health data. This calls for accurate recording and proper documentation of health information, psychiatric symptoms, and care plans. PsyNACS© is equipped with a database content filter that displays alerts for capturing inappropriate words, entries, or inputs.

Like with any medical and health records, information security and ethics remain to be the greatest concern. Both systems and risks management can be difficult tasks for nursing or any health professionals. In essence, only patients and their lawful representatives may request information. As a result, confidential personal information can be managed separately from the psychiatric nursing assessments and care plans to prevent unauthorized disclosure and leaks. PsyNACS© uses a dedicated internet line or a Virtual Private Network (VPN) to ensure information safety.

Handling patient information in healthcare settings requires additional levels of protection for privacy and confidentiality. A top the terminal management on the client end, a third-party risk management system such as antivirus software is highly recommended against data breaches. Other security features include establishing quality procedures for handling electronic information, setting identity and password management procedures for authorized access, clarifying server management procedures to oversee servers, and ensuring the security of communication paths.

PsyNACS© offers a holistic approach to psychiatric nursing assessment. It collects health information to have a better assessment of patient needs and determine the most appropriate nursing interventions. PsyNACS© is organized strategically into information blocks (**Figure 2**) for (a) common in psychiatry, (b) with dementia, (c) with complication, and (d) additional information. This is achieved by integrating the PADs as the *key areas* of psychiatric assessment (left column) and the CADs as the *subareas* with corresponding nursing assessment items (right column). Thus, patient-centered nursing care can be planned and delivered using the psychiatric assessment with 9 areas, 31 subareas, and 209 items.

The database prototype for PsyNACS© displays the recommended and relevant health information that has been entered recurrently into the system as individual-level data. This requires active participation and utilization among professional nurses at the point of care. By weighing critical information from psychiatric nurses, it becomes possible for nurses to use the system with greater usability and functionality. The aggregate data in the database will grow eventually into big data, which can be analyzed for quality improvement.

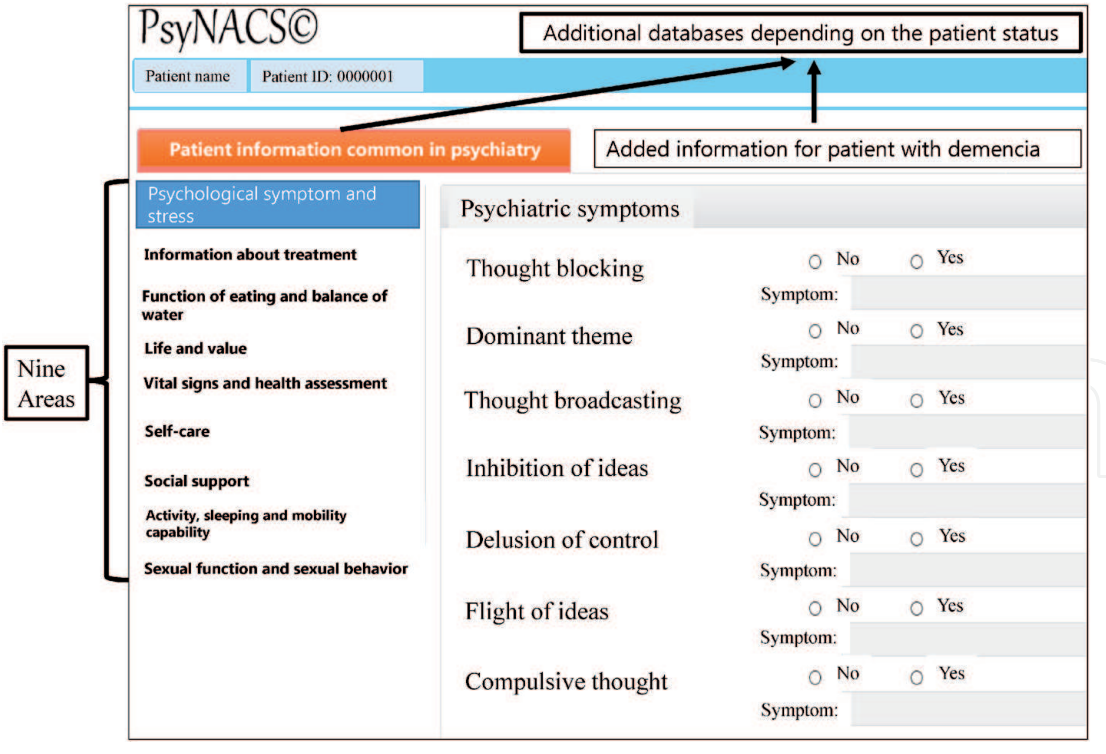

Figure 2.
PsyNACS© sample screen for area 1 - psychiatric symptom and stress.

In practice PsyNACS© was evaluated at a selected psychiatric hospital in Japan. Ten nurse managers who were experts in manipulating electronic medical charts in their respective psychiatric hospital participated and answered the questionnaire. They entered patient information data using the laptop-type of PsyNACS©. Evaluative processes included operability and efficiency of the system determined through the survey questionnaire. Five of the 10 participants responded that the system was good. Four participants declared that the information input method was efficient. However, regarding time required for inputting data was found to be significantly different among individual participants. Familiarity of the system operation was the main determinant (presented at the International Conference on Ethics, Esthetics, and Empirics in Nursing, Songkhla, Thailand, July, 5–7. 2017). Integrating PsyNACS© into nursing practice will provide nurses with better access to health information that allow them to perform holistic assessment and provide quality care that is responsive to current standards and contexts of Japanese psychiatric nursing.

3. Humanoid-nurse robots of the future

The Government of Japan's direction for robots in healthcare strongly coincides with the Fourth Industrial Revolution (4IR) [17] and Society 5.0 [18] in which a massive integration of highly advanced and recognized disruptive technologies such as AI, IoT, and quantum computing is expected to flourish. Nevertheless, this is quite challenging for healthcare, more so in psychiatric nursing which is lagging behind the manufacturing and other service industries. In order to thrive, information and communication technology are crucial for using humanoid robots in healthcare area. Despite technological advancements, the maturity of existing ideologies of Humanoid-Nurse Robots (HNRs) are yet a forthcoming consideration [19].

The HNRs of the future has no single definition, morphology (form), and physiology (function). Rather than a concrete conception, the HNRs of the future is considered a product of the collective visions of nursing and healthcare leaders as they reimagine the future of healthcare demands. In the context of psychiatric nursing and in older adult care in Japan, the HNRs are expected to assist and work with nurses in carrying out healthcare tasks and activities. Having a clear vision of HNRs as the supreme technological advancement in healthcare, the demands are for robots to be programmed in such a way that it can independently perform nursing-related technical skills, and simultaneously demonstrate value-added expressions of humanness such as respect, compassion, empathy, and caring [20]. Therefore, HNRs are envisioned to be of high-quality, expressing patient-centeredness, and efficient with communication.

First, being of high-quality means that HNRs are data-driven achieved by linking PsyNACS© with HNRs. Credible health information should be captured from meaningful nurse–patient interactions. The PsyNACS© as the conversation database and along with relevant data such as electronic medical records, history and physical examination, laboratory, and radiology results can be linked to AI enhancing HNRs to acquire reliable databases regarding patients with mental illness and dementia. In addition to PsyNACS© integration with HNRs, the quality of HNRs is frequently influenced by the global proliferation of robots in healthcare, especially in hospitals, communities, and in home settings. Producing high-quality HNRs also means having data-driven policies and guidance on shared nurse–robot practices. Therefore, it becomes essential for nurses to play leadership roles in the design, implementation, and evaluation of nurse-robot partnerships [21] and eventually transform this into standards of nursing practices.

Secondly, HNRs have patient-centered designs [22, 23]. The ethical standards of human nurses are primarily grounded on the value of caring [24]. This impacts the quality of nursing care. In psychiatric nursing, nurses need to address both the physical and psychosocial needs of patients particularly those with mental illness and dementia. This poses greater challenges to HNRs which are originally designed as provider-centric in order to improve the efficiency of healthcare workers.

Patient-centered designs can be accomplished by focusing on patient needs and therapeutic conversational contents of professional nurses. Given that HNRs can be both a technological tool and a care partner, this will also entail looking into the code of ethics for nurses in Japan (Japanese Nursing Association, 2003). The current provision mentions nothing about HNRs; only focusing on collaboration among nursing and healthcare personnel. Therefore, the nurse-robot partnership should carefully consider and meet the nursing code of ethics [25].

Lastly, HNRs are capable of efficient communication. Currently designed/developed robots usually engage in one-way communications – each time simply asking one-sided questions to attempt a dialog. Optimizing structured conversations are needed to elicit desired levels of engagement and participation. This can be achieved through the creation of a "Caring Dialogue Database" for HNRs to provide better information about the patients, and to share experiences of human-robot interactions. Moreover, it is vital to generate a dialogical pattern that enables HNRs to demonstrate empathy particularly with people who have psychiatric illnesses [26].

The present-day advanced communication robot systems possess limited functionality in carrying conversations and keeping smooth communication pattern similar to humans, unless this system is connected to a cloud database with distinctive voice assistant services. Using a cloud database with big data capacity complicates information management and security features, increasing risks of data breach and leakage of electronic, sensitive, and confidential data. By installing data security systems, and protective features, HNRs can learn to express more sympathetic behavior over time by undergoing repeated cycles of information processing allowing for secured inputs and outputs of information through the cloud database.

4. The future artificial "brain" for HNRs: associating PsyNACS© with AI systems

What is the brain of a computer? The obligatory answer is the Central Processing Unit (CPU) that performs tons of rapid data processing operations and instructions per second [27]. This is the typical way to define the future artificial "brain" of the HNRs in layman's term. It is metaphorically straightforward to compare human beings with computers wherein human brains and computer processing units function similarly. The CPU or control system is the central nervous system, sensors as the afferent sensory system, and actuators as the efferent motor system [28]. However, this becomes quite difficult and complicated when the task is to describe robot "physiology" and features. For that reason, to successfully characterize the artificial brain of the HNRs in the future, it is critically important to understand the entity that it must emulate – *the professional nurse*.

Amisha et al. described artificial intelligence (AI) as using technology to generate a human-level cognition. In this chapter, the AI does not merely refer to the artificial "brain" of the robot, but rather it characterizes a feature that can understand human language and replicate the behaviors of a professional nurse. To achieve this, AI requires a specialized database like PsyNACS© as well as the capability to communicate verbally and nonverbally. Such ability to control, manage, and operate the HNRs is known as the AI system [29] (**Figure 3**).

HNRs should be able to establish trust and rapport with patients in a similar fashion as a professional human nurse does when fostering a nurse–patient relationship. To have a shared understanding of the patients' life experiences, the HNRs need to understand the patient's illnesses, and treatments. Like nurses, HNRs need to genuinely convey caring to patients and their families through the language of caring.

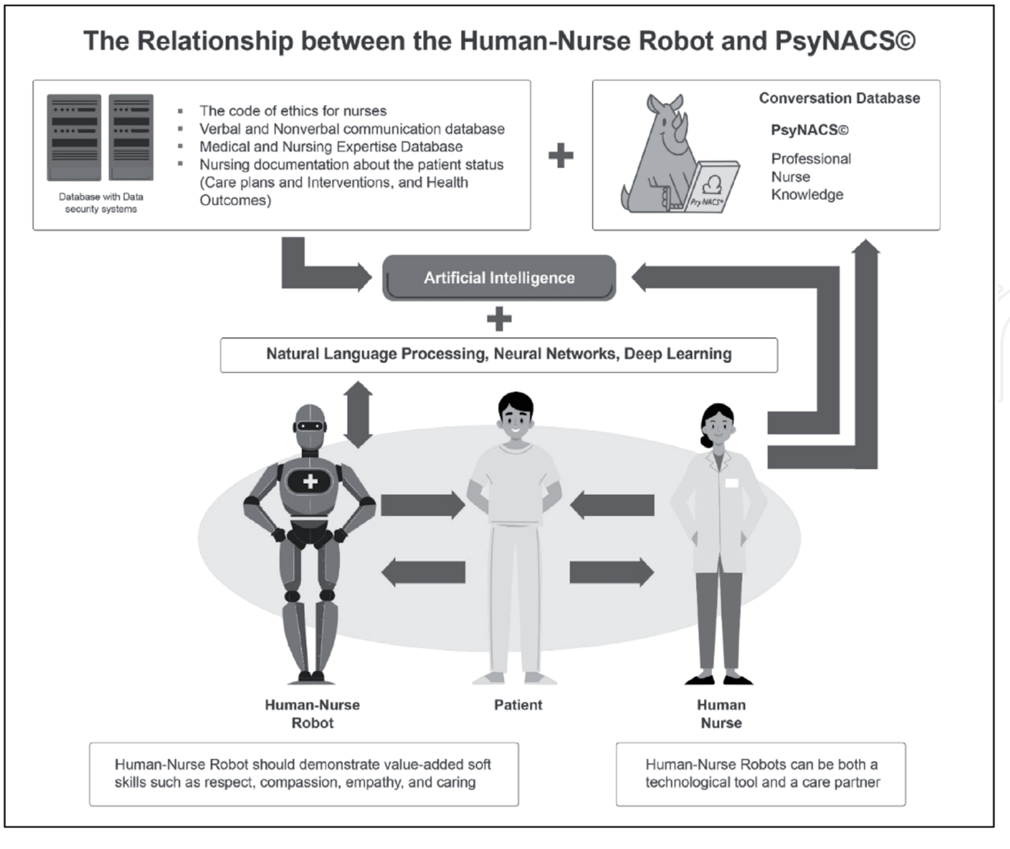

Figure 3.
The relationship between the humanoid-nurse robot and PsyNACS©.

Nurses have self-consciousness that allows them to express their emotions, particularly demonstrating tender loving care without being coached by other people.

Artificial "brains" and artificial consciousness may well be necessary features for HNRs [30] in order to demonstrate initiative and express autonomously without any human inducement or mediation. While nursing care is fundamentally a human-to-human relationship, it becomes a nonhuman-to-human relationship in the case of HNRs [31]. This raises many controversial issues and ethical concerns for patient safety which must be addressed accordingly [24].

If HNRs are to support and care for patients directly, they must hold the same level of comprehensive judgment ability and responsiveness like that of a competent professional nurse who use any of the following processes, such as theory-based nursing care practice, the utility of the traditional nursing process of assessing, diagnosing, planning, implementing, and evaluating, and clinical decision-making, critical thinking, problem-solving, and rapid response and feedback. These processes guide professional practice while emphasizing the individuality of every patient during the practice of professional nursing care. An additional level of intelligence, skillfulness and competence [19] are required in the event that HNRs are assigned to care for patients autonomously or independently.

A successful nurse–patient relationship also relies on effective communication. The future artificial "brain" of HNRs is envisioned to have the capacity to convey a smooth conversation with appropriate patient-centered responses. For HNRs to have such a feature, it entails all the essences of AI such as Natural Language Processing (NLP), neural networks, and deep learning in generating voice contents [32–34]. In addition to verbal content, HNRs need to demonstrate nonverbal communication patterns that are important aspects of effective nurse–patient communications such as eye contact, proxemics, kinesics, expressions, and tone [35–38].

Figure 3 shows the relationship between the robot and PsyNACS© with a conceptual diagram. It may seem therefore that both verbal and nonverbal messages are the life-bloods of successful therapeutic communication in psychiatric nursing. Due to the expected physiological intricacies of the artificial brain, the design and development of HNRs of the future calls for participatory dialog and trans-professional collaboration between healthcare professionals, technology engineers, and care stakeholders. Nursing professionals can provide critical inputs with empirical value at point-of-care. In particular, nurses can contribute to the development of the artificial "brain" for HNRs by sharing their professional knowledge, clinical expertise, care competencies, and nursing documentation that contains relevant and reliable information about the patient status, care plans and interventions, and health outcomes. These information can be organized and amassed using the PsyNACS© framework and database. As a result, a natural conversation *would be* possible between HNRs and humans (e.g., patients and their families) provided that the artificial brain, PsyNACS©, and AI are well-integrated. This allows HNRs of the future to communicate efficiently and respond appropriately and accurately to patients while carefully considering the all-inclusive situation comprising the patient condition, the psychiatric database, and the healthcare environment.

Insofar as robots can be considered as 'mere' artifacts of technological advancement, our trust in and reliance on HNRs must be based on functional and ethical criteria [39]. We can always judge the worth and value of HNRs if their functionalities are approached as means to an end. This teleological approach focuses on the end-result of the HNRs' function that is, whether HNRs have been successful or not in performing tasks. Looking at the outcome itself may overlook the intention of the HNRs. Using a deontological view, we can evaluate HNRs if it is doing the right thing. This also takes into account the goodwill behind the motives and actions of HNRs. Lastly, nursing care is a virtue-driven human experience. We cannot simply assess the HNRs solely based on its obligated and consequential programming. Our evaluation should also consider the value systems in providing quality and safe professional nursing care. As mentioned, HNRs must affirm high-quality, patient-centered, and communication-efficient features. In this light, what can we learn about the value of HNRs in the context of psychiatric nursing care? – With efficiency and wholesome appreciation of being caring entities, *HNRs are more than robots and all the more so than mere tools!* [40].

5. Conclusion

In this chapter, we described the nursing landscape in Japan, PsyNACS©, and HNRs of the future in the context of psychiatric nursing. First, considering the nursing landscape in Japan facilitates a well-defined understanding of the current nursing and healthcare situations to guide the future of psychiatric nursing. Second, a data-driven approach is needed in addressing quality and safety issues in healthcare. We demonstrated how PsyNACS© originated from nursing research, and how we translated it into practice. It allows a secured holistic psychiatric nursing assessment for better care plans and services. The quality of PsyNACS© database content can be enhanced with repeated clinical use. Third, visionary leadership aids in reimagining the future of HNRs to be high-quality, patient-centered, and communication-efficient. Fourth, the artificial "brain" for the HNRs of the future might be incorporated the PsyNACS© database and AI with NLP, neural networks, and deep learning. Collaboration between healthcare professionals, technology engineers, and care stakeholders is essential for the development of HNRs capable of both verbal and nonverbal communication. In summary, integrating PsyNACS© with AI brings HNRs to greater heights – a better quality of nursing care than today.

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Conflict of interest

The authors have no conflicts of interest directly relevant to the content of this article.

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