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Research Trends in Artificial Intelligence-Associated Nursing Activities Based on a Review of Academic Studies Published From 2001 to 2020

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The present study referred to the technology-based learning model to conduct a systematic review of the dimensions of nursing activities, research samples, research methods, roles of artificial intelligence, applied artificial intelligence algorithms, evaluation measure of algorithms, and research foci. Based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses procedure, this study obtained and analyzed a total of 102 high-quality artificial intelligence–associated nursing activities studies published from 2001 to 2020 in the Web of Science database. The results showed: (1) In terms of nursing activities, nursing management was explored the most, followed by nursing assessment; (2) quantitative methods were most frequently adopted in artificial intelligence–associated nursing activities studies to investigate issues related to patients, followed by nursing staff; (3) the most adopted roles of artificial intelligence in artificial intelligence–associated nursing activities studies were profiling and prediction, followed by assessment and evaluation; (4) artificial intelligence–associated nursing activities studies frequently mixed applied artificial intelligence algorithms and evaluation measure of algorithms; (5) in the dimension of research foci, most studies mainly paid attention to the design or evaluation of the artificial intelligence systems/instruments, followed by investigating the correlation and affect issues. Based on the findings, several recommendations are raised as a reference for future researchers, educators, and policy makers.

KEY WORDS: Artificial intelligence, Nursing activities, Research trends

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Rapid advancement in computer technologies, in particular, artificial intelligence (AI) technologies, has provided new opportunities to facilitate medical services.[1,2] Artificial intelligence is a computer technique that enables computers to behave like humans, giving them the ability to analyze, reason, make decisions, and self-correct.[3,4] Artificial intelligence–associated nursing activities (AINAs), referring to the use of AI technologies in nursing services, education, or decision-making, have received attention from numerous researchers in recent years[3–6]; for instance, a neural network-based text classification model system has been proposed to assist nurses in documenting patient care and potentially reducing the documentation workload.[7] Machine learning models of big data have been applied to assist in clinical decision-making.[8] In addition, with regard to nursing care, AI technology has been verified by researchers as effectively assisting in nursing care–related tasks such as patient bed allocation, drug administration, and patient care.[4,6] In terms of nursing professional learning, AI technology can enhance nursing staff's and students' professional knowledge and skills.[1] For example, in one study, students were able to repeatedly operate and practice in the AI-simulated contexts to enhance their related professional skills, which further reduced their learning anxiety and increased their confidence.[9]

Huang et al[10] reviewed 77 papers in the nursing and infectious disease field and pointed out five innovative technologies with great potential for nursing activities, namely, AI, the Internet of Things, information and communications technology, simulation technology, and e-learning. Studies have shown that Internet of Things is most frequently adopted in assessment areas, AI is most frequently used in prevention and control areas, information and communications technology is most frequently used in management areas, and simulation and e-learning are most frequently applied in nursing education.[10] Researchers have specified that AI technology can analyze massive amounts of data in daily clinical practice (eg, electronic healthcare record systems) and can effectively support clinical decision-making.[11] With the assistance of AI technologies, the performance of nursing management can be enhanced.[6,10]

In recent years, the application of AI in the nursing field has been recognized by several researchers.[4,12,13] The review

studies on the application of AI in the nursing field have mainly focused on nursing pain education,[3] primary care,[4] and AI agents in healthcare.[5] Few studies could be found that reviewed papers on AI in nursing activities. In order to understand the research trend of AI application in nursing activities, the present study referred to Chang et al,[1] Huang et al,[10] and Hwang and Tu[14] and analyzed the trend of Social Sciences Citation Index AINA studies from the Web of Science database published over the past 2 decades from the perspective of nursing activities, research samples, research methods, roles of AI, applied AI algorithms, the evaluation measure of algorithms, and research foci. As suggested by previous review studies,[1,10,14] it is important to perceive the trends of a research field by reviewing the studies published in the past 2 decades (ie, 2001–2020); moreover, it is important to compare what was found in the first decade (ie, 2001–2010) and in the second decade (ie, 2011–2020) to see the paradigm shifts between the two time periods.

Accordingly, the research questions of the present study were as follows:

1. From 2001 to 2020, what were the major nursing activities in AINA studies?
2. From 2001 to 2020, what were the research samples selected for AINA studies? What were the research methods adopted in AINA studies?
3. From 2001 to 2020, what were the roles of AI in AINA studies?
4. From 2001 to 2020, what were the applied AI algorithms and evaluation measure of algorithms in AINA studies?
5. From 2001 to 2020, what were the main research foci in AINA studies?

RESEARCH METHODS

Process of Data Searching and Collection

According to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses[15] and previous studies related to AI and nursing,[1,14,16] the current study searched for articles published between 2001 and 2020 in the Web of Science database with the following keywords in titles, abstracts, or keywords: the "artificial intelligence" substring ("artificial intelligence" or "machine intelligence" or "intelligent support" or "intelligent virtual reality" or "chat bot*" or "machine learning" or "automated tutor*" or "personal tutor*" or "intelligent agent*" or "expert system*" or "neural network*" or "natural language processing" or "chatbot*" or "intelligent system" or "intelligent tutor*") and the "nursing" substring ("nurs* skill" or "nurs* knowledge" or "nurs* training" "nurs*" or "pupil nurse" or "midwifery" or "nurse academic" or "nurse educator" or "nurse teacher"). A total of 215 articles were obtained after excluding non-articles. Duplicates, articles not written in English, literature reviews, and articles not related to the research topic (AINAs) were removed after screening. After careful selection, a total of 102 suitable articles were retained. Figure 1 presents the article selection process.

Data Distribution

Taking the fluctuation of technologies into account, the current study referred to Chang et al[1] and Zheng et al[17] and classified 102 AINA studies into two periods: a total of 12 AINA studies were published in the first period (2001–2010); and 90, in the second period (2011–2020). Starting from 2015, there has been an increase in the publication number of AINA studies. In addition, the nine journals with the greatest amount of literature published between 2001 and 2020, from the most to least, are *CIN: Computers, Informatics, Nursing*; *International Journal of Medical Informatics*; *Journal of the American Medical Informatics Association*; *Journal of Medical Internet Research*; *International Journal of Environmental Research and Public Health*; *JMIR Medical Informatics*; *Journal of Biomedical Informatics*; *Nurse Education Today*; and *Nursing Research*.

Theoretical Model, Data Coding, and Analysis

In this study, the categories for analyzing the target studies were adapted from the model for reviewing AI in education research proposed by Hwang and Tu,[14] who suggested that, to investigate the trends of AI-based applications, it is important to review the literature from several dimensions, that is, the roles of AI, research samples, research methods, applied AI algorithms, and research issues. In addition, to explore research issues related to AINA, a systematic review was conducted by referring to the coding scheme of Chang et al,[1] Huang et al,[10] and Hwang and Tu.[14] The dimensions of coding and analysis included nursing activities, research samples, research methods, roles of AI, applied AI algorithms, evaluation measures of algorithms, and research foci.

Table 1 illustrates the overall coding scheme of this study. The coding items of the "nursing activities" dimension were determined by referring to the categories suggested by Huang et al.[10] The items in the "research sample" and "research methods" dimensions were determined based on the categories suggested by Chang et al.[1] The coding items of the "roles of AI," "applied AI algorithms," and "research foci" dimensions were determined by referring to the categories suggested by Hwang and Tu.[14] The coding items of the "evaluation measures of algorithms" dimension were determined by referring to the categories suggested by Luan and Tsai.[18] Moreover, two researchers who had more than 5 years' experience of conducting studies related to technologies in nursing applications were invited to conduct the coding. The kappa value of the coding results was 0.86, showing high consistency.[19] For the inconsistent coding values, the

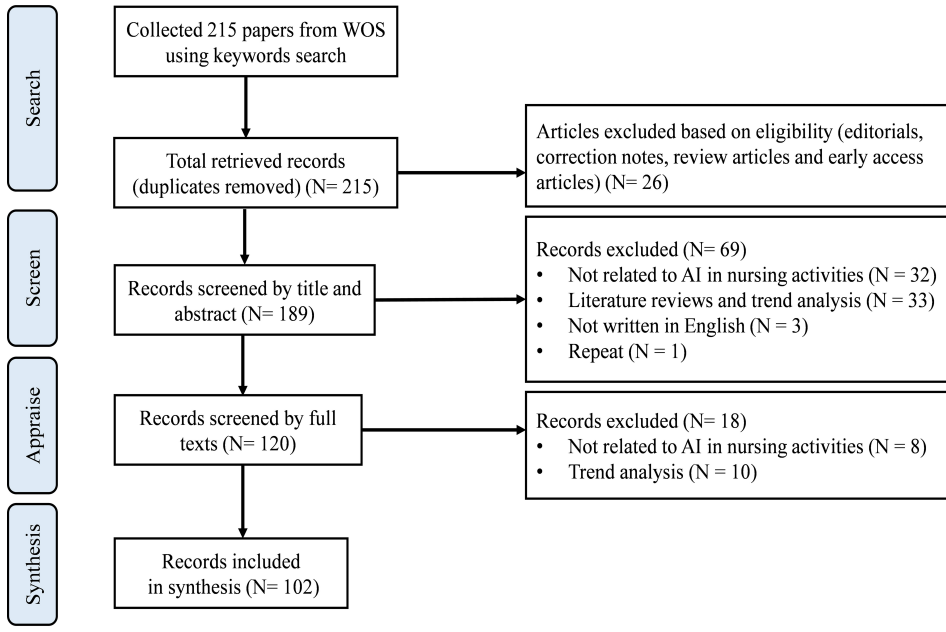


FIGURE 1. PRISMA flowchart for scoping review.

researchers were asked to discuss them until agreement was reached.

RESEARCH RESULTS

Nursing Activities

Table 2 shows the major nursing activities in AINA studies published between 2001 and 2020. By referring to the study of Huang et al,[10] this study categorized AI-associated activities into four major categories: (1) prevention and control (14 studies) as essential elements of patient safety and quality of care, including prediction and early detection of disease and quality improvement; (2) nursing management (47 studies), that is, improving nursing quality and patient satisfaction is an important component of nursing, including planning or organizing, decision support/making, patient management, and care management; (3) nursing assessment (37 studies) involves the nursing process and daily nursing tasks such as urinary tract infection assessment, imaging assessment, vascular assessment, and temperature measurement; and (4) nursing education (four studies) includes continuing training for nursing staff and school training for students. In the first period (2001–2010), assessment was the major nursing activity in AINA studies (6 out of 12 studies), followed by recording (two studies), care management (two studies), decision support/making (one study), and school training (one study). In the second period (2011–2020),

Table 1. Coding Schemes of This Study

Dimension	Coding Items
Nursing activities	Prevention and control (including predicting and detection and quality improvement), nursing management (including decision support/making, patient management and care management), nursing assessment (including assessment and recording), and nursing education (including continuing education and school training)
Research sample	Students, nursing staff, patients, others, non-specified, and mixed
Research methods	Quantitative, qualitative, and mixed methods
Roles of AI	Profiling and prediction, intelligent tutoring systems, assessment and evaluation, and adaptive systems and personalization
Applied AI algorithms	Artificial neural networks, Bayesian inferencing and networks, convolutional neural networks, data mining, decision trees, evolutionary algorithms, fuzzy logic algorithms, *k*-nearest neighbor, knowledge elicitation methods via interviewing domain experts, linear regression, logistic regression, machine learning, and natural language processing, random forest, support vector machines, others, and mixed
Evaluation measure of algorithms	Accuracy, AUC, F1 score, recall/sensitivity, precision, others, mixed, and none
Research foci	Cognition (eg, learning performance, higher order skills, collaboration or communication), affect (eg, technology acceptance, attitude, motivation, and satisfaction), skills, behavior, correlation, system design or evaluating AI system/instrument performance, and others

Table 2. Distribution of Major Nursing Activities in AINA Studies in Each Period

Nursing Activities		2001–2010	2011–2020	2001–2020	Total, %
Prevention and control	Predicting and detection	0	14	14	13.73
	Quality improvement	0	0	0	
Nursing management	Care management	2	16	18	46.08
	Decision support/making	1	10	11	
	Patient management	0	18	18	
Nursing assessment	Assessment	6	19	25	36.27
	Recording	2	10	12	
Nursing education	Continue education	0	0	0	3.92
	School training	1	3	4	

assessment was the major nursing activity in AINA studies (19 out of 90 studies), followed by patient management (18 studies), care management (16 studies), predicting and detection (14 studies), decision support/making (10 studies), recording (10 studies), and school training (three studies).

As shown in Table 2, from the first to the second period, the numbers of AINA studies related to "nursing management" and "prevention and control" increased the most. For example, in the second period, Hunter et al[20] applied data-to-text technology to an electronic patient record system, which could automatically produce helpful natural language nursing shift summaries; Buisseret et al[21] designed a method integrating clinical tests and motion capture sensors to optimize the prediction of the risk of falls. Nevertheless, quality improvement of "infection prevention and control" as well as the issues related to continuing education have not been explored in AINA studies.

Research Sample and Research Methods

Table 3 shows the distribution of research samples in AINA studies. From 2001 to 2020, the most frequently explored research sample in AINA studies was patients (58 studies), followed by nursing staff (23 studies), mixed (10 studies), non-specified (five studies), students (four studies), and others (two studies). In addition, in Table 3, it was found that few studies explored nursing staff and patients in the nursing education activities of the AINA studies.

As demonstrated in Table 3, in the first period, patients (4 out of 12 studies) and nursing staff (four studies) accounted for the majority, followed by mixed (two studies), students (one study), and non-specified (one study). In the second period, patients (54 out of 90 studies) and nursing staff (19 studies) were the most frequently explored research samples, followed by mixed (eight studies), non-specified (four studies), students (three studies), and others (two studies). Furthermore, in the second period, in addition to patients and nursing staff, AINA studies also explored issues related to students, the elderly, and data and records in the hospital. For example, Gochoo et al[22] adopted wireless passive infrared sensors to collect the elderly's health data and used several AI algorithms to infer and predict dementia.

From 2001 to 2020, the most adopted research method was quantitative (90 out of 102 studies), followed by qualitative (seven studies) and mixed methods (five studies). After comparing AINA studies published in the two periods, it was found that qualitative and mixed methods started to be adopted by researchers in the second period.

Roles of Artificial Intelligence in Artificial Intelligence–Associated Nursing Activities

Figure 2 shows the distribution of roles of AI in AINA studies. From 2001 to 2020, the most adopted role of AI in AINA studies was profiling and prediction (63.73%), followed by

Table 3. Distribution of Research Samples in AINA Studies in Each Period

	Students	Nursing Staffs	Patients	Others	Non-specified	Mixed
2001–2010 (n = 12)						
Prevention and control	0	0	0	0	0	0
Nursing management	0	2	1	0	0	0
Nursing assessment	0	2	3	0	1	2
Nursing education	1	0	0	0	0	0
2011–2020 (n = 90)						
Prevention and control	0	0	10	2	0	2
Nursing management	0	8	29	0	4	3
Nursing assessment	1	11	15	0	0	2
Nursing education	2	0	0	0	0	1
Total (N = 102)	4	23	58	2	5	10

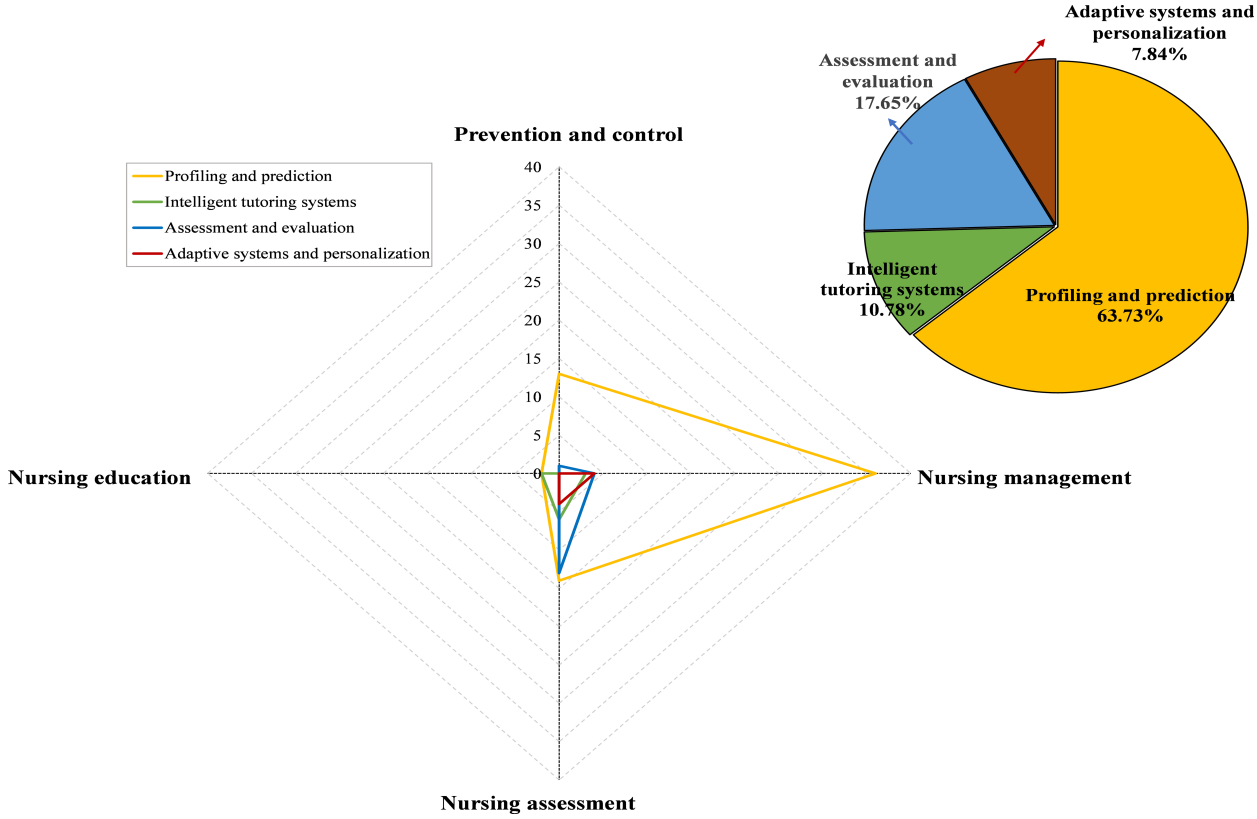


FIGURE 2. Roles of AI and AI-associated nursing activities.

assessment and evaluation (17.65%), intelligent tutoring systems (10.78%), and adaptive systems and personalization (7.84%). Figure 2 also presents that the most adopted role of AI in care management in the AINA studies was profiling and prediction (36 out of 47 studies), followed by assessment and evaluation (four studies), adaptive systems and personalization (four studies), and intelligent tutoring systems (three studies). For example, Bosque[23] developed an intravenous infusion nanotechnology monitoring system to warn nurses of impending peripheral intravenous infusion failure. In the AINA studies, the most frequent role of AI in the nursing assessment component was profiling and prediction (14 out of 37 studies), followed by assessment and evaluation (13 studies), intelligent tutoring systems (six studies), and adaptive systems and personalization (four studies). For instance, Lindberg et al[24] used tree-based machine learning methods to determine the most important predictors of inpatient falls and performed cross-validation. In the aspects of prevention and control, the most adopted role of AI was profiling and prediction (13 out of 14 studies), followed by assessment and evaluation (one study). No studies could be found to adopt intelligent tutoring systems or adaptive systems and personalization. For example, Chun et al[12] investigated factors related to early pressure injury progression and applied a machine learning approach to develop a model to predict these outcomes. In terms of aspects of nursing education, the most adopted roles of AI were profiling and prediction (two out of four studies) and intelligent tutoring systems (two studies), whereas no research could be found to adopt assessment and evaluation or adaptive systems and personalization. For instance, Kwon et al[25] showed how one application of machine learning might support nursing work and discussed how nurses could help improve its relevance and performance. Shorey et al[26] developed and examined the use of virtual patients to prepare nursing undergraduate students for communicating with real-life patients, their family members, and other nursing staff during their clinical tenure.

Applied Artificial Intelligence Algorithms and the Evaluation Measures of Algorithms

Table 4 shows the distribution of applied AI algorithms in AINA studies. From 2001 to 2020, the most applied AI algorithm was mixed (48 out of 102 studies), with natural language processing (21 studies) and artificial neural networks (seven studies) in the second and third places. In the first period, the most applied AI algorithms were knowledge elicitation methods via interviewing domain experts (three studies) and mixed (three studies), followed by case-based reasoning

Table 4. Applied AI Algorithms and Evaluation of Algorithms in Each Period

	2001–2010	2011–2020	2001–2020
Applied AI algorithms			
Artificial neural networks	1	6	7
Bayesian inferencing and networks	0	1	1
Case-based reasoning	2	0	2
Convolutional neural networks	0	1	1
Data mining	0	1	1
Decision trees	0	3	3
Evolutionary algorithms	0	1	1
Fuzzy logic algorithms	0	1	1
Knowledge elicitation methods via interviewing domain experts	3	0	3
Linear regression	0	1	1
Logistic regression	0	1	1
Machine learning	0	4	4
Natural language processing	2	19	21
Random forest	0	2	2
Support vector machines	0	1	1
Others	1	2	3
Mixed	3	45	48
Evaluation of AI algorithms			
Accuracy	4	8	12
AUC	0	4	4
F1 score	0	1	1
Recall/sensitivity	0	4	4
Precision	0	1	1
Others	1	6	7
Mixed	1	50	51
None	6	16	22

Abbreviation: AUC, area under the curve.

(two studies), natural language processing (two studies), artificial neural networks (one study), and others (one study). For instance, Martin[27] developed and assessed an expert system for calculating the most likely diagnosis, presented photos of the typical ocular findings, and offered information about management and treatment. In the second period, the most applied AI algorithm was mixed (45 studies), whereas the second was natural language processing (19 studies), and the third was artificial neural networks (six studies). For instance, Moen et al[7] developed a system based on artificial neural networks and classification to conduct text classification on EHRs, which assisted nurses in effective management in hospitals.

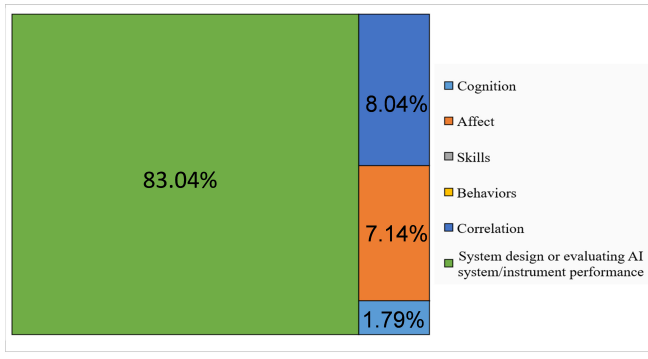
In the first period, the most adopted AI algorithms in AINA studies were fuzzy logic algorithms. Fuzzy logic is a mathematical logic model developed based on the concept of partial truth values (ie, ranging from "perfectly right" to "perfectly wrong") and has become a widely used instrument for managing imprecision and uncertainty. It has been used in various application domains such as differential diagnosis of alterations in urinary elimination.[28] In the second period, the most adopted AI algorithms in AINA studies included random forest, support vector machines (SVMs), decision trees, logistic regression, artificial neural networks, data mining, others, Bayesian inferencing and networks, and so on. As can be seen from Table 4, it has become a trend to adopt mixed AI algorithms in AINA studies. For example, Horng et al[29] used an SVM, logistic regression, naive Bayes, and random forests to build four models to predict infection, incrementally adding vital signs, chief complaints, and free text nursing assessment. Shorey et al[26] applied natural language processing and a neural network and classification to develop virtual patients to facilitate nursing staff's communication skills training. Sánchez-Montañés et al[30] applied various AI algorithms (eg, logistic regression, decision tree, Bayesian network, random forest, and bi-clustering algorithms to build a mortality prediction model for COVID-19 patients).

Table 4 also shows the distribution of adopted evaluation measures of algorithms in AINA studies. From 2001 to 2020, the most adopted evaluation measure of algorithms in AINA studies was mixed (51 out of 102 studies), with no evaluation measure of algorithms (22 studies) and accuracy (12 studies) in the second and third places. In the first period, no

evaluation measure of algorithms (six studies) accounted for the majority, followed by accuracy (four studies), mixed (one study), and others (one study). For example, Leung and Mao[31] evaluated the accuracy of artificial neural networks to develop telephone triage assistants and obtained positive feedback. In the second period, the most adopted evaluation measure of algorithms was mixed (50 studies), with no evaluation measure of algorithms (16 studies) and accuracy (eight studies) in the second and third places. For instance, Lee et al[32] compared the effects of six machine learning methods (ie, random forest, logistics regression, linear SVM, polynomial SVM, radial SVM, and sigmoid SVM) on predicting falls in nursing homes. On the other hand, from 2001 to 2020, the most adopted evaluation measure of algorithms was recall/sensitivity, specificity, and accuracy. For instance, Moseley and Mead[33] evaluated the accuracy, recall/sensitivity, and specificity of data mining and machine learning to develop a nursing education system that increased the quality of nursing education training at schools. In the second period, there were several newly adopted evaluation measures of algorithms in AINA studies at the same time, including area under the curve, F1 score, positive/negative predictive value, precision-recall curve, precision, and receiver operating characteristic curve.[34–36]

Research Foci

Figure 3 shows the distribution of research foci in AINA studies published from 2001 to 2020. The most frequently explored research focus in AINA studies was system design or evaluating AI system/instrument performance (83.04%), followed by correlation (8.04%), affect (7.14%), and cognition (1.79%). However, a few research foci have not been investigated in AINA studies, such as skills and behaviors. In the aspect of nursing management, the most frequently explored research focus in AINA studies was system design or evaluating AI system/instrument performance (45 studies), followed by correlation (five studies) and affect (one study). For instance, Sandhu et al[37] adopted semi-structured interviews to examine the factors affecting the application of a machine learning sepsis early warning system in clinical workflows. For the aspect of nursing assessment, the most frequently explored research focus was system design or evaluating AI system/instrument performance (34 studies), followed by affect (four studies) and correlation (three studies). For example, Hu et al[38] used natural language processing techniques applied to a corpus to calculate the number of different healthcare topics and performed sentiment analysis to explore patients' sentiments regarding different healthcare services. In their study, issues related to patient safety received the most attention, followed by information technology and service efficiency. As for the aspect of prevention and control, the most frequently explored research focus was system design or evaluating AI system/instrument performance (13 studies), followed by correlation (one study). For instance, Sun et al[39] provided information about COVID-19 infection prevention measures, and identified and predicted the risk and possibility of COVID-19 infection in nursing homes by using a machine learning approach. Galvan et al[40] applied artificial neural networks of self-organizing maps to analyze and predict the possible factors influencing the spread



	2001-2010				2011-2020			
	Nursing management	Nursing assessment	Prevention and control	Nursing education	Nursing management	Nursing assessment	Prevention and control	Nursing education
Cognition	0	0	0	0	0	0	0	2
Affect	0	0	0	0	1	4	0	3
Skills	0	0	0	0	0	0	0	0
Behaviors	0	0	0	0	0	0	0	0
Correlation	1	0	0	0	4	3	1	0
System design or evaluating AI system/instrument performance	3	8	0	1	42	26	13	0

FIGURE 3. Research foci of the AINA studies in each period.

of COVID-19. With regard to the aspect of nursing education, the most frequently explored research focus was affect (three studies), followed by cognition (two studies) and system design or evaluating AI system/instrument performance (one study). For instance, researchers showed that combining AI and virtual reality technology in a learning environment to train students with virtual patients could enhance their self-efficacy and communication skills.[9,26]

As can be seen from Figure 3, in the first period, in the dimensions of nursing management, nursing assessment, and nursing education in AINA studies, the most frequently explored research focus was system design or evaluating AI system/instrument performance (12 studies); among those studies, there was one that discussed issues related to system design or evaluating AI system/instrument performance and correlation at the same time.[41] On the other hand, the most frequently explored research issue in the second period was system design or evaluating AI system/instrument performance (81 studies), followed by correlation (nine studies), affect (eight studies), and cognition (two studies). During this period, AINA studies began to discuss issues related to cognition and affect.

DISCUSSION

Nursing Activities

In AINA studies, the most frequently explored nursing activity was nursing management, followed by nursing assessment. In the first period, nursing assessment accounted for the majority of studies,[27] whereas nursing management accounted for the majority in the second period, followed by nursing assessment. Moreover, nursing management received a great deal of attention in AINA studies.[42] For instance, Ladios-Martin et al[43] integrated data mining and machine learning through the Norton scale and Braden scale to effectively predict the risk of pressure injury. This allowed nurses to pay attention to patients at a high risk of pressure injury without increasing their workload. Tawfik et al[44] established a nurse staffing prediction model and evaluated deviation from predicted nurse staffing as a contributor to patient outcomes. In the aspect of nursing assessment, with the development of nursing techniques, the data of patients could be collected through Internet of Things and sensors[21]; for example, Ocagli et al[45] integrated various AI algorithms to evaluate and classify patients' physical conditions and to provide adequate nursing assistance. In addition, among the nursing activities, few AINA studies could be found to examine quality improvement in the dimension of prevention and control or continuing education in the dimension of nursing education.

Research Samples and Research Methods

From 2001 to 2020, the most frequently discussed research sample in AINA studies was patients, followed by nursing staff. From the perspective of nursing activities, in the aspects of nursing management and nursing assessment, the most frequently explored research sample was patients, followed by nursing staff. With regard to the aspects of prevention and control (eg, prediction and early detection of disease and quality improvement), patients accounted for the majority, whereas students accounted for the majority in the aspect of nursing education. On the other hand, few AINA studies could be found to explore patients in AI-supported nursing education activities, nursing staff in AI-supported continuing education activities, or students in AI-supported prevention and control, nursing management, and nursing assessment activities. Furthermore, the results showed that the sample size of AINA studies increased significantly, indicating that the advancements in AI technology enhanced the ability to predict and evaluate the data.[30] Most of the AINA studies adopted quantitative methods as the research method, whereas several adopted qualitative methods[9] and mixed methods[26] in the second period. Besides adopting quantitative methods to evaluate and measure the application of AI in the nursing field, researchers also focused on nursing staff's or nursing students' perceptions and experience of AINAs in AINA studies, for example, the nursing staff's opinions on AI-assisted professional judgment through interviews[37]; the nurses' viewpoints on the use of robots in pediatric units[46]; student users' attitudes and experience; and clinical instructors' points of view on students' clinical performance after the virtual patient training.[9]

Roles of Artificial Intelligence in Artificial Intelligence–Associated Nursing Activities

The most adopted role of AI in nursing activities was profiling and prediction, followed by assessment and evaluation. In the first period, assessment and evaluation accounted for the majority, whereas profiling and prediction accounted for the majority in the second period, followed by assessment and evaluation. Exploring profiling and prediction as the roles of AI in AINA studies showed the greatest growth. In addition, with the advancements of AI technologies, such techniques as algorithms, prediction models, natural language processing, and machine learning could be applied to analyze substantial data in hospitals (eg, patients' medical records, nursing records, data of medical systems) so as to assist hospitals in accurately predicting the incidence of diseases,[47] standardizing terminology for the emergency department,[48] and supporting nursing operations and efficiency.[2,41]

In terms of nursing activities, the most frequently adopted role of AI was profiling and prediction.[40,49] Besides, in AI-supported prevention and control, no AINA studies could be found to explore the two roles of AI (ie, intelligent tutoring systems and adaptive systems and personalization). With regard to AI-supported nursing education, no AINA studies could be found to explore assessment and evaluation or adaptive systems and personalization as the roles of AI.

Applied Artificial Intelligence Algorithms and Evaluation Measures of Algorithms

The advancements in AI technology have facilitated the development of nursing applications. The application of AI algorithms has also become increasingly diverse, and there is a trend towards exploring the integration or comparison of various AI technologies. In AINA studies, the most adopted algorithm was mixed, followed by natural language processing. In the first period, such algorithms as knowledge elicitation methods via interviewing domain experts and mixed accounted for the majority, whereas the most adopted algorithm in the second period was mixed, followed by natural language processing. For instance, an electronic classification system for health records was developed based on artificial neural networks and classification to reduce the time and effort nurses spent on recording care in hospitals.[7] Some researchers used various AI algorithms for the evaluation in order to increase the accuracy of data processing.[25,41] Furthermore, there were some AI algorithms that were less frequently adopted by AINA studies, such as case-based reasoning, knowledge elicitation methods via interviewing domain experts, classification, convolutional neural networks, evolutionary algorithms, and fuzzy logic algorithms.

In the early stage, only a few AINA studies were related to the "evaluation measures of algorithms." Most AINA studies did not use any evaluation measures of algorithms; instead, they investigated the participants' perceptions[9,37,46] or the effectiveness of using AI in terms of improving the health of older adults.[50] With the progress of AI technology, the evaluation measure of algorithms has become more diverse, such as area under the curve, F1 score, positive/negative predictive value, precision-recall curve, precision, and receiver operating characteristic curve. From 2001 to 2020, the most frequently adopted evaluation measure of algorithms was recall/sensitivity, followed by specificity and accuracy. The mixed evaluation measure of algorithms could increase the accuracy of systems to promote the accuracy and efficiency of AI application in the nursing field.[29]

Research Foci

From the research issues explored, the AINA studies focused on developing systems and assisting doctors with medical diagnosis, a finding similar to that of Kueper et al.[4] In nursing activities of prevention and control, nursing management, and nursing assessment, most of the AINA studies put emphasis on system design or evaluating AI system/instrument performance.[38] In contrast, the issues related to cognition, affect, skills, behaviors, and correlation were scarcely explored, especially cognition, skills, and behaviors. Moreover, few AINA studies could be found to explore the application of AI technology in nursing education, especially for issues related to affect, cognition, skills, behaviors, correlation, and system design, or evaluating AI system/instrument performance.

CONCLUSIONS

The present study analyzed a total of 102 AINA studies published from 2001 to 2020 in the Web of Science database. Researchers indicate that AI technology can assist the professional training of nursing staff and students. It can also help diagnose patients' physical conditions and predict the risk of diseases and accidents, which can foster development in the nursing and medical fields.[3,9,25,49] This study classified and summarized the research findings as follows: (1) it analyzed the distribution of nursing activities in AINA studies, (2) it identified research samples and research methods that were less explored in AINA studies, (3) it proposed roles of AI that were less adopted in AINA studies, (4) it pointed out AI algorithms and evaluation measures of algorithms that were less applied in AINA studies, and (5) it indicated research foci that were less discussed in AINA studies.

Based on the findings of the study, several recommendations for future AINA research are given: (1) proposing effective strategies to foster nursing staff's and students' AI knowledge and skills and investigating the factors influencing their attitudes towards applying AI technologies to practical applications; (2) developing personalized learning systems to provide AI literacy training for nursing staff and students, and evaluating the training outcomes from diverse dimensions, such as learning achievement, self-efficacy, problem-solving skills, critical thinking skills, and communication skills; (3) exploring patients' and nursing staff's perceptions and acceptance of using AI technologies in personalized care; (4) developing and adopting measures to assess the effectiveness of applying AI technology to nursing activities, such as tests, questionnaires, interviews, rubrics, or coding schemes for behavioral pattern analysis; (5) developing AI technologies to optimize or improve the accuracy of medical diagnosis and treatment, such as analyzing medical diagnostic images with image recognition technologies and expert systems; (6) using AI technologies for nursing data analysis to improve nursing care quality, such as enabling real-time diagnosis and health alerts for individual patients, and preventing and controlling nursing-associated infections; and (7) organizing interdisciplinary research teams to apply AI technologies in smart care, such as home care robots for older adults and patients, and health promotion systems for older adults.

To sum up, this study analyzed the AINA research published in the past 2 decades from diverse perspectives. The findings could be a good reference for nursing staff, teachers, and policy makers in nursing institutes, as well as researchers in the field for conducting their work and research in the future.

On the other hand, the current study has some limitations: first, only the Web of Science database was considered;

second, the coding was conducted based on the technology-based learning review model; the analytical results would be influenced by the model representing the classification and coding schemes. Therefore, it is suggested that a larger scale review be conducted in the future by taking more academic databases and other review models into account.

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