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Original Paper

Demand Forecasting of Nurse Talents in China Based on the Gray GM (1,1) Model: Model Development Study

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Abstract

Background: In a global context, the shortage of nursing personnel has emerged as a significant challenge, particularly in countries such as China experiencing population aging. The inadequacy of nursing human resources has become one of the primary threats affecting the quality of health services available to Chinese residents. Therefore, forecasting the demand for nursing personnel has become an important issue.

Objective: This study presents a Gray GM (1,1) forecasting model for predicting the future 10-year demand for nursing workforce and the number of specialized geriatric nurses, aiming to provide a scientific basis for the development of policies in health care institutions in China.

Methods: Based on data from the China Statistical Yearbook 2022, the Gray GM (1,1) model was used to predict the demand for nursing jobs and geriatric nurses over the next 10 years (2024-2033).

Results: The results indicate that from 2024 to 2033, amidst a continuous growth in the overall population and an increasingly pronounced trend of population aging, the demand for nursing workforce in China, especially for specialized geriatric nurses, is projected to steadily increase.

Conclusions: The paper provides a reference basis for the establishment of China's health care workforce system and the involvement of government departments in health care workforce planning.

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KEYWORDS

nursing human resource; nursing manpower; Gray GM (1,1) model; forecasting; nursing

Introduction

Health human resources are an essential foundation for achieving universal health coverage and the United Nations Sustainable Development Goals [1]. In 2016, the World Health Organization (WHO) released the "Global Strategy on Human Resources for Health: Workforce 2030" [2] with a vision to strengthen health systems to ensure equitable access to health workforce services and accelerate progress toward universal health coverage and the UN Sustainable Development Goals. Following this, in 2022, the "National Nursing Career Development Plan (2021-2025)" [3] issued by China's National Health Commission explicitly expressed the crucial role of nursing human resource planning in achieving universal health coverage and sustainable development goals. Therefore, the comprehensive promotion of high-quality nursing development and the improvement of the population's health level are among the primary development goals of China's future medical system. In China, registered nurses [4] are individuals who have

completed relevant nursing professional education, obtained a nursing qualification certificate, and are registered and legally licensed to practice in medical institutions, including hospitals, health centers, community health service centers, clinics, and nursing homes. As direct providers of medical nursing services in China, registered nurses have always been an indispensable part of Chinese medical institutions, playing a key role in ensuring patient health and medical safety, and contributing significantly to advancing the construction of health development goals worldwide [5]. Despite increasing attention and implementation of measures such as improving remuneration and optimizing career advancement pathways to prevent the loss of nursing human resources in recent years, the issue of nursing staff shortage and uneven distribution in China has remained prominent [5].

Registered nurse density per 1000 population [5] refers to the number of registered nurses per 1000 permanent residents, indicating the availability and capacity of health care services within a particular country or region [6]. A higher value implies better assurance of public health needs in that area. The "2020 World Nursing Report" [7] highlights significant disparities in nurse supply among countries. According to WHO statistics, Sweden has the highest number of nurses per capita globally, with 21.67 nurses per thousand people [8]. Norway follows closely with 18.35 nurses per thousand people or more, while the United States and Japan have 15.69 and 12.7 nurses per thousand people, respectively [8]. Conversely, China's registered nurse density stands at only 3.56 nurses per 1000 population, revealing a notable gap compared with the developed nations [9]. In addition, the increasing trend of aging population in China has indeed brought about a growing pressure on the demand for health care services [10]. In 2021, the population aged 65 years and older in China accounted for 14.2% of the total population, indicating a doubling of the proportion of older individuals from 7% to 14% over 21 years. It is projected that by 2050, the population aged 60 years and older in China will increase to 478.9 million. With the increasing proportion of the older adult population in China, the demand for caregiving services is correspondingly rising [11].

In previous studies, it has been widely reported that an increased presence of registered nurses significantly improves patient outcomes and plays a crucial role in ensuring patient safety [12]. However, in recent years, some scholars have raised concerns regarding this viewpoint. They argue that an excessive number of nurses could lead to additional expenses for health care institutions and wastage of manpower [13]. Some studies even indicate a correlation between an excessive allocation of nursing staff and poorer quality of care [14]. Such as Park's Optimized Nurse Staffing (Sweet Spot) Estimation Theory emphasizes the crucial balance between nursing quality, cost, and staffing levels, making a significant contribution to enhancing the effectiveness of health care workforce planning [15]. As widely known, effective health care workforce planning drives the establishment of resilient and sustainable health care systems [16], with workforce demand forecasting playing a crucial role in health care workforce planning [17]. Therefore, to clarify the current status of nursing human resource allocation in China, further seeking the balance point between nursing quality, cost, and the level of nurse staffing, it is essential to conduct accurate forecasting and analysis of the future demand for nurses in China. It is worth noting that Park et al [18] suggested integrating mathematical programming into nursing research to assist nursing leaders and managers in determining optimal nurse staffing and composition. Consequently, adopting mathematical models to predict the demand for nursing personnel is highly feasible.

Currently, many scholars in health care research use mathematical models and algorithms for predictive purposes. The methods are mainly divided into 3 categories: first, machine learning models for demand prediction, such as the study by Vollmer research team in 2021, which developed a machine learning–based model to predict emergency department demand [19]; in 2022, Soltani et al [20] used deep machine learning models to predict the demand of patients with end-stage cancer at home. Second, time series models, such as using time series analysis to investigate depression rates during the COVID-19 crisis in Peru [21]; Zhang et al [5] used time series analysis to assess the impact of the "National Nursing Development Plan" on the nursing human resources in China, concluding that the implementation of the plan significantly expanded the scale of nursing human resources and optimized allocation efficiency. Third, the use of hybrid models, such as Chung development of a dynamic model to forecast the demand for cancer nurses over the next decade [17]. Human resources for nurses are influenced by various external and internal factors, such as economic conditions, industry development trends, and environmental changes, as well as organizational strategic goals, business requirements, and talent adjustment policies [22]. Therefore, nurse workforce forecasting requires flexibility and adaptability, aiming for rapid and accurate predictions through simple means whenever possible. The aforementioned machine learning models, time-series models, and hybrid models have demonstrated good predictive performance. However, they generally require large amounts of historical data and involve complex processes. Although data accumulation on nursing human resources in China has been relatively extensive to date, nurse workforce dynamics are influenced by various factors such as national policies and socioeconomic conditions. Consequently, historical data accumulated over the long term may not be applicable to the current situation. Therefore, there is a need to identify a model that does not rely on extensive data. Fortunately, the Gray GM (1,1) model [23] provides a structurally simple and widely applicable mathematical forecasting model, using a small amount of data to forecast within an unknown required data range. Due to its high predictive accuracy, good performance, and convenience, the Gray GM (1,1) model has been widely applied in fields such as construction, ecological environment, and the medical industry [23], especially during the COVID-19 crisis, with many scholars applying it to COVID-19 prediction and achieving outstanding results [24]. In terms of human resource forecasting, relevant studies can be traced back to 2007 when Lin et al [25] used the gray model to forecast the long-term demand and supply of nursing staff in Taiwan, showing good results. However, as the data included in this study are limited to the Taiwan region, it is not applicable to predict the nursing workforce in mainland China. Therefore, building upon previous

research, this study uses the latest data to construct a Gray GM (1,1) model for forecasting the demand for nursing positions in mainland China over the next 10 years. Furthermore, incorporating current social development trends, an analysis of the forecast results is provided.

Methods

Data Source

The research object was registered nursing talent resources per thousand people in China. Data were extracted from the China Statistical Yearbook 2022 [26] from which the total population and registered nurse numbers were collected from 2008 to 2021, and the registered nurses per thousand population were calculated.

Procedures

First, we used Excel 2019 to enter and process the raw data and used descriptive statistical methods to study the dynamic trends of registered nursing talent resources per thousand people in China. Subsequently, the Gray GM (1,1) model was applied to model the registered nursing talent resources per thousand population, and the model was used to forecast the demand of these resources over the next 10 years. In addition, we have also forecasted the demand for geriatric nurses in China. Finally, we used the MATLAB 2023 software (MathWorks Inc) to design a model program for fitting and prediction, and the accuracy of the predictions was evaluated.

Ethical Considerations

All procedures in this study are conducted in accordance with the guidelines of our institutional ethics committee and the principles of the Declaration of Helsinki. Since all data are extracted from public databases, informed consent is not required for the use of these data. All research results will be reported accurately and truthfully, and the confidentiality and security of the data will be ensured. This study has been approved by the Ethics Review Committee of the School of Medicine, Wuhan University of Science and Technology (ID 2024097), for both the study and the entire research protocol.

Results

The Development of Nurse Practitioners in China From 2008 to 2021

According to the data from the "China Statistical Yearbook 2022 [26]," as shown in Table 1, the total number of registered nurses in China has been increasing annually from 1,678,091 in 2008 to 5,019,422 in 2021, with an average annual growth rate of 8.14%. The number of registered nurses per thousand people in the country increased by 2.29, with an average annual growth rate of 7.64%.

Table 1. Development of the number of practicing nurses per 1000 national population from 2008 to 2021.

Year	Total population (unit: 10,000 persons)	Number of registered nurses (unit: person)	Number of nurses per thousand population (unit: person)
2008	1,32,802	16,78,091	1.27
2009	1,33,450	18,54,818	1.39
2010	1,34,091	20,48,071	1.53
2011	1,34,916	22,44,020	1.66
2012	1,35,922	24,96,599	1.85
2013	1,36,726	27,83,121	2.04
2014	1,37,646	30,04,144	2.20
2015	1,38,326	32,41,469	2.37
2016	1,39,232	35,07,166	2.54
2017	1,40,011	38,04,021	2.74
2018	1,40,541	40,98,630	2.94
2019	1,41,008	44,45,047	3.18
2020	1,41,212	47,08,717	3.34
2021	1,41,260	50,19,422	3.56

Population Forecast in China

Construction of Chinese population Gray GM (1,1), the prediction model. Take the population number from 2008 to 2021 as the original sequence:

(1)

Step 1: First accumulation of raw data $X^{(0)}$:

(2)

Step 2: Neighborhood mean generation was performed on the sequences after cumulative generation. Neighborhood mean generation is an equivalence time series, and new data are

generated with the average construction of adjacent data. Set the newly generated neighbor mean sequence *Z*, yielding:

(3)

Step 3: Construct data matrix *B* and data vector *Y*:

(4)

Step 4: Calculate the development coefficient â and the Gray System residual  :

(5)

Calculation results indicate that: â=–0.0051  =132807.551

Step 5: Establish a model to solve the time-response function and predict it.

The whitening equation under the Gray GM (1,1) model "$X^{(0)}(k)+aZ^{(1)}k=b$ "is:

(6)

Step 6: Generate the model:

(7)

Step 7: Find the generated sequence prediction value  $(k+1)$ and model reduction values  $(k+1)$: Bring k=0,1, 2..., 14 into the model to calculate $X^{(1)}$, among them take  (1) =  (1)=132802, got by the formula :  $(k+1)$= $(k+1)$-$X^{(1)}k$:

(8)

Calculate the simulated values.

Step 8: Evaluation of the model-fitting effect.

Using MATLAB 2023 software, the fitting results were tested using the posterior difference test method. In the gray prediction model of the national total population, the posterior difference ratio C value was 0.0226, and the small probability error *P* value was equal to 1.000. Table 2 shows that the model has high accuracy and a good fitting effect.

Table 2. Evaluation table of posterior difference ratio and probability of small error.

Predicting rank accuracy	*P* value	*C* value
Good	≥.95	≤.35
Qualified	.8, .95	.35, .5
Manage with an effort	.7, .8	.5, .65
Unqualified	≤.7	>.65

Step 9: Model prediction

The established model can predict the total population value for the next decade (2024-2033).

Population-to-Nurse Ratio Prediction

To predict the number of registered nurses per thousand population, Gray GM (1,1), model, input model code, and annual data were input into the MATLAB software, and the model was established as follows:

(9)

The posterior difference ratio *C* value was 0.005, and the small error probability *P* value was 1.000, with a better model accuracy level.

Forecast Results of Nurse Demand Under the Total Population

The above prediction results for the future population size population-nurse ratio were added into the formula: demand for registered nurses in a certain year = population forecast (10,000) 10 predicted number of nurses per 1000 population to obtain the number of demands for registered nurse resources in the next 10 years (Table 3). As can be seen from Table 3, the Gray GM (1,1) model predicts that by 2032, the total population will exceed 1.5 billion, the population of nurses per 1000 people will reach 8.357, and the demand for registered nurses will rise to 12.58 million.

Table 3. Forecast results of total population and demand number of nurses between 2024 and 2033.

Year	Population measurement (unit： 10,000 person)	Number of nurses per thousand population (unit： person)	Nurse requirements (unit： person)
2024	144503.493	4.574	66,09,590
2025	145244.674	4.932	71,63,467
2026	145989.656	5.318	77,63,730
2027	146738.460	5.734	84,13,983
2028	147491.104	6.183	91,19,375
2029	148247.609	6.666	98,82,185
2030	149007.993	7.188	107,10,695
2031	149772.279	7.751	116,08,849
2032	150540.484	8.357	125,80,668
2033	151312.629	9.011	136,34,781

Demand Forecast Results of Nurses Under the Trend of Population Aging

Our study investigates the aging population trend in China in recent years, which has shown a significant shift toward an older demographic structure. Population aging is recognized as a crucial factor that influences the demand for nursing professionals in our country [10]. In light of this, we used the Gray GM (1,1) model and analyzed data from the China Statistical Yearbook 2022 to predict the future numbers of the older adult population and the corresponding demand for nurses in the age group from 2024 to 2033 in China. The detailed forecast results are shown in Table 4. In 2033, the older adult population in China can reach 350.39 million, the number of nurses per 1000 older adult population is nearly 9, and the requirement of geriatric nurses reached 31,33,882. Owing to the slow growth of the older adult population from 2008 to 2018, the predicted total older adult population is likely to be underestimated.

Table 4. Forecast results of total older adult population and demand of nurses from 2024 to 2033.

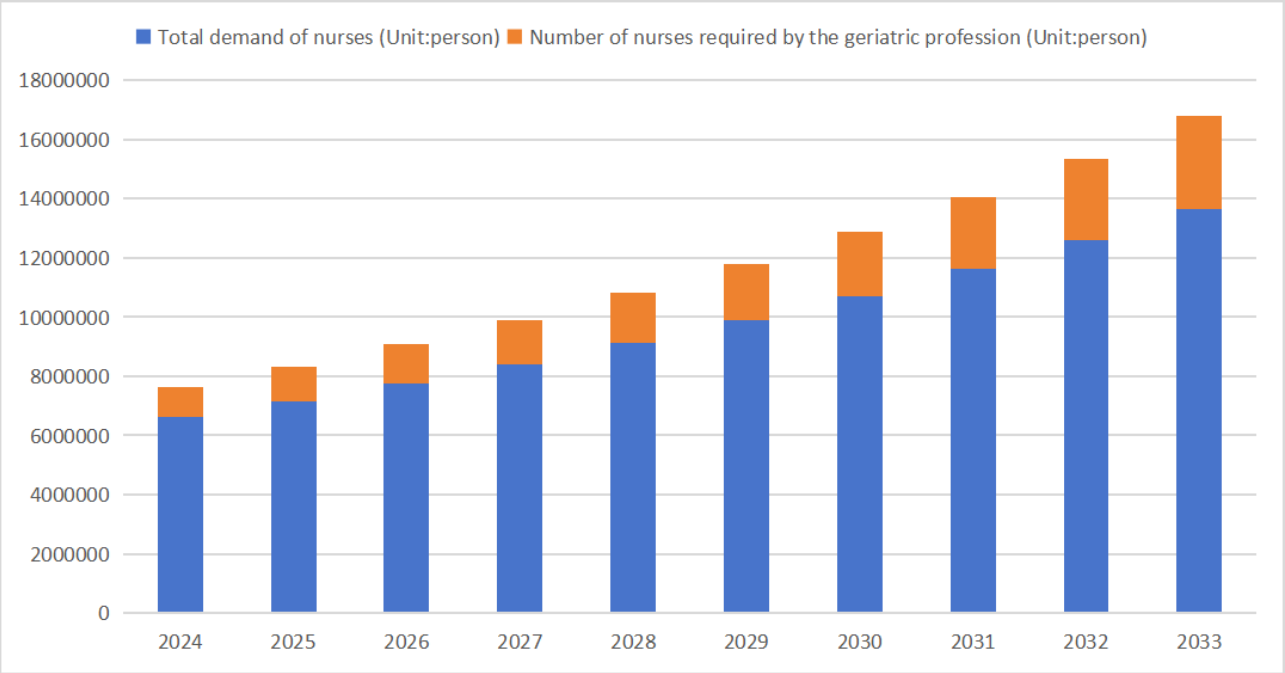
Year	Total older adult population (unit： 10,000 person)	Number of nurses per thousand older adult population (unit： person)	Requirements of geriatric nurses (unit： person)
2024	22704.306	4.544	10,31,684
2025	23825.734	4.899	11,67,223
2026	25002.553	5.282	13,20,635
2027	26237.498	5.695	14,94,226
2028	27533.441	6.14	16,90,553
2029	28893.394	6.619	19,12,454
2030	30320.519	7.137	21,63,975
2031	31818.133	7.695	24,48,405
2032	33389.719	8.296	27,70,011
2033	35038.929	8.944	31,33,882

Visual Analysis of the Demand Proportion of Geriatric Nurses

By using the prediction data generated through the gray model constructed in the paper, we can conduct a comparative analysis between the demand for geriatric nurses and the total demand for nurses in the next decade, as shown in Figure 1. From Figure 1, it can be observed that the demand for geriatric nurses in China is projected to steadily rise over the next 10 years. By the year 2024, the demand is estimated to be more than 1.03 million, and by 2033, it is anticipated to reach more than 3.13 million. This growth trend is primarily attributed to the aging population in China and the increasing demand for older adult care services. Furthermore, a more in-depth analysis reveals that the proportion of geriatric nurses within the overall demand for nurses is increasing annually from 2024 to 2033. In 2024, geriatric nurses constitute around 10% of the total, while this proportion is expected to rise to 20% by 2033. This indicates that in the coming decade, the role of specialized geriatric nurses in China's nursing workforce will become increasingly significant. In conclusion, the demand for geriatric nurses in China is projected to steadily increase over the next decade, with their proportion within the nursing workforce rising annually. To address this trend, it is imperative for China to enhance the training and education of geriatric nurses to meet the growing demand for older adult care services.

Simultaneously, attention must also be given to the overall expansion of the nursing workforce to ensure the quality and coverage of health care services.

Figure 1. The proportion of geriatric nurse demand from 2024 to 2033.



Discussion

Principal Findings

The research findings indicate that from 2008 to 2021, the total number of registered nurses in China experienced a rapid overall growth rate, with an average annual growth rate of 8.14%. The number of registered nurses per thousand population increased from 1.27 to 3.56. Based on the forecast results from Tables 3 and 4, under the gradual increase in the nurse-to-population ratio, by 2033, the number of registered nurses per thousand population in China is projected to reach 9.01, and the number per thousand older adult population could reach 8.94, approaching the current number in the United States. However, it should be noted that the growth in nurse numbers is also influenced by certain external factors not accounted for in this model, potentially introducing bias into the forecast results.

The Total Workforce of Nurses in China Is Steadily Increasing, Yet There Remains a Shortage Compared With the Demand for Medical Services

In recent years, with the support of the government and collaboration among health departments, the nursing industry in China has experienced rapid development and achieved significant outcomes. By the end of 2021, the proportion of registered nurses in China with a graduate degree had increased to 0.3% (14,900/5,019,422) [5]. The proportion holding bachelor's degrees has risen to 34.2% (17,16,645/50,19,422), and the proportion of those with university education has reached 47.2% (23,69,168/50,19,422) [5]. However, despite the improvement in the quality of nursing talents, the scarcity of nursing professionals in China persists. Currently, the total number of registered nurses in China exceeds 5.2 million, but the ratio of registered nurses per thousand people is only about 3.7, below the WHO's recommended standard of 5 nurses per thousand people. According to the "Healthy China 2030" planning outline [27], it is projected that by 2030, China will need 4.7 registered nurses per thousand people, indicating a need for nearly 2 million more nurses to fill this gap. Furthermore, factors such as the aging population in developing countries and the rapid increase in the number of patients with chronic disease will not only increase the demand for nursing care but also worsen the severe shortage of nursing professionals [28]. There is a significant gap in the number of nurses in China; therefore, it is necessary to formulate relevant guiding policies and coordinate the planning of the development of the nursing profession in China to meet the growing demand for clinical nursing services among the population.

The Population Aging Trend Increases the Demand for the Geriatric Medical Care Service Model

As China's economy and society continue to develop, population aging has become an inevitable trend [10]. According to this study's predictions, by 2033, China's older adult population will reach 360 million, with a demand for 3 million nurses in the older adult care sector. Compared with younger individuals, the nursing needs of older adults are diverse and multilayered, requiring higher comprehensive qualities from geriatric nurses [29]. Therefore, nurturing geriatric nursing personnel has become a focal point in the development of the nursing profession. However, despite the severity of the aging society, there still exists a lack of relevant training in geriatric nursing within the nursing profession. For instance, a study by Nawagi et al [30] revealed that almost no courses on geriatric nursing knowledge or improving care capabilities for older patients were incorporated into nurses' training at all levels. This rings alarm bells for China to advance the development of geriatric nursing. Strictly speaking, we should focus on addressing the deficiencies

in the nursing field and promote the comprehensive development of geriatric nursing to meet the needs of an aging society. In addition, it is suggested to optimize the existing medical nursing service model and vigorously develop long-term care and home care service models that can meet the nursing needs of older adults, promoting collaboration among disciplines such as nursing, rehabilitation, medicine, and social work, and continuously enhance the skill levels of clinical caregivers to meet the diverse care needs of the older adult population [31].

Exploring New Approaches Actively to Promote the Development of Nursing Education in China

Undoubtedly, there is a strong link between education and human resources [32]. High-quality education provides a solid foundation for the development of nursing human resources. In recent years, numerous studies have highlighted the role of nursing education in addressing nursing shortages, and governments worldwide have actively implemented various measures to develop nursing education in response to the shortage of nurses in their countries [22]. The development of computer and software technology offers infinite possibilities for nursing practice, and we must adapt to and embrace teaching methods that are relevant to the new generation [33]. The roles of virtual reality technology and artificial intelligence in fostering nursing students' cognition and skill mastery have been further confirmed, and their development in the education sector is receiving increasing attention [34,35]. However, for many researchers and educators, they still remain quite novel and unfamiliar [35]. Therefore, we recommend that health institutions and education departments increase investment and support for new technologies such as artificial intelligence in nursing education, comprehensively elevate the level of nursing education and practice in China, and better meet society's demand for nursing talent [36]. Second, moreover, according to a study in China [37], only a small percentage of high school students are willing to pursue nursing education. This low professional recognition undoubtedly exacerbates the shortage of nursing professionals. The research also indicates that in China, nurses' roles often depend heavily on doctors, inevitably leaving the public with stereotypical impressions such as "mechanical" and "hectic," which significantly diminishes the professional identity of nursing [37]. Therefore, it is imperative to promote the reshaping of the nursing profession's image, enhance public awareness regarding the societal stature of nurses, and attract more talents to the field of nursing.

Statistical Prediction Provides Strong Evidence for Optimizing the Resource Allocation in the Health Industry

Statistical forecasting [38] applies statistical principles and methods to predict and analyze future trends and developments within specific domains. By collecting data and using appropriate statistical models, forecasters can predict future trends and provide scientific evidence for decision-making. Its characteristics include objectivity, scientific rigor, and forward-looking perspective [23]. This study uses the gray model to forecast the demand for nursing personnel in China, estimating the overall trend and quantity of future nursing personnel based on limited historical data. Compared with other forecasting methods, the gray model requires less data, thus offering broad application prospects in manpower forecasting. However, gray models are relatively adept at handling linear or approximately linear relationships. Considering this, we suggest that in practical applications, adjustments and corrections should be made to the predictive results based on real-world circumstances. In the future, this model can be further optimized in terms of data processing and parameter optimization to enhance overall accuracy [23].

Conclusions

The study proposes a gray forecast model to predict the nursing manpower demand in China over the next 10 years, with a specific focus on the projected quantity of geriatric nurses amidst the trend of population aging. Our findings underscore the immediate need for health care and educational organizations to implement improvement measures to bridge the gap between the supply and demand for nurses. In addition, we have identified the future required number of nurses, providing a reference basis for governmental involvement in health care workforce planning.

Limitations

Similar to many studies, this research also has its limitations. The study exclusively uses a gray model to forecast the overall nursing demand in China, without considering the impact of geographical disparities on nursing resource allocation. Given China's vast geographical expanse, there are significant differences in nursing resource distribution among regions. Developed areas may have higher levels of nurse manpower resources than impoverished regions, which could lead to inaccuracies in the forecasting results due to regional imbalances. In addition, factors, such as low birth rates, nurse migration, and the increase in patients with chronic disease, also significantly influence nursing demand. Therefore, future research will explore the impact of these factors on nursing manpower and continue to refine relevant models for precise forecasting.

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Data Availability

The main data source of this study is China Statistical Yearbook, which has been cited in the text. As an authoritative compilation of statistical data, the report can also serve as an important reference source of information for other studies.

Authors' Contributions

All authors contributed to writing the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

None declared.

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Abbreviations

WHO: World Health Organization

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Viewpoint

Perspectives on Artificial Intelligence in Nursing in Asia

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Abstract

Artificial intelligence (AI) is reshaping health care, including nursing, across Asia, presenting opportunities to improve patient care and outcomes. This viewpoint presents our perspective and interpretation of the current AI landscape, acknowledging its evolution driven by enhanced processing capabilities, extensive data sets, and refined algorithms. Notable applications in countries such as Singapore, South Korea, Japan, and China showcase the integration of AI-powered technologies such as chatbots, virtual assistants, data mining, and automated risk assessment systems. This paper further explores the transformative impact of AI on nursing education, emphasizing personalized learning, adaptive approaches, and AI-enriched simulation tools, and discusses the opportunities and challenges of these developments. We argue for the harmonious coexistence of traditional nursing values with AI innovations, marking a significant stride toward a promising health care future in Asia.

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KEYWORDS

machine learning; ML; artificial intelligence; AI; algorithm; predictive model; predictive analytics; predictive system; practical model; deep learning; ChatGPT; chatbot; nursing; nurse; nursing education; personalized education; Asia

Introduction

Artificial intelligence (AI) is generally defined as a machine-based system that can make predictions, recommendations, or decisions to influence real or virtual environments based on human-defined objectives [1]. These systems—including branches such as robotics, machine learning, deep learning, and natural language processing—can imitate human cognitive functions such as reasoning, learning, and decision-making [2,3]. Over the years, AI has made significant advancements based on improved computer processing capabilities, access to large data sets for training, and algorithm designs [4]. AI-based technologies such as AI-powered decision support systems and AI-powered monitoring systems have been widely adopted by health care systems to improve patient care, enhance efficiency, and reduce costs [5,6]. Nurses are at the forefront of this revolution. AI can augment nurses' abilities, thus improving patient outcomes and increasing clinicians' and patients' satisfaction [7-10].

The adoption of AI in nursing in Asia is varied but is a growing trend in the region. This viewpoint discusses our multifaceted perspectives on the use of AI in nursing practice and education, with a specific focus on Asian countries. It is important to note that this paper is not intended to be a systematic review of the topic but rather aims to highlight developing trends and prospects in the field.

Applications of AI in Nursing

Applications of AI in Nursing Practice and Research

The introduction of AI in nursing in Asia, as in other parts of the world, began to gain prominence in the late 20th century and continued to evolve over the years; however, the specific timeline for the first use of AI in nursing in Asia can vary depending on the region and health care institution (Table 1). Some Asian countries, particularly those with advanced health care systems and a strong focus on technology, may have adopted AI in nursing earlier than others. Regions such as Singapore, South Korea, Japan, India, and China have embraced

AI-powered chatbots and virtual assistants, revolutionizing nursing practice and education, and addressing basic health queries [11-14].

As shown in Table 1, in practice and clinical research, Taiwan, South Korea, Japan, Singapore, and China have demonstrated significant advancements in the integration of AI. In Taiwan, data-mining techniques have significantly enhanced the prediction of nursing issues, while an electroencephalogram classification algorithm has greatly improved seizure monitoring. Hu et al [15] developed an inpatient pressure injury prediction model with an impressive 87.2% recall rate, benefiting high-risk patients. In South Korea, the automated sepsis risk assessment system (Auto-SepRAS) has excelled in categorizing sepsis risk, emphasizing its continuous monitoring value. AI-driven tools have effectively reduced hospital-acquired pressure ulcer rates and intensive care unit stays [16]. Additionally, recent studies in South Korea used machine learning–based analytical methods and natural language processing to accurately predict adverse drug reactions [17], pressure injury staging [18], and improve hospital data management capabilities [19]. Japan's focus on advanced health care analytics is evident through the works of Nakatani et al [20] and Kawashima et al [21], which leveraged natural language processing and machine learning to predict hospital inpatient falls (area under the receiver operating characteristic curve of 0.834) and needs of cancer patients in palliative care, respectively. A study in China used machine learning–based analytical methods for the early detection of delirium in children with critical illnesses [22]. These examples illustrate the remarkable progress in AI integration in nursing across these Asian countries, contributing to improved patient care and safety.

The application of AI-based triage systems in health care facilities and AI-powered telemedicine can further improve access to health care for those who live in remote and conflict-affected areas [23-25]. A research group in Turkey used machine learning to assess pediatric pain to help address patient needs and experiences in clinical practice [26]. Despite the potential benefit of integrating AI into nursing practice to improve patient care and health care delivery, research in this area in developing countries is currently limited, and more studies are needed to explore the feasibility, acceptability, and effectiveness of AI-based solutions in real-world nursing settings.

A bibliometric analysis and science mapping study on AI research in nursing revealed that China has published 89 papers and that Japan and Korea each published 19 papers in this field among Asian countries [27]. In addition, a multinational collaboration network focusing on AI research in nursing has been formed, encompassing nations in Asia such as Japan, Thailand, India, China, Korea, and Singapore. However, the study lacked instances or a comprehensive examination of how Asian nations are implementing AI technology in the nursing domain, and it also failed to address the consequences of such technology on nursing practice and education. These limitations underscore the necessity for increased region-specific research and deliberate global cooperation to optimize the use of AI technology in the nursing domain within Asian nations.

Table 1. Examples of artificial intelligence (AI) in nursing practice and research across Asia.

Authors, year, and country	Study type	AI features	AI feature description	Application in nursing	Key findings
Aydın and Özyazıcıoğlu [26], 2023, Turkey	Primary research; observation study	ML[a] (CNNs[b])	Deep-learning models for visual data analysis, using layers to automatically learn and extract features from images	Postoperative pain assessment in children	ML closely matched children's self-reported pain scores, demonstrating potential for clinical application
Back et al [16], 2016, South Korea	Primary research	AI-powered sepsis risk assessment system (Auto-SepRAS)	AI is used to analyze patient data and predict the likelihood of sepsis	Sepsis risk assessment	Auto-SepRAS demonstrated moderate predictive power for early sepsis identification in hospitalized patients
Hu et al [15], 2020, Taiwan	Primary research	ML (decision tree, logistic regression, random forest)	ML algorithms to make predictions and classifications based on data	Inpatient pressure injury prediction	The random forest model was the most accurate with key identified risk factors, including skin integrity and systolic blood pressure
Jeon et al [17], 2020, South Korea	Primary research	Temporal-difference method in reinforcement learning	Combining aspects of Monte Carlo methods and dynamic programming	ADRs[c]	Employing temporal-difference learning for analyzing ADRs from nursing notes offers promise for drug safety surveillance
Kawashima et al [21], 2024, Japan	Primary research	ML (XGBoost[d])	ML algorithm based on gradient boosting used for classification and regression tasks	Specialist palliative care needs prediction	The predictive model showed potential to replace traditional screening tools, with high accuracy in identifying palliative care needs
Kim et al [18], 2023, South Korea	Primary research	CNN	Deep-learning models for visual data analysis	Pressure injury staging	The CNN model improved the accuracy of pressure injury staging decisions among health professionals
Khan et al [24], 2019, Bangladesh	Perspective	DHIS2[e], EHR[f], big data, AI, ML	The use of AI and ML in medical health record software	Health data warehouse, EHRs, workforce strategy	Bangladesh integrated fragmented health systems into a unified digital health platform, advancing national health care delivery and planning
Lei et al [22], 2023, China	Primary research	ML (XGBoost, logistic regression, random forest)	ML algorithms based on gradient boosting	Delirium prediction in pediatric intensive care	The XGBoost model was the best performer for early prediction of delirium in critically ill children
Nakatani et al [20], 2020, Japan	Primary research	NLP[g] and ML	NLP focuses on the interaction between computers and human language; ML involves prediction algorithms	Predicting inpatient falls	High accuracy in predicting inpatient falls using nursing records with NLP and ML techniques
Shi et al [27], 2023, global (including Asia)	Bibliometric analysis	Various AI technologies	Not applicable	General nursing practice	Rapid growth in publications and citations in the field of AI in nursing, highlighting key areas such as nurse rostering, nursing diagnosis, decision support, and big data management; developed countries lead in publications and collaboration

[a]ML: machine learning.

[b]CNN: convolutional neural network.

[c]ADR: adverse drug reaction.

[d]XGBoost: extreme gradient boosting.

[e]DHIS2: District Health Information Software 2.

[f]EHR: electronic health record.

[g]NLP: natural language processing.

Applications of AI in Nursing Education and Patient Support

As shown in Table 2, in nursing education, the integration of AI promises improved learning outcomes and an overall elevation in the quality of training by allowing personalized learning experiences [28-30]. Through intricate algorithms, educational content can be tailored to resonate with individual student needs, accounting for their unique strengths, weaknesses, and learning styles. This ensures content delivery in a manner most conducive to comprehension and retention. Adaptive learning allows students to assimilate knowledge at their own pace, optimizing their educational journey. Engaging and interactive modules instill genuine enthusiasm in learners, fostering an environment conducive to in-depth exploration and understanding [31,32]. Moreover, simulation tools enhanced by AI capabilities revolutionize hands-on nursing training, providing safe and controlled environments for students to practice and refine their skills. Real-time feedback within these simulations allows for immediate correction and learning that are instrumental in building clinical confidence [33-37]. The specific integration of AI in nursing education in Asia is varied by country and institution. Nevertheless, it is increasingly recognized as a valuable tool for improving the quality of education and for preparing nursing students for the complex health care environment.

While some countries such as India, Pakistan, Bangladesh, Turkey, and Afghanistan may face limited resources and infrastructure, several attempts have been made to develop low-cost, culturally tailored AI technologies to improve patient care, optimize workflow efficiency, and enhance clinical decision-making (Table 2). Examples of such AI applications in these countries include the implementation of AI-powered chatbots for patient education and support [23,38].

Table 2. Examples of artificial intelligence (AI) in nursing education and patient support across Asia.

Authors, year, and country	Study type	AI features	AI feature description	Application in nursing	Key findings
Nurse education and provider training					
Chen et al [31], 2022, China	Primary research	Chatbot	AI program designed to simulate conversation with human users	History-taking instruction program	Identified a need for chatbot-based history-taking instruction to provide more practice and feedback opportunities
Liao et al [8], 2015, Taiwan	Primary research; case study	BPN[a], ANFIS[b]	BPN is a machine-learning model that learns by adjusting its connections based on errors. ANFIS combines neural networks and fuzzy logic to learn and make decisions from data.	Support decision-making in nursing; generate nursing diagnoses	AI can assist in accurately generating nursing diagnoses with an agreement rate of up to 87% between system suggestions and nurse-made diagnoses.
Liaw et al [37], 2023, Singapore	Primary research; RCT[c]	AI in virtual reality simulation	Using AI to create realistic and interactive virtual environments, enhancing the user's experience	Sepsis care and interprofessional communication training	Virtual reality simulations with AI-powered doctors were effective for sepsis team training without inferior outcomes
Castonguay and Lovis [30], 2023, Canada	Reflection article	ChatGPT	A language model developed by OpenAI designed to understand and generate human-like text based on the input it receives	Nursing education, research, and practice	ChatGPT could revolutionize nursing education by supporting students' learning, improving digital literacy, and facilitating critical thinking. Despite potential biases and limitations, it can serve as a tool for research, teaching, and summarizing complex documents. Its integration requires collaboration to establish competencies and ethical guidelines for AI use in nursing
Patient education and support					
Cheng et al [32], 2023, Taiwan	Primary research; interventional study	AI chatbot	AI program designed to simulate conversation with human users	Peritoneal dialysis care	The AI chatbot significantly improved patient satisfaction and reduced infection rates
Castonguay et al [29], 2023, global (including Asia)	Comparative study	AI	A technology that enables machines to mimic human intelligence, allowing them to learn, reason, and make decisions	AI maturity in health care systems	Most OECD[d] countries are at the emerging level of AI maturity in health care. Only the United States and the United Kingdom have achieved the integrated ecosystem level, indicating mature, collaborative AI use in health care. The study underscores the need for adaptable, context-specific AI strategies for health care across different countries.

Authors, year, and country	Study type	AI features	AI feature description	Application in nursing	Key findings
Castonguay et al [28], 2024, global (including Asia)	Editorial	AI language models	Systems that use AI to understand and generate human-like text based on the data they have been trained on	Health care digitalization	AI language models have significant potential to improve decision-making and patient engagement in health care. Challenges include ensuring reliability, transparency, and ethical use. The new journal section aims to explore, showcase, and address these challenges.
Park et al [19], 2024, South Korea	Primary research	NLP[e]	Focuses on the interaction between computers and human language	Patient interaction, health records management	Enhanced communication and improved data management capabilities
Simsek-Cetinkaya and Karaveli Cakir [38], 2023, Turkey	Primary research; interventional design	Interactive screen-based simulation	A digital tool that lets users engage with simulated scenarios on a screen, allowing them to practice skills or experience situations	Breast self-examination training	AI simulation increased student satisfaction but was less effective than standard simulation for teaching skills
Wang et al [23], 2022, India	Primary research; interventional study	AI chatbot	AI program designed to simulate conversation with human users	Sexual and reproductive health education	The chatbot engaged users, particularly young men, providing a private space for discussing sensitive health topics

[a]BPN: back-propagation neural network.

[b]ANFIS: adaptive neuro-fuzzy inference system.

[c]RCT: randomized controlled trial.

[d]OECD: Organisation for Economic Co-operation and Development.

[e]NLP: natural language processing.

Challenges of AI in Nursing Practice in Asia

While AI promises to revolutionize health care in Asia, it also presents several challenges. A primary concern is the lack of consistent standards and regulations for AI tools. This lack of standardization can lead to patient safety issues, particularly if devices from different manufacturers do not integrate smoothly or yield inconsistent results [39]. Biases embedded within AI algorithms are another significant concern. If the training data for these algorithms do not represent diverse populations, the AI systems might produce discriminatory or unequal outcomes. Such biases could exacerbate existing health care disparities or introduce new ones, thus challenging the equity and fairness of care delivery [40].

Ethical challenges—particularly related to data privacy and informed consent—are also paramount. As the health care industry increasingly relies on vast data sets, ensuring data security and transparent usage is crucial. Addressing patient autonomy and consent for data usage is of utmost importance. Moreover, disparities in resources and infrastructure across Asia's vast landscape can hinder uniform AI adoption. While urban health care centers readily adopt AI, rural areas may face challenges such as outdated equipment or inconsistent internet connectivity. Finally, the integration of AI necessitates an educational shift for nurses, emphasizing a balance between clinical knowledge and technological skills [41-44].

The use of an AI-powered chatbot in nursing education presents some challenges. One of the foremost challenges is the need for adequate infrastructure and resources to implement AI technologies effectively. Many educational institutions may face financial constraints or lack the technical infrastructure required for seamless AI integration. Additionally, there are concerns related to the appropriate and ethical use of AI in education, including issues of data privacy, bias in AI algorithms, and transparency in decision-making processes. Educators and institutions must also address the potential resistance to change among faculty members and students who may be unfamiliar with AI-based tools and systems. Balancing the human touch and critical thinking skills that are so intrinsic to nursing with the technological advancements in AI poses another challenge, as this requires a thoughtful approach to curriculum design and the development of AI-enhanced educational content that aligns with nursing practice.

Furthermore, while some AI-powered dialogue systems (eg, ChatGPT, Microsoft Bing AI, Google Gemini) have the potential to enhance nursing education by providing instant access to information, facilitating virtual simulations, and offering personalized learning experiences, there are concerns regarding their potential misuse. Growing concerns are related to students becoming overly dependent on AI-generated responses along with the risk of misinformation or inaccurate guidance because these systems lack access to up-to-date evidence-based knowledge or clinical expertise [29,34,44]. In nursing education,

where critical thinking, empathy, and clinical judgment are vital, overreliance on AI could inadvertently undermine these essential skills.

Introducing AI integration in nursing in Asia presents several challenges that are rooted in resource constraints, technological infrastructure disparities, data privacy concerns, cultural acceptance, resistance to change, education and training gaps, the need for ethical and legal frameworks, language diversity, and integration with existing health care systems. Resource limitations often hinder investments in AI technology and staff training, while disparities in technological infrastructure and connectivity across regions can hinder access to advanced AI tools. Developing robust data-protection regulations and cybersecurity measures is essential to address privacy concerns. Overcoming cultural and traditional health care practices, as well as ensuring that AI is embraced by both health care providers and patients, requires a thoughtful approach. Education and training are crucial, as health care professionals need specialized training to effectively use AI tools. Developing ethical guidelines and legal frameworks, as well as addressing the issues related to language diversity and the seamless integration of AI with existing systems, are complex but necessary steps to ensure successful AI adoption in nursing across Asia. Despite these challenges, many Asian countries are actively working to overcome these barriers, recognizing the potential benefits of AI in nursing for improving patient care, increasing efficiency, and enhancing health care outcomes.

Summary and Prospects

In summary, the advent of AI is indicating a significant transformation in the field of nursing across Asia. Embracing these innovations necessitates the recognition of the enduring importance of the human touch and empathy within the profession. When effectively integrated, AI can complement and coexist with the core values of traditional nursing, paving the way for a harmonious and promising future in health care. Despite our interpretation of current evidence and perspective of the role of AI in nursing practice and education in Asia, this is not a systematic review. The limitation of this viewpoint is that the potential lack of comprehensive data specific to AI use in nursing across all Asian countries, the depth of analysis and generalizability of findings, and cultural and contextual differences across countries may not be fully captured to shape our perspectives. These limitations highlight the need for a follow-up systematic review paper and further research.

Conflicts of Interest

None declared.

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Abbreviations

AI: artificial intelligence

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Viewpoint

Centralized Pump Monitoring System: Perception on Utility and Workflows by Nurses in a Tertiary Hospital

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Abstract

Nurses play a key role in providing in-hospital care to patients. Worldwide, there has been a shortage of nursing staff, putting enormous strain on the existing nursing workforce physically and mentally. A vicious cycle of demanding workplaces exacerbated by perennial shortages leads to attrition and high staff turnover. A centralized, automated infusion pump monitoring system optimizes and augments nurses' performance in the hospital by cutting down on nurse visits to the patient's bedside for every matter, whether significant or insignificant. This viewpoint intends to highlight that by filtering out the noise effectively, nurses can focus on improving patient outcome–led interventions and enhancing the quality of care.

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KEYWORDS

infusion management; nurse efficiency; pump monitoring system; nurse attrition

Introduction

A centralized, automated infusion pump monitoring system (PMS) is a dynamic mechanism that integrates multiple infusion pumps into a central location, such as a nurse station. By generating alerts, infusion pumps with drug libraries from dose error-reduction systems can warn nursing staff about potential prescribing, calculation, and programming errors. The pumps are equipped with hard limits (ie, disallow bypass and prevent the start of the infusion) or soft limits (ie, warn of outside range parameters but permit users to start the infusion). Drug libraries can be customized according to institutional needs and can be classified based on care areas, specific patient groups, or body weight configurations. The system can help improve patient safety, comfort, and outcomes by ensuring accurate and timely administration of treatments and preventing treatment-related adverse events [1].

This viewpoint focuses on nursing challenges in general wards, the PMS, and the key outcomes from a survey conducted at a multispecialty hospital in Thailand.

Nursing Challenges in General Wards and PMS Utility

In a general ward, patients are generally conscious, and the alarm originating from infusion pumps may disturb patients, create unwanted anxiety, and incur additional nurse visits to the patient's bedside [2,3]. Responding to each alert and distress call warrants nurse visits for visual checks, which is time-consuming and physically demanding and enhances cognitive stress [2,3]. This was also found in the survey, which is discussed later. Nursing as a profession is beset with a stressful environment [4-7]. The exhaustion is both physical and mental. Work exhaustion compounded by the stressful job of handling emergencies and responding to distress calls and

alarms for multiple patients in a general ward could take a heavy toll on the state of the personal health of nurses. We have demonstrated the state of affairs in a hospital's general ward, whereby a nurse has to manage multiple patients. If the process is manual, it leads to physical exertion, stress, and exhaustion. As illustrated in the left-hand side of Figure 1, a nurse makes an investigative visit to the patient's bed upon registering distress calls (orange arrow) and then returns to the central station (black arrow). After finding a solution, the nurse makes another visit to the patient's bed and administers remedial measures (gray arrow). However, if a ward is equipped with a PMS, as illustrated on the right-hand side of Figure 1, the nurse can identify the problem on the centralized monitor (eg, blockade) and solve the issue in a single visit. Therefore, the additional steps for each patient call are eliminated, resulting in less physical effort and exhaustion. Staff burnout impacts organizational performance, patient safety, and health outcomes if appropriate interventions are not undertaken.

Figure 1. In general wards, the use of a PMS with an infusion system reduces nurse's movement and improves workflow efficiency in comparison to without a PMS. PMS: pump monitoring system.

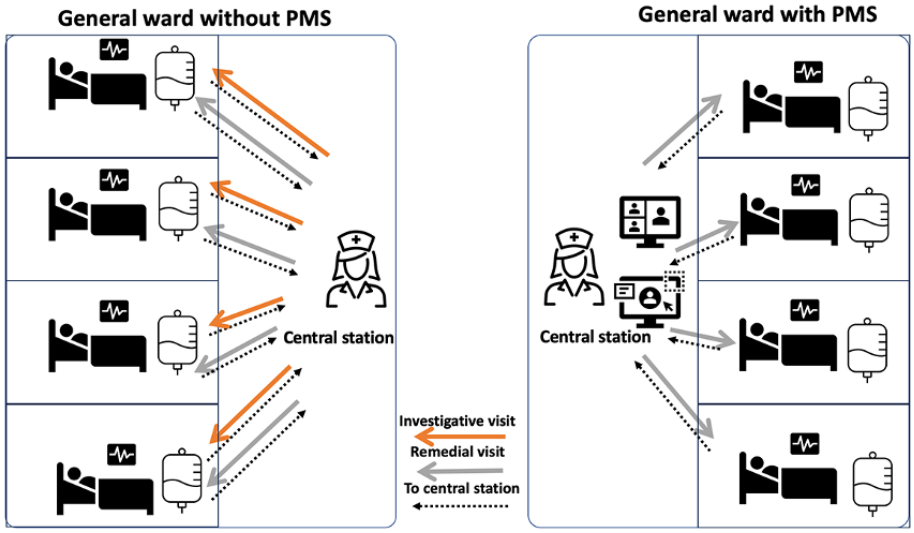
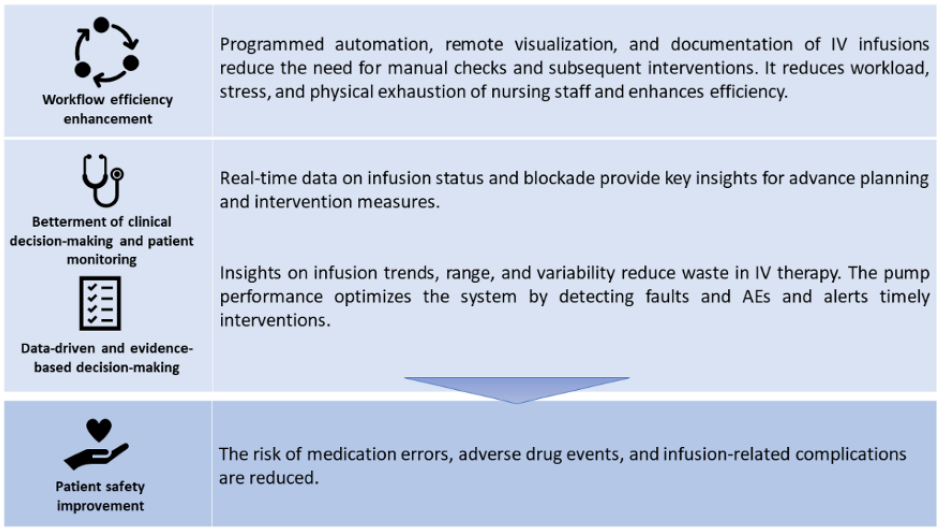


Figure 2. PMS benefits to the stakeholders in care delivery. Workflow efficiency improvement, better decision-making, and closer patient monitoring result in greater patient safety standards. AE: adverse event; IV: intravenous; PMS: pump monitoring system.



Impact of a PMS on Nurses' Workflow in Hospitals

A PMS is critical in reducing physical movements with the centralized display of the infusion status on the monitor. Regardless of the clinical settings, a PMS prevents undetected infusion errors, such as incorrect doses or infusion data, and facilitates care coordination and collaboration with other health care professionals by sharing intravenous infusion data and alerts through the network and health information systems [8]. Several benefits have been attributed to the PMS, benefitting all the stakeholders—patients, nurses, and care providers—in the health care ecosystem, as shown in Figure 2.

Key Outcomes of the Nurse Survey in a General Ward

Overview

We present the survey conducted in Bangkok Hospital Sanamchan (210 beds), situated in Mueang District, Nakhon Pathom Province, Thailand. A cross-sectional survey of the 91 nurses working in the general ward was conducted in October 2023, and they were asked to report their feedback on a 7-point Likert scale. We manually explained the presented questions to the nurses, and they submitted their responses in complete privacy on a paper-based system. The key objectives of the survey were as follows:

- To evaluate the work efficiency of nursing staff after the implementation of a PMS. The efficiency parameters included reducing the frequency of entering patients' rooms to check pump status, decreasing the number of nurse calls, and other related factors.
- To examine the potential impact of the PMS on nursing workflow, work planning, and patient recovery.

The response scheme was as follows: 1="Strongly disagree," 2="Disagree," 3="Somewhat disagree," 4="Neither agree OR disagree," 5="Somewhat agree," 6="Agree," and 7="Strongly agree." The responses were compiled in Microsoft Excel, and an inferential analysis was applied to the data. The results were interpreted using the central tendency analysis of mean and plotted in an intuitive graphical form. The full survey is shown in Multimedia Appendix 1.

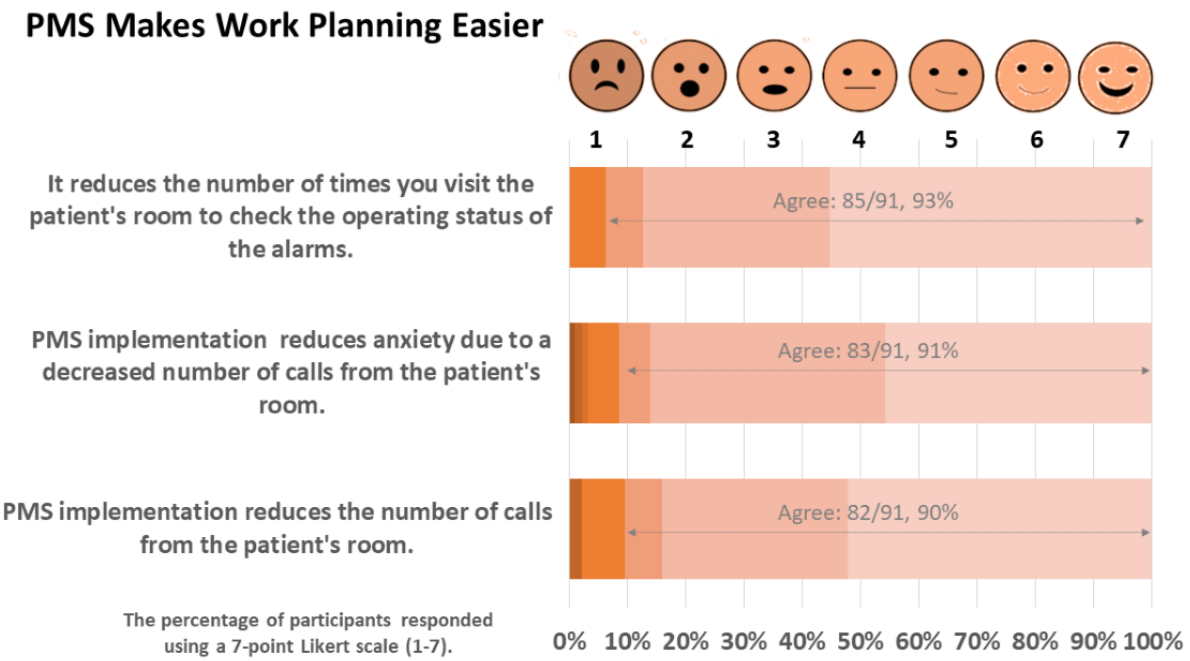
Ethical Considerations

No institutional review board approval was sought. This is because this study focuses solely on gathering feedback to gain perception on the use of the PMS software, similar to a product use survey. Participants were not selected according to any pattern or priority; instead, all nurses working in the general ward were chosen to respond. The purpose of the survey is to evaluate the satisfaction and effectiveness of the PMS software after its installation in the general ward. The survey is entirely anonymous, with no personal details and identities disclosed in any documentation, and it involves no patient data. All participants were fully informed about the survey's purpose and provided their consent. As the survey seeks to gather feedback on the software product before and after its implementation, without involving patient data or interventions, it falls outside the scope of requiring institutional review board approval.

Impact of the PMS on the Work Planning of Nurses

The respondents stated that the PMS reduces the number of visits to the patient's room to check on the pump's operating status (85/91, 93%), and they felt that their anxiety was reduced due to fewer calls from the patient's room (83/91, 91%). A similar level of response (82/91, 90%) was received on the decrease in the number of calls from patients' rooms due to PMS adoption (Figure 3).

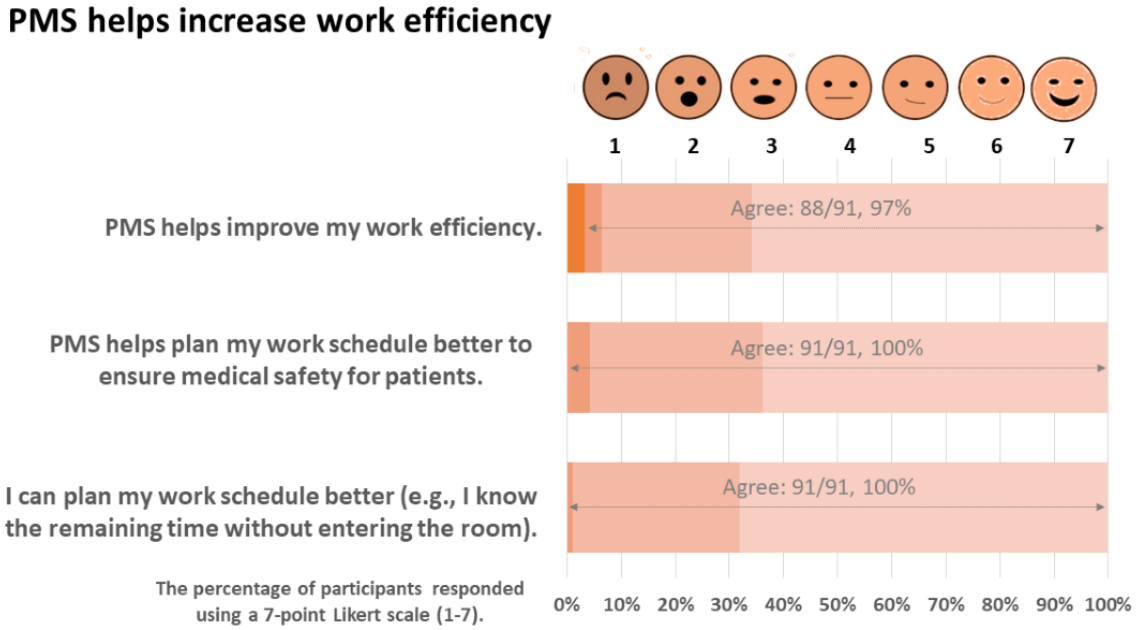
Figure 3. PMS impact on work planning and efficiency. PMS: pump monitoring system.



Impact of the PMS on Work Efficiency

The respondents reported that the PMS helps improve work efficiency (88/91, 97%), helps in work schedule planning to ensure patient safety (91/91, 100%), and saves time (91/91, 100%; Figure 4).

Figure 4. Work efficiency with PMS integration in the workflow. PMS: pump monitoring system.



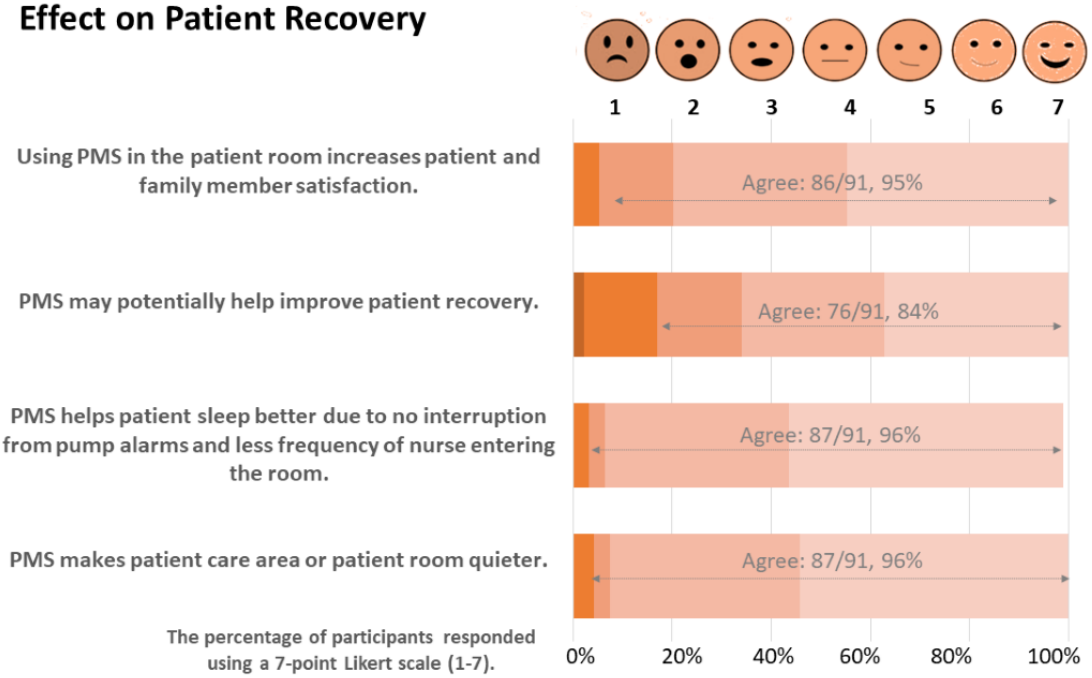
Impact of PMS Integration on Patient Recovery

Approximately 95% (86/91) of respondents stated that use of a PMS in a patient's room increases patient and family member satisfaction. Meanwhile, 84% (76/91) of respondents indicated that the PMS may help improve patient recovery. Approximately 96% (87/91) of respondents mentioned that patients sleep better due to the lack of disruption and fewer nursing staff visits to the room, making the patient care area quieter (Figure 5).

The findings outline 2 broad attributes: PMS's benefits and its impact on improving patient outcomes. Figures 3 and 4 show that workflow planning and efficiency are enhanced with the PMS, whereas Figure 5 shows that patient recovery is possibly boosted due to better rest, fewer sleep disturbances, and less care delivery–generated stress.

We would like to highlight that large-scale studies in diverse settings are needed to reproduce and replicate the results we have obtained. These outcomes must be viewed from an indicative perspective and may not be representative phenomena of PMSs across all health care systems.

Figure 5. Effect of the PMS on patient recovery. PMS: pump monitoring system.



Critical Implications for Patient Care

The survey findings point to the issue of nurse distraction and continuous disengagement from the involved tasks when any patient distress signals are heard in a general ward setting. The resultant anxiety and immediate dash to check on the patient's status has 2 significant adverse impacts: the mental and physical health of the nurses. The general ward is relatively spread out, and the diverse patient mix makes nursing care more strenuous. While there are many established benefits of PMS models, we would like to draw our implications from the outcomes of this survey as a more pragmatic approach.

The most apparent benefits of the PMS for the nursing staff are the ability and flexibility to plan work schedules in a more organized and efficient way, reduce multiple movements, and discharge patient care duties with less exhaustion and greater focus [8]. Also, the PMS ensures no unnecessary patient distress, sleep disturbances, and bedside environment instability. The resultant effect on patient recovery and outcomes is compounded due to more efficient nursing care in the hospital [9,10].

PMS application requires an integrated, multimodal approach to render efficiencies and deliver benefits at scale. This includes infrastructure, training, network, interoperability of the health information systems, and monitoring with a collective approach to align with the goals of enhancing the quality of patient care.

Future Trends

Technology and data-driven innovation have resulted in the development of PMS models to advance patient care faster. Also, with PMS integration into electronic health records, more and more real-world data are being generated, resulting in more advanced PMS models [11,12].

To achieve an interconnected, interoperational ecosystem, the wireless connectivity of PMS; image recognition—barcode medication administration and radio-frequency identification; computerized prescriber order entry; and integration into electronic health records seem to be the next steps forward. Each of these technologies exists and is being used in hospitals, but these may be operated in "silos" and not as integrated, interconnected ecosystems. It is envisaged that these technologies, when working in unison as a cohesive force, can provide auto-programming and auto-documentation; clinical decision support; clinical surveillance; and an alert mechanism that highlights critical situations demanding immediate intervention and communicates to the health care professional who is best positioned to solve the problem.

Conclusion

A PMS enhances the nursing staff's functional and physical capabilities during their workflows, enabling better performance within the hospital environment. A more systematic approach and reduced exhaustion contribute to fewer nursing care errors. As a result, the quality of patient care improves, leading to better care outcomes. Eventually, all the stakeholders in the health care ecosystem—patients, clinicians, and nursing staff; the health care system itself; and society would benefit at different levels.

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Data Availability

The survey data can be made available upon a reasonable request to the corresponding author.

Authors' Contributions

All the authors contributed equally to conceptualizing, formal analysis, project administration, writing review, and editing. NC led the hospital survey and analysis at Bangkok Hospital Sanamchan.

Conflicts of Interest

OS and AG are employees of Terumo Asia Holdings Pte Ltd, Singapore. NC has no conflicts of interest to declare.

Multimedia Appendix 1
Pump monitoring system (PMS) use survey.
[DOCX File , 37 KB - apinj_v8i1e60116_app1.docx]

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Abbreviations

PMS: pump monitoring system

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Review

Current Evidence of the Application of Music in Tai Chi Exercise: Scoping Review

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Abstract

Background: Music has frequently been used in movement exercises to enhance health benefits. However, scientific evidence regarding the application of music to Tai Chi practice is limited.

Objective: This scoping review aims to understand how music has been used in Tai Chi practice and whether music could be applied to Tai Chi practice to help optimize its benefits.

Methods: PubMed, CINAHL, CNKI, and Weipu databases were searched. We included studies that compare Tai Chi practice experience or health outcomes between individuals practicing Tai Chi with music and those practicing Tai Chi without music. Studies published through September 2022 were identified. Two researchers (YD and YH) independently performed study selection and data extraction. Thematic analysis was used to summarize and categorize the findings of the included studies.

Results: Seven studies were included in this review. All 7 included studies are experimental studies. Practicing Tai Chi with music might lead to positive perceptions of Tai Chi practice (eg, motivation, concentration, enjoyment, compliance, and performance) and higher evaluations of Tai Chi instructional quality, especially for Tai Chi beginners. The effects of incorporating music into Tai Chi practice on health outcomes are inconclusive due to the heterogeneities of the sample size, and the intervention components, lengths, and frequencies of the included studies.

Conclusions: Applying music to Tai Chi practice may result in positive Tai Chi practice experience and adherence, particularly for beginners, which could help improve the dissemination and implementation of Tai Chi interventions for public health. However, whether applying music to Tai Chi practice leads to synergetic effects on health outcomes needs further investigation.

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KEYWORDS

Tai Chi; exercise; music; synergetic effects; review; scoping review; thematic analysis; health outcome; motivation; performance; dissemination; implementation; public health; data extraction

Introduction

Tai Chi, originating in China, is an ancient Chinese martial art that evolved into a sport and mind-body exercise. It is characterized by slow and gentle movements, deep breathing, and meditation. There are various types of Tai Chi such as Chen, Yang, Hao, Wu, and Sun styles [1]. Among these, Chen style is the oldest, characterized by slow and smooth movements with fast and explosive ones; Yang Style is the most widely practiced globally, characterized by slow, gentle, and flowing movements

[1]. Each style may include simplified forms, traditional forms, short forms, and long forms. A Tai Chi form is a sequence of movements that are performed in a slow, continuous, and flowing manner, integrating principles of balance, relaxation, and alignment [1,2].

Widely recognized as a valuable therapeutic intervention, Tai Chi is often recommended by health professionals and embraced by the public to complement conventional medical treatments [3]. Its slow and deliberate movements, encompassing aerobic, stretching, balance, and strengthening exercises, have garnered increasing attention among populations with various health statuses and within the scientific community for their potential health benefits [4-6]. Evidence-based research underscores Tai Chi's health benefits, including but not limited to improvements in balance [7,8], muscle strength [9], cardiovascular and metabolic health [10-13], physical and cognitive function [14-18], mental health [19,20], and quality of life [21-24].

Incorporating music into movement exercises is a common practice to enhance ergogenic effects [25]. In China, Tai Chi practitioners often use soft, relaxing Chinese folk music to promote relaxation and concentration during Tai Chi practice [26,27]. Using music during Tai Chi practice has also been reported in populations outside of China [28,29]. While studies examining Tai Chi's effects on health outcomes are on the rise, few have explored the use of music during Tai Chi practice in Western populations [30-32]. Previous research has inadequately addressed the application of music in Tai Chi practice [33], and studies assessing Tai Chi with music seldom investigate potential synergistic effects on health outcomes [34,35]. Furthermore, the ongoing debate surrounding the use of music during Tai Chi practice reflects different perspectives on music's impact [36]. Some argue that Tai Chi is a form of moving meditation, suggesting that engaging in Tai Chi with music may hinder the attainment of "rujing" (the absence of idle thoughts or the cultivation of stillness). Conversely, others indicate that music can aid in reducing distractions and facilitating "rujing" by calming the mind [36]. Scientific evidence is thus imperative to guide best practices in incorporating music into Tai Chi for optimal health benefits.

Therefore, this study aims to explore current evidence regarding the application of music in Tai Chi practice through a scoping review of studies comparing Tai Chi practiced with music to that practiced without. Our objectives include understanding how music has been applied to Tai Chi practice, evaluating what specific outcomes were assessed in the current scientific literature, and exploring whether practicing Tai Chi with music offers advantages over practicing Tai Chi without music.

Methods

Study Design

We used the updated Arksey and O'Malley five-stage framework [37] to guide the conduct of the scoping review. Specifically, we followed these steps: (1) identifying the research question based on the research team's experience in conducting Tai Chi–related research and reviewing current literature; (2) identifying relevant studies; (3) selecting the studies; (4) charting the data; and (5) collating, summarizing, and reporting results. Steps 2-5 are described in detail below. Additionally, we used the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-analysis extension for Scoping Reviews) guidelines [38] to draft and report this scoping review. The PRISMA-ScR checklist can be found in Multimedia Appendix 1. We registered this review at the Open Science Framework [39].

Data Search

We searched the electronic databases PubMed and CINAHL in September 2022. Medical Subject Headings terms "Tai Chi" and "music" were used to build the search strategy on PubMed. The search strategies for PubMed are illustrated in Multimedia Appendix 2. Subsequently, the search terms used on CINAHL were constructed based on the PubMed search strategy. Given that Tai Chi originated in China, where the use of music during Tai Chi is common, we also searched Chinese databases CNKI and Weipu. "太极" (Tai Chi) and "音乐" (music) were used to search through Chinese databases. We did not set language or publishing year restrictions in the database searches as we aimed to comprehensively cover this topic in this scoping review.

Eligibility Criteria

Inclusion criteria were (1) studies with comparisons between Tai Chi with music and Tai Chi without music, (2) published journal studies, and (3) at least 1 study group examining Tai Chi with music and 1 group examining Tai Chi without music. Given the broad scope of this scoping review, no age limit was set. Outcomes could encompass any measurements evaluated in the studies such as Tai Chi practice adherence and health outcomes. Exclusion criteria were (1) studies with nonempirical design, such as view paper, review paper, and protocols, and (2) experimental studies without comparisons between Tai Chi with and without music.

Study Selection

First, all search records were merged, and duplicates were removed. The eligibility criteria were then discussed and refined by the study team based on the search processes. YD screened the title and abstract based on the inclusion and exclusion criteria. YD and YH independently screened the full papers according to the eligibility criteria. Any discrepancies were resolved through discussions and consultations with a third researcher (GXW).

Data Extraction

YD drafted the data extraction form. YD and YH tested the extraction by charting 2 studies independently and refined the data extraction form accordingly. The form included study location, study design, sample characteristics, Tai Chi selection, music selection, assessed outcomes, and study findings. YD and YH independently extracted data from each study according to the extraction form. Any discrepancies were resolved through discussions and consultations with a third researcher (GXW). Data were extracted in the original published language, and a bilingual researcher translated the Chinese data into English after synthesis, which was then checked by a native English speaker.

Synthesis

We used a narrative approach to summarize, analyze, and assess the evidence in this review. Specifically, one table charted the characteristics of included studies, and another table summarized the use of Tai Chi and music in each study. A thematic analysis approach [40] was adopted to summarize and categorize the findings of included studies. First, YD created a codebook based on the coding of the extracted data and summarized the findings for each code. Second, YH and GXW reviewed the codes and summary findings against the extracted data. Summary quotes are quotes summarized by the authors but not direct quotes from the studies included. Subsequently, YD, YH, and GXW categorized the codes into subthemes. The study team reviewed the themes, subthemes, codes, and summary quotes. Given the scoping nature of this review, no assessment of study quality was conducted.

Results

A total of 491 papers in English or Chinese were identified, including 260 papers in CNKI, 155 papers in Weipu, 45 papers in PubMed, and 31 papers in CINAHL (Figure 1). We removed 21 duplicated papers, leaving 471 papers for the title and abstract screening. Of those, we considered 20 studies for full-text screening. We further excluded 13 papers after a full-text screening due to reasons of being opinion papers (n=7), lacking a comparison between Tai Chi with and without music (n=5), and involving other components in the Tai Chi with music group (n=1). Figure 1 indicates the reasons and numbers of excluded studies in each screening stage.

All 7 included studies are clinical trials (Table 1); 6 studies were conducted in China and 1 in the United States. Five of the 6 studies in China included only college students, and the rest focused on nurses with impaired mental health. The study conducted in the United States primarily included older adults. Five studies reported gender distributions; 2 reported 100% female, 1 reported 9% female, and the other 2 consisted of 53% and 47% female, respectively. All 7 studies included at least 2 study groups; 1 group for Tai Chi with music and another for Tai Chi without music. For studies with available intervention frequencies, it ranged from 14 to 16 sessions within 7 weeks (about 1 and a half months) to 3 months. The retention rate ranged from 72% to 100%. The sample size included in the final analysis ranged from 13 to 162 participants.

Figure 1. PRISMA diagram of selected studies. PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-analysis.

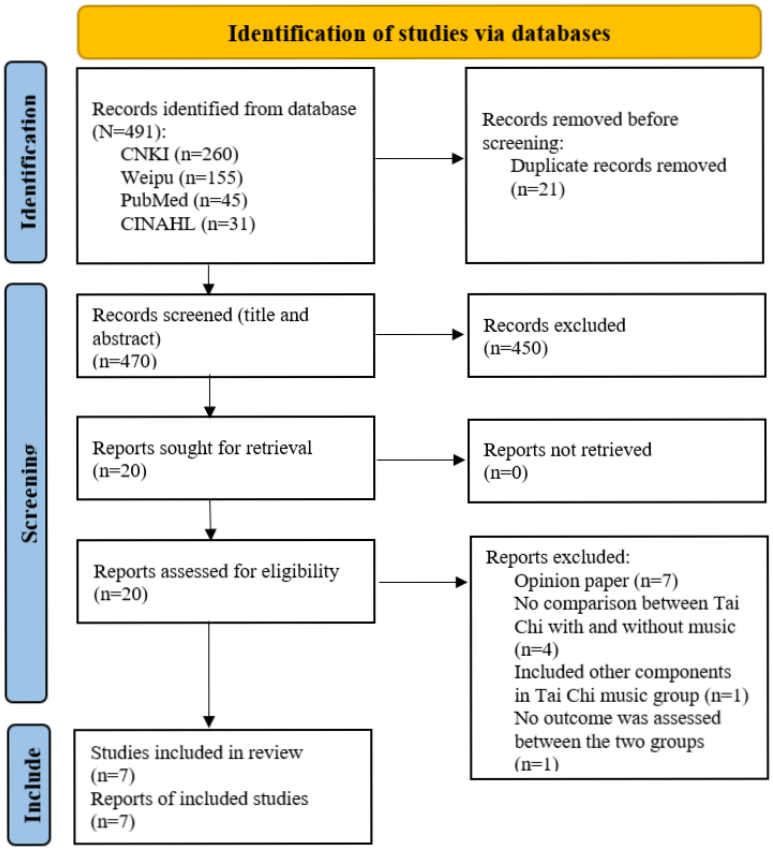


Table 1. Study characteristics.

Study	Location	Design	Population or setting	Age and sample size	Intervention	Frequency and length	Measurements	Retention
Du et al (2017) [31]	United States	Cluster randomized controlled trial	Adults in a senior day activity center	• Age: 50-82 years old • Intervention (n=12): 72.3, SD 5.7 • Control (n=6): 62.0, SD 10.3 • Gender: 95.5% female; 100% female retained	• Intervention: Tai Chi with music • Control: Tai Chi without music	• Once a week for 15 weeks. • Recorded video was sent home to promote home practice	• Dynamic gait index • Fear of falling • Tai Chi practice compliance	72%
Li (2013) [41]	China	Randomized controlled trial	Students at a local university	• Age: not available. • Intervention (n=30). • Control (n=29). • Gender: 100% female	• Intervention: Tai Chi with music • Control: Tai Chi without music	• Not mentioned	• Tai Chi learning motivation • Concentration • Satisfaction with instruction • Overall performance (correctness, consistency, pace, style, overall)	100%
Liu et al (2020) [19]	China	Randomized controlled trial	Registered nurses with impaired mental health working in the operation room in 4 local public tertiary hospitals	• Age: not available • Intervention: Tai Chi with music (n=30); Tai Chi only (n=30); music only (n=30). • Control: nonactive (n=30). • Gender: not available	• Intervention (three groups): (1) Tai Chi with music; (2) Tai Chi only; (3) music only. • Control: nonactive	• August 2018 to October 2018	• Physical symptom, depression, and anxiety indicators (SCL-90[a]) • Coping style (SCSQ[b])	100%
Lv et al (2019) [42]	China	Cluster controlled trial	Students at a local university	• Age: not available. • Tai Chi beginner (n=16). • Tai Chi proficient (n=16). • Gender: not available	• Tai Chi beginner (four scenarios): (1) no music; (2) relaxing and soft music; (3) joyful and fast music; (4) sad music • Tai Chi proficient (four scenarios): (1) no music; (2) relaxing and soft music; (3) joyful and fast music; (4) sad music	• Not mentioned	• Interest in Tai Chi (PESIS[c]) • Galvanic skin response	100%
Zhang (1999) [43]	China	Randomized controlled trial	Students at a local university	• Age: not available • Intervention (n=76) • Control (n=86) • Gender: 47% female	• Intervention: Tai Chi with music • Control: Tai Chi without music	• From September 1997 to July 1998	• Tai Chi performance evaluated by Tai Chi instructors	100%

Study	Location	Design	Population or setting	Age and sample size	Intervention	Frequency and length	Measurements	Retention
Zhang (2009) [44]	China	Randomized controlled trial	Students at a local medical school	• Age: not available • Intervention (n=70) • Control (n=74) • Gender: 53% female	• Intervention: Tai Chi and Tai Chi sword with music • Control: Tai Chi and Tai Chi sword without music	• Twice a week for 7 weeks.	• Tai Chi performance evaluated by two Tai Chi instructors • Practice outside of class	100%
Zhao and Wang (2017) [45]	China	Randomized controlled trial	Students at a vocational and technical college	• Age: not available • Intervention (n=49) • Control (n=44) • Gender: 9% female	• Intervention: Tai Chi with music • Control: Tai Chi without music	• 16 sessions from September 2016 to December 2016	• Interests in Tai Chi • Perceived difficulties of learning Tai Chi • Positive emotion inspiration • Instruction quality • Tai Chi performance evaluated by two Tai Chi instructors	100%

[a]SCL-90: Symptom Checklist-90.

[b]SCSQ: Simplified Coping Style Questionnaire.

[c]PESIS: Sports Situational Interest Scale Chinese version.

Table 2 shows the Tai Chi styles or forms, the music type being used, and how the study applied music to Tai Chi practice. Three of the 7 studies specified Tai Chi styles and forms (the 24-form simplified Yang style). There were variations in music selections used for Tai Chi practice. In the study conducted in the United States, a board-certified music therapist selected the music; others did not specify how the music was selected or by whom. Various music types were selected, but the studies in China used Chinese music or Chinese medicine principle-oriented music; while the US study used Western music with instruments familiar to the ethnic groups. Five of the 7 studies described how they used music during Tai Chi practice. Among the 5 studies, 3 studies did not use music during Tai Chi instructions and used music only when practicing Tai Chi routines; 1 study used music throughout the Tai Chi sessions. The remaining study did not provide Tai Chi instructions; however, it assessed body responses to diverse types of music while practicing Tai Chi routines.

Thematic analysis revealed two major themes with corresponding subthemes: health outcomes including (1) physical health and (2) mental and emotional health; and experience of Tai Chi practice including (1) Tai Chi practice and (2) perceived instruction quality (Table 3). Included studies assessed various outcomes to compare the efficacy of Tai Chi with and without music. First, the assessed health outcomes included but were not limited to physical and mental health. Overall, practicing Tai Chi with music led to significantly better balance (dynamic gait index); and a trend of better physical health indicators and better mental health (depression and coping), which were not significant. Tai Chi beginners had significantly higher skin response to Tai Chi with slow, gentle music or relaxing, joyful music than advanced practitioners; higher skin response was found in advanced practitioners compared to those beginners when practicing Tai Chi without music. Second, for the experience of Tai Chi practice, at least 1 study showed that practicing Tai Chi with music led to multiple outcomes such as higher adherence in and outside of class [31,44], more confidence in learning and mastering Tai Chi [44,45], better concentration and enjoyment [41], less perceived difficulties [45], and better performance [41,43-45]. Third, instruction quality was assessed in 3 studies, 2 of which reported a higher satisfaction rate in the Tai Chi with music groups [41,44], and more participants rated the instruction high quality in the Tai Chi with music group compared to the control group [43].

Table 2. Tai Chi and music selection.

Study	Tai Chi selection	Music selection	The use of music for Tai Chi practice
Du et al (2017) [31]	The first 12 forms of the 24-form simplified Yang-style Tai Chi	Music was selected by a board-certified music therapist who had worked with older adults for over 10 years. For this study, Western music was selected to provide a grounded atmosphere—familiar, comfortable, and easily integrated into the background—rather than Eastern music, whose different tonal structure, harmony, or rhythmic structure may have been a distraction. The music selected aimed to provide a rhythmic structure intended to guide but not fully direct or entrain movement. Harmony was similarly considered, with the musical selection using Western 12-tone major and minor scales. The instrumentation of the selected music was Western (nature sounds, flute, using instruments familiar to the ethnic group largely represented by our sample).	The same recorded asynchronous instrumental music with nature sounds was used at each session for TC + M[a] class, when participants performed learned Tai Chi forms. The music therapist was present in each class for assistance and consultation. All new Tai Chi forms were instructed in silence; asynchronous music, which means there is no conscious attempt from the individual to match their movements with the rhythm of the music, was only used while practicing previously learned movements.
Li (2013) [41]	The 1-12 forms of the 24-form simplified Yang-style Tai Chi	Not mentioned.	First, the instructor demonstrated performing two forms with music, which were instructed later. Second, instructing the two forms without music. Third, participants practiced Tai Chi with music following the instructor. Fourth, participants practiced Tai Chi with music. Fifth, the instructor corrected postures and movements without music, and finally, participants practiced Tai Chi with music.
Liu et al (2020) [19]	The 24-form simplified Yang-style Tai Chi	The principle of five-element music therapy was adopted. It is believed that ancient Chinese music consists of 5 notes (gong, shang, jiao, zhi, and yu), which were collected with the 5 elements of nature (metal, wood, water, fire, and earth). In addition, the 5 elements correspond to the 5 main body organs (heart, liver, spleen, lungs, and kidneys). Music was selected based on participants' health status per Chinese medicine principles.	Not mentioned.
Lv et al (2019) [42]	Tai Chi (style not mentioned)	Relaxing and soft music, joyful and fast music, and sad music, respectively.	Each of the three types of music was randomly selected and applied to Tai Chi practice. The skin response test was done after participants felt calm and continued feeling calm even after the test was initiated in 30 seconds. Then participants started practicing Tai Chi with each type of music. PESIS[b] was completed right after practicing with each type of music and practicing with each type of music was done for at least 5 minutes.
Zhang (1999) [43]	Tai Chi and Tai Chi sword	Different and appropriate music was selected for Tai Chi and Tai Chi sword accordingly.	Not mentioned.
Zhang (2009) [44]	Tai Chi (style not mentioned)	Fishermen's Song at Eventide, which is characterized by meaningfulness and soothe, aligning with the feature of Tai Chi, was used.	Music was played while the instructor was demonstrating the whole Tai Chi routine or when participants were practicing learned forms.
Zhao and Wang (2017) [45]	Tai Chi (style not mentioned)	Music was selected to align the Tai Chi style with the rhythm and pace of music, as well as the demographics and cultural background of Tai Chi practitioners. The music being used was popular Chinese music.	First, one music was used during warm-up exercise, followed by another music, which is enthusiastic, to increase the willingness to learn of students; Second, the combination of joyful, relaxing, and victory music was played while the instructor provided the opening of the class. Third, the instructor demoed Tai Chi three times with music and then instructed each form with music in the background.

[a]TC + M: Tai Chi and music.

[b]PESIS: Sports Situational Interest Scale Chinese version.

Table 3. Themes of outcomes, and study findings between those who practiced Tai Chi with music and those without music.

Themes and findings		Author
Health outcomes		
Physical health		
DGI[a]	The post-DGI score in Tai Chi with music group was significantly higher than Tai Chi without music group after adjusting age.	Du et al (2017) [31]
Physical symptoms	There was a trend of better physical health indicators in Tai Chi with music group than Tai Chi only group or music only group. However, this was not significant.	Liu et al (2020) [19]
Galvanic skin response	Tai Chi beginners had significantly higher skin response values compared to advanced practitioners when practicing Tai Chi with all 3 types of music (more obvious effects to less: soft and relaxing, fast and joyful, and sad music) compared to more advanced users. However, in the Tai Chi group without music, there were no differences in skin response between beginners and the more advanced. Listening to sad music had the lowest response in both beginner and advanced groups.	Lv et al (2019) [42]
Mental and emotional health		
Depression, anxiety	After the intervention, there was a trend of better physical health indicators in the Tai Chi with music group than Tai Chi only group or music only group. However, this was not significant.	Liu et al (2020) [19]
Coping style	There was a trend of better positive coping and negative coping in the Tai Chi with music group compared to Tai Chi only group or music only group. However, this was not significant.	Liu et al (2020) [19]
Inspiration and arouse	More participants in the Tai Chi with music group rated the class as effective or very effective for inspiration and arousal.	Zhao and Wang (2017) [45]
Fear of falling	Post fear of falling in the Tai Chi with music group was better than in the Tai Chi only group, though not statistically different.	Du et al (2017) [31]
Experience of Tai Chi practice		
Tai Chi practice		
Tai Chi learning motivation	After the intervention, significantly higher motivation and concentration were found in the Tai Chi with music group compared to the Tai Chi only group.	Li (2013) [41]
Interest in Tai Chi	Participants self-reported interests in Tai Chi increased significantly from baseline to end of study only in the Tai Chi with music group.	Zhao and Wang (2017) [45]
Concentration	Better concentration was found in the intervention group; concentration was higher postintervention in the intervention group.	Li (2013) [41]
Enjoyment of Tai Chi practice	Beginner experienced higher enjoyment from practicing Tai Chi with all 3 types of music (more obvious effects to less: soft and relaxing, fast and joyful, and sad music) compared to more advanced, but no differences in enjoyment between beginners and more advanced were found in the Tai Chi without music group. Listening to sad music has the lowest response in both beginner and advanced groups.	Lv et al (2019) [42]
Perceived difficulties of learning Tai Chi	More participants rated learning Tai Chi as very difficult in the control group, while significantly more participants in the intervention group rated learning Tai Chi as easy after the intervention.	Zhao and Wang (2017) [45]
Self-efficacy (confidence and perceived mastering in Tai Chi practice)	More participants were confident in learning Tai Chi in the Tai Chi with music group, and more participants reported mastering Tai Chi after the intervention.	Zhang (2009) [44]; Zhao and Wang (2017) [45]
Tai Chi performance score[b]	Significantly better performance was found in the Tai Chi with music group.	Zhang (1999) [43]; Li (2013) [41]; Zhang (2009) [44]; Zhao and Wang (2017) [45]
Tai Chi class compliance	The compliance rate in the Tai Chi with music group (84%) is higher compared to the Tai Chi without music group class (71%), but the difference was not statistically significant.	Du et al (2017) [31]
Practice outside of class	Significantly more participants in the Tai Chi with music group practiced outside of class than in the Tai Chi only group.	Zhang (2009) [44]
Perceived instruction quality		
Satisfaction with instruction	More participants experienced significantly better satisfaction with the instruction given in the intervention group.	Li (2013) [41]; Zhang (2009) [44]

Themes and findings		Author
Instruction quality	More participants rated very high quality of the instructions in terms of content sequency and structure, the arrangement of exercise intensity and frequency, instruction style, and overall instruction quality.	Zhao and Wang (2017) [45]

[a]DGI: dynamic gait index.

[b]Tai Chi performance score was rated based on the Tai Chi movements in correctness, consistency, pace, and style; obvious errors, moderate errors, and minor errors were also assessed.

Discussion

Principal Findings

This scoping review aimed to map out the application of music in Tai Chi practice. We identified 7 studies published in either Chinese or English using controlled trials to compare the differences between practicing Tai Chi with and without music on various outcome measures. Most studies were conducted in China, and the selection and use of music for Tai Chi practice were heterogeneous. There is clear positive evidence supporting the beneficial effects of applying music to Tai Chi practice to improve the perceived quality of Tai Chi instructions and promote Tai Chi learning experience, enjoyment, concentration, adherence, and movement performance. However, further investigations are needed regarding how music should be selected in Western culture, its benefits in beginners versus advanced practitioners, and whether listening to music alone would lead to similar health benefits compared to practicing Tai Chi with music.

The studies included in this review used various types of music for Tai Chi practice, and music was used either throughout the instruction and routine practice or only for routine practice but not during instruction. In general, the music selected was soothing, soft, and relaxing [31,44,45]; aligned well with the soft, gentle, slow, and graceful movements of Tai Chi; and suitable to participant culture [31,45]. The finding is consistent with another study reviewing the psychophysical effects of music in sports and exercise [46]. The review indicated that the keys to selecting music should include considering not only the sociocultural background of the practitioners but also the nature of the physical activity and coordination with the physical activity task [46]. Therefore, music was often used in sports for pre-event preparations, warm-ups, and training sessions. In this review, music was played either throughout the Tai Chi class session or only during practicing the Tai Chi routines, both of which formats showed favorable effects [31,45]. However, since most of the included studies were conducted in China, further investigation is needed to determine the generalizability of these findings to other regions. In addition, Tai Chi has been strongly recommended to improve balance and promote health in the aging populations; while most included studies focused on Chinese college students, studies assessing to what extent the findings may apply to older populations are warranted.

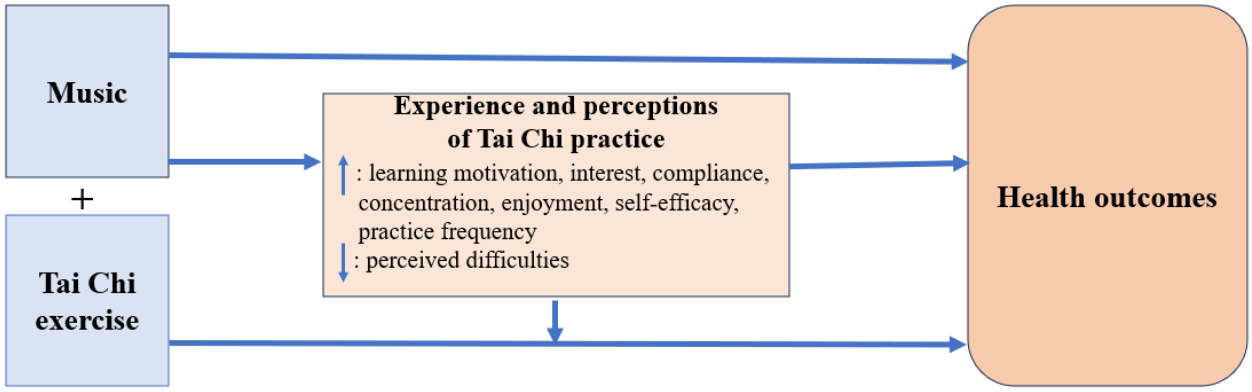
Evidence from many studies suggests that music could promote positive effects during exercise, such as increasing motivation, happiness, confidence, relaxation, and performance levels [47,48]. Similarly, we found that practicing Tai Chi with music could yield higher learning motivation [41], concentration [41], enjoyment [42], confidence [43,45], performance and compliance [31,41,43-45], and lower perceived difficulties in learning Tai Chi [45]. Previous studies reported that many people who do not habitually engage in exercises often find it difficult to initiate an exercise routine, and some well-documented barriers to regular exercise engagement include a lack of motivation and enjoyment and feeling bored and physically uncomfortable [49]. The findings from the included studies may suggest that adding music to Tai Chi practice could help alleviate the barriers to engaging in Tai Chi exercise, especially for beginners. For example, among the included studies, one study found that Tai Chi beginners had a stronger positive influence from music than advanced practitioners assessed by galvanic skin responses (a signal for capturing the autonomic nerve responses) and subjective enjoyment [50]; this may indicate that Tai Chi beginners may benefit more from using music when practicing Tai Chi in comparison to more advanced users [42]. Music could likely help beginners feel relaxed and focused, and promote Tai Chi exercise in those who are new to learning Tai Chi. For more advanced Tai Chi practitioners, this may vary depending on various factors such as the practitioner's mood and environment [36]. As an exercise that originated in Asian culture, adding music affiliated with Western populations may help promote its instruction, implementation, and dissemination. However, further investigations are needed to confirm this assumption.

The findings differ when assessing improvements in health outcomes through adding music. Balance, as measured by the dynamic gait index, was found to be significantly improved in the study participants incorporating music, but not in their counterparts practicing Tai Chi without music after a 15-week Tai Chi intervention. Balance is a frequently studied measurement of Tai Chi's effects on health [51], and the Centers for Disease Control and Prevention also highly recommends that older adults practice Tai Chi to improve balance [52]. For other assessed health measurements, although not significant, trends showed better outcomes in the Tai Chi with music group such as physical symptoms and depression. For other health measurements, no significant improvements were detected, which could be due to the relatively short intervention lengths. Further research with longer interventions and a larger sample size is warranted to explore the possible symbiotic effect of Tai Chi and music on health outcomes.

Integrating music into Tai Chi practice may offer a promising avenue for enhancing its benefits on health outcomes in a holistic approach. First, based on the findings of this review, the health benefits could be through the pathway of a positive influence of added music on perceived enjoyment and concentration, improved adherence or compliance, and overall positive experience. In addition, as evidenced in the literature, listening to music alone could improve a variety of health

outcomes including but not limited to mental health, cognitive function, and cardiovascular health [53-58]. Therefore, we hypothesized a theoretical framework of adding music to Tai Chi practice to increase its benefits on health outcomes (Figure 2). Future research could focus on whether the application of music to Tai Chi practice leads to synergistic effects on health outcomes. This includes both physical (eg, mobility, balance, and metabolic health), cognitive (eg, orientation and memory), and mental health (eg, stress and depression symptoms). Studies could also aim to quantify these outcomes and understand the underlying mechanisms driving these potential benefits. It is also warranted to investigate which music (such as type of music, its tempo, and rhythm) is appropriate to maximize health benefits, and how these factors might influence different populations such as various age groups and health conditions. These investigations may provide insights into how to improve health through a holistic approach. Last, but not least, qualitative studies to gather in-depth insights from participants on their experiences, preferences, and perceptions of Tai Chi practice with music may provide valuable information to guide the development of tailored and effective Tai Chi exercise programs. Tools and recommendations could be developed to guide interventions using music to Tai Chi practice for health benefits.

Figure 2. Conceptual framework of applying music to Tai Chi practice to increase Tai Chi's health benefits.



Limitations

The findings of this scoping review should be interpreted with caution due to the majority of included studies being conducted in China among college students. Even though music has been used during Tai Chi practice in other populations as reported in prior studies [26], the mechanisms of using music in Tai Chi practice in various populations have been understudied. Further research is needed to explore the mechanisms and the potential harms or benefits and establish the practicality of using music for Tai Chi practice in other regions and populations. In addition, the heterogeneous interventions, lengths, and frequencies of the included studies may further limit the application of the findings.

Conclusions

Based on the findings of the included studies, Tai Chi style or form selection, the music used during Tai Chi practice, and the studied populations were heterogeneous. Various outcomes, such as differences in Tai Chi practice experience, instruction quality, and health outcomes, were assessed. There is positive evidence supporting the beneficial effects of applying music to Tai Chi practice to improve the perceived quality of Tai Chi instructions and promote Tai Chi learning experience, enjoyment, concentration, adherence, and movement performance. Particularly, including music in Tai Chi practice may promote Tai Chi among individuals new to Tai Chi practice through perceived better instruction and learning experience. Therefore, applying music to Tai Chi learning and practice might help promote the implementation of Tai Chi in the general population. However, further study with a rigorous study design is needed to clarify if there are synergistic effects of Tai Chi and music on health outcomes.

Acknowledgments

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Authors' Contributions

YD and HN searched the literature. YD, GXW, and YH screened the studies and extracted the data. YD wrote a draft of this article as a lead author. GXW, HN, PR, EG, and ZY reviewed the drafts of this article and made comments. All authors read and approved the final article.

Conflicts of Interest

None declared.

Multimedia Appendix 1
PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) checklist.
[PDF File (Adobe PDF File), 525 KB - apinj_v8i1e60104_app1.pdf]

Multimedia Appendix 2
Search strategies used on PubMed for finding research articles about the application of music in Tai Chi exercise.
[DOCX File , 18 KB - apinj_v8i1e60104_app2.docx]

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Abbreviations

PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-analysis extension for Scoping Reviews

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Original Paper

The Use of Immersive Virtual Reality Training for Developing Nontechnical Skills Among Nursing Students: Multimethods Study

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Abstract

Background: Immersive virtual reality (IVR) is a niche technology rising in popularity in nursing education. Although there is an abundance of evidence to demonstrate the effect of virtual reality (VR) on desired learning outcomes, this evidence is limited to technical or procedural skills or managing a single patient with clinical problems. Nontechnical skills (NTS), such as communication, decision-making, teamwork, situation awareness, and managerial skills, have not been explored using IVR technology.

Objective: This study aimed to (1) investigate the potential efficacy of the IVR system virtual reality hospital (VR-Hospital, or VR-Hosp), a single-user game we developed, on nursing students' NTS, sense of presence in the virtual clinical environment, and satisfaction and self-confidence in learning; (2) identify variables that predict NTS; and (3) explore students' experience in using VR-Hosp.

Methods: A multimethods design with a quantitative and qualitative approach was adopted. Participants were provided with VR-Hosp with 3 scenarios in training. VR-Hosp adopted a multibed, multipatient, multitask approach and was embedded with various clinical situations. Learning outcomes were measured after the training, followed by group interviews.

Results: In total, 202 students joined the study. Results revealed high levels of satisfaction and self-confidence in learning. Significant achievement in NTS was perceived by the students. The levels of satisfaction and self-confidence in learning and the involvement and sensory fidelity domains in the sense of presence were positive predictors of NTS.

Conclusions: The promising results offer a basis for designing IVR activities for nursing education. Further investigations are imperative to determine the impact of IVR technology on learning outcomes in clinical practice.

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KEYWORDS

education; educational; hospital; hospitals; nontechnical skills; nurse; nurses; nursing education; nursing; satisfaction; self-confidence; simulation; simulations; virtual reality; VR; immersive

Introduction

Background

Immersive virtual reality (IVR) is a niche technology that has been rising in popularity in nursing education. In the past decade, clinical practice opportunities have declined for nursing students due to personnel shortages and an increasing demand for clinical services [1,2]. Notably, virtual reality (VR) simulations have been recognized for their tremendous potential in nursing education and have shown benefits in performance and knowledge in emergency skills training and single-patient management [3]. In some countries, simulations and other new technology-based training approaches have been accepted as alternatives to replace some of the required clinical hours [4]. Their potential to replace clinical hours became more evident from the closure of clinical venues during the COVID-19 crisis [2,5]. To enable nursing students to develop the competence to solve problems in the clinical context, they not only need to apply the knowledge and skills that they have learned but also need to make decisions when facing situations that they were never taught or had never previously encountered. The question, therefore, is whether VR-based education is a plausible solution to strengthen clinical competence.

Virtual Reality in Nursing Education

VR is a rapidly expending field, and its definition is complex, ranging from the use of computer-based applications to generate simulated environments depicted on a computer screen to 3D environments with interactive functions and stimuli [6]. VR can be delivered in immersive or nonimmersive modes to establish a varied perception of reality [7]. Examples of nonimmersive modes include online or computer learning and video games. In contrast, IVR education tools or systems are usually delivered using a head-mounted device (HMD) to provide full immersion and interaction in a virtual environment. IVR 3D visualization features make it possible to interact with the virtual environment and offer a deeper sense of presence that distinguishes IVR from web-based or 2D technologies [8]. Bystrom et al [9] and Dang et al [10] have defined a sense of presence as the subjective experience of participants being present within a virtual environment, which is a critical determinant of the level of engagement in immersive learning. Indeed, Dubovi et al [11] found that students' sense of presence within VR training is positively associated with their conceptual and procedural learning of medication administration. In clinical simulation, a higher sense of presence also allows nursing students to assume a greater degree of responsibility for patient outcomes and reflect on their clinical reasoning and problem-solving skills [12]. We understand the benefits of repeatable training using a simulated environment for building self-confidence and self-efficacy in one's performance without compromising safety for patients [13]. However, few studies have evaluated the relevance of a sense of presence in the acquisition of nontechnical skills (NTS) in nursing students.

Nontechnical Skills

NTS are defined as cognitive and interpersonal skills that promote worker safety and complement workers' technical skills, which include the domains of communication, situation awareness, teamwork, leadership, and decision-making [14]. Traditional health education has primarily focused on the development of clinical knowledge and technical skills, often overlooking NTS [15]. However, increasing evidence links failures in NTS to poor patient outcomes [16]. In multidisciplinary settings, health professionals' leadership, teamwork, and communication skills are crucial for clinical competence and patient safety [17]. Additionally, in complex and dynamic environments, situation awareness (defined as an individual's perception, comprehension, and projection of events) and critical thinking (which involves reasoning, deducing, and inducing based on this understanding) are considered essential skills for health care professionals in making effective clinical decisions [18-21]. For instance, an examination of fatal medical accident reports submitted to a third-party safety agency in Japan over a 3-year period found that approximately 50% of these incidents stemmed from failures in NTS, particularly those involving situational awareness, teamwork, and decision-making capabilities [22]. Thus far, most IVR systems have focused on improving knowledge, mastering technical or procedural skills, developing emergency responses, or cultivating soft skills, such as empathy and communication [23-25]. Only a limited number of VR software programs have been designed for learning NTS. Examples of these 2 aspects are task prioritization according to professional guidelines [26] and single-patient management and deterioration detection [27,28]. It is noteworthy that inconsistent results have been found in high-IVR systems for risk perception and safety training in high school students [29]. Systematic reviews have revealed that VR is most effective in improving theoretical knowledge but not affective outcomes and NTS [30-33]. More evidence is needed to substantiate the use of VR technology to prepare nursing students to meet the clinical demands for NTS.

Methods

Study Design and Objectives

This study adopted a multimethods design to investigate the efficacy of using IVR via the virtual reality hospital (*VR-Hospital*, or VR-Hosp system (developed by the authors and their team) on developing NTS among undergraduate nursing students. VR-Hosp (short-term patent: HK30083446) is a single-user game that was developed using Unity Pro and HTC Vive Cosmos. Its unique feature of adopting a multibed, multipatient, multitask approach aimed to create a realistic clinical environment with various situations that do not necessarily have a direct relationship to patients' illnesses. From this, the following research objectives were derived:

- To investigate the efficacy of VR-Hosp on students' (1) NTS, (2) sense of presence in the virtual clinical environment, and (3) satisfaction and self-confidence in learning
- To identify variables that predict NTS

Qualitative data were collected through focus groups to investigate students' learning experiences.

Study Participants and Setting

Participants were undergraduate nursing students in a university in Hong Kong. They were recruited between 2021 and 2022 through convenient sampling from among students taking the "Fundamentals of Nursing" course, a mandatory subject for nursing students.

Virtual Reality Hospital

Conceptual Framework

A simulation model [34] was used to guide the development of VR-Hosp. This model offered a framework to structure the objectives, fidelity, and complexity of the simulation design in relation to (1) teacher and student factors and educational practices, (2) design characteristics and simulation, and (3) outcomes.

Teacher Factors, Student Factors, and Educational Practices

The educational practices listed in the simulation model were active learning, feedback, interactions, expectations, diversity in learning, and time spent on tasks. In VR-Hosp, unlike traditional teaching, where learning experiences rely heavily on teachers, VR-Hosp is an immersive VR game with predetermined instructions and game flow. As such, the practice factors are relatively standardized. The activities, time, and criteria for completion were preset based on the learning objectives. Therefore, the expectations were consistent even when the tasks differed. Students were required to make distinctions between and select their actions in response to various tasks to attain the designated goals. Active participation took place since students had to play the game individually and proceed independently. They obtained prompt feedback on whether their actions were correct through answering multiple-choice questions (MCQs).

Design Characteristics and Simulation

According to the simulation model, design characteristics relate to objectives, fidelity, complexity, cues, and debriefing. The objective of using IVR in learning is to create a sense of presence that affects learning outcomes. This sense of presence is mapped on to the concept of learning space, as delineated from experiential learning theory [35]. The concept of learning space is that students learn through transactions between the person and the environment. This points to the need for fidelity and complexity in the virtual environment. Learners should be able to subjectively experience their needs, goals, unconscious influences, memories, beliefs, and events, when positioned in the dynamics, interdependence, tension, and forces of the environment.

The fidelity of VR-Hosp was attained through validation of the content and coherence of the stimulus and response elements between the VR and the actual tasks, according to 4 of the 6 principles stated by Harris et al [36]: (1) face validity (whether the VR game looks and feels realistic), (2) physical fidelity (details and realism of the physical elements), (3) psychological fidelity (perceptual and cognitive features of the real task), and (4) affective fidelity (elicits emotional responses, such as stress or fear, in a similar way to the real task) [36]. Construct validity that measures the distinction in performance between novices and experts was not examined at this stage. Ergonomic fidelity was deemed irrelevant since VR-Hosp was not designed to train students in psychomotor skills.

Cues that popped up during the IVR game were essential to motivate and lead the students forward to complete the leaning tasks. In VR-Hosp, such cues were available to guide them. MCQs were also incorporated into the game. If a teacher-guided debriefing session was not available, when students played VR-Hosp individually or with peers, the MCQs would allow them to reflect on their justification for the actions that they performed.

Intervention Content

In VR-Hosp, an HMD and a controller held in the right hand were used by players to navigate the 3D virtual ward environment, where there were 3 cubicles, with 6 beds in each cubicle. VR-Hosp was evaluated by a panel of 6 experts, including 3 nursing academics with experience in developing VR games and 3 clinical mentors with rich experience in supervising clinical placements. The game was pretested by another 3 clinical mentors and 2 nursing students for acceptability in terms of content, game instructions, and game flow before it was launched.

VR-Hosp offered 3 scenarios. Each scenario lasted for approximately 10 minutes and comprised 2-3 levels of complexity tailored to students with different levels of clinical experience. The scenarios were named as follows: (1) clinical practicum orientation, (2) managing multiple tasks, and (3) prevention of errors. These 3 scenarios were developed to align with the learning objectives of VR-Hosp: (1) being aware of safety issues, (2) being alerted to contextual incidents/issues in the clinical environment, and (3) prioritizing nursing activities. The 3 scenarios featured the unpredictability of the clinical context with unexpected issues arising randomly. Each scenario within the game provided a context that allowed the students to apply and reinforce the learning objectives. By starting with simpler scenarios and progressively moving to more complex ones, the game aligned with the students' learning journey, ensuring an appropriate level of challenge and growth.

Each time a player logged in to VR-Hosp, patient deployment, incidents, MCQs, and answer options were generated at random. The VR game used speech recognition and voice recording features (in Cantonese) for students to record dialogues in response to patients' needs or nurse instructions before implementing care.

The voice-recording feature allowed players to respond to the requests of avatar patients or ward staff. This feature is unidirectional (ie, players must carry out the required actions before progressing to the next step in the game, with the goal of challenging players to critically reflect on the course of actions without any external assistance). Once the players completed the required actions, the MCQs appeared to provide an opportunity for them to reflect on their responses and select appropriate answers. The MCQs were developed based on the principle of reflective learning, facilitating a moment of re-evaluation and critical thinking, reinforcing the learning

objectives, and promoting a deeper understanding of the scenarios [37]. In addition, the voice recordings and answers could be reviewed after the VR-Hosp session. By revisiting their interactions, students could, therefore, identify areas for improvement, reinforce their learning, and engage in meaningful discussions during the debriefing.

Based on expert feedback, the response prompts were revised and optimized to provide clearer instructions and ensure a logical progression of clinical scenarios. Revisions to the MCQs were also guided by expert opinions to enhance clarity and alignment with the learning objectives. For instance, to foster critical thinking and promote a comprehensive approach to patient care, the MCQs were refined to simulate realistic dialogues, moving away from standard textbook answers. Moreover, we added answer choices that encouraged players to consider fall risk assessments instead of immediately helping the patient back to bed. The accuracy of the answers was verified, allowing for further refinements. To increase the realism of avatar patients and the clinical environment in VR-Hosp, adjustments were made to the visual and behavioral aspects of the avatars to make them more lifelike and relatable, thereby facilitating realistic patient interactions. For example, in the VR-Hosp simulation, an older male patient exhibiting an unsteady gait was depicted in the ward. His features were adjusted to more accurately reflect the movements typical of an older person. Additionally, to address the issue of VR sickness, we fine-tuned the visual and auditory elements, optimized frame rates, and implemented techniques such as smooth transitions and minimizing sudden camera movements.

Figure 1 displays a cubicle, depicts the VR-Hosp environment with a ringing call bell during orientation, and shows a clinical pitfall with inconsistent signage on diet and the meal delivery trolley. These scenarios require students to be attentive to virtual environments found in clinical settings.

Figure 1. Screen capture of VR-Hosp: (a) cubicle, (b) VR-Hosp environment with a ringing call bell during orientation, and (c) clinical pitfall with inconsistent signage on diet and the meal delivery trolley. VR-Hosp: virtual reality hospital.

Procedure

Three sets of VR-Hosp equipment, including HMDs and controllers, and 43-inch televisions mounted on movable stations, were prepared for students to practice on. There were 19 groups of students, with 12-14 students per group. In the first 30 minutes of a 2-hour session, students were given a briefing and practiced operating the controller and the HMD in the VR environment. They were presented with 1 of 3 different clinical scenarios using VR-Hosp to deliver patient care in a hospital ward setting with 3 cubicles. Afterward, they were divided into 3 teams of 4-5 students each and played VR-Hosp on their own. The members of each team took turns at being either a VR player or an observer, while the virtual game was played on the television screen at the same time to enable vicarious learning. The nurse tutor ensured each student in each group had the same amount of exposure to VR-Hosp (ie, 15 minutes), offered technical support on-site, and held a debriefing after each session.

Measures

The following outcomes were assessed immediately after the VR-Hosp session: virtual nontechnical skills, sense of presence in a virtual clinical environment, and student satisfaction and self-confidence in learning.

Virtual Nontechnical Skills

The primary outcomes were 5 personal skills measured using the virtual nontechnical skills (v-NOTECHS) system. Statements in the v-NOTECHS system were modified from the original NOTECHS rating system [14] to facilitate self-reporting on these behavioral parameters during engagement with the VR-Hosp game. The v-NOTECHS system consists of 5 domains: (1) communication and interaction (communication), 3 items; (2) situation awareness and vigilance (situation awareness), 3 items; (3) cooperation and team skills (teamwork), 5 items; (4) leadership and managerial skills (leadership), 5 items; and (5) decision-making, 5 items. One item in the communication domain of the original scale, "waited for acknowledgement from scrub nurse," was deemed irrelevant in the VR-Hosp learning activities. Players rated the items on a 5-point Likert scale, ranging from 1for strongly disagree to 5 for strongly agree. Cronbach α coefficients in the original scale are between .77 and .87.

The Presence Questionnaire Version 3.0

The Presence Questionnaire (PQ) was adopted to measure the players' sense of presence in this virtual clinical environment [38]. The scale explores how players' psychological state or attention shifts from the physical to the virtual environment. It consists of 4 domains: (1) involvement (involve—how natural or compelling is it to interact with the environment and control the objects?), 12 items; (2) adaptation/immersion (immersion—how much were you engaged in and focused on the assigned tasks?), 22 items; (3) sensory fidelity (sensory—the degree of coherence for stimulating multiple senses), 17 items; and (4) interface quality (interface—how much did the control or display devices interfere with concentration on the tasks?), 17 items. The highest scores for these 4 domains were 84, 50, 42, and 21, respectively. Note that the items under interface quality were negatively worded. The item scores were reversed so that the higher scores indicated less distraction and delay in the game experience. The respondents gave their ratings using a 7-point Likert scale, ranging from 1 for strongly disagree to 5 for strongly agree.

Student Satisfaction and Self-Confidence in Learning

The Student Satisfaction and Self-Confidence in Learning (SSSCL) scale was selected to investigate the design of VR-Hosp [39]. The scale consists of 5 items for the satisfaction subscale (satisfaction), measuring satisfaction with the content and instructions of the game. The second subscale, self-confidence in learning (self-confidence), has 8 items, measured on a 5-point Likert scale. This subscale measures players' self-confidence in learning associated with the development of NTS. The internal consistency of the SSSCL scale is good. Cronbach α coefficients are .92 and .82 for the satisfaction and self-confidence subscales, respectively.

Qualitative Data

An independent senior research assistant who had been trained in conducting semistructured interviews led 4 online focus group sessions. Purposive sampling was used based on the participants' sociodemographic background (ie, gender, year of study) and whether they had exposure to clinical experience (yes, no) to ensure the representativeness of the focus group sample. Each group consisted of 4-5 participants. Another assistant was present to take notes. The main question posed to the participants was, Can you share your experience with the VR-Hosp game and how it affected your learning? Further inquiries were made about the impact of the experience on their studies; the aspects they liked or disliked; and the skills, knowledge, and other benefits they acquired. Each group's digital audio recording lasted around 45 minutes and was transcribed word for word for further analysis.

Data Analysis

Descriptive statistics were computed to show the demographic profile of the students and to capture their self-reported performance in developing their NTS using VR-Hosp. Cronbach α was used to inspect the internal consistency of the questionnaires (α≥.70: good reliability; α=.60: acceptable reliability) [40].

Hierarchical multiple linear regression was used to identify the incremental predictive values of different variables on NTS. In block 1, we aimed to establish baseline relationships by considering the influence of age and gender on NTS, as these sociodemographic characteristics can affect the development of NTS [41,42]. In block 2, we accounted for experience-based factors, specifically prior clinical experience and VR game experience, which not only are associated with the development of NTS but also allowed us to establish their incremental predictive value on NTS beyond the influence of sociodemographic variables [31,43]. Considering a sense of presence has been associated with more positive outcomes in technical skills among nursing students, in block 3, the VR-Hosp game experience measured using the PQ was included to determine its predictive value for NTS, considering the influences from previous blocks [11]. Finally, key predictors in the design of VR-Hosp and confidence in mastering the teaching content using VR, as measured using the SSSCL scale, were entered after considering the contributions in previous blocks. The Technology Acceptance Model (TAM) consists of 3 key components—computer self-efficacy, perceived usefulness, and perceived ease of use—which have been found to positively affect the behavioral intention to learn a health procedure [44]. We used the SSSCL subscale scores because the constructs measured by these subscales closely parallel the components of TAM. For example, the self-confidence subscale of the SSSCL is highly associated with the TAM components computer self-efficacy and perceived ease of use, while the satisfaction subscale is closely linked to the perceived usefulness component [45,46].

NVivo version 11 was used to manage the focus group data. Inductive content analysis was used to examine and analyze the interview data, with the aim of identifying the main categories (themes) in the data and patterns among the subcategories [47].

The unit of analysis was a statement from the transcripts of the focus groups. The exploration and interpretation of the meanings of data led to the emergence of meaningful units of subcategories, and a name was given to each subcategory corresponding to the meanings of its coding. Lastly, the subcategories were condensed to achieve the status of a theme. To ensure trustworthiness, each transcript was analyzed independently by 2 researchers (authors KC and TL), who then met to discuss the data and reach a consensus on the themes [47]. The researchers analyzed the data until they reached the point of data saturation, when no new findings emerged.

Ethical Considerations

This study was approved by the Human Subject Ethics Subcommittee of the Hong Kong Polytechnic University (approval number: HSEARS20211229002). Informed consent was obtained from all individuals included in this study. Students' participation was entirely voluntary and would not affect their subject or curriculum in any sense.

Results

Participant Characteristics

Of the 237 undergraduate nursing students taking the preclinical VR-Hosp workshop, 202 (85.2%) students consented and participated in the study. Among the participants, who had a mean age of 20.2 (SD 1.45) years (females: n=150, 74.3%), 163 (80.7%) had no clinical experience, while the remaining students had less than 30 days of clinical experience. It is noteworthy that more than 80% (n=167) of the participants had no VR experience prior to VR-Hosp. Sociodemographic characteristics are summarized in Table 1.

Table 1. Demographic measures of the participants (N=202) who played the VR-Hosp[a] game.

Measures	Value
Age (years), mean (SD)	20.2 (1.45)
Gender, n (%)	
Male	52 (25.7)
Female	150 (74.3)
Clinical practicum experience, n (%)	
No clinical experience yet	163 (80.7)
Clinical placement for 15 days	27 (13.4)
Clinical placement for 30 days	12 (5.9)
Experience in playing IVR[b] games, n (%)	
Never	166 (82.2)
1-3 years	36 (17.8)

[a]VR-Hosp: virtual reality hospital.

[b]IVR: immersive virtual reality.

Outcome Assessment

The overall Cronbach α coefficients of the 3 instruments were excellent (Table 2) at .93 (v-NOTECHS system), .95 (SSSCL scale), and .92 (PQ), confirming that the construct was internally consistent (criterion α≥70).The reliability of the v-NOTECHS subscales administered to the target population were satisfactory, with Cronbach α ranging from .70 to .90 (communication=.70, situation awareness=.70, teamwork=.84, leadership=.79, and decision-making=.90). Cronbach α coefficients of the 4 PQ subscales were .90, .85, .80, and .74, respectively. The SSSCL instrument used in the study also achieved a Cronbach α of .93 for the satisfaction subscale and .91 for the self-confidence subscale.

Table 2. Outcome measures after participants played the VR-Hosp[a] game and reliabilities of the scales used.

Outcome assessments	Mean (SD)	Cronbach α
v-NOTECHS[b]		.93
Communication and interaction[c]	4.3 (0.54)	.70
Situation awareness and vigilance[c]	4.1 (0.55)	.70
Cooperation and team skills[c]	4.1 (0.55)	.84
Leadership and managerial skills[c]	4.1 (0.50)	.79
Decision-making[c]	4.1 (0.52)	.90
SSSCL[d] scale		.95
Satisfaction with the content and instructions[c]	4.3 (0.56)	.93
Self-confidence in learning[c]	4.2 (0.53)	.91
PQ[e]		.92
Involvement (maximum score=84)	57.6 (8.71)	.90
Adaptation and immersion (maximum score=50)	28.3 (4.95)	.85
Sensory fidelity (maximum score=42)	39.6 (5.95)	.80
Interface quality (maximum score=21)	11.0 (3.39)	.74

[a]VR-Hosp: virtual reality hospital.

[b]v-NOTECHS: virtual nontechnical skills.

[c]Maximum score=5.

[d]SSSCL: Student Satisfaction and Self-Confidence in Learning.

[e]PQ: Presence Questionnaire.

Efficacy on Nontechnical Skills

The survey showed that the learning outcomes for NTS were largely satisfactory, with mean scores ranging from 4.1 (SD 0.50) to 4.3 (SD 0.54) out of 5 in the v-NOTECHS scales. In the subscales satisfaction with instructions and self-confidence in learning from the SSSCL scale, mean scores of 4.3 (SD 0.56) and 4.2 (SD 0.53) were also reported, respectively, in the 5-point Likert scale. The sum of the scores for the 4 PQ domains were involvement=57.6, adaptation and immersion=28.3, sensory fidelity=39.6, and interface quality=11.0 (Table 2).

Predictions of Learning Outcomes

Self-confidence emerged as a significant predictor of 3 v-NOTECHS skills (Table 3): situation awareness (β=.21, P=.03, adjusted R^2=0.351, $F_{2,187}$=2.084, P≤.001), team skills (standardized coefficient β=.49, P<.001, adjusted R^2=0.392, $F_{2,187}$=39.36, P≤.001), and leadership skills (β=.31, P=.002, adjusted R^2=0.377, $F_{2,187}$=22.32, P≤0.001). Satisfaction was documented as a significant predictor of 3 v-NOTECHS skills: communication and interaction (β=.34, P=.001, adjusted R^2=0.336, $F_{2,187}$=20.01, P≤.001) and decision-making (β=.39, P<.001, adjusted R^2=0.392, $F_{2,187}$=33.44, P≤.001).

Table 3. Hierarchical regression analysis.

Block of variables	Communication and interaction			Situation awareness and vigilance			Cooperation and team skills			Leadership and managerial skills			Decision-making		
	β	*P* value	△R^2	β	*P* value	△R^2	β	*P* value	△R^2	β	*P* value	△R^2	β	*P* value	△R^2
Block 1															
Gender	.03	.65	0.006	.04	.54	0.004	.09	.20	0.010	.14	.06	0.019	.09	.21	0.008
Age	.07	.31	—[a]	–.05	.52	—	–.04	.62	—	.01	.93	—	.01	.88	—
Block 2															
Gender	.04	.61	0.002	.06	.42	0.017	.10	.15	0.016	.14	.06	0.001	.09	.20	0.004
Age	.07	.39	—	–.03	.76	—	–.04	.16	—	–.01	.88	—	–.01	.93	—
VR[b] experience	.05	.52	—	.12	.11	—	.13	.08	—	.01	.87	—	.06	.42	—
Clinical experience	0	.91	—	–.08	.31	—	–.03	.72	—	.04	.65	—	.02	.81	—
Block 3															
Gender	–.01	.88	0.186[c]	.01	.89	0.226[c]	.07	.34	0.110[c]	.08	.20	0.208[c]	.04	.51	0.163[c]
Age	.11	.15	—	.01	.92	—	–.02	.81	—	.02	.77	—	.01	.89	—
VR experience	.03	.67	—	.10	.13	—	.12	.09	—	–.01	.86	—	.04	.56	—
Clinical experience	–.02	.78	—	–.08	.29	—	–.03	.66	—	.03	.69	—	.02	.76	—
Involvement	.30	.02	—	.25	.05	—	.12	.36	—	.18	.15	—	0	.98	—
Sensory fidelity	.16	.13	—	.27	.01	—	.21	.06	—	.11	.26	—	.22	.04	—
Immersion	0	.99	—	–.01	.90	—	.03	.81	—	.19	.07	—	.23	.03	—
Interface quality	–.12	.08	—	–.03	.62	—	–.09	.20	—	–.13	.04	—	–.09	.19	—
Block 4															
Gender	.03	.59	0.142[c]	.03	.57	0.104[c]	.09	.14	0.256[c]	.11	.07	0.149[c]	.09	.11	0.217[c]
Age	.09	.19	—	0	.98		–.02	.74		.01	.83		–.01	.87	
VR experience	.04	.56	—	.10	.08		.13	.03		0	.97		.05	.41	
Clinical experience	–.04	.54	—	–.09	.16	—	–.06	.35	—	.01	.91	—	0	.96	—
Involvement	.24	.04	—	.21	.07	—	.07	.54	—	.14	.23	—	–.07	.56	—
Sensory fidelity	.14	.13	—	.27	.01	—	.21	.02	—	.11	.22	—	.21	.02	—
Immersion	–.14	.17	—	–.13	.19	—	–.15	.12	—	.06	.56	—	.06	.51	—
Interface quality	–.05	.44	—	.02	.78	—	–.03	.65	—	–.08	.20	—	0	.94	—
Self-confidence	.10	.33	—	.21	.03	—	.49	<.001	—	.31	.002	—	.16	.103	—
Satisfaction	.34	.001	—	.16	.12	—	.08	.41	—	.14	.17	—	.39	<.001	—

[a]Not applicable.

[b] VR: virtual reality.

[c]*P*<.001.

Qualitative Data

Basic patterns and coding were clustered and organized into categories (Multimedia Appendix 1). Content analysis yielded 3 categories corresponding to user experience and intended learning outcomes (ILOs). The first category pointed to the fidelity of VR-Hosp. The subcategories were physical fidelity, psychological fidelity, and affective fidelity. The other 2 categories deduced were found to match with the items in the SSSCL subscales and the v-NOTECHS system and, thus, were named satisfaction in learning and development of NTS. The items in the satisfaction subscale indicated the effectiveness of the VR activities in promoting enjoyment and the motivation to learn. Items in the subscale self-confidence in learning pointed

to the development of expected knowledge and skills, as specified in the v-NOTECHS system measuring self-reported learning outcomes.

Category I: Fidelity

Realism was noted in VR-Hosp.

Physical Fidelity

It was observed that not only "the graphics and images were constructed in detail" (student 0207) but also the narrow working space between beds was simulated (student 0304), and "a patient suddenly climbed out of bed and ran really quickly" (student 0310). The chaotic situation in clinical settings was further revealed when discrepancies were noted when the food in the meal cart differed from that indicated in the signage above the patient's bed (student 1405).

The positive reports from students that VR-Hosp provides a realistic simulation consistent with a hospital environment were corroborated by the quantitative findings of high sensory fidelity scores in the PQ, which measures the degree of coherence in stimulating multiple senses.

Psychological Fidelity

Students continually tried to make sense of the chaotic and ad hoc incidents occurring in the virtual environment. Student 0307 mentioned:

> *I actually experienced the chaos of clinical practice. It feels like what I have learnt was not actually "learnt."*

Another student was stunned by having to create a voice recording in response to the assignment on patients' needs and nurses' tasks. The importance of communication became clear, moving the focus solely on psychomotor skills to understand patients' needs (student 0608).

The unexpectedly immersive learning experience was closely aligned with the level of involvement—specifically, how natural or compelling it is to interact with the environment and control objects. This was particularly evident when students had to create a voice recording in response to an assignment on patients' needs and nurses' tasks, prompting them to reflect on the importance of communication in addressing patients' needs.

Affective Fidelity

Tension was reported in the realistic situations embodied in the immersive interactions in VR-Hosp:

> *In the virtual game, I heard an alarm go off. This would not have occurred in laboratory practice. This made me feel very nervous.* [Student 0204]
>
> *I felt overwhelmed.* [Student 0811]

These qualitative findings were also corroborated by the adaptation and immersion scores, which assessed how engaged and focused participants were on the assigned tasks. Tensions observed from the realistic and immersive interactions in VR-Hosp offered them a novel learning experience beyond traditional laboratory practice.

Category II: Satisfaction in Learning

In this category, students said that this training method was helpful and effective.

> *Traditional teaching was somehow fragmented, and only focused on a specific area…This VR-Hosp offered us a chance to understand the workflow. In this way, we have learned better.* [Student 0706]

Not only did they come across various situations that they "did not see in textbooks" (student 1303), but they also had to "analyze information before reporting the patient's condition" (student 1109). Students enjoyed the learning activities and asserted that the games motivated them to learn. Student 1503 said:

> *The game that I played was distributing meals to the patients. I did not realize that the meal signage could differ from the actual order.*

Category III: Self-Confidence in Learning

Development of Communication and Interaction

Communication and interaction skills are core components of NTS. Multiple students highlighted how the VR experience helped them realize the importance of these NTS, which they had previously overlooked (students 0608, 0908, and 1306). Another participant also added:

> *I know communication is important, because I have to respond and find out the priorities of various situation.* [Student 0913]

Development of Situation Awareness

Situation awareness was perceived as a vital skill by many students. They had learned to be observant and alert not only to the environment but also to the patients' actions to ensure patient safety. As a student mentioned:

> *Being a nurse, we have to be highly alert since so many different things could happen...What if I did not pay attention and the patient suddenly collapsed?* [Student 0410]

Another student echoed:

> *Many a time during laboratory practice, we perform the skills in a step-by-step manner. But in reality, it would not happen as planned. There would be sudden incidents.* [Student 1312]

Development of Decision-Making

Decision-making was 1 of the central learning outcomes. Knowledge and clinical reasoning all came into play. Moreover, prioritization was deemed "essential since tasks came up one after another" (student 0710). "[We] have to judge by ourselves" (students 0105, 0211, 0510, and 0907) was a comment that was made many times. In addition, students said, "We needed to determine the priority" (student 1301), learned to "analyze the information" (students 1008 and 1506), "think critically" (student 1401), and "know the rationale for our actions" (student 0311).

Student 1004 pointed out that "it felt so real that you would be asked to do another thing while you are busy." Students also found that they needed to "multitask" (student 1403) and that "there is an internal timer" (student 0713). One student best summarized the experience of playing VR-Hosp:

> *We had to be efficient, accurate, and careful.* [Student 0406]

Discussion

Principal Findings

This study was the first of its kind to explore nursing students' experience in using the immersive game VR-Hosp to learn NTS. Overall, findings suggested that VR-Hosp has the potential to facilitate NTS learning in order to complement current educational strategies.

Both quantitative and qualitative findings indicated the positive effects of VR-Hosp training in enhancing nursing students' NTS through a high-stress, time-critical IVR environment that customized real-life clinical situations with multitasking and episodes of interruption, demanding heightened awareness and prompt decision-making. Sensory fidelity signified the realism and coherence of the senses, for example, sound and movement, and the examination of virtual objects from multiple viewpoints. Huang et al [48] found that a high sense of presence might generate a cognitive overload when individuals are trying to complete virtual tasks, and thereby negatively affect satisfaction. In contrast, visual, auditory, and tactile stimulations were found to be vital for novice nurses to detect cues related to patients' conditions [49,50]. In a similar vein, sensory fidelity in VR-Hosp allowed the students to play individually with high concentration and meticulous cognitive and perceptual responses, to critically think, and make appropriate decisions. Consistent with another study, sensory modalities to imitate real-world movements were crucial in learning [51].

In our quantitative findings, critical sensory input was found to be associated with perception and comprehension of the situation [52]. More importantly, the meaningfulness and coherence of the content and activities were established as factors that promote learning and the goals of higher education [53]. The high satisfaction and self-confidence scores, coupled with their predictions of these 2 NTS, unpacked the meaningfulness of using VR-Hosp. These findings were further complimented by students' feedback, which indicated that the virtual environment realistically offered space for them to make decisions and react to the visual or auditory alarms, instead of providing a step-by-step guide. Students were required to multitask within a set period and to tend to episodes of sudden demands. Prioritization and communication with the patient or other members of the health care team were significant. Students had to contemplate the rationale for their actions and reconsider their justifications when answering the MCQs in response to the virtual situations. Hence, the IVR activities facilitated the building of situation awareness and vigilance, as well as decision-making.

The qualitative findings provided further insights into the distinct contributions of the game's design to the development of NTS among nursing students. Detecting and handling alarms, hazards, and clinical pitfalls were the learning activities in VR-Hosp. Students commented how VR-Hosp heightened their excitement, eliciting stress and nervousness when encountering unexpected incidents and equipment alarms during the game play. It was uncovered that the voice-recording feature in VR-Hosp made the students feel compelled to communicate with the nurse and patient during the game. They could not proceed to the next action if they did not talk to the patients and other health care workers. Such forced interactions urged them on to communicate with the avatar and engaged them in performing the designated activities. Altogether, these qualitative findings echoed the learning space concept in the experiential learning framework [35], contributing evidence of VR-Hosp's sensory fidelity value to physical, psychological, and affective fidelity.

Previous studies have reported that gender and experience in playing VR games are factors that affect satisfaction and usability scores [23]. In contrast, our quantitative findings revealed that gender and literacy in VR technology do not have an impact on situation awareness and decision-making. It was interesting to discover that the other 3 domains in the sense of presence did not predict either situation awareness or decision-making. These domains were involvement (controlling and moving in the virtual environment), immersion (proficiency and consistency with the real world), and interface quality. This means that interference in using control devices, delay in experiencing actions, and distraction in visual display did not hinder students' confidence in their ability to develop the desired skills. It was inconclusive whether naturalistic interactions are the element that influence how the form and content of the learning modalities operate in virtual learning environments [54]. That said, it was likely that exposure to IVR clinical practice was significant in helping novice nurses develop and master the skills of situation awareness and decision-making regardless of the control of VR devices.

Overall, this study offers evidence of the sensation fidelity of the VR environment as an essential feature to achieve learning outcomes. Our findings suggest that VR-Hosp has the potential to facilitate the development of situation awareness and decision-making, complementing current educational strategies. For instance, IVR provides a cost-effective and accessible alternative to traditional pedagogy, such as high-fidelity simulation. Although high-fidelity simulation is an effective educational strategy, certain limitations, such as shortages of personnel, resources, and space and the lack of available qualified facilitators, can impact its implementation and effectiveness. However, IVR eliminates the need for physical resources and a dedicated space, allowing students to engage in realistic scenarios using VR headsets or other devices. This scalability enables a larger number of students to participate simultaneously, enhancing accessibility and reducing logistical constraints. With the use of IVR, facilitators can guide and debrief students, leveraging the recorded interactions and performance data to provide targeted feedback and facilitate reflective learning.

Limitations

This study adopted a convenience sampling method; thus, it is difficult to generalize the results. The study involved a cross-sectional survey collected after VR-Hosp practice; thus, the cause and effect of this VR teaching strategy could not be determined. NTS in the real world are often influenced by external factors, such as high uncertainty and time pressure [55]. Considering that v-NOTECHS scores were self-reported, further work is needed to objectively evaluate the learning outcomes and assess whether these skills can be sustainably translated to realistic settings. When implementing VR-Hosp, students took turns in being players and observers. This might have interfered with the immersive experience since the observers communicated with the players during the activity, for example, in locating alarms and when answering MCQs. There might also have been bias when obtaining qualitative feedback, since the process was conducted during the debriefing session moderated by the teachers. However, the information that was obtained forms a basis for future studies to compare its impact with that of other educational pedagogies. In addition, the use of HMDs in IVR can lead to VR sickness, such as nausea, dizziness, and blurred vision [56]. Although our study did not report cases of VR sickness, its presence could negatively impact the immersive learning experience. Future research should include measures such as the Virtual Reality Sickness Questionnaire to evaluate its effect on the desired learning outcomes [57]. Additionally, future studies using IVR may consider striking a balance between realism and incorporating elements shown to reduce VR sickness, such as narrowing the horizontal field of view, partially limiting the degrees of freedom in navigation control, and increasing tactile feedback [58].

Conclusion

VR-Hosp appears to be a promising educational pedagogy for enhancing NTS, including situation awareness and decision-making ability, in nursing students. VR-Hosp portrays a nonlinear world that challenges students to operationalize what they have learned in traditional classroom teaching and simulation practices. The findings add evidence to the determinants of learning outcomes from the aspects of a sense of presence, satisfaction, and self-confidence in learning. This should motivate the undertaking of future work on VR-based teaching and learning activities in higher education.

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Authors' Contributions

All authors made substantial contributions to (1) developing the immersive virtual reality game software, (2) developing the study conception and design, (3) acquiring data and analyzing and interpreting them, and (4) drafting the paper and revising it critically for important intellectual content. All authors have agreed on the final version of the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Content analysis: overview of categories and subcategories.
[DOCX File , 26 KB - apinj_v8i1e58818_app1.docx]

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Abbreviations

HMD: head-mounted device
IVR: immersive virtual reality
MCQ: multiple-choice question
NTS: nontechnical skills
PQ: Presence Questionnaire
SSSCL: Student Satisfaction and Self-Confidence in Learning
TAM: Technology Acceptance Model
v-NOTECHS: virtual nontechnical skills
VR: virtual reality
VR-Hospital/VR-Hosp: virtual reality hospital

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Original Paper

Examining the Evidence on the Statistics Prerequisite for Admission to Doctor of Nursing Practice Programs: Retrospective Cohort Study

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Abstract

Background: Doctor of Nursing Practice (DNP) programs in the United States confer the highest practice degree in nursing. The proportion of racial and ethnic minority DNP students, including those of Asian descent, keeps increasing in the United States. Statistics is commonly required for DNP programs. However, there is insufficient evidence regarding the number of years within which statistics should be taken and the minimum grade required for admission to the program.

Objective: This study aimed to examine the associations of statistics prerequisite durations and grades for admission with the course performances within the DNP program. We also explored whether a postadmission statistics overview course can prepare students for a DNP statistics course as well as a required statistics prerequisite course.

Methods: A retrospective cohort study was conducted with a sample of 31 DNP students at a large university in the Mid-Atlantic region. Statistical analysis of data collected over 5 years, between 2018 and 2022, was performed to examine the associations, using Spearman rank correlation analysis and Mann-Whitney *U* test (*U*).

Results: The performance of students in a DNP statistics course was not associated with prerequisite duration. There was no significant association between the duration and the DNP statistics course letter grades (ρ=0.12; *P*=.66), neither with exam 1 (ρ=0.03; *P*=.91) nor with exam 2 scores (ρ=0.01; *P*=.97). Prerequisite grades were positively associated with exam 1 grades (ρ=0.59; *P*=.02), but not exam 2 (ρ=0.35; *P*=.19) or course grades (ρ=0.40; *P*=.12). In addition, no difference was found in the performance of students whether meeting the prerequisite requirements or taking a 1-month, self-paced overview course (exam 1: *U*=159, *P*=.13; exam 2: *U*=102, *P*=.50; course letter grade: *U*=117, *P*=.92).

Conclusions: No evidence was found to support the need for limits on when prerequisites are completed or grade requirements. Opting for a statistics overview course after admission can serve as a viable alternative to the statistics prerequisite, effectively preparing students for advanced quantitative data analysis in a DNP program.

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KEYWORDS

Doctor of Nursing Practice; admission prerequisite; statistics requirement; biostatistics; nursing education

Introduction

Doctor of Nursing Practice (DNP) programs in the United States prepare nurse leaders, conferring the highest practice degree in nursing. The proportion of racial and ethnic minority DNP students, including those of Asian descent, increased from 21% in 2010 to 37% in 2020 [1]. Several countries in East and Southeast Asia have begun implementing practice-oriented

nursing doctorate programs, similar to DNP programs in the United States [2]. The American Association of Colleges of Nursing (AACN) documents that guide the development of DNP program curricula emphasize the importance of DNP graduates being prepared to lead evidence-based practice [3]. To fulfill this, DNP graduates should possess the competence to translate research into practice, evaluate evidence, apply research in decision-making, and implement viable clinical innovations to effect practice change [4].

Integration of research into clinical practice for evidence-based practice requires a firm understanding of statistics. Insufficient knowledge and reasoning skills in statistics can lead to inaccurate interpretation and application of knowledge [4]. Accordingly, it is common that DNP programs require statistics as an admission prerequisite. A total of 17% of DNP programs in the United States mandate applicants to complete a graduate-level statistics course before admission [5]. Some programs include statistics as a core course in their DNP curriculum [6], often requiring undergraduate-level statistics as a prerequisite.

While completion of a statistics course before admission to DNP programs is frequently required, there has been little evidence or consensus about the specific timeframe within which this prerequisite should be fulfilled [5] or whether prerequisites are even needed [7]. Candidates are largely affected by the existence and duration of this requirement; a tight, short timeframe may discourage them from applying to the program as it may mean they have to retake a statistics course to meet the requirement [8]. Such a duration requirement, when unnecessary, is disadvantageous to both applicants seeking to advance their education and to schools aiming to expand the qualified applicant pools [8]. Previous research has indicated limited evidence linking prerequisite coursework to subsequent performance [9,10]. There is no published evidence showing a differential effect of prerequisite statistics on the admission or academic performance of racial and ethnic minority DNP students. Furthermore, admission requirements have changed over time, implying that specific year criteria may not always be a good standard [7]. As the specific duration criteria of prerequisites vary across the DNP programs and limited evidence supports the need for prerequisite requirements, it is vital to address the existing gaps in prerequisite courses and to examine the evidence supporting the criteria [11].

Therefore, this study aimed to investigate the questions: (1) Is the time elapsed since students' completion of the statistics prerequisite (duration) associated with their performance in a DNP statistics course? (2) Are the grades of the statistics prerequisite course associated with students' performance in a DNP statistics course? and (3) Does a postadmission statistics overview course prepare students for a DNP statistics course as well as a required statistics prerequisite course?

Methods

Study Design and Sample

We conducted a retrospective cohort study that involved the analysis of data collected over 5 years, between 2018 and 2022. The unit of analysis was data from individuals. The data sources consisted of the transcripts and class artifacts of the students who were enrolled in a DNP program–required statistics course at a large university in the Mid-Atlantic region. We did not collect their demographics for anonymity. The DNP program in this study is designed to empower nurses to practice at the highest level of clinical practice and improve systems and safety as nurse leaders. The executive, hybrid format allows students to attend in-person classes once a month, with the balance of online learning. At the end of the program, students complete a quality improvement scholarly project that synthesizes and demonstrates the knowledge and skills they have learned throughout the program. Statistics play a key role in analyzing data for this scholarly project. While the DNP program required completing a prerequisite statistics course with a grade of at least B within 5 years of the program start, it also allowed the students who had not met either the grade requirement or the duration requirement of 5 years to alternatively take a summer statistics overview course. The 1-month, online, asynchronous, self-paced summer overview course was supervised by a faculty member and contained 5 modules (research design, sampling, measurement, descriptive statistics, and inferential statistics). In order to pass the course, the students were required to demonstrate at least 80% proficiency with the content through an end-of-the-course exam that they could take a maximum of 2 times. DNP statistics course grades were accessed by the course professor (HDB). The grades and the years and semesters of the prerequisite statistics course were obtained through the School of Nursing Office of Admissions and Student Services. The passing status of the summer overview course was obtained from the Director of the DNP program.

Measures

Duration Since Statistics Prerequisite

Students started taking the DNP statistics course at various elapsed times after completion of the prerequisite statistics course. To compute the duration of this elapsed time (DET), first, the years and months were identified for (1) when students had completed the prerequisite statistics courses based on their transcript (May for the spring semester, August for the summer semester, and December for the fall semester) and (2) when students had started taking the DNP statistics course (August). Then, we calculated the DET in months by subtraction between the 2 time points.

Doctor of Nursing Practice Statistics Course Performances

In total, 3 DNP statistics course artifacts were used to measure the course performance of students: exam 1 and exam 2 scores (both with a possible score range of 0 to 15), and course letter grades (1=B–, 2=B, 3=B+, 4=A–, 5=A, and 6=A+). No study participants received a grade below B in the course.

The contents of the 2 exams were not cumulative. Exam 1 occurred at the midterm and exam 2 at the end of the semester. Each included 25 multiple-choice questions. The exams assessed students' understanding of the statistical theories and interpretation of the results from various statistical tests (eg, descriptive statistics, *t* tests, one-way ANOVA, repeated

measures ANOVA, analysis of covariance, multiple linear regression, logistic regression, and nonparametric tests). The course letter grades also reflected other course artifacts (eg, a statistical analysis critique paper) that were excluded from this study due to a lack of immediate relevance to the prerequisite statistics grades. The course was taught by the same faculty member during the entire 5-year study period. The faculty maintained the other format (eg, exam length) and the difficulty level of the exams across cohorts of students, supported by comparable exam scores and course grades, on average, over the years.

Prerequisite Statistics Performance

The letter grades of the statistics courses in the transcripts that students had submitted for admission were used to measure the performance of the students for the prerequisite statistics course (1=B–, 2=B, 3=B+, 4=A–, 5=A, and 6=A+). The DNP program required a grade of at least B– for admission.

Ethical Considerations

All participants were informed of the purpose, content, process, and potential risks and benefits of the study. The informed consents were voluntarily obtained, and participants were informed that they could withdraw from the study whenever they wanted. No compensation was provided for study inclusion. The data used in this study were stored in the institutional encrypted storage. All study data were accessible only to the approved researchers. This study was approved by the University of Virginia Institutional Review Board (#5525) and adhered to ethical standards.

Statistical Analysis

Descriptive and inferential statistics were calculated using IBM SPSS Statistics (version 28) [12]. Frequencies and proportions in percent for categorical variables and their means (SDs) and medians (IQRs) for continuous variables were computed. A Spearman rank correlation analysis was used to explore the association between the DET and their DNP statistics course performance (study question 1) and statistics prerequisite course grades and students' DNP statistics course performance (study question 2) because the study data did not meet the normality assumption. A Mann-Whitney *U* test was used to investigate differences in DNP statistics course performance based on the completion of a statistics overview course or required statistics prerequisite (study question 3). The significance level for all statistical tests was set at the conventional level of P=.05.

Results

Sample Characteristics

Out of 86 students who had taken the DNP program statistics course and were invited to the study, a total of 31 (36%) students agreed to participate. From the 31 student participants in the sample, 16 (52%) students met the 5-year statistics prerequisite requirement for admission, and 15 (48%) students successfully completed the summer overview course. There were no missing data.

Among the 16 students who fulfilled the 5-year statistics requirement, the mean DET between taking the prerequisite statistics course and the DNP statistics course was 39.6 (SD 19.7; range 12-80) months, or approximately 3.5 years. Most of them (11/16, 69%) received an A in their prerequisite statistics course. In the total sample of 31 students, which was used to answer study question 3, the distribution of the letter grades in the DNP statistics course was left skewed, with predominantly A+ or A. Their mean scores for exam 1 and exam 2 were 13.4 (SD 1.5) out of 15 and 13.1 (SD 1.5) out of 15, respectively (Table 1).

Table 1. Sample characteristics of the study participants.

Characteristics	Descriptive statistics
Transcript grade of the prerequisite statistics course (n=16), n (%)	
A	11 (69)
B	4 (25)
B–	1 (6)
Duration (months elapsed from prerequisite; n=16)	
Mean (SD)	39.6 (19.7)
Median (IQR)	34 (27.0-53.5)
Year taking the DNP[a] statistics course (n=31), n (%)	
2018-2019	5 (16)
2020-2021	19 (61)
2022	7 (23)
DNP statistics course grade (n=31), n (%)	
A+	15 (48)
A	10 (32)
A–	4 (13)
B+	2 (6)
DNP statistics course performances (maximum score=15; n=31)	
Exam 1	
Mean (SD)	13.4 (1.5)
Median (IQR)	13.8 (12.8-14.5)
Exam 2	
Mean (SD)	13.1 (1.5)
Median (IQR)	13.7 (12.0-14.4)

[a]DNP: Doctor of Nursing Practice.

Association Between Duration and Class Performance

There was no significant association between the DET and the DNP statistics course letter grades (ρ=–0.12; *P*=.66). Also, the DET was neither significantly associated with exam 1 (ρ=0.03; *P*=.91) nor exam 2 scores (ρ=–0.01; *P*=.97; Table 2). There was no difference between those who had a DET within 5 years and more than 5 years in their scores of exam 1 (14.2 out of 15 vs 14.2 out of 15), exam 2 (13.2 out of 15 vs 13.6 out of 15), and course grades (12/13, 92% students earned A– or above vs 3/3, 100% earned A– or above; Table 3).

Table 2. Association of class performance with prerequisite duration and transcript grade (n=16).

Class performance	Duration	Transcript grade
Exam 1 score		
ρ	0.03	0.59
P value	.91	.02
Exam 2 score		
ρ	–0.01	0.35
P value	.97	.19
DNP[a] course letter grade		
ρ	–0.12	0.40
P value	.66	.12

[a]DNP: Doctor of Nursing Practice.

Table 3. Comparison of the course performances by prerequisite duration (≤5 years vs >5 years; n=16).

Course performance	Duration	
	≤5 years (n=13)	>5 years (n=3)
Exam 1		
Mean (SD)	14.2 (0.9)	14.2 (0.9)
Median (IQR)	14.4 (13.8-15.0)	14.4 (13.8-14.7)
Exam 2		
Mean (SD)	13.2 (1.4)	13.6 (1.9)
Median (IQR)	13.8 (12.6-13.8)	14.4 (12.9-14.7)
Letter grade, n (%)		
A+	6 (46)	2 (67)
A	4 (31)	0 (0)
A–	2 (15)	1 (33)
B+	1 (8)	0 (0)

Association Between Prerequisite Performance and Class Performance

There was a significant and large association between letter grades in the prerequisite statistics course and exam 1 scores in the DNP statistics course (ρ=0.59; *P*=.02). However, the prerequisite letter grades were not significantly associated with exam 2 scores and the DNP statistics course letter grades, respectively (ρ=0.35, *P*=.19; ρ=0.40, *P*=.12). All other effect sizes were close to 0 (Table 2).

Comparison Between Statistics Prerequisite and Overview Course

For the 31 students in the full sample, there were no differences in all 3 DNP statistics course performance measures between those who met the statistics prerequisite requirement and those who took the statistics overview course (exam 1: *U*=159, *P*=.13; exam 2: *U*=102, *P*=.50; course letter grade: *U*=117, *P*=.92). Exam 1 scores were slightly higher (14.2 out of 15 vs 13.5 out of 15) among those who met the prerequisite, but the difference was not significant (Table 4).

Table 4. Comparison between those who met the statistics prerequisite and those who took the overview course (n=31).

	Exam 1	Exam 2	Course letter grade
Total (n=31)			
Mean (SD)	13.9 (1.1)	13.3 (1.7)	5.2 (0.9)
Median (IQR)	14.4 (13.2-14.7)	13.9 (12.6-14.4)	5.0 (5.0-6.0)
Prerequisite group (n=16)			
Mean (SD)	14.2 (0.9)	13.3 (1.4)	5.2 (1.0)
Median (IQR)	14.4 (13.5-15.0)	13.8 (12.0-14.1)	5.5 (4.5-6.0)
Overview course group (n=15)			
Mean (SD)	13.5 (1.2)	13.3 (2.0)	5.3 (0.9)
Median (IQR)	13.8 (12.9-14.4)	14.4 (12.6-14.7)	5.0 (5.0-6.0)
U [a]	159.0	102.0	117.0
P value	.13	.50	.92
Pearson correlation coefficient (*r*) (effect size)	0.28	0.13	0.02

[a]Mann-Whitney *U* test

Discussion

We did not find a significant association between the duration after students' completion of the statistics prerequisite and their DNP statistics course performance. When a DNP program requires statistics as an admission prerequisite, a duration requirement is often attached (eg, 5 years) [11]. The rationale is that the knowledge of statistics has a limited shelf-life. However, there is no known evidence after what year the knowledge degrades significantly enough to warrant retaking a course. In our study, there was no such critical time point. Furthermore, our study result showed no overall association of duration with performance in the higher-level statistics course. Although the duration in our study sample only spanned from

12 to 80 months, there is little reason to suppose a significant association beyond the period.

Likewise, we did not find a correlation between course grades in the prerequisite statics course and performance in a DNP statistics course. Although exam 1 scores were positively associated with the prerequisite grades, the association did not continue for exam 2 or the overall course grades. In this context, the disadvantage for the students with lower prerequisite course grades was overcome by the end of the semester. One possible explanation for this is that the attenuation of the significant association over the semester might be related to what and how students and faculty contribute to the learning process. The faculty might have put more effort into helping the students with lower prerequisite grades, and at the same time, those students might have sought more academic support from the faculty. However, future research is needed to verify these claims. It also needs to be reiterated that all participating students in this study had at least a B– grade in their prerequisite statistics course, as this was an admission requirement. Therefore, the absence of the correlation over time may not apply to candidates who earned lower than B– in their prerequisite course. Nevertheless, our study findings highlight the necessity for evidence-based criteria regarding statistics requirements, which may differ from current DNP admission practices in many programs.

It is noteworthy that we did not find a difference in students' performance whether they met the prerequisite requirements or took an alternative overview course. A faculty-supervised, 1-month, self-paced, online statistics overview course was as effective in preparing the students for the DNP statistics course as a statistics course taken as a prerequisite. The effectiveness of the statistics overview course presents a novel avenue diverging from the conventional statistics prerequisite in DNP programs. This pathway allows these programs to gauge the readiness of students for their enrollment in an advanced graduate-level statistics course within the program itself, eliminating the need for them to undertake an additional statistics course before joining the program. Also, this strategic initiative has the potential to foster greater equity and inclusivity within DNP program learning cohorts. By affording students the chance to familiarize themselves with essential content over a condensed timeframe, the approach eliminates the necessity of seeking an external course. Providing such an overview course after students are admitted, rather than requiring them to take an external course as a prerequisite to admission, can align with and strengthen increasing diversity, equity, and inclusion efforts at academic institutions. Our study had several limitations. The study sample size was small and recruited from one DNP program. We also did not collect data on potential confounding variables such as student sociodemographics (age, social support, work status, etc) and their academic tracks (part-time and full-time). Further research is needed to explore whether and how these student characteristics influence the outcomes. Also, collaborative or comparative studies with other health care education programs can be conducted to gain insights from diverse perspectives.

In conclusion, we did not find evidence to support requiring candidates to complete a statistics prerequisite course for admission within a fixed number of years. Instead, there is a need to establish evidence-based criteria regarding statistics requirements. Alternatively, offering a statistics overview course can be an effective way to prepare students for a higher-level statistics course in DNP programs. With support, students have the potential to achieve desirable learning outcomes.

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Data Availability

The datasets generated during and/or analyzed during this study are not publicly available due to confidentiality.

Authors' Contributions

HDB conceptualized the study, conducted data analysis, and took the main role in writing the manuscript. SP collected data, performed data analysis and interpretation, and drafted and revised the manuscript. BAQ contributed to data collection and critically revised the manuscript. JT and LBW contributed to the conception and design of the study and critically revised the manuscript.

Conflicts of Interest

None declared.

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Abbreviations

AACN: American Association of Colleges of Nursing
DET: duration of elapsed time
DNP: Doctor of Nursing Practice

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Original Paper

Factors That Affect the Quality of Life of Mothers Caring for Children With Medical Needs at Home: Cross-Sectional Questionnaire Study

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Abstract

Background: The number of children requiring daily medical care is on the rise, with many being cared for at home. This situation places a significant burden on mothers, who often serve as the primary caregivers.

Objective: This study aimed to clarify the factors that affect the quality of life of mothers with children who require home health care.

Methods: A questionnaire study was conducted among mothers of children needing medical care at home, with 46 participants responding. The questionnaire included items regarding the child's condition, the mother's situation, and the World Health Organization Quality of Life-26scale.

Results: Factors influencing the quality of life of mothers included whether the child attended daycare or school (β=.274; *P*=.04), the duration of home care (β=.305; *P*=.02), and the presence or absence of position changes (β=–.410; *P*=.003). The presence or absence of position changes had the most significant impact (adjusted R^2=.327).

Conclusions: The most significant factor affecting the quality of life of mothers of children requiring home medical care is the presence or absence of positional changes.

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KEYWORDS

home care; children with special health care needs; children with medical complexity; mother; quality of life; caregiver; questionnaire

Introduction

Children requiring medical care are those who, owing to medical advancements, continue to need medical care interventions such as suctioning secretions and tube feeding after long-term hospitalization in units like the neonatal intensive care unit. These children often rely on medical devices such as ventilators and gastrostomy tubes daily [1]. In the United States, children with special health care needs were defined in 1998 as those who have or are at increased risk for chronic physical, developmental, behavioral, or emotional conditions and require health and related services beyond what is generally required by children [2]. This definition includes children with congenital or acquired multisystem diseases, those with severe neurological conditions with significant functional impairments, and those who may require medical devices for daily life. These children

are classified as having medical complexity and are medically fragile, with various intensive care needs that cannot be easily met by existing medical models [3].

Advancements in perinatal and neonatal medicine have increased the number of children whose lives are saved. In Japan, the number of children requiring medical care has doubled over the past decade, reaching 20,000 nationwide [1]. Many of these children, such as those using ventilators, are discharged directly from the neonatal intensive care unit to home [4].

The Ministry of Health, Labour and Welfare's *Report on the Actual Conditions of Children Requiring Medical Care and Their Families* reveals that 94% of caregivers are mothers and 5.3% are fathers, indicating that mothers are primarily responsible for care. It also reports that numerous families are nuclear, suggesting that the caregiving burden is heavily concentrated on mothers [5]. These children often require not only life-sustaining medical procedures but also observation and care for symptoms unique to their condition to maintain stability, making it difficult for others to take over the mother's role [6]. Consequently, mothers bear a significant burden and are often responsible for coordinating various social resources, including medical, welfare, educational, and public health services [6]. Despite insufficient support systems, families are primarily responsible for providing care. Matsui [5] found that the combined percentage of families who reported "agree" or "somewhat agree" to various lifestyle concerns was high: 71.1% for "chronic sleep deprivation," 70.4% for "feeling strong anxiety about not knowing how long this will continue," 69.7% for "unable to visit a medical institution when their own health deteriorates," and 68% for "daily life is a continuous state of tension." These high percentages indicate that their daily lives are continuously tense, sleep deprived, and anxious. This finding shows that mothers of children who require medical care experience significant caregiving and emotional burdens.

Furuya et al [7] have revealed that the quality of life (QOL) of parents of children with severe conditions tends to be generally low, influenced by the high caregiving burden at home. Senses Dinc et al [8] also reported that parents of children with Down syndrome have lower QOL than mothers of healthy children. They noted that the birth of a child with Down syndrome resulted in increased expenses and reduced participation in social and personal leisure activities, potentially affecting the mother's QOL. In addition, factors that lower the subjective QOL of mothers of children with severe physical and intellectual disabilities at home include the child's deteriorating health, decisions regarding treatment for secondary disabilities, the burden of dual caregiving for both parents and children, and anxiety over the mothers declining caregiving capacity. Conversely, factors that enhance subjective QOL include a sense of the child's growth, social connections, fulfillment from reclaiming the mother's social role, and family support during critical situations [9]. While there are scattered reports on the QOL of mothers of children with disabilities, few have specifically clarified the characteristics of the QOL of mothers of children requiring medical care. Comprehending these characteristics is crucial for providing support to improve their QOL. Therefore, this study had the following objective: to identify factors influencing the QOL of mothers of children requiring home medical care.

Methods

Study Participants

This study targeted mothers aged 20 years and older who had children (aged 3-12 years) requiring home medical care from late infancy to school age. To avoid imposing an excessive burden due to the home care situation and the child's condition, mothers for whom the survey would be overly burdensome were excluded. In addition, mothers with multiple children requiring home medical care were excluded, as their sense of burden was expected to differ. Children who require medical care are often discharged from the hospital after about 6 months to a year, and in a survey of children who had been receiving home care for less than a year and a half, the majority of the children were aged between 1 and 3 years [10]. Based on this, we decided that the lower age limit of the children should be 3 years, as this is the age at which they would be familiar with childcare and home care. We also decided that the upper age limit of the children should be 12 years, as this is the age at which they would be in elementary school, based on their physical size and the school system.

Recruitment

The study was conducted in Fukuoka Prefecture, Japan, a region with a population of 5 million, including an area with 1 million residents. The target population was children requiring medical care and their families who are supported by pediatric home care through home-visit nursing stations and clinics. The study content was elucidated to these facilities, which were then asked to select eligible mothers and distribute the questionnaires. The questionnaires were anonymous and self-administered, with respondents instructed to return them by mail. The survey period was from April to September 2016.

Survey Items

This study was based on research into the factors that increase the burden of caring for a child [7], research into the factors that reduce QOL [8], and research into the factors that improve QOL [9]. The research framework was set up and the survey was conducted by focusing on the mother's situation, including the sense of burden of child-rearing, and the child's situation, including medical care, as factors related to the mother's QOL.

The survey included the following: the child's situation (age, disease, required medical care, daily life support, possession of a disability certificate, daycare or school attendance at nursery or regular school, and duration of home care) and the mother's situation (age group, marital status, presence of cohabiting grandparents, presence of siblings of the child requiring medical care, occupation, household income, education level, and time spent caring for the child requiring medical care).

QOL was assessed using the Japanese version of the World Health Organization Quality of Life-26 (WHOQOL-26) [11], which has been verified for reliability and validity. The WHOQOL-26 defines QOL as "an individual's perception of their position in life in the context of the culture and value

systems in which they live and in relation to their goals, expectations, standards, and concerns." While there are various scales with high reliability and validity for measuring QOL, this study adopted the concept of QOL, defined by the World Health Organization (WHO) as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." Therefore, the WHOQOL-26 was used, aligning with this interpretation. The WHOQOL-26 consists of 26 items, including 24 items across 4 domains (physical, psychological, social relationships, and environment) and 2 items that ask about the overall QOL. It seeks subjective judgments from the respondents. The physical domain includes activities of daily living, dependence on medication and medical aids, energy and fatigue, mobility, pain and discomfort, sleep and rest, as well as work capacity. The psychological domain includes body image, negative feelings, positive feelings, self-esteem, spirituality, religion, personal beliefs, thinking, learning, memory, and concentration. Social relationships include personal relationships, social support, and sexual activity. The environmental domain encompasses financial resources, freedom, physical safety and security, accessibility, quality of health and social care, home environment, opportunities to acquire new information and skills, participation in and opportunities for recreation and leisure activities, living environment, as well as means of transport. The respondents were asked to reflect on their circumstances over the past 2 weeks. Responses are given on a 5-point Likert scale ranging from 1 (not at all) to 5 (very much). Higher scores indicated a higher QOL. Cronbach α for the WHOQOL-26 ranged from 0.66 to 0.84.

Statistical Analysis

Participant and child attributes, children's medical care, and WHOQOL-26 scale scores were analyzed using the Mann-Whitney *U* test. The correlation between the caregiving burden scale and WHOQOL-26 was analyzed using Spearman rank correlation analysis. A multiple regression analysis was conducted for items exhibiting significant differences. The multiple regression analysis confirmed no multicollinearity between the independent variables, with no variables having a variance inflation factor exceeding 5. The statistical software used for these analyses was JMP Pro 15 (JMP Statistical Discovery LLC).

Ethical Considerations

This study was conducted with the approval of the Clinical Research Ethics Review Committee of the Regional Department of Medical Care, to which the author was affiliated (2019-191). Participation in the questionnaire survey was voluntary and anonymous, and consent was obtained through the completion and return of the questionnaire.

Results

Participant Attributes

Table 1 shows the characteristics of the participants. Questionnaires were distributed to mothers providing home care to children requiring medical care. Responses from those not providing medical care (including bedridden care) or from grandparents were excluded, resulting in 46 mothers being included in the analysis. The average age of the 46 children was 5.8 (SD 2.3) years. Children's conditions varied widely, with epilepsy (n=19, 41%) and cerebral palsy (n=16, 35%) being the most common. In addition, 23 (50%) children had two or more conditions, indicating that numerous children had multiple medical issues. Regarding disability certificates, 45 (98%) children had an identification booklet for individuals with physical disabilities, which was issued when a person was judged to have a certain level of physical disability and enabled access to welfare services, such as medical expense subsidies, tax benefits, and discounts on public transportation. In addition, 34 (74%) children had an identification booklet for individuals with intellectual disabilities, which enables access to similar welfare services as the identification booklet for individuals with physical disabilities. Numerous children have obtained both certificates.

Table 1. Participant attributes (N=46).

Participant attributes	Value, n (%)
Mother's age group (years)	
20s	5 (11)
30s	23 (50)
40s	18 (39)
Marital status	
Married	42 (91)
Other	4 (9)
Siblings	
Yes	37 (80)
No	9 (20)
Cohabiting grandparents	
Yes	9 (20)
No	37 (80)
Occupational status	
Yes	11 (24)
No	35 (76)
Household income (JP ¥10,000[a])	
≤400	15 (33)
400 or more	29 (63)
Missing data	2 (4)
Child's age (years)	
3-5	22 (48)
6-9	23 (50)
Missing data	1 (2)
Daycare or school attendance	
Yes	35 (76)
No	10 (22)
Missing data	1 (2)
Home medical care period (years)	
<5	19 (41)
5 or more	25 (54)
Missing data	2 (4)
Hospitalization	
Yes	27 (59)
No	19 (41)

[a]US $1=JP ¥105 on average from April to September 2016.

Characteristics of QOL

Attributes of Mothers and Children and Their QOL

Table 2 shows the attributes of research participants and children, and WHOQOL-26 scores. Analysis of the attributes of mothers and children and their QOL revealed significant disparities in QOL scores based on certain attributes. Significant disparities were observed between marital status and social relationships QOL (*P*=.03); between children's age and physical QOL (*P*=.007); between daycare or school attendance and WHOQOL-26 score (*P*=.03) and environmental QOL (*P*=.04); between duration of home care and WHOQOL-26 score (*P*=.005), physical QOL (*P*=.007), and environmental QOL (*P*=.007); and between psychomotor developmental delay and

physical QOL (*P*=.04). The WHOQOL-26 scores were significantly higher for the group with daycare or school attendance (*P*=.03) and for those with a home care duration of 5 years or more (*P*=.005). Physical QOL was significantly higher in children aged 3-5 years (*P*=.007), those with a home care duration of less than 5 years (*P*=.007), and those with psychomotor developmental delay (*P*=.04). Environmental QOL was significantly higher in the group with daycare or school attendance (*P*=.04) and in those with a home care duration of less than 5 years (*P*=.007). Regarding the duration of home care, while the WHOQOL-26 scores were higher for those with a duration of 5 years or more (*P*=.005), the physical and environmental QOL scores were higher for those with a duration of less than 5 years (both *P*=.007).

Table 2. Attributes of research participants or children and WHOQOL-26[a] scores (Kruskal-Wallis test for mother's age group and Mann-Whitney *U* test for others).

Attributes	Participants (N=46), n (%)	WHOQOL-26 score	*P* value	Physical QOL[b]	*P* value	Psychological QOL	*P* value	Environmental QOL	*P* value	Social relationship QOL	*P* value	Overall QOL (2 items)	*P* value
Mother's age group (years)			.50		.21		.77		.47		.70		.54
20s	5 (11)	3.31		3.51		3.20		3.25		3.27		3.20	
30s	23 (50)	3.15		3.20		3.27		2.96		3.49		2.80	
40s	18 (39)	3.03		2.99		3.12		2.92		3.46		2.75	
Marital status			.89		.61		.54		.49		.03		.80
Married	42 (91)	3.12		3.14		3.22		2.96		3.50		2.82	
Other	4 (9)	3.11		3.29		3.04		3.09		3.00		2.88	
Siblings			.87		.90		.38		.11		>.99		.91
Yes	37 (80)	3.10		3.13		3.24		2.91		3.45		2.82	
No	9 (20)	3.20		3.23		3.08		3.25		3.48		2.83	
Cohabiting grandparents			.39		.75		.42		.45		.04		.53
Yes	9 (20)	2.99		3.10		3.06		2.82		3.22		2.72	
No	37 (80)	3.15		3.16		3.24		3.01		3.51		2.85	
Occupation			.28		.69		.40		.18		.83		.55
Yes	11 (24)	3.28		3.29		3.33		3.15		3.45		2.95	
No	35 (76)	3.07		3.11		3.16		2.92		3.46		2.79	
Household income (JP ¥10,000[c])			.71		.09		.42		.60		.27		.22
≤400	15 (34)	3.15		3.32		3.29		2.87		3.33		3.00	
400 or more	29 (66)	3.07		3.03		3.12		2.98		3.51		2.69	
Child's age (years)			.11		.007		.54		.31		.31		.22
3-5	22 (49)	3.23		3.36		3.29		3.04		3.53		2.93	
6-9	23 (51)	2.98		2.91		3.10		2.88		3.39		2.70	
Daycare or school attendance			.03		.22		.25		.04		.14		.54
Yes	35 (76)	3.17		3.18		3.25		3.06		3.50		2.86	
No	10 (22)	2.87		2.97		3.00		2.58		3.30		2.65	
Home medical care period (years)			.005		.007		.07		.007		.35		.10
<5	19 (41)	2.94		3.43		3.40		3.23		3.54		2.97	
5 or more	25 (54)	3.34		2.93		3.50		2.79		3.39		2.60	
Hospitalization			.14		.10		.15		.68		.13		.30
Yes	27 (59)	3.03		3.02		3.09		2.95		3.36		2.72	
No	19 (41)	3.24		3.33		3.36		3.02		3.60		2.97	
Psychomotor developmental delay			.06		.04		.15		.051		.41		.55
Yes	10 (22)	3.37		3.49		3.45		3.27		3.50		2.90	
No	36 (78)	3.05		3.06		3.14		2.89		3.44		2.81	
Multiple diseases			.40		.89		.59		.46		.79		.27
Yes	21 (46)	3.16		3.17		3.23		3.03		3.48		2.98	
No	25 (54)	3.09		3.13		3.19		2.93		3.44		2.70	

[a]WHOQOL-26: World Health Organization Quality of Life-26.

[b]QOL: quality of life.

[c]US $1=JP ¥105 on average from April to September 2016.

Medical Care for Child and Mother's QOL

Children's medical care and mothers' QOL are represented in Table 3. The Mann-Whitney *U* test was conducted to examine the relationship between the medical care situation of the children and the QOL of the mothers. Significant disparities were observed in the WHOQOL-26 scores, with the group not requiring position changes scoring higher than the group that did (*P*=.003). Among the various aspects of medical care, the presence or absence of positional changes exhibited the most significant disparities in QOL (from *P*=.02 to *P*=.003).

Table 3. Medical care for child and mother's QOL[a] (Mann-Whitney *U* test).

Medical care	Participants (N=46), n (%)	WHO-QOL-26[b]	*P* value	Physical QOL	*P* value	Psychological QOL	*P* value	Environmental QOL	*P* value	Social relationship QOL	*P* value	Overall QOL (2 items)	*P* value
Ventilator use			.80		.31		.39		.87		.47		.41
Yes	8 (17)	3.14		3.00		3.36		2.96		3.58		3.06	
No	36 (78)	3.11		3.16		3.18		2.99		3.42		2.76	
Tracheotomy site care			.87		.60		.28		.82		.09		.94
Yes	14 (30)	3.17		3.07		3.37		3.02		3.64		2.82	
No	30 (65)	3.09		3.16		3.14		2.97		3.36		2.82	
Oxygen inhalation			.28		.21		.28		.35		.86		.16
Yes	15 (33)	2.99		2.95		3.05		2.91		3.47		2.60	
No	30 (65)	3.18		3.23		3.28		3.02		3.44		2.93	
Inhalation			.08		.002		.22		.36		.67		.06
Yes	31 (67)	3.03		2.95		3.14		2.93		3.48		2.68	
No	13 (28)	3.32		3.55		3.39		3.11		3.36		3.15	
Aspiration			.58		.22		.45		.67		.57		.51
Yes	31 (67)	3.08		3.08		3.15		2.96		3.48		2.79	
No	14 (30)	3.20		3.28		3.30		3.05		3.38		2.89	
Position change			.003		.003		.03		.02		.07		.19
Yes	23 (50)	2.92		2.88		3.02		2.81		3.30		2.65	
No	21 (46)	3.34		3.46		3.47		3.16		3.62		2.98	
Care for gastrostomy or enterostomy			.81		.12		.77		.89		.42		.97
Yes	14 (30)	3.09		2.94		3.25		3.02		3.55		2.79	
No	28 (61)	3.14		3.24		3.22		2.98		3.39		2.80	
Feeding tube			.08		.004		.40		.24		.71		.78
Yes	29 (63)	3.02		2.94		3.14		2.92		3.43		2.79	
No	14 (30)	3.31		3.53		3.34		3.14		3.48		2.80	

[a]QOL: quality of life.

[b]WHOQOL-26: World Health Organization Quality of Life-26.

Factors that Affect WHOQOL-26 scores

Table 4 shows the predictors of QOL in mothers of children with medical care.

Table 4. Predictors of QOL[a] in mothers of children with medical care[b].

Variable	β	*t*	*P* value
Presence or absence of daycare or school attendance	.274	2.13	.04
Home medical care period (2 groups)	.305	2.33	.02
Presence or absence of position change	–.410	–3.16	.003

[a]QOL: quality of life.

[b]F=7.79 (P<.001); adjusted R^2=.327.

The significant factors influencing the WHOQOL-26 scores were examined based on the scores, attributes of the mothers and children, and the presence or absence of medical care, considering previous research findings. Three independent variables—daycare or school attendance, 2 groups of home care periods, and the presence or absence of position changes—were entered into the multiple regression analysis, with the WHOQOL-26 scores as the dependent variable. The variance inflation factor values of the independent variables were all below 5, indicating no multicollinearity. The presence or absence of daycare or school attendance (P=.04), home care periods (P=.02), and the presence or absence of position changes (P=.003) all had a significant impact on WHOQOL-26 scores. Position changes, home care periods, and the presence or absence of daycare or school attendance influenced the WHOQOL-26 scores, with position changes having the greatest impact.

Discussion

Principal Findings

In this study, we used the WHOQOL-26 scale to examine the QOL of mothers caring for children who require medical care at home. Standard data for the WHOQOL-26 scale were obtained from random population samples [11]. Compared with these standard data, the WHOQOL-26 scores of mothers caring for children requiring medical care at home were lower than those of the general population.

Factors Related to the QOL of Mothers of Children Requiring Medical Care at Home

Multiple regression analysis identified factors influencing the WHOQOL-26 scores, including the presence or absence of daycare or school attendance, duration of home care, and presence or absence of position changes. The following section examines these factors.

Daycare or School Attendance

The WHOQOL-26 scores were significantly higher in the group with daycare or school attendance. Daycare or school attendance provides not only connections between the family and health care providers but also social connections with families of similar children and educators. These factors are believed to contribute to improvements in maternal QOL.

Matsuzawa et al [12] cited a “Lack of opportunities to seek advice or obtain information” as one of the challenges experienced by parents of children requiring medical care. They reported limited interactions with other family members and insufficient opportunities for consultation with their children. Daycare or school attendance contributes to obtaining opportunities for advice and information, as well as alleviating challenges through interactions with other families. It is, therefore, considered a significant contributing factor to enhancing maternal QOL.

Furthermore, through daycare or school attendance, children can receive appropriate therapy and education to promote their growth and development. In addition, there have been reports [13] of children wishing to experience as many external activities as possible while staying healthy, indicating the importance of parents in promoting their children’s growth and development through experiences outside the home. Daycare or school attendance encourages children’s growth and development, resulting in mothers feeling satisfied with their children’s growth and development, thus enhancing their parenting satisfaction. Furthermore, through daycare or school attendance, parents may receive advice from experts on signs of growth that are not easily noticed under normal circumstances, leading to joy for parents and contributing to the enhancement of maternal QOL.

Duration of Home Care

With regards to the duration of home care, significantly higher WHOQOL-26 scores were obtained in the group with a duration of 5 years or more. It is possible that through continued long-term home care, there is stabilization of the child’s health condition as a result of improvement in the child’s growth and the family’s management abilities. In their study on factors influencing the empowerment of mothers of children with disabilities during home care, Noguchi and Ohmachi [14] reported that a longer duration from diagnosis was significantly associated with higher levels of maternal empowerment. In this study, it is considered that the duration of home care, which correlates with the length of time from diagnosis, is related to a high level of maternal empowerment, resulting in significantly higher WHOQOL-26 scores in the group with a duration of 5 years or more of home care. Baker and Claridge [15] stated that numerous mothers found the transition period post their child’s diagnosis to be very difficult and stressful. However, most families were able to establish new daily routines and felt that they could manage their children’s illness. Therefore, it is believed that creating a life together as a family with a child receiving medical care may lead to stabilization in life. These findings suggest that patients with longer periods of home care may ultimately experience improvements in their QOL.

However, it should be noted that this study targeted young mothers ranging from 20 to 40 years of age, while the children’s ages were aged 12 years and younger. Considering the

possibility of a lighter body weight during growth and development, mothers might not perceive home care as a significant burden. Research on the duration of home care is limited, and further studies on these factors are needed.

Position Changes

In the context of caring for children examined in this study, a significant association was found between the necessity of positional changes and the QOL of mothers. This association was substantial and treated with the same importance as other medical care items in the study.

Matsui and Takada [16] reported that managing artificial ventilation, aspiration, and injections for children with severe disability during the night increased mothers' caregiving burden. However, they did not find significant disparities in assistance with excretion or position changes, suggesting that these tasks were perceived as extensions of child-rearing. In this study, position changes exhibited a significant association with mothers' QOL, likely because, unlike typical child-rearing tasks that diminish as children grow, the need for positional care persists. In addition, as children's bodies change, meticulous care for contractures, fractures, and pressure ulcers becomes necessary, adding a substantial burden and impacting maternal QOL.

Kaya et al [17] reported a higher prevalence of musculoskeletal disorders among caregivers of children with cerebral palsy compared to those of healthy children. Although this study did not identify specific contributing factors, it is conceivable that conditions like lower back pain in mothers would exacerbate their burden, significantly affecting their QOL. Other research [18] highlighted the cumulative fatigue characteristics among mothers raising children with disabilities who require home medical care. These mothers experienced higher levels of cumulative fatigue than the general female population, with no seasonal or temporal variations, and many consistently reported higher average values throughout the year than the average complaint rate among the general female population. Therefore, comprehending caregivers' medical history and fatigue status is crucial, and there is a need for more research on interventions to improve caregivers' physical functioning in the future [19].

While other studies have investigated items related to medical care, little focus has been given to positional changes. Compared with the use of ventilators or oxygen inhalation, the significant impact on QOL may be less apparent. However, position changes require care approximately every 2 hours, including during the night, leading to significant time constraints and the inability to secure adequate sleep. Consequently, positional changes have a substantial impact on QOL. It is essential to consider this when discussing necessary support for the child and family, and such discussions should be conducted collaboratively with the family.

Support Toward Improving the QOL of Mothers of Children Requiring Medical Care at Home

The findings of this study show that the QOL of mothers caring for children requiring medical care at home is related to whether the child attends school or daycare, the duration of home care, and the necessity for positional changes. In addition, it was associated with a sense of caregiving burden. Caregivers must comprehend these factors as related elements and focus on collecting relevant information to consider the necessary support. However, previous studies have reported that services are still insufficient in this regard [6,13].

In 2021, a law was enacted to support children requiring medical care and their families [20]. This law explicitly identifies children requiring medical care as a legal category that enables structured support. Measures, such as the placement of nurses in daycare centers and schools to accommodate these children, as well as subsidy systems, have been established, which are expected to enhance the caregiving environment for children and reduce the caregiving burden on families. Similar to Japan, Caicedo [21] noted that the transition to home care is progressing in the United States, and support systems are needed. The study reported that among 3 groups—home care only, home care with the use of daycare, and institutional care—the home care–only group faced significant threats to physical and mental health [21], underscoring the substantial burden of home care alone. This finding aligns with trends in South Korea and Japan; mothers typically bear the sole responsibility for caring for children with disabilities [22], reflecting a global recognition of the substantial burden on these mothers and the need for robust support systems. Sharing and adapting support strategies across countries is crucial to provide effective assistance to mothers in each nation. Suzuki et al [23] reported that care coordination by nurses could alleviate the burden on parents resulting from home medical care for children who require medical devices. Using various support systems and having nurses assume care coordination roles are anticipated to further reduce the burden on parents, improving their QOL and overall well-being.

Regarding the QOL of mothers based on the condition of their children, a study on the QOL of mothers with children with attention-deficit/hyperactivity disorder [24] reported that the mother's QOL was not associated with the child's inattentiveness or hyperactivity symptoms as evaluated by the mother but with factors related to the mother and family, including the mother's own inattentiveness, hyperactivity, depressive symptoms, perceived family support, and living conditions. Similarly, this study found that the presence of multiple medical conditions in children requiring medical care, intellectual developmental delays, and the need for severe care such as mechanical ventilation or oxygen therapy did not significantly correlate with the mother's QOL. This aligns with previous research, suggesting that the child's symptoms are not necessarily the most significant factors affecting the mother's QOL, which caregivers must comprehend. However, previous research has indicated that the more severe a child's functional limitations, the more likely the mother is to experience depression [25]. It has been reported that parents who care for children with tracheostomies at home have low QOL scores and show moderate levels of distress [26]. This suggests that a child's condition can have a significant impact on the mother and that it is crucial to recognize the complexity of assessing a mother's QOL based solely on the child's condition. In order to provide high-quality care coordination for the family with children with a medical complexity, care coordinators need to

pay attention to the evaluation and care planning of the entire family, especially the mother, who is the main caregiver in Japan [27]. Few countries take into account the opinions of families when formulating policies and national frameworks for providing care for children who use long-term ventilators [28]. It is important to properly assess the QOL of mothers, support them while taking into account the opinions of their families, and consider support for the whole country.

Limitations

One of the limitations of this study was the small sample size, which limited the statistical power of the analysis.

Second, the adjusted R^2 value of the multiple regression analysis was 0.327, indicating that the related factors did not fully elucidate the variance in the results, suggesting that other factors should be explored.

To address the disadvantages of a prior fragmented administration across different ministries, the Children and Families Agency was established in 2023, focusing on supporting children and their families. Given that this study was conducted before the law was enacted, it can serve as a reference for future comparative studies.

Conclusions

Factors related to the QOL of these mothers included the presence of daycare or school attendance (β=.274), the length of home care (β=.305), and the need for postural changes (β=.41). The need for postural changes was found to have the most significant effect.

Acknowledgments

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Conflicts of Interest

None declared.

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Abbreviations

QOL: quality of life
WHO: World Health Organization
WHOQOL-26: World Health Organization Quality of Life-26

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Original Paper

A Random Forest Algorithm for Assessing Risk Factors Associated With Chronic Kidney Disease: Observational Study

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Abstract

Background: The prevalence and mortality rate of chronic kidney disease (CKD) are increasing year by year, and it has become a global public health issue. The economic burden caused by CKD is increasing at a rate of 1% per year. CKD is highly prevalent and its treatment cost is high but unfortunately remains unknown. Therefore, early detection and intervention are vital means to mitigate the treatment burden on patients and decrease disease progression.

Objective: In this study, we investigated the advantages of using the random forest (RF) algorithm for assessing risk factors associated with CKD.

Methods: We included 40,686 people with complete screening records who underwent screening between January 1, 2015, and December 22, 2020, in Jing'an District, Shanghai, China. We grouped the participants into those with and those without CKD by staging based on the glomerular filtration rate staging and grouping based on albuminuria. Using a logistic regression model, we determined the relationship between CKD and risk factors. The RF machine learning algorithm was used to score the predictive variables and rank them based on their importance to construct a prediction model.

Results: The logistic regression model revealed that gender, older age, obesity, abnormal index estimated glomerular filtration rate, retirement status, and participation in urban employee medical insurance were significantly associated with the risk of CKD. On RF algorithm–based screening, the top 4 factors influencing CKD were age, albuminuria, working status, and urinary albumin-creatinine ratio. The RF model predicted an area under the receiver operating characteristic curve of 93.15%.

Conclusions: Our findings reveal that the RF algorithm has significant predictive value for assessing risk factors associated with CKD and allows the screening of individuals with risk factors. This has crucial implications for early intervention and prevention of CKD.

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KEYWORDS

chronic kidney disease; random forest model; risk factors; assessment

Introduction

Chronic kidney disease (CKD) is characterized by chronic structural and functional impairment of the kidney of >3 months, caused by various factors. CKD is diagnosed based on the presence of pathological injury for more than 3 months, abnormal glomerular filtration rate (GFR), abnormal blood or urine composition, abnormal imaging findings, or an index estimated GFR (eGFR) of <60 mL/minute/1.73 m^2 [1]. CKD is a major global health concern. Between 1990 and 2015, the

annual mortality rate attributed to CKD increased at an average rate of 3.4% per year, and the global prevalence rate of CKD increased to 14.3% [2]. The economic burden due to CKD accounts for 31.4% of the global annual burden of living with disability [3-6]. In China, the prevalence of CKD among patients aged 18 years and older is 10.8%, encompassing approximately 120 million patients, indicating that approximately 1 in 10 Chinese individuals have had CKD [1]. Nevertheless, the awareness rate of CKD is low, and only 12.5% of patients know about their illness. CKD is highly prevalent and its treatment cost is high but unfortunately remains unknown. Therefore, early detection and intervention can mitigate the treatment burden on patients and decrease disease progression.

In recent years, risk factors including hypertension, diabetes, and obesity, which are associated with CKD, have gradually shown a trend toward affecting the younger population [7]. CKD is closely linked with an increased risk of all-cause mortality, cardiovascular disease (CVD), renal failure, and other adverse health outcomes, causing a serious disease burden [8-10]. CKD is a major health concern due to its high prevalence, low awareness rate, high treatment cost, increased risk of combined cardiovascular events, and early mortality. Early intervention, treatment, and controlling the risk factors of CKD can decelerate and decrease disease progression and consequently reduce overall morbidity and mortality. Hence, diagnosis and risk factor assessment for patients with early-stage CKD are of immense significance.

With continuous advancements in artificial intelligence technology, many researchers have attempted to use machine learning models in the medical field. Many studies have reported that machine learning algorithms can improve the decision-making abilities of clinicians in different fields, including clinical prediction. A study published in *The Lancet* [11] developed a feasible and effective machine learning–based risk stratification model for predicting adverse events post hospital discharge in patients with acute coronary syndromes. The random forest (RF) algorithm was first proposed by Leo Breiman and Adele Cutler in the early 21st century [12]. In the last few years, the use of the RF algorithm for disease risk prediction has garnered increasing attention due to its high accuracy. Furthermore, some researchers have used econometric models based on logistic regression (LR) and RF to predict the risk of acute ovarian failure [13]. Additionally, Let et al [14] constructed an RF model to improve the early detection and prediction of the incidence of venous thromboembolism in patients with lung cancer.

Some researchers have explored the application of machine learning algorithms in disease prediction, compared them with traditional statistical regression models, and reported the differences in the performance of various prediction models. While comparing conventional LR models with the RF algorithm, many studies reported that the RF algorithm is more advantageous than the LR model. A previous study investigated the predictability of the RF algorithm, the LR model, and deep neural network models and found that machine learning models, particularly deep neural network models, can improve the long-term prognosis prediction of patients with ischemic stroke [15]. Another study constructed an interpretable RF model to predict severe acute pancreatitis and found that the RF model showed better precision and diagnostic accuracy than the LR and Bedside Index Of Severity In Acute Pancreatitis models [16]. Some researchers used 5 machine learning algorithms separately to predict the malnutrition status of 5-year-old children in Bangladesh and found that the accuracy of the RF algorithm was 68.51%, which was greater than that of other algorithms [17]. Another study reported that the RF algorithm is a better predictive model for older patients with hip fractures and high-risk mortality within 1 year after surgery [18].

A longitudinal study involving 143,043 patients with hypertension was performed to predict long-term CVD risk. The study reported that advanced machine learning algorithms using RF performed better than traditional LR [19]. A longitudinal cohort study compared clinical risk predictions among patients with CVD using 19 prediction techniques. The study also reported that excluding LR and commonly used machine learning algorithms from long-term risk prediction models underestimated the disease risk [20].

Researchers have also investigated the advantages of using RF models in predicting kidney diseases. A previous study reported the performance of 4 prediction tools, namely deep learning, plain Bayesian, RF, and LR, for predicting all-cause mortality in patients with CKD. The study showed that Bayesian networks and LR showed superior prediction abilities [21]. However, another study reported that plain Bayesian, RF, and LR performed adequately well and showed high sensitivity for screening end-stage renal disease in patients with CKD, which is inconsistent with previous reports [22]. Another previous study constructed 3 algorithms, namely RF, plain Bayesian, and LR, to classify glomerular and tubular injury and found that RF showed the best performance in terms of accuracy, sensitivity, and specificity. These findings suggest that RF can facilitate early diagnosis of glomerular and tubular injury to mitigate CKD progression [23]. Therefore, previous studies on the viability of RF models have reported inconsistent conclusions due to differences in research perspectives and subjects.

Methods

Data Source

The data for this study were collected from the CKD screening population in Jing'an District from January 1, 2015, to December 22, 2020. Information obtained included demographic and sociological characteristics, height, weight, diastolic and systolic blood pressure, health insurance type, screening date, urinary protein and urinary albumin-creatinine ratio (UACR), blood creatinine, eGFR, and screening results. In total, 103,960 records were initially screened and CKD diagnoses were categorized based on *ICD-10* (*International Statistical Classification of Diseases, Tenth Revision*) criteria. Records with incomplete or duplicate data were excluded, resulting in a final sample size of 40,686 cases for analysis. These data are considered credible and authentic.

Definition of Grouping

The participants were categorized based on dichotomous variables: 1 for the nonmanagement population (indicating the

absence of CKD) and 2 for the management population (indicating the presence of CKD).

Covariance

We used the 11 factors identified in the univariate analysis as explanatory variables for the LR model. The grouping and assignment of the dependent and independent variables are listed in Table 1.

Table 1. Grouping and assignment of dependent and independent variables.

Name	Variable	Value assignment
CKD[a] screening	Y	1. Nonmanagement population; 2. Management population
Gender	x_1	1. Male; 2. Female
Age	x_2	1. <65 years; 2. 65-75 years; 3. ≥75 years
BMI	x_3	1. Normal: 18.5-24; 2. Underweight: <18.5; 3. Overweight: 24-28; 4. Obesity: ≥28
History of hypertension	x_4	1. No; 2. Yes
Index blood creatinine	x_5	1. Normal; 2. Abnormal
Index eGFR[b]	x_6	1. No; 2. Yes
Index urinary protein	x_7	1. Negative; 2. Positive
Albuminuria	x_8	1. No; 2. Yes
Urine albumin-creatinine ratio	x_9	1. <30; 2. 30-300; 3. ≥300
Working status	x_{10}	1. Retired staff; 2. Unemployed person; 3. Others[c]
Type of medical insurance	x_{11}	1. Urban employee medical insurance; 2. Urban resident medical insurance; 3. Others[d]

[a]CKD: chronic kidney disease.

[b]eGFR: estimated glomerular filtration rate.

[c]Others include students, freelancers, and workers.

[d]Others include the poverty relief system, out-of-pocket insurance, new rural cooperative medical system (NRCMS), commercial medical insurance, and free medical service. The same as below.

Statistical Model

A database was established using Excel (Microsoft Corp) 2010, and SAS (version 9.4; SAS Institute Inc) statistical software was used for data analysis. The chi-square test was performed for 1-way analysis to select variables for inclusion in the model, with the threshold for statistical significance set at $P<.05$. Based on the GFR stage, albuminuria (Alb) grouping, and the distribution of data, the study categorized participants for CKD screening into management (suspected and diagnosed patients) and nonmanagement (healthy individuals) populations. The resulting dichotomous LR model was then used for subsequent analysis.

The RF Algorithm

RF is a classification algorithm that uses multiple decision trees to train and predict samples. Specifically, the algorithm samples the training data set N times with replacement and selects a random subset of training samples each time. The remaining undrawn samples are subsequently used to evaluate the prediction error of the model.

Training Validation Split

The data set of 40,686 participants was randomly split into the following 2 subsets using simple random sampling in Python 3.6: one for validation sample set A including 13,549 cases (or 33.3% of the total data set), and the other for then training sample set B including 27,139 cases (or 66.7% of the total data set). The first subset A constituted the external validation sample set with 3000 cases (accounting for 7.4% of the total data set). The RF algorithm was subsequently applied to the training sample set to evaluate the importance of each variable and construct a CKD risk factor model. This model was used to predict the test sample set, with a minimum prediction accuracy threshold of 70%.

Parameters

The mean number of feature selections was used for each random tree (mtry) in the model.

For a set with predictors, a typical number is the rounded square root of mtry [12]. Only 11 features were used in this study. We did not use the square root method to calculate mtry. However, we randomly selected a certain number of features each time

and fixed ntree to adjust mtry to determine the values that minimized generalization errors as the optimal value of mtry.

The mean number of random trees was used in the RF algorithm (ntree) in the model. (1) Using bootstrap resampling, 20% of the B set was randomly split and was used as an internal validation set and 80% was used as the training set. (2) Assuming that the number of the decision tree was ntree, for each node, mtry features were randomly selected. These mtry features were used to divide the sample set, and the index Gini was used to determine the best partitioning method. (3) For determining the mean error of the test set, steps (1), (2), and (3) were repeated. With each iteration of step (2), the ntree was increased by 1. ntree gradually increased from 1 to 200. We obtained the set for average generalization error, and observed the variation in the average generalization error with ntree. When the optimal model was achieved, we obtained the number of ntrees.

Variable Importance

After establishing the RF model, it was used for prediction. Given the abundance of trees in the forest, determining which variables have the most significant impact on predictions can be challenging. Fortunately, an important method was used to assess the significance of variables in the model. Specifically, for each variable, in each decision tree of an RF, the decrease in the splitting criterion function (residual squared or Gini index) caused by that variable was measured. The decrease in magnitude for each decision tree was then averaged to determine the importance of the variable. The importance of each feature variable was ranked and plotted in order, resulting in a variable importance plot.

Ethical Considerations

The Institutional Review Committee Board at Shanghai Changzheng Hospital affiliated with the Naval Medical University approved this study with written consent (No.2016SL020). This observational study analyzed existing data sources, which did not contain any patient-identifiable information. This study did not involve the collection, use, or transmission of individually identifiable data.

Results

LR Model With 2 Classifications

Results of Single Factor Analysis

An LR model with 2 classifications (CKD and non-CKD) was used for analysis. As shown in Table 2, the results of the univariate analysis indicate a statistically significant distribution of differences in CKD status in the investigated population across 11 variables: gender, age, BMI, history of hypertension, index blood creatinine, index eGFR, index urinary protein, Alb, UACR, working status, and type of health insurance (P<.05).

Table 2. Distribution and comparison of baseline characteristics among patients diagnosed with CKD[a].

Variable name	Total participants, n	Management population, n (%)	Chi-square (*df*)	*P* value
Gender			47.43 (1)	<.001
Male	17,205	16,052 (93.30)		
Female	23,481	21,473 (91.45)		
Age (years)			7811.50 (2)	<.001
<65	9638	6864 (71.22)		
65-75	20,156	19,783 (98.15)		
≥75	10,892	10,878 (99.87)		
BMI (kg/m^2)			220.31 (3)	<.001
Normal (18.5-24)	19,444	17,545 (90.23)		
Underweight (<18.5)	1021	936 (91.67)		
Overweight (24-28)	15,387	14,457 (93.96)		
Obesity (≥28)	4834	4587 (94.89)		
History of hypertension			8.62 (1)	.003
No	37,513	34,556 (92.12)		
Yes	3173	2969 (93.57)		
Index blood creatinine			62.35 (1)	<.001
Normal	39,959	36,798 (92.09)		
Abnormal	727	727 (100)		
Index eGFR[b]			1164.79 (1)	<.001
Normal	16,817	14,603 (86.83)		
Abnormal	23,869	22,922 (96.03)		
Urine protein indicators			387.10 (1)	<.001
Negative	36,557	33,396 (91.35)		
Positive	4129	4129 (100)		
Albuminuria			519.68 (1)	<.001
No	35,329	32,168 (91.05)		
Yes	5357	5357 (100)		
Urinary albumin-creatinine ratio			580.49 (2)	<.001
<30	34,793	31,632 (90.91)		
30-300	5207	5207 (100)		
≥300	686	686 (100)		
Working status			1471.67 (2)	<.001
Retired staff	37,406	35,062 (93.73)		
Unemployed person	204	142 (69.61)		
Others	3076	2321 (75.46)		
Type of medical insurance			111.97 (2)	<.001
Urban worker	22,909	21,405 (93.43)		
Urban resident	16,626	15,055 (90.55)		
Others	1151	1065 (92.53)		

[a]CKD: chronic kidney disease.

[b]eGFR: estimated glomerular filtration rate.

Multivariate Analysis

On univariate analysis, variables with statistically significant differences were subjected to multivariate analysis as explanatory variables in binary LR to establish a regression model. The variables were screened using the input method with a significance level of α=.05. The results of the multivariate analysis are presented in Table 3. The risk of CKD was lower in women than in men (odds ratio [OR] 0.909, 95% CI 0.829-0.997). Furthermore, the risk of CKD gradually increased with an increase in age, with people aged 75 years and older (OR 256.759, 95% CI 151.115-436.259) and those aged 65-75 years (OR 20.471, 95% CI 18.209-23.013) being at higher risk than those younger than 65 years. Moreover, individuals with a BMI above the normal range were at a higher risk of CKD. People with a BMI of ≥28 (OR 2.024, 95% CI 1.426-1.733) and those with a BMI of 24-28 (OR 1.572, 95% CI 1.426-1.733) were at a higher risk of CKD than those with a normal BMI. Similarly, people with an abnormal eGFR index were at a higher risk of CKD (OR 1.397, 95% CI 1.271-1.537) than those with a normal eGFR. Compared with other participants, retirees (OR 2.432, 95% CI 2.162-2.736) and people with medical insurance for urban employees (OR 1.769, 95% CI 1.319-2.372) were at higher risk of CKD.

Table 4 shows that in the test sample, a high proportion of records (98.9%) was accurately predicted. Specifically, the prediction model correctly identified all management population records, whereas only 6.4% of nonmanagement population records were accurately predicted.

Although dichotomous LR offers notable advantages including fast training, easy understanding, and high interpretability, its limitations should be acknowledged. First, its effectiveness may be hampered when managing imbalanced data sets, as observed in this study where indicators including urine routine proteins (PROs) exhibited excessive ORs because of the higher proportion of abnormal values within the management population. Second, similar to the accuracy rates of linear models, the accuracy rates of LR models may not be optimal because the latter can experience difficulty in fitting the true data distribution. Herein, imbalanced data sets in the regression model led to statistically insignificant urine test results. Thus, to overcome these limitations, we considered using a machine learning approach.

Table 3. Logistic regression analysis of factors affecting chronic kidney disease in people with different characteristics.

Variable name	β		Wald chi-square (*df*)	*P* value	Odds ratio (95% CI)
Female gender (reference: male)	–0.095	0.047	4.103 (1)	.04	0.909 (0.829-0.997)
Age (years; reference: ≤65 years)					
65-75	3.019	0.060	2555.045 (1)	<.001	20.471 (18.209-23.013)
≥75	5.548	0.270	420.803 (1)	<.001	256.759 (151.115-436.259)
BMI (kg/m^2; reference: normal [18.5-24 kg/m^2])					
Underweight (<18.5)	–0.286	0.148	3.737 (1)	.05	0.751 (0.562-1.004)
Overweight (24-28)	0.452	0.050	82.521 (1)	<.001	1.572 (1.426-1.733)
Obesity (≥28)	0.705	0.081	76.341 (1)	<.001	2.024 (1.728-2.370)
Having a history of hypertension (reference: no)	0.127	0.089	2.031 (1)	.15	1.135 (0.953-1.352)
Abnormal index blood creatinine (reference: normal index blood creatinine)	16.407	1054.200	0.000 (1)	.99	1.33×10^7 (0.000-0.000)
Abnormal index eGFR[a] (reference: normal index eGFR)	0.335	0.048	47.630 (1)	<.001	1.397 (1.271-1.537)
Positive urine protein indicators (reference: negative urine protein indicators)	15.990	436.534	0.001 (1)	.97	8.80×10^6 (0.000-0.000)
Having albuminuria (not having albuminuria)	17.360	403.317	0.002 (1)	.97	3.46×10^7 (0.000-0.000)
Urine albumin-creatinine ratio (reference: <30)					
30-300	17.435	440.654	0.002 (1)	.97	3.73×10^7 (0.000-0.000)
≥300	15.824	1063.960	<0.001 (1)	.99	7.45×10^6 (0.000)
Working status (reference: other)					
Retired staff	0.889	0.060	218.852 (1)	<.001	2.432 (2.162-2.736)
Unemployed person	–0.032	0.203	0.026 (1)	.87	0.968 (0.651-1.441)
Type of medical insurance (reference: other)					
Urban employee medical insurance	0.570	0.150	14.504 (1)	<.001	1.769 (1.319-2.372)
Urban resident medical insurance	–0.159	0.151	1.116 (1)	.29	0.853 (0.634-1.146)

[a]eGFR: estimated glomerular filtration rate.

Table 4. Classification of model predictions.

Real test	Prediction of chronic kidney disease status		Percentage of accurate predictions, %
	Nonmanagement population, n	Management population, n	
Chronic kidney disease			
Non-management target population	3	44	6.4
Management target population	0	3818	100.00
Total percentage			98.90

Machine Learning: RF Algorithm

Modeling

The data set was split into 66.7% of samples, which corresponded to 27,139 records, randomly selected without replacement. The control method was applied by fixing the ntree (number of means of random trees in the RF algorithm) constant and debugging the mtry (mean number of feature selections used for each random tree) parameter. In each iteration, a certain number of features were randomly selected, and the average generalization error value was computed for 11 trials. The change in the error rate of the model, with respect to mtry, is depicted in Figure 1. The error rate decreased significantly when the number of features changed from 1 to 2, followed by an increase close to the minimum value, which was achieved when mtry=4. Next, the mtry value was set to 4, and the ntree value was adjusted accordingly. In total, 200 random trials were conducted to gauge the average generalization error of the test set (Figure 2). The generalization error rate decreased rapidly from 1 to 10, decreased slowly from 10 to 25, and thereafter flattened and stabilized. Thus, the optimal model was identified when the ntree value was 166.

Figure 1. The effect of mtry on the error rate of random forest algorithm.

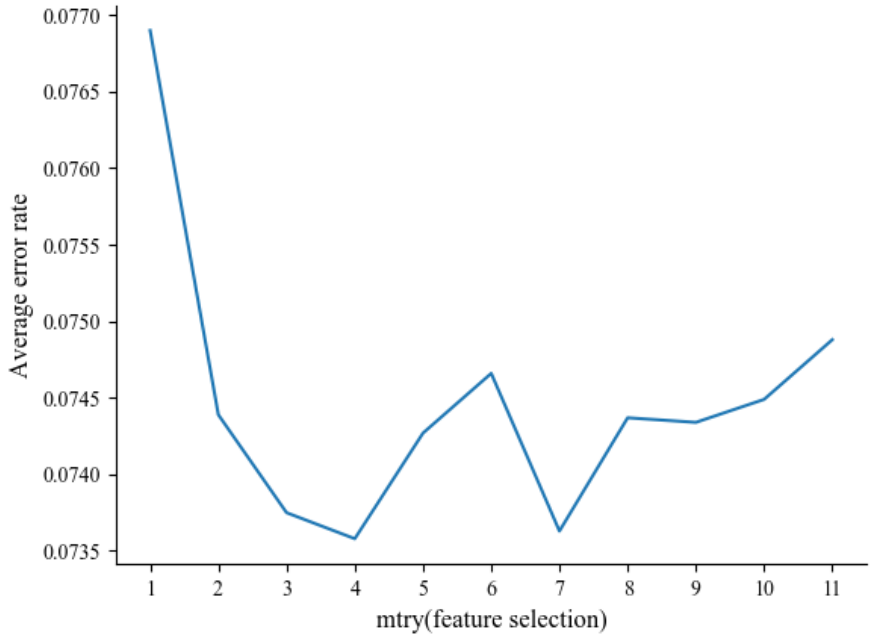
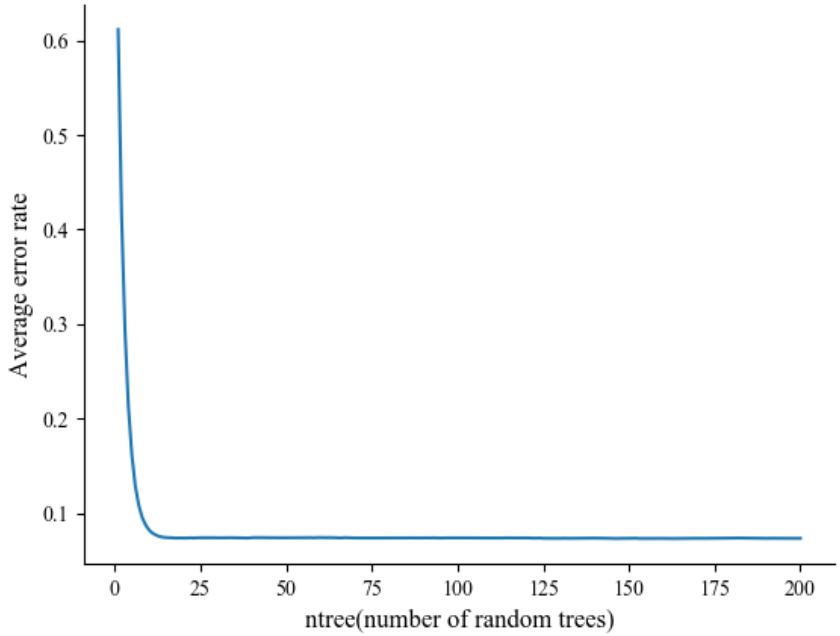


Figure 2. The effect of ntree on the error rate of the random forest (RF) algorithm.

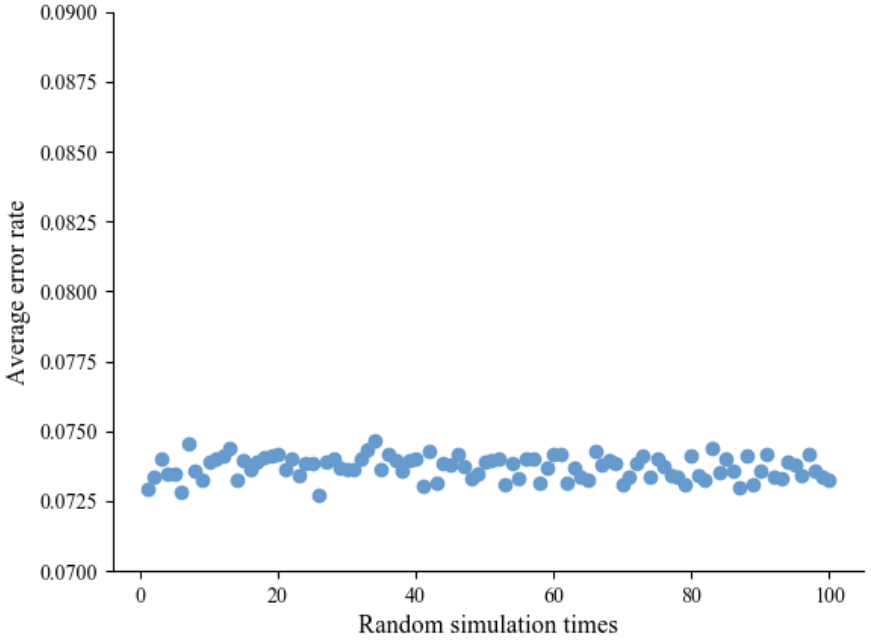


Analysis of the Results of the RF Algorithm

The RF algorithm was trained on a test data set comprising 27,139 records, with ntree=166 and mtry=4. Using these parameters, the algorithm was applied to classify the test set data, and the importance ranking of each feature was determined (Multimedia Appendix 1). The 4 most important features identified were age, Alb, working status, and UACR. These features were further selected for the prediction study, which yield a final classification accuracy rate of 92.67%.

Next, 100 random trials were conducted to ensure the reliability of our results. The generalization error plot is presented in Figure 3. The error was concentrated around 0.0735, with a small fluctuation and an average error of 7.371%. Our results indicate a good generalization ability of the model, suggesting its reliability in classification tasks.

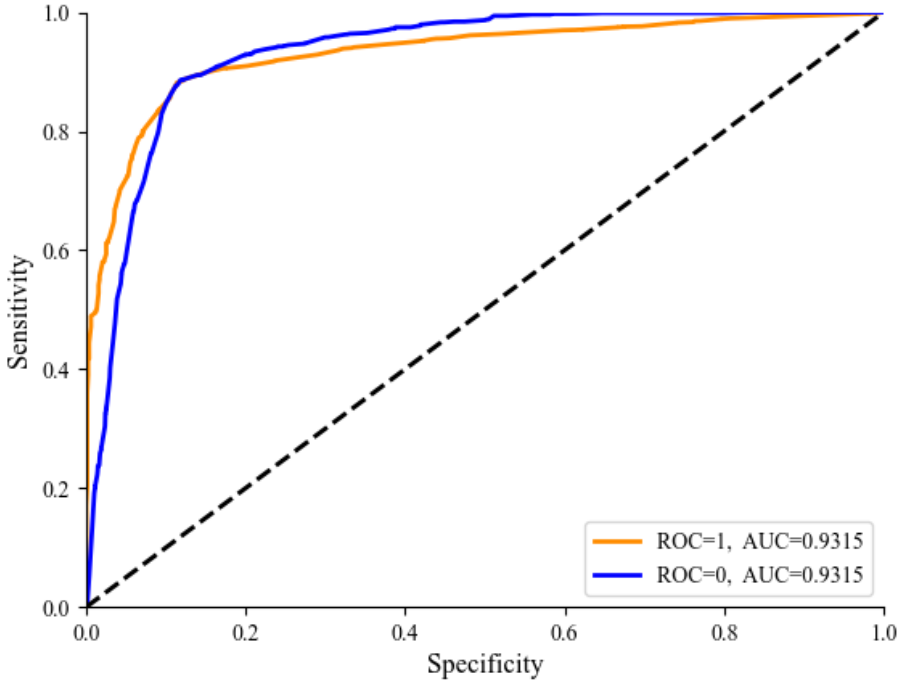
Figure 3. The generalization error rate of the random forest algorithm was estimated by conducting 100 randomized trials.



Comparison of the Sensitivity and Specificity of RF Models

The area under the receiver operating characteristic curve (AUC) of the RF model based on the training and test sets was 93.15% (Figure 4). The RF algorithm outputs voting results (0s and 1s), whereas the receiver operating characteristic curve requires voting probability data. Converting probabilities to voting results can lead to error because of extreme probabilities, such as 0.01515526 and 0.98484474. Therefore, we calculated the AUC to assess model performance and the classification prediction rate to indicate the accuracy of the model. Herein, the RF algorithm achieved an accuracy rate of 92.67%, with some degree of error. These results suggest that the model exhibited good predictive power and accurately classified new data samples.

Figure 4. Receiver operating characteristic (ROC) curve of chronic kidney disease prediction by the random forest algorithm. AUC: area under the receiver operating characteristic curve.



Confusion Matrix

Four possible predicted results were as follows: true positives, false positives, true negatives, and false negatives. Table 5 shows the confusion matrix of the RF model. The precision, recall, and F_1-score were 0.951, 0.984, and 0.967, respectively.

Table 5. Confusion matrix of the random forest algorithm model.

	Predicted values (=1)	Predicted values (=0)
Actual values (=1)	True positive: 12,505	False negative: 209
Actual values (=0)	False positive: 640	True negative: 195

Discussion

Principal Findings

A risk assessment model for CKD was developed in this study using dichotomous LR and RF models. Our results indicate that gender, older age, BMI beyond the normal range, abnormal index eGFR, retirement status, and urban employee medical insurance were significantly associated with a higher risk of CKD. By leveraging the RF model, the most important factors for CKD development were older age, abnormal urinary test results (eg, Alb, UACR, and index PRO indicators), and high BMI.

In China, the number of studies on the assessment of risk factors for CKD and the investigation of methods for risk prediction is increasing and LR analysis is commonly being performed. Feng et al [24] used an adjusted LR model to investigate CKD prevalence and related risk factors in 38 megacities across China. Liu et al [25] and Yang et al [26] performed cross-sectional studies to analyze risk factors for diabetic nephropathy in Shanghai, whereas a community-based, 7-year-long cohort study from Tianjin used LR to examine the association between the high triglyceride waist phenotype and risk of CKD development [27]. Yan et al [28] performed LR analysis to assess the correlation between residual cholesterol levels and CKD, and identify other significant risk factors affecting middle-aged and older individuals residing within a city. Gradual advancements in machine learning models have prompted further scrutiny of the divergent performance and inherent limitations of the conventional LR approach. To distinguish this study from previous studies that followed the LR approach for exploratory purposes, we used the RF algorithm to rank risk factors that were subjected to single-factor analysis according to their relevance and consequently evaluated comparative predictive precision by performing LR analysis using training samples. Our results reveal that both the RF and LR models achieved an overall accuracy rate exceeding 90% in the prediction test set. Conversely, the dichotomous LR model exhibited a marginally superior predictive performance than the RF model. Nevertheless, one should pay attention to the tendency of LR to result in excessive ORs when imbalanced data are used. Although LR exhibits excellent predictive abilities and desirable attributes such as high accuracy and stability, and ease of operation with a minimal possibility of overlearning during classification prediction, RF has the ability to assess the importance of variables when classifying data into suitable categories while compensating for errors in imbalanced sets of categorical data.

Our results indicate that age was the primary significant factor in the RF model, and LR analysis confirmed that higher age was significantly associated with CKD. Compared to participants aged ≤64 years, those aged 65-75 years and older were at a significantly higher risk of CKD, which is in line with previous results [29,30]. The risk of CKD increases with age; thus, early screening and risk prediction for CKD are crucial for middle-aged and older people.

A cross-sectional study published in *The Lancet* [31], using a nationally representative sample of Chinese adults also identified independent factors associated with kidney damage, which included age and gender. Age and gender are independent CKD risk factors [32]. Many studies worldwide have shown that women are at a higher risk of CKD [33,34], and similar observations have been reported in China [24,30]. This correlation may be attributed to differences in the prevalence of primary diseases and the availability of medical resources across genders [35]. However, our results show that females in the survey population were at a lower risk of CKD than were males, which is inconsistent with the majority of previous results. Our data include information regarding the registered population in a district of Shanghai. The exclusion of samples with incomplete information and regional differences, as well as the presence of unregistered patients, may have led to bias, ultimately yielding inconsistent results.

Next, this study shows that people with a higher-than-normal BMI were at a higher risk of CKD, similar to a time-series study that investigated risk factors regarding CKD burden in China from 1991 to 2011 and identified the correlation between high BMI and CKD [36]. Obesity is an important risk factor for CKD worldwide [24,25,37-39]. Potential obesity-associated factors that may lead to or aggravate CKD include hemodynamic disorder and renal tissue hypoxia [40,41]. However, weight loss through diet and regular exercise can reverse kidney damage; hence, maintaining a healthy lifestyle and controlling body weight could prevent or decelerate CKD progression to a certain extent [42]. Additionally, this study shows that CKD risk was higher in people who had urban employee medical insurance. These people were employed and had relatively better economic conditions; however, health risk factors such as work stress and unhealthy lifestyles probably contribute to an increased CKD risk [43].

Moreover, people with abnormal urine test results (Alb, UACR, and PRO indicators) were at a higher CKD risk, which is consistent with previous results reported worldwide [36,44,45]. Similarly, a Chinese study using 4 machine learning models, comprising 19,270 adult samples, showed that UACR, Alb, age, and gender were important CKD risk factors [44]. Urine tests can serve as an early warning system for CKD detection. Similarly, our risk prediction model could guide decision-making regarding early CKD screening.

Limitations

Herein, we effectively assessed the risk of CKD by combining internal data for model construction and testing. However, this study has some limitations. First, the generalization ability of the model remains unknown because the study did not include external data for external validation. Second, owing to the bias in data collection, our results were inconsistent with those of the previous studies. Finally, more prospective studies are required to verify the predictive power and practical utility of our model. Thus, health care professionals should routinely evaluate the level of agreement within and between models before reaching any clinical decision on the basis of the present limitations and previous findings [46].

Conclusions

In conclusion, the RF model has significant predictive value for assessing risk factors associated with CKD and is capable of correcting errors in imbalanced categorical data sets. It can be used to screen individuals with risk factors, which is of great significance for early intervention and prevention of CKD.

For the prevention and treatment of CKD, early intervention can involve a low-protein diet, regular physical examination, actively promoting urine examination, and screening of high-risk groups to achieve early detection, early treatment, early diagnosis, and early intervention of CKD, and to reduce the social and personal losses caused by diseases and improve people’s quality of life.

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Data Availability

The data sets used or analyzed in this study are available from the first author upon reasonable request.

Authors' Contributions

LX and CM obtained the funding. PL, YL, HL, LX, CM, and LY conceived and designed the experiments. PL, YL, HL, and LY performed the experiments, analyzed the data, and contributed reagents, materials, and analysis tools. PL drafted the manuscript. All authors participated in the discussion, revision, and approval of the final manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Importance ranking of each indicator in the random forest algorithm.
[PNG File , 16 KB - apinj_v8i1e48378_app1.png]

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Abbreviations

Alb: albuminuria
CKD: chronic kidney disease
CVD: cardiovascular disease
eGFR: estimated glomerular filtration rate
GFR: glomerular filtration rate
ICD-10: International Statistical Classification of Diseases, Tenth Revision
LR: logistic regression
OR: odds ratio
PRO: urine routine protein
RF: random forest
UACR: urinary albumin-creatinine ratio

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Original Paper

Toward Sustaining Web-Based Senior Center Programming Accessibility With and for Older Adult Immigrants: Community-Based Participatory Research Cross-Sectional Study

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Abstract

Background: During the COVID-19 pandemic, many community-based organizations serving Asian Americans pivoted to provide web-based care and social services. Asian American community leaders in the United States Pacific Northwest, including Asian Health & Service Center expressed that there are older immigrant adults who experienced backlash from discrimination, fear, and anxiety owing in part to anti-Asian hate and isolation, including from infection precautions. Pivoting supported staying safe from COVID-19 transmission and anti-Asian hate crimes.

Objective: This study aims to examine the readiness of diverse groups of older Asian American immigrant adults (Chinese, Koreans, and Vietnamese) to use a web-based senior center, including technology access and telehealth use, and to identify the psychosocial health impacts that a web-based senior center could be positioned to meet.

Methods: A community-based participatory research approach was used to conduct a cross-sectional survey study in an Asian-based health and service center in 2022. We selected surveys from the National Institutes of Health–supported PhenX Toolkit. Analyses were performed using R software.

Results: There was an 88.2% (216/245) response rate. Overall, 39.8% (86/216) of participants were Chinese, 25% (54/216) were Korean, and 24.5% (53/216) were Vietnamese. There were significant group differences in mobile data plans (P=.0005). Most had an unlimited mobile data plan (38/86, 44% Chinese; 39/54, 72% Koreans; 25/53, 47% Vietnamese). Significant group differences existed regarding whether they started using a new electronic device to communicate with friends or family after the COVID-19 outbreak (P=.0005); most were Korean participants (31/54, 57%). For written text and audio or video apps, most Chinese participants used WeChat (65/85, 76%; 57/84, 68%, respectively), most Koreans used KakaoTalk (49/54, 91%; 49/54, 91%, respectively), and most Vietnamese used Facebook Messenger for written text (32/50, 64%) and Apple Face Time (33/50, 66%) or Facebook Messenger (31/50, 62%) for audio or video. Significant group differences existed regarding whether to try telehealth (P=.0005); most Vietnamese expressed that they would never consider it (41/53, 77%). Significant group differences existed regarding how well they were able to concentrate (χ^2_2=44.7; P<.0001); Chinese participants reported a greater inability (median 5, IQR 4-6). With regard to difficulties in life experiences (χ^2_2=51; P<.0001), the median was 6 (IQR 5-7) for the Vietnamese group. Significant group differences existed in having had a family/household member's salary, hours, and contracts

reduced (*P*=.0005) and having had a family/household member or friend fallen physically ill (*P*=.0005)—most Vietnamese (15/53, 28%) and Korean participants (10/53, 19%).

Conclusions: To build an efficacious, web-based senior center with web-based care and social service options, more older adults need access to the internet and education about using technology-enabled communication devices. Addressing the unique psychosocial impacts of the COVID-19 pandemic on each group could improve health equity. The strength of the participating older adults was observed and honored.

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KEYWORDS

Asian American; Chinese; Korean; Vietnamese; community-based participatory research; CBPR; COVID-19; health equity; immigrants; older adults; psychosocial; technology access; telehealth use; web-based senior center; mobile phone

Introduction

Background

During the COVID-19 pandemic, many community-based organizations (CBOs), such as culturally based health and social service centers quickly pivoted to provide web-based services to maintain contact with clients. Although the pivot to web-based contact helped to maintain care and social services, questions remain about how to best provide web-based care and social services and whether older adults can access care and services in a meaningful way. The sustainability of web-based care and social services is important because of reports by older adults that they continue to experience anti-Asian hate [1,2] and isolation [1]. During the COVID-19 pandemic, many Asian Americans avoid leaving their home to go to public places such as grocery stores, church, and school, and many have not talked with a health care provider or mental health professional about their feelings of isolation [3]. Providing web-based services can address both safety and isolation concerns; however, it is important for CBOs serving older Asian Americans to understand how they engage with technology and which devices and platforms they commonly use. Our community and academic partnership studied these issues at the request of a CBO serving Asian Americans in the Pacific Northwest. Findings reflect a drive toward health equity and responsiveness to community-identified priorities for sustaining and growing web-based social and health services after the COVID-19 pandemic. We intentionally disaggregated group data into granular, within group–specific data to address concerns expressed in the extant literature [2,4,5] and by CBOs that aggregated Asian American data are not always helpful at an actionable community level for countering systemic issues and for advancing health equity ideals.

Many Asian American CBOs serving older adults reported escalated racial discrimination during the COVID-19 pandemic, such as hate crimes or microaggressions [6]. Asian Americans experienced aggravated physical and mental health problems or violence [4]. Many were afraid to seek care because of anti-Asian xenophobia [5]. Older Asian American immigrants continue to be particularly vulnerable when they leave home owing to hate crimes against Asian individuals, with great adverse effects experienced by older adults who are undocumented, facing poverty, and having limited English proficiency [5]. Between March 2020 and April 2023, Stop AAPI Hate received 17,804 reports of hate incidents, including verbal harassment, shunning, physical assault, civil rights violations, harassment via the web, and more [1]. Asian Americans experienced psychological distress, stress, and depression during the COVID-19 pandemic. Southeast Asian individuals experienced more psychological distress than White (not Hispanic) individuals [7]. Chinese and Vietnamese reported that racial and ethnic discrimination and violence against their population led to feelings of stress and depression, and some reported being treated unfairly because of their race and ethnicity [3]. Furthermore, Koreans with preexisting chronic diseases were heavily affected, thus experiencing worse health outcomes [8]. Despite these known discriminations amid the COVID-19 pandemic, studying mental health among Asian Americans, particularly among Asian subgroups, was not prioritized in the United States [7]. Web-based care can be a necessary response to address continuity in delivering care and social services for constituents at risk for infection and criminal victimization.

Web-based care was a part of the pivot during the COVID-19 pandemic; however, this was isolating to many older Asian American immigrants [6]. Older adult users in the general population increasingly integrate technology and mobile devices into their daily lives [9], but this is not necessarily true for older Asian Americans. A study including older White Canadians showed that they were primarily concerned with avoiding the virus and with health care efficiencies [1] that web-based services can address, whereas older Korean immigrants were primarily worried about autonomy, technology dependence, and the burden of learning a new technology for engaging in social and health services [10]. Such worries, along with more broadly reported concerns by older adults about needing to be technology savvy and wanting in-person physical health exams [11] are not easily mitigated with web-based services. Despite these findings, in a national study of 40 CBOs serving Asian Americans, researchers found that technology was a connector for organizations [6]. Thus, understanding how to integrate technology in a meaningful way is important for successfully sustaining web-based contact with clients. Many resilient organizations have reflected on their commitment to serve communities with pride by adapting and preparing to face future crises [6].

Community Context

Asian American community leaders at the Asian Health & Service Center (AHSC) in Oregon in the United States Pacific Northwest expressed concerns that there are older Asian American immigrant adults who experienced backlash regarding

discrimination, fear, and anxiety in part from anti-Asian hate and isolation, including from social distancing for infection protection since the COVID-19 outbreak. AHSC is a culturally diverse, nonprofit CBO and a trusted source for health care and social services [12]. Most clients are older Chinese, Korean, and Vietnamese immigrants [1]. The chief executive director reported that they required a fast pivot to use more technology owing to concerns expressed by older Asian American immigrant adults. This pivot included training staff to deliver health care and social services remotely (ie, distance). COVID-19 Asian response teams were created that consisted of community health workers (CHWs) and behavioral health counselors. Health care and social services were delivered via audio and video calls while attempting to maintain the AHSC holistic health care and social services model of social engagement, public health information, and support for health needs. There is a crucial need to engage to inform rebuilding as a web-based senior center after COVID-19 with a web-based care and social services option. AHSC community leaders identified priorities based on expressed concerns, and this included engaging culturally diverse, older Asian American immigrant adult clients by centering their voice, learning about their technology access and telehealth use to extend reach in client support and mental health counseling, and uplifting a dedicated community workforce of culturally diverse and multilingual CHWs for web-based outreach and care of older Asian American immigrant adults to advance health equity. AHSC community leaders raised that conducting a survey study can be a step in centering the voice and engaging the participation of older Asian American immigrant adults by clarifying what is meant by web-based care.

Community Engagement to Advance Health Equity

Community engagement is essential to advance health equity. Academic and community researchers should comprehensively embed methods of community-based participatory research (CBPR) that is action oriented into the design of research studies [13]. There is a need to fully engage communities in community-involved care settings to ensure sustainability in the context of direct application to real-world care delivery [13]. Community engagement in scientific design and procedures is important for collaborative research decision-making based on a shared working understanding [1]. Community engagement through CBPR and citizen science, where participatory action drives research direction for sustainability in population health science, is important [1,14]. Authentic intentionality for an inclusive collaboration partnership needs to include conceptualization, design, implementation, and dissemination. The Community Connected Health initiative set forth by the White House Office of Science and Technology Policy underscored the need to work with communities. Emphasis is placed on CBOs to prioritize their technological needs and goals while integrating strengths and keeping the end users in mind while designing and have support for a representative and diverse health technology workforce [15]. Furthermore, a need exists for thoughtful approaches to equity and inclusion in collecting and using data and for organizations to be involved in community-based health care delivery through actionable data [15]. We built upon a long-standing, cross-sector, and trusted community-academic partnership between AHSC and a public Washington State University (WSU) College of Nursing since 2015. As a community and academic partnership, we conducted previous CBPR studies regarding capacity building on health-assistive smart home monitoring technology adoption and perceptions about smart home adoption by older Asian American immigrant adults, including Chinese, Koreans, and Vietnamese. Details were reported elsewhere [16,17].

This CBPR Study

CBO leaders organically drove the purpose, aims, and design for this study in partnership with a nursing science research team. The aims they identified for this CBPR cross-sectional survey study were to explore two domains: (1) examine the readiness of diverse groups of Asian American immigrant older adults (Chinese, Koreans, and Vietnamese) to use a web-based senior center, including technology access and telehealth, and (2) identify the psychosocial health impacts of older Asian American immigrants among Chinese, Korean, and Vietnamese groups that a web-based senior center could be positioned to meet. As a step to understand the potential sustainability of web-based social and health services, we investigated the behaviors and attitudes toward the internet; access to the internet and associated devices; experiences and attitudes toward telehealth; and psychosocial impacts, including needs and effects of the COVID-19 outbreak on diverse Asian American immigrant groups of older adults (Chinese, Koreans, and Vietnamese) in the United States Pacific Northwest. Findings may inform future studies in maintaining and growing web-based senior centers with a web-based care option for a culturally diverse, nonprofit, Asian-based health and social service center.

Methods

CBPR Cross-Sectional Survey Study Design

We used a CBPR approach to design, implement, and interpret this cross-sectional survey study and used the principles of mutual trust, rapport, respect, learning, and mentoring [18]. CBPR included equitable involvement of diverse partners throughout the research and dissemination process [18]. Our cross-sector partnership was culturally diverse, multilingual, and multidisciplinary. WSU College of Nursing academic nurse researchers included the principal investigator (PI) with a Vietnamese and Guamanian Micronesian Islander background, specialty in CBPR with immigrants and marginalized communities, and health equity in health-assistive technology adoption; co-PI with a White and Native American background and smart home health-assistive monitoring and informatics specialty; and a statistician with a White background and history in data analysis and management and smart home health-assistive monitoring. AHSC community partners included the chief executive director with a Chinese background and experience in social work and immigrant community health; 3 program managers in community health including the senior program manager with a Korean background and specialty in aging and disability, community program manager with a Chinese background and public health management and policy specialty, and community health project manager with a Chinese

background and public health specialty; and 4 CHWs with a Chinese, Korean, or Vietnamese background and specialties in psychology, communication disorders, and sciences; education; fine arts; or health promotion and health behavior.

We used surveys from the National Institutes of Health–supported PhenX Toolkit that included the COVID-19 Technology Accessibility Survey (for technology access), Technology Telehealth Use, and Psychosocial Impact of COVID-19 Survey [19]. In addition, the PI, co-PI, and AHSC chief executive director codeveloped the items about written and audio or video communication apps, internet service provider, mobile phone use, mobile data plan, and access to the internet via a mobile phone (ie, technology access). The PI and co-PI consulted with a biostatistician and discussed with the nurse researcher statistician regarding the selection of items and technical functionality. The chief executive director and 3 program managers at AHSC reviewed and pretested the survey (Multimedia Appendices 1 and 2) for face validity and technical functionality. AHSC community partners discussed among themselves about meaningful interpretation and discussed with academic nurse researchers on a regular basis throughout the research process. AHSC community partners spoke English and Chinese Cantonese, Chinese Mandarin, Korean, or Vietnamese and assisted the academic nurse researchers with outreach, recruitment, and interpretation. This aligns with the AHSC holistic health care and social services model, which provides cultural and linguistic interpretation in the context of a real-world health and social service setting [12]. The study was conducted at the AHSC in the United States Pacific Northwest between March 2022 and April 2022.

Ethical Considerations

This study underwent a limited review and received a certificate of exemption from full board review by the WSU Human Research Protection Program (18816). Each participant received a shopping gift card worth US $10 (eg, grocery) upon completion that honored and thanked them.

Measurements

As of October 29, 2020, at the beginning of the CBPR design, the PI reviewed 94 COVID-19 survey protocols that were made publicly available for use, the PhenX Toolkit by the trans–National Institutes of Health working group, that consisted of the National Institute on Aging and the Office of Behavioral and Social Sciences Research [20]. Owing to the urgency of need for COVID-19–specific survey measurements at the time, these items did not undergo the same level of standardization, harmonization, or psychometric testing as per the PhenX consensus process [20]. Our academic and community partnership discussed, selected, consulted, and pretested the survey as described previously in the *CBPR Cross-Sectional Survey Study Design* section. Therefore, each item incorporated in the survey was treated as its own variable, rather than contributing to the measurement scales. The survey consisted of the following: sociodemographic and background items from our previous CBPR [17]; technology access items from the National Institute on Aging Alzheimer's Disease Research Centers and Levey [21] and from the items codeveloped by the PI, co-PI, and AHSC chief executive director; telehealth use items from the Institute on Aging at the University of Florida [22]; and psychosocial health impact items from the National Institute of Mental Health Intramural Research Program [23]. Of the technology access items, we incorporated our codeveloped items as described previously. We used the secure and password-protected WSU Qualtrics web-based platform, formatted the survey, and entered the participant responses.

Participants, Recruitment, and Data Collection

Overall, 7 trained program managers and CHWs at AHSC reached out to clients from the AHSC registry and used a script to provide oral information about the study primarily via telephone, with some in-person communication. The script contained information similar to the consent form that included the study purpose, investigators, eligibility, voluntary participation, procedures, shopping gift card for completion, and contact information. If an individual expressed interest, an AHSC community partner referred them to the web-based Qualtrics site that has the combined consent form, eligibility, and survey. Through the consent form, individuals were informed about the study purpose and investigators. Only a unique study number will be used to follow up for providing a shopping gift card, and it will be accessible to community-academic research partnership. Responses will be entered into the secure Qualtrics web-based platform and retained for 3 years. The survey takes approximately 30 minutes. The participants were also informed about the potential for risks, such as emotional discomfort, feeling of embarrassment, or loss of privacy if the participant chooses to have interpretation assistance. Individuals were asked to participate in the study if they were eligible and complete the survey. Participants could choose either Chinese Cantonese, Chinese Mandarin, Korean, or Vietnamese interpretation assistance from an AHSC community partner as they completed the survey. This convenient and purposive sample included a total of 216 individuals who identified as an Asian American immigrant and were aged ≥60 years.

Data Analysis

All statistical analyses were performed using R (version 4.2.0) [24] and RStudio (version 2022.7.1) [25], with the *tidyverse* (version 1.3.1) [26], *arsenal* (version 3.6.3) [27], *labelled* (version 2.9.1) [28], and *psych* (version 2.2.5) [29] packages. We analyzed the data of older Asian American immigrants as a whole and as disaggregated data that are stratified by race and ethnicity. Of the 216 older Asian American immigrant adults, a subtotal was 193 (89.4%) across Chinese, Korean, and Vietnamese groups. There was low participation of Taiwanese and multiracial individuals, and a participant reported as being Asian and having a different ethnicity than listed previously; therefore, we described meaningful interpretation of group-wide comparisons across and among Chinese, Korean, and Vietnamese groups alongside the total group of older Asian American immigrant adults. For the purpose of this paper about learnings from a real-world CBPR survey study, we decided not to combine groups with low participation into less meaningful aggregated data. This also protects the privacy of these individual analyses. Frequencies and percentages were reported for categorical variables, ordinal variables, and

variables with select-all response categories (ie, >1 response). Means (SDs) were reported for continuous variables, and medians (IQRs) were reported for continuous and ordinal variables. We used Bonferroni correction to maintain a cross-study, family-wise error rate of 0.05; thus, α=.0008 was the cutoff for statistical significance among Chinese, Korean, and Vietnamese groups. Therefore, all *P* values were reported to 4 decimals to be specific and align with a meaningful data analysis, and we reported data at a granular level to align with disaggregated data science. For mutually exclusive categorical variables, Fishers exact tests were performed to examine for any group differences and the variables under consideration (*P*=.0008). We also reported χ^2 (*df*) and *P* values for continuous and ordinal variables from Kruskal-Wallis rank sum tests.

We maintained a health equity lens as a community-academic partnership. The PI and statistician discussed the data and data analysis outputs first, and then with the co-PI, and this informed a culturally responsive discussion with AHSC community partners with regard to the observed response patterns. The statistician maintained field note records that captured reflexivity where we discussed potential bias as a community-academic partnership. Analytics and outputs reflected the insights gained from these discussions, contributing to the reflexive nature of the study. These records were reviewed by the PI and discussed within the community-academic partnership. Such discussions and record keeping promoted communication transparency as a way to address potential bias. We achieved meaningful data interpretation by being responsive to community partners.

Results

Overview

In total, AHSC community partners reached out to 245 older Asian immigrant adult clients, of whom 25 (10.2%) declined to participate in the study. Reasons for not participating included the survey length and not having experience with telehealth. The length of time to complete the survey was 60 minutes. After the statistician performed initial screening for duplicate or erroneous entries, then we discussed as a community-academic partnership and 88.2% (216/245) of the survey responses were retained for data analysis—response rate: 216/245, 88.2% and completion rate: 216/216, 100% (ie, started and completed the survey). The completeness rate (ie, no missing responses and completed answering the survey items) was approximately 93.9% (203/216). Absolute and total numbers are shown in all tables.

Sociodemographics and Background of Participants

In total, there were 216 older Asian American immigrant adults. Overall, 39.8% (86/216) identified as Chinese, 25% (54/216) as Korean, 24.5% (53/216) as Vietnamese, 6.9% (15/216) as Taiwanese, and 3.2% (7/216) as multiracial, and 0.5% (1/216) reported as having a different Asian ethnicity than listed previously. There were 89.4% (193/216) participants across older Chinese, Korean, and Vietnamese immigrant adults. Most Chinese (34/86, 40%) and Korean (28/54, 52%) participants had postsecondary education, and most Vietnamese participants (27/53, 51%) graduated from high school. Of the Chinese, Korean, and Vietnamese participants, 60.6% (117/193) reported <US $15,000 as total household income before taxes, of which 59% (51/86) is Chinese, 56% (30/54) is Korean, and 68% (36/53) is Vietnamese. Overall, 97.9% (189/193) of participants have a regular place of care for nonemergency health care services. Furthermore, 95% (82/86) of the Chinese participants and all Korean (54/54, 100%) and Vietnamese (53/53, 100%) participants reported having a regular place of care.

Multimedia Appendix 3 summarizes the sociodemographics and background characteristics of older Asian American immigrant adults and Chinese, Korean, and Vietnamese groups.

Behaviors, Attitudes, and Access to the Internet and Internet-Enabled Devices

Table 1 summarizes the behaviors, attitudes, and access to the internet and internet-enabled devices of older Asian American immigrant adults and Chinese, Korean, and Vietnamese groups. Overall, 13% (7/53) of Vietnamese and 2% (2/86) of Chinese participants reported not having a mobile phone at all. In total, most participants (208/216, 96.3% older Asian American immigrants; 185/193, 95.9% across Chinese, Koreans, and Vietnamese) reported that they have or have access to a smartphone or tablet; 97% (83/86) of Chinese participants, 100% (54/54) of Korean participants, and 91% (48/53) of Vietnamese participants reported access. Less than half (97/216, 44.9% older Asian American immigrants; 85/193, 44% across Chinese, Koreans, and Vietnamese) of the participants have or have access to a PC (either desktop or laptop); 37% (32/86) of Chinese participants, 57% (31/54) of Korean participants, and 42% (22/53) of Vietnamese participants reported access. In total, most participants (160/215, 74.4% older Asian American immigrants; 144/192, 75% across Chinese, Koreans, and Vietnamese) have a national internet service provider; 71% (60/85) of Chinese participants, 82% (44/54) of Korean participants, and 76% (40/53) of Vietnamese participants have a national internet service provider. Some participants (22/215, 10.2% older Asian American immigrants; 20/192, 10.4% across Chinese, Koreans, and Vietnamese) have no internet service provider; 11% (9/85) of Chinese participants, 7% (4/54) of Korean participants, and 13% (7/53) of Vietnamese participants have no internet service provider. Most participants have an unlimited mobile data plan (116/216, 53.7% older Asian American immigrants; 102/193, 52.8% across Chinese, Koreans, and Vietnamese); 44% (38/86) of Chinese participants, 72% (39/54) of Korean participants, and 47% (25/53) of Vietnamese participants have an unlimited mobile data plan. However, there was a statistically significant difference among Chinese, Korean, and Vietnamese groups (*P*=.0005), with Korean participants reporting having unlimited data at a much higher rate (39/54, 72%) than Chinese participants (38/86, 44%) or Vietnamese participants (25/53, 47%). There were also significant differences among groups (*P*=.0005) about having started using a new electronic device to communicate with friends and family after the COVID-19 outbreak with most being Korean participants (31/54, 57%) followed by Chinese participants (15/86, 17%) and a Vietnamese (1/53, 2%) participant. There were no significant differences among groups with regard to technology savvy responses (χ^2_2=3.2; *P*=.202). Overall, very

few participants (9/216, 4.2% older Asian American immigrants; 7/193, 3.6% across Chinese, Koreans, and Vietnamese) perceived themselves to be very technology savvy. Most participants perceived themselves to be only a little technology savvy (76/216, 35.2% older Asian American immigrants; 67/193, 34.7% across Chinese, Koreans, and Vietnamese; 26/86, 30% Chinese; 17/54, 32% Koreans; 24/53, 45% Vietnamese) or not at all (93/216, 43.1% older Asian American immigrants; 82/193, 42.5% across Chinese, Koreans, and Vietnamese; 41/86, 48% Chinese; 25/54, 46% Koreans; 16/53, 30% Vietnamese).

Table 1. Behaviors, attitudes, and access to the internet and internet-enabled devices of older Asian American immigrant adults and Chinese, Korean, and Vietnamese groups.

Variables	Total older Asian American immigrants (n=216)[a]	Subtotal across older Chinese, Korean, and Vietnamese immigrants (n=193)[b]	Chinese immigrants (n=86)[c]	Korean immigrants (n=54)[c]	Vietnamese immigrants (n=53)[c]	*P* value	Chi-square (*df*)[d]
Does not have a mobile phone, n (%)	10 (4.6)	9 (4.7)	2 (2)	0 (0)	7 (13)	.003[e]	N/A[f]
Has a smartphone or tablet or is able to access one, n (%)	208 (96.3)	185 (95.9)	83 (97)	54 (100)	48 (91)	.048[e]	N/A
Has a PC (desktop or laptop) or is able to access one, n (%)	97 (44.9)	85 (44)	32 (37)	31 (57)	22 (42)	.0565[e]	N/A
Has access to other internet-enabled device (eg, smartwatch, smart home device, or television), n (%)	15 (6.9)	13 (6.7)	8 (9)	3 (6)	2 (4)	.4213[e]	N/A
Who is your internet provider? (multiple responses)[g], n (%)						.1794[e]	N/A
National internet service provider	160 (74.4)	144 (74.6)	60 (71)	44 (82)	40 (76)		
Regional or local internet service provider	13 (6)	12 (6.2)	6 (7)	5 (9)	1 (2)		
Mobile phone	7 (3.3)	6 (3.1)	5 (6)	1 (2)	0 (0)		
National internet service provider and mobile phone	2 (0.9)	1 (0.5)	1 (1)	0 (0)	0 (0)		
Regional or local internet service provider and mobile phone	1 (0.5)[a]	0 (0)	0 (0)	0 (0)	0 (0)		
Specified an internet provider different from abovementioned ones	2 (0.9)	1 (0.5)	0 (0)	0 (0)	1 (2)		
Not sure	8 (3.7)	8 (4.2)	4 (5)	0 (0)	4 (8)		
None	22 (10.2)	20 (10.4)	9 (11)	4 (7)	7 (13)		
Mobile data plan type, n (%)						.0005[e]	N/A
Capped or limited plan	10 (4.6)	9 (4.7)	6 (7)	1 (2)	2 (4)		
Capped or limited plan amount unsure	39 (18.1)	36 (18.7)	14 (16)	6 (11)	16 (30)		
Not applicable (ie, no mobile phone)	10 (4.6)	9 (4.7)	2 (2)	0 (0)	7 (13)		
None	4 (1.9)	4 (2.1)	3 (4)	0 (0)	1 (2)		
Unlimited	116 (53.7)	102 (52.8)	38 (44)	39 (72)	25 (47)		
Unsure about plan type	37 (17.1)	33 (17.1)	23 (27)	8 (15)	2 (4)		
Do you consider yourself to be technology savvy?						.202[d]	3.2 (2)
Score, median (IQR)	2 (1-2)	2 (1-2)	2 (1-2)	2 (1-2)	2 (1-2)		
Not at all, n (%)	93 (43.1)	82 (42.5)	41 (48)	25 (46)	16 (30)		
A little, n (%)	76 (35.2)	67 (34.7)	26 (30)	17 (32)	24 (45)		

Variables	Total older Asian American immigrants (n=216)[a]	Subtotal across older Chinese, Korean, and Vietnamese immigrants (n=193)[b]	Chinese immigrants (n=86)[c]	Korean immigrants (n=54)[c]	Vietnamese immigrants (n=53)[c]	*P* value	Chi-square (*df*)[d]
Somewhat so, n (%)	38 (17.6)	37 (19.2)	16 (19)	12 (22)	9 (17)		
Very much so, n (%)	9 (4.2)	7 (3.6)	3 (4)	0 (0)	4 (8)		
Overall, how confident do you feel using computers, smartphones, or other electronic devices to do the things you need to do online?						.4224[d]	1.7 (2)
Score, median (IQR)	2 (1-3)	2 (1-3)	2 (1-3)	2 (1-2.8)	2 (1-3)		
Not at all confident, n (%)	89 (41.2)	80 (41.5)	34 (40)	26 (48)	20 (38)		
Only a little confident, n (%)	66 (30.6)	57 (29.5)	27 (31)	14 (26)	16 (30)		
Somewhat confident, n (%)	50 (23.1)	47 (24.4)	21 (24)	14 (26)	12 (23)		
Very confident, n (%)	11 (5.1)	9 (4.7)	4 (5)	0 (0)	5 (9)		
Have you started using a new electronic device to communicate with friends and family after the COVID-19 outbreak? (yes), n (%)	52 (24.1)	47 (24.4)	15 (17)	31 (57)	1 (2)	.0005[e]	N/A
Before the COVID-19 outbreak, would you say technology has had a mostly positive effect on our society or a mostly negative effect on our society[h]?						.0221[d]	7.6 (2)
Score, median (IQR)	3 (2-3)	3 (2-3)	2 (2-3)	2.5 (2-3)	3 (2-3)		
1=mostly negative, n (%)	7 (3.3)	6 (3.1)	2 (2)	4 (7)	0 (0)		
2=equal positive and negative effects, n (%)	98 (45.6)	88 (45.8)	47 (55)	23 (43)	18 (34)		
3=mostly positive, n (%)	110 (51.2)	98 (51)	36 (42)	27 (50)	35 (66)		
After the COVID-19 outbreak, would you say technology has had a mostly positive effect on our society or a mostly negative effect on our society?						0.2518[d]	2.8 (2)
Score, median (IQR)	3 (2-3)	3 (2-3)	3 (2-3)	3 (2-3)	3 (2-3)		
1=mostly negative, n (%)	6 (2.8)	5 (2.6)	0 (0)	5 (9)	0 (0)		
2=equal positive and negative effects, n (%)	78 (36.1)	69 (35.8)	33 (38)	19 (35)	17 (32)		
3=mostly positive, n (%)	132 (61.1)	119 (61.7)	53 (62)	30 (56)	36 (68)		

[a]Responses from participants who identified as Chinese, Korean, Vietnamese, Taiwanese, and multiracial and a participant who specified Asian race and ethnicity different from those listed previously.

[b]Responses from participants who identified as Chinese, Korean, and Vietnamese.

[c]Responses from participants who identified as Chinese, Korean, or Vietnamese.

[d]Kruskal-Wallis rank sum test.

[e]Fisher exact test.

[f]N/A: not applicable.

[g]Overall, 1 missing response from the Chinese group; total sample size=215; subtotal sample size=192; Chinese sample size=85; Korean sample size=54; Vietnamese sample size=53.

[h]Total sample size=215; subtotal sample size=192; Chinese sample size=85; Korean sample size=54; Vietnamese sample size=53.

Apps Used for Written and Audio or Video Communication

Table 2 shows the apps used for written and audio or video communication by older Asian American immigrant adults and Chinese, Korean, and Vietnamese groups. Approximately half of the participants (103/212, 48.6% older Asian American immigrants; 91/189, 48.1% across Chinese, Koreans, and Vietnamese) used email for written communication, with email use at 44% (37/85) for Chinese participants, 57% (31/54) for Korean participants, and 46% (23/50) for Vietnamese participants. Most participants used mobile phone texting for written communication (131/212, 61.8% older Asian American immigrants; 118/189, 62.4% across Chinese, Koreans, and Vietnamese; 42/85, 49% Chinese; 44/54, 82% Koreans; 32/50, 64% Vietnamese). The following results were regarding written communication apps and audio or video communication apps. Chinese participants used WeChat the most for written communication (65/85, 77%) and audio or video communication (57/84, 68%) among the apps. Korean participants were the only participants who reported having used KakaoTalk with most use for written communication (49/54, 91%) and audio or video communication (49/54, 91%). Vietnamese participants mostly reported the use of Facebook Messenger (32/50, 64%) for written communication and Apple Face Time (33/50, 66%) or Facebook Messenger (31/50, 62%) for audio or video communication. Some participants did not use any of the written communication apps (20/212, 9.4% older Asian American immigrants; 17/189, 8.9% across Chinese, Koreans, and Vietnamese); 18% (9/50) of Vietnamese participants, 7% (6/85) of Chinese participants, and 4% (2/54) of Korean participants did not use written communication apps. Some participants did not use any of the audio or video communication apps (22/211, 10.4% older Asian American immigrants; 20/188, 10.6% across Chinese, Koreans, and Vietnamese); 20% (10/50) of Vietnamese participants, 11% (9/84) of Chinese participants, and 2% (1/54) of Korean participants did not use audio or video communication apps.

Table 2. Apps used for written and audio or video communication by older Asian American immigrant adults and by Chinese, Korean, and Vietnamese groups.

Variables	Total older Asian American immigrants, n (%)[a]	Subtotal across older Chinese, Korean, and Vietnamese immigrants, n (%)[b]	Chinese immigrants, n (%)[c]	Korean immigrants, n (%)[c]	Vietnamese immigrants, n (%)[c]
What communication apps are you using for written communication?[d] (multiple responses)					
Email	103 (48.6)	91 (48.1)	37 (44)	31 (57)	23 (46)
Mobile phone texting	131 (61.8)	118 (62.4)	42 (49)	44 (82)	32 (64)
Facebook Messenger	49 (23.1)	44 (23.3)	7 (8)	5 (9)	32 (64)
WhatsApp	11 (5.2)	9 (4.8)	9 (11)	0 (0)	0 (0)
WeChat	74 (34.9)	66 (34.9)	65 (77)	1 (2)	0 (0)
KakaoTalk	49 (23.1)	49 (25.9)	0 (0)	49 (91)	0 (0)
Line	24 (11.3)	10 (5.3)	10 (12)	0 (0)	0 (0)
Specified a written communication app different from abovementioned ones (ie, Twitter, Google Chat, Skype, LinkedIn, Telegram, Zalo, Viber, Instagram, and TikTok)	29 (13.7)	27 (14.3)	6 (7)	4 (7)	17 (34)
None	20 (9.4)	17 (8.9)	6 (7)	2 (4)	9 (18)
What communication apps are you using for audio/video communication?[e] (multiple responses)					
Apple FaceTime	83 (39.3)	73 (38.8)	21 (25)	19 (35)	33 (66)
Video Android	20 (9.5)	19 (10.1)	6 (7)	13 (24)	0 (0)
Facebook Messenger	39 (18.5)	38 (20.2)	3 (4)	4 (7)	31 (62)
Zoom	31 (14.7)	29 (15.4)	13 (16)	16 (30)	0 (0)
WeChat	65 (30.8)	58 (30.9)	57 (68)	1 (2)	0 (0)
KakaoTalk	49 (23.2)	49 (26.1)	0 (0)	49 (91)	0 (0)
Line	20 (9.5)	7 (3.7)	7 (8)	0 (0)	0 (0)
Specified an audio/video communication app different from abovementioned ones (ie, Skype, WhatsApp, Telegram, Zalo, Viber, Tango, and FCC HD)	24 (11.4)	21 (11.2)	8 (10)	2 (4)	11 (22)
None	22 (10.4)	20 (10.6)	9 (11)	1 (2)	10 (20)

[a]Responses from participants who identified as Chinese, Korean, Vietnamese, Taiwanese, and multiracial and a participant who specified Asian race and ethnicity different from those listed previously.

[b]Responses from participants who identified as Chinese, Korean, and Vietnamese.

[c]Responses from participants who identified as Chinese, Korean, or Vietnamese.

[d]Overall, 4 missing responses, of which 1 (25%) was from the Chinese group and 3 (75%) were from the Vietnamese group; total sample size=212; subtotal sample size=189; Chinese sample size=85; Korean sample size=54; Vietnamese sample size=50.

[e]Overall, 5 missing responses, of which 2 (40%) were from the Chinese group and 3 (60%) were from the Vietnamese group; total sample size=211; subtotal sample size=185; Chinese sample size=84; Korean sample size=54; Vietnamese sample size=50.

Experience With and Attitudes Toward Telehealth

Table 3 summarizes the experiences and attitudes of older Asian American immigrant adults and Chinese, Korean, and Vietnamese groups toward telehealth. Overall, approximately one-fourth of the older Asian American immigrant adults (48/215, 22.3%; across Chinese, Korean, and Vietnamese groups: 42/192, 21.9%) already had a telehealth appointment, with Korean participants at 28% (15/54), Chinese participants at 25% (21/85), and Vietnamese participants at 11% (6/53). There were significant differences among the groups (P=.0005) that expressed they would never consider trying a telehealth appointment. Just less than half of the older Asian American immigrant adults (95/215, 44.2%; 87/192, 45.3% across Chinese, Koreans, and Vietnamese groups; 22/85, 26% Chinese; 24/54, 44% Koreans; 41/53, 77% Vietnamese) reported that they would never consider trying a telehealth appointment. Participants were able to choose >1 response regarding specific concerns about telehealth services. More than half of the participants worried about the quality of health care (121/212, 57.1% older Asian American immigrants; 110/190, 57.9% across Chinese, Koreans, and Vietnamese; 34/83, 41% Chinese; 30/54, 56%

Koreans; 46/53, 87% Vietnamese), less than half of the participants were not convinced that a telehealth diagnosis can ever be truly accurate (93/212, 43.9% older Asian American immigrants; 81/190, 42.6% across Chinese, Koreans, and Vietnamese; 27/83, 33% Chinese; 23/54, 43% Koreans; 31/53, 59% Vietnamese), and approximately one-third of the participants have never used telehealth services before and do not know how to start (68/212, 32.1% older Asian American immigrants; 61/190, 32.1% across Chinese, Koreans, and Vietnamese; 13/83, 16% Chinese; 20/54, 37% Koreans; 28/53, 53% Vietnamese). There were significant differences in perspectives regarding the main advantages of telehealth services among Chinese, Korean, and Vietnamese groups (P=.0005). Approximately half of the total older Asian American immigrant adults (102/214, 47.7%) reported no need for transportation as the main advantage of telehealth services, whereas approximately all Vietnamese participants (47/53, 89%) selected this reason as the main advantage, as compared with half of Korean participants (28/54, 52%), and less than one-fourth of Chinese participants (20/85, 24%). In total, less than half of the participants (95/215, 44.2% older Asian American immigrants; 81/192, 42.2% across Chinese, Koreans, and Vietnamese; 24/85, 28% Chinese; 22/54, 41% Koreans; 35/53, 66% Vietnamese) reported that a telehealth visit will never match an in-person visit. Furthermore, 39% (33/85) of Chinese participants reported that although telehealth does not compare with in-person visits, it Is a good option for initial consultation or basic care; followed by 28% (15/54) Korean participants and 17% (9/53) Vietnamese participants. There were significant differences in having the COVID-19 outbreak change the perspectives about telehealth use among groups (χ^2_2=20.6; P<.0001), and the median was 2 (IQR 2-3) for the Chinese group, 1 (IQR 1-3) for the Korean group, and 2 (IQR 1-2) for the Vietnamese group. Most Korean participants (33/54, 61%) reported to be less likely to use telehealth, approximately half of Chinese participants reported having the same opinion as before the COVID-19 outbreak (47/85, 55%), more than half of Vietnamese participants reported having the same opinion as before the COVID-19 outbreak (29/52, 56%), and more than one-fourth of Chinese participants (25/85, 29%) reported to be more likely to use telehealth in the future.

Table 3. Experience and attitudes of older Asian American immigrant adults and Chinese, Korean, and Vietnamese groups toward telehealth.

	Total older Asian American immigrants[a]	Subtotal across older Chinese, Korean, and Vietnamese immigrants[b]	Chinese immigrants[c]	Korean immigrants[c]	Vietnamese immigrants[c]	*P* value	Chi-square (*df*)[d]
Have you considered trying a telehealth appointment?						.0005[e]	N/A[f]
Sample size, n	215	192	85	54	53		
No, and I would never consider a telehealth appointment, n (%)	95 (44.2)	87 (45.3)	22 (26)	24 (44)	41 (77)		
No, but I would consider a telehealth appoint, n (%)	37 (17.2)	31 (16.1)	20 (24)	7 (13)	4 (8)		
Yes, I have considered it, but I have not yet had an appointment, n (%)	35 (16.3)	32 (16.7)	22 (26)	8 (15)	2 (4)		
Yes, and I have already had a telehealth appointment, n (%)	48 (22.3)	42 (21.9)	21 (25)	15 (28)	6 (11)		
Does anything in particular concern you about telehealth services?[g] (multiple responses)						N/A	N/A
Sample size, n	212	190	83	54	53		
I worry about the quality of health care, n (%)	121 (57.1)	110 (57.9)	34 (41)	30 (56)	46 (87)		
I am not convinced a telehealth diagnosis can ever be truly accurate, n (%)	93 (43.9)	81 (42.6)	27 (32.5)	23 (43)	31 (59)		
I do not want my appointment to be recorded, n (%)	12 (5.7)	10 (5.3)	8 (10)	1 (2)	1 (2)		
I worry about the privacy of my personal health information, n (%)	21 (9.9)	19 (10)	15 (18)	1 (2)	3 (6)		
I do not have an electronic device to access telehealth services, n (%)	26 (12.3)	25 (13.2)	5 (6)	12 (22)	8 (15)		
I have never used telehealth services before and do not know how to start, n (%)	68 (32.1)	61 (32.1)	13 (16)	20 (37)	28 (53)		
A medical interpreter is not available for me, n (%)	19 (9)	14 (7.4)	12 (15)	0 (0)	2 (4)		
Specified reason is different from abovementioned ones, n (%)	27 (12.7)	25 (13.2)	16 (19)	9 (17)	0 (0)		
What do you view as the main advantage to telehealth services?						.0005[c]	N/A
Sample size, n	215	192	85	54	53		
Quicker access to care, n (%)	52 (24.3)	46 (23.9)	32 (38)	9 (17)	5 (9)		
Greater access to care in remote areas, n (%)	14 (6.5)	13 (6.8)	13 (15)	0 (0)	0 (0)		

	Total older Asian American immigrants[a]	Subtotal across older Chinese, Korean, and Vietnamese immigrants[b]	Chinese immigrants[c]	Korean immigrants[c]	Vietnamese immigrants[c]	*P* value	Chi-square (*df*)[d]
No need for transportation, n (%)	102 (47.7)	95 (49.5)	20 (24)	28 (52)	47 (89)		
The ability to take less time out of my day, n (%)	32 (14.9)	28 (14.6)	10 (12)	17 (32)	1 (2)		
Avoid overcrowding of waiting rooms, n (%)	14 (6.5)	10 (5.2)	10 (12)	0 (0)	0 (0)		
Which of the following might deter you from making a future telehealth appointment?[h] (multiple responses)						N/A	N/A
Sample size, n	210	188	81	54	53		
I just prefer to meet with someone in person, n (%)	158 (75.2)	139 (73.9)	43 (53)	44 (82)	52 (98)		
Greater access to care in remote areas, n (%)	18 (8.6)	18 (9.6)	9 (11)	9 (17)	0 (0)		
I do not want to mess with technology, n (%)	49 (23.3)	47 (25)	18 (22)	7 (13)	22 (42)		
I am not convinced that someone could give good health care by telehealth, n (%)	58 (27.6)	54 (28.7)	17 (21)	4 (7)	33 (62)		
I do not think my internet connection is good enough, n (%)	19 (9)	19 (10.1)	7 (9)	7 (13)	5 (9)		
Do you feel that people get comparable health care through telehealth as they do for in-person visits?						.0015[c]	N/A
Sample size, n	215	192	85	54	53		
No, telehealth care will never match the quality of an in-person visit, n (%)	95 (44.2)	81 (42.2)	24 (28)	22 (41)	35 (66)		
No, but telehealth is a good option for initial consultation or basis care, n (%)	60 (27.9)	57 (29.7)	33 (39)	15 (28)	9 (17)		
Yes I think the care is comparable, n (%)	41 (19.1)	37 (19.3)	16 (19)	14 (26)	7 (13)		
I am not sure, n (%)	19 (8.8)	17 (8.9)	12 (14)	3 (6)	2 (4)		
Has the COVID-19 outbreak changed your view of telehealth?						<.0001[d]	20.6 (2)
Sample size, n	214	191	85	54	52		
Score, median (IQR)	2 (1-2)	2 (1-2)	2 (2-3)	1 (1-3)	2 (1-2)		
1=I am less likely to use telehealth, n (%)	72 (33.6)	67 (35.1)	13 (15)	33 (61)	21 (40)		
2=I have the same opinion compared to before the COVID-19 outbreak, n (%)	91 (42.5)	81 (42.4)	47 (55)	5 (9)	29 (56)		
3=I am more likely to use telehealth, n (%)	51 (23.8)	43 (22.2)	25 (29)	16 (30)	2 (4)		
Would you wear a smartwatch to help your doctor track your symptoms between appointments?						.0128[d]	8.7 (2)

	Total older Asian American immigrants[a]	Subtotal across older Chinese, Korean, and Vietnamese immigrants[b]	Chinese immigrants[c]	Korean immigrants[c]	Vietnamese immigrants[c]	*P* value	Chi-square (*df*)[d]
Sample size, n	215	192	85	54	53		
Score, median (IQR)	2 (1-4)	2 (1-3.2)	1 (1-4)	3 (1-4)	2 (1-2)		
1=not likely, n (%)	103 (47.9)	92 (47.9)	45 (53)	23 (43)	24 (45)		
2=somewhat likely, n (%)	31 (14.4)	31 (16.1)	6 (7)	2 (4)	23 (43)		
3=likely, n (%)	26 (12.1)	21 (10.9)	12 (14)	3 (6)	6 (11)		
4=very likely, n (%)	55 (25.6)	48 (25)	22 (26)	26 (48)	0 (0)		

[a]Responses from participants who identified as Chinese, Korean, Vietnamese, Taiwanese, and multiracial and a participant who specified Asian race and ethnicity different from those listed previously.

[b]Responses from participants who identified as Chinese, Korean, and Vietnamese.

[c]Responses from participants who identified as Chinese, Korean, or Vietnamese.

[d]Kruskal-Wallis rank sum test.

[e]Fisher exact test.

[f]N/A: not applicable.

[g]Overall, 4 missing responses, of which 3 (75%) were from the Chinese group and 1 (25%) was from Asian race and ethnicity was different from those listed previously.

[h]Overall, 6 missing responses, of which 5 (83%) were from the Chinese group and 1 (17%) was from Asian race and ethnicity was different from those listed previously.

Psychosocial Needs and Effects of the COVID-19 Pandemic

Multimedia Appendix 4 summarizes the psychosocial needs of and effects of the COVID-19 pandemic on older Asian American immigrant adults and Chinese, Korean, and Vietnamese groups. There were significant differences among Chinese, Korean, and Vietnamese groups, pertaining to overall psychosocial health, social distancing, worries, and functioning. For overall psychosocial health with regard to how well they have been able to concentrate or focus during the COVID-19 outbreak (1=not at all to 10=extremely well; χ^2_2=44.7; *P*<.0001), the median was 8 (IQR 8-9) for the Korean group, 6 (IQR 1-8) for the Vietnamese group, and 5 (IQR 4-6) for the Chinese group. With regard to how much they have been able to maintain social distance (1=not at all to 10=at all times; χ^2_2=33.6; *P*<.0001), the median was 10 (IQR 9-10) for the Korean group, 9 (IQR 9-10) for the Vietnamese group, and 8 (IQR 6-10) for the Chinese group. With regard to how stressful it has been to maintain social distancing owing to the COVID-19 outbreak (1=not at all stressful to 10=extremely stressful; χ^2_2=16.1; *P*=.0003), the median was 7 (IQR 5-9) for the Vietnamese group, 5 (IQR 2-9.8) for the Korean group, and 5 (IQR 1-7) for the Chinese group. For the following worry-related items (1=not at all worried to 10=extremely worried), such as how worried they have been about SARS-CoV-2 (χ^2_2=37.9; *P*<.0001), that they will be infected with SARS-CoV-2 (χ^2_2=75.5; *P*<.0001), that a family member will be infected with SARS-CoV-2 (χ^2_2=55.3; *P*<.0001), and that people around them will be infected with SARS-CoV-2 (χ^2_2=70.1; *P*<.0001), the median was 8 (IQR 7-9), 9 (IQR 9-9), 9 (IQR 9-9), and 9 (IQR 9-9), respectively, for the Vietnamese group; 7 (IQR 4-8), 7 (IQR 4-8), 7 (IQR 5-8), and 7 (IQR 5-8), respectively, for the Chinese group; and 5 (IQR 1-8), 2 (IQR 1-5), 4.5 (IQR 1-7.8), and 2 (IQR 1-6), respectively, for the Korean group. With regard to how worried they have been about not being able to afford or access food during the COVID-19 pandemic (χ^2_2=62.6; *P*<.0001), how worried they were about access to important resources, such as transportation or housing owing to the COVID-19 outbreak (χ^2_2=45.4; *P*<.0001), and how the COVID-19 crisis in their area created financial problems for participants or their family (χ^2_2=17.7; *P*=.0001), the median was 7 (IQR 5-8), 6 (IQR 1-8), and 2 (IQR 1-8), respectively, for the Vietnamese group; 3 (IQR 1-5), 3 (IQR 1-5), and 3 (IQR 1-5), respectively, for the Chinese group; and 1 (IQR 1-2), 1 (IQR 1-1), and 1 (IQR 1-1), respectively, for the Korean group. With regards to functioning, participants have experienced difficulties in life owing to the COVID-19 outbreak (1=experienced no difficulties to 10=experienced extreme difficulties; χ^2_2=51; *P*<.0001) and the distress they have had owing to the COVID-19 outbreak (1=not at all distressed to 10=extremely distressed; χ^2_2=22.1; *P*<.0001), the median was 6 (IQR 5-7) and 7 (IQR 5-7), respectively, for the Vietnamese group; 5 (IQR 2-6) and 5 (IQR 2-6), respectively, for the Chinese group; and 1 (IQR 1-3) and 4.5 (IQR 1-6.8), respectively, for the Korean group.

Most participants reported that 2 people lived in their house including themselves (112/215, 52.1% older Asian American immigrants; 99/192, 51.6% across Chinese, Koreans, and Vietnamese; 51/85, 60% Chinese; 27/54, 50% Koreans; 21/53, 40% Vietnamese). There were *significant* differences with

regard to having had a family/household member's salary, *hours*, or contracts significantly reduced (*P*=.0005) and having had a family/household member or friend fallen physically ill (*P*=.0005) owing to the COVID-19 outbreak. Most Vietnamese participants (15/53, 28%) had a family/household member's salary, *hours*, or contracts significantly reduced, followed by Korean (8/53, 15%) and Chinese (2/81, 2%) participants. Most Korean participants (10/53, 19%) reported having had a family/household member or friend fallen physically ill, followed by Chinese (7/81, 9%) and Vietnamese (0/53, 0%) participants. There were *significant* differences among Chinese, Korean, and Vietnamese groups in how relationships have been between members of family/household during the COVID-19 outbreak (1=extremely negative to 10=extremely positive; χ^2_2=33.2; *P*<.0001), and the median was 9 (7.2-10) for the Korean group, 9 (IQR 7.8-9.2) for the Vietnamese group, and 6 (IQR 5-8) for the Chinese group. There were *significant* differences among Chinese, Korean, and Vietnamese groups regarding what the exercise activity level has been (χ^2_2=20.2; *P*<.0001) and how much they have engaged in hobbies (χ^2_2=26.6; *P*<.0001) since the COVID-19 outbreak—the median was 5 (IQR 4-5) and 6 (IQR 5-7), respectively, for the Vietnamese group; 5 (IQR 3-5) and 5 (IQR 5-5), respectively, for the Korean group; and 4 (IQR 3-5) and 5 (IQR 5-5), respectively, for the Chinese group.

Discussion

Principal Findings

In a group of 216 older Asian American immigrant adult participants, we found significant differences in technology access, telehealth use, and psychosocial health impacts among the Chinese, Korean, and Vietnamese groups. In our CBPR cross-sectional survey study, we examined the readiness for a web-based senior center among older Asian American immigrant adults and specifically among Chinese, Korean, and Vietnamese groups. We also identified the psychosocial needs and effects of the COVID-19 pandemic that a web-based senior center could be positioned to meet.

Socioeconomic status is an important context when planning a web-based senior center because financial resources are often limited. It is important to avoid adding financial burden while trying to be intentional in providing web-based care and social services via mobile apps. In our study, most Chinese (38/86, 44%), Korean (39/54, 72%), and Vietnamese (25/53, 47%) older participants had an unlimited mobile data plan, followed by a small group that had a limited mobile data plan. Of those using limited plans, many (39/216, 18.1%) were unsure about their data limits. More than half of older Asian American immigrant adult participants (123/216, 56.9%), including older Chinese, Korean, and Vietnamese participants, reported <US $15,000 as total household income before taxes. According to an AHSC leader, staff has assisted many older Asian American immigrant clients and applied for an affordable internet plan during the COVID-19 pandemic.

Overall, more than half of the older Asian American immigrant adult participants (131/212, 61.8%), including older Chinese, Korean, and Vietnamese participants, reported using mobile phone texting for written communication, followed by approximately half of the participants (103/212, 48.6%) using email for written communication in our study. Both mobile phone texting and email can present challenges for older adults. Challenging intrinsic factors can affect the adoption of a web-based senior center. For example, having less dexterity, experiencing tremors or physical changes resulting from arthritis or stroke, not having confidence in using new apps or platforms, and not being interested in learning new ways to access social and health services are known barriers to using technology for health purposes [30-32]. Extrinsic barriers include limited to no access to digital communication devices for all older adults, not having trust in technology, belief that mobile phones are for communication rather than accessing health and social services, and cultural beliefs that technologies detract from family time [31] or may dismantle cultural expectations for children and grandchildren to care for their older family members as they age [17].

There is a gamut of available information and communication technology devices and apps, including written and audio or video. We found that only 2% (1/53) of the Vietnamese older participants started using a new electronic device to communicate with friends and family after the COVID-19 outbreak, followed by more than half of Korean older participants (31/54, 57%) and less than one-fifth of Chinese older participants (15/86, 17%). This may be owing to not knowing what is available, not knowing how to use the device, or the degree of comfort with use. Our findings differ from those of a study that focused on South Koreans, where researchers identified themes that included a reluctance to learn about and use new technology and ambivalence regarding using technology-enabled services for connection with family or acquaintances [10]. In our study, for written and audio or video communication apps, most older Chinese participants (65/85, 77%; 57/84, 68%, respectively) used WeChat, most Korean participants (49/54, 91%; 49/54, 91%, respectively) used KakaoTalk (this app was exclusively used by the Korean group), and most Vietnamese participants used Facebook Messenger for written communication (32/50, 64%) and Apple Face Time or Facebook Messenger for audio or video communication (33/50, 66%; 31/50, 62%, respectively). Our results suggest that there are differences among groups that must be considered by CBOs offering web-based care and social services. Different communities tend to use specific communication platforms and have preferences regarding the types of services that are acceptable when using web-based platforms. It is important to note that, early in the COVID-19 pandemic, there was no existing cross-cultural communication system that was free, quickly available, and easy for symptom monitoring of large, diverse populations [33]. For example, in China, WeChat is mostly well known and is among the frequently used, web-based, health service social media platforms [34]. Our community-academic partnership kept in mind that individual COVID-19 prevention and control apps, such as WeChat in China, were developed by adding to existing social apps with regard to the management of the COVID-19 outbreak [35]. KakaoTalk is a mobile instant messenger based in South Korea (ie, host country) and is the most popular and cross-platform

social media service in South Korea [36]. In our study, findings imply that cultural and country-based web-based communication platforms, such as WeChat and Kakao Talk, are important sustainable connections with diverse Asian immigrant groups [34-36] for sustainable accessibility [37]. Our study results suggest that culturally based CBOs serving diverse communities need to navigate community contexts, capacity, and operations and determine the capacity for providing sustainable cultural, linguistic, and health care services via web-based care. CBOs and researchers need to consider how to best use these platforms, given that personal health information may be a part of certain communications. Authenticity and intentionality will be needed regarding which web-based services are best suited for these various platforms.

Web-based care is different from in-person care. In our study, few older Asian American participants, including Chinese, Korean, and Vietnamese participants perceived themselves to be very technology savvy. Furthermore, most Vietnamese older participants (41/53, 77%) expressed that they would never consider trying a telehealth appointment. A few older Chinese and Korean participants expressed the same view. Thus, CBOs and researchers need to consider intentionally using multiple communication platforms; ones that each community group is already familiar with. This will likely improve sustainability because it will relieve community members from having to learn something new to access health and social services.

We made additional important contributions to the literature about what to consider regarding sustaining accessibility in telehealth. We found that more than half of older Asian American immigrant adults (121/212, 57.1%) worry about the quality of health care with web-based care and social services. Less than half (93/212, 43.9%) were not convinced that a diagnosis made via telehealth would result in an accurate diagnosis. For example, most Vietnamese among Asian American immigrants (28/53, 53%) had never used telehealth services and do not know how to start. These findings align with what CBOs have reported—that is, most older Asian American clients struggled to use web-based platforms and web-based programs and had limited technological literacy despite having compatible computers and platforms [6]. Of importance, according to older Chinese, Korean, and Vietnamese immigrants, the main advantage of telehealth was not needing transportation services. Implications from our study suggest that there is a need to further enhance older Asian American immigrant clients' readiness for a web-based senior center, and one way is to engage and collaborate with more clients in subsequent intervention design and training in technology and telehealth delivery. According to AHSC community partners, regarding their work with older Asian American immigrant adult clients, they expressed the importance to build trust over time. For example, there are clients who were more willing to share concerns after their staff built personal connections.

Regarding overall psychosocial health in our study, older Chinese immigrants had a reduced ability to concentrate or focus during the COVID-19 outbreak. Furthermore, older Chinese, Koreans, and Vietnamese engaged less in exercise and hobbies. According to a program manager at AHSC, many older Chinese clients enjoyed being at the center in person for physical activity (eg, Tai Chi and light aerobics) and hobbies (eg, singing, dancing, and social groups) before the outbreak. A few older Chinese participants expressed that they did not have a place to go to for physical activity or engaging in hobbies. Some chose to stay at home and away from crowds owing to infection precautions, and in particular, Chinese older adults wanted to avoid anti-Asian hate. AHSC community leaders examined anti-Asian hate more specifically in another initiative apart from what our community-academic partnership's CBPR research cross-sectional survey study aimed in this study. Our partnership remains cognizant that among the anti-Asian hate incidents was the use of the terms, China virus or Wuhan virus, which relates a virus with a race, ethnicity, or city instead of to the biological SARS-CoV-2 or COVID-19, and this does not align with the World Health Organization [37]. Researchers discovered profound discrimination and violence among Asian American populations; for example, Chinese and Vietnamese commonly experienced being yelled at and being given *dirty looks* for carrying the virus [3]. Our findings suggest that there may be a need for increased caregiving efforts; a need for caregiver support; and a need for increasing services for social, health, and financial stressors; however, the extent is different among groups. For example, most Vietnamese immigrants, followed by Chinese and Korean immigrants, experienced stress owing to maintaining social distancing, worry about SARS-CoV-2, and worry about infecting themselves and people. In another example, most Vietnamese immigrants, followed by Chinese and Korean immigrants, worry about not being able to afford or access food and important resources, such as transportation or housing; feel that the crisis created financial problems for them or their family; experienced difficulties in life and distress; and had a family/household member's salary, hours, or contracts significantly reduced. These results align with the findings by Quach et al [3] and Tiwari and Zhang [7]. CBOs should include psychosocial services in the web-based portfolio. Psychosocial services will likely need to be administered on different platforms to different community groups. Psychosocial services will need to be tailored to the specific needs of each community group because they would be different across groups.

To meet these needs and to support safety while offering the broadest possible access to care, CBOs may wish to consider rebuilding after the pandemic by adding web-based health and social services for older adults. To reduce barriers for clients, consideration should be given to the needs of specific cultural groups and the technology platforms already in use by each group. A CBO web-based senior center should be designed for use across multiple free platforms such as Facebook, WeChat, KakaoTalk, or any other platform used by a specific group that a CBO serves. An important component of intentional planning and design includes conducting a survey to discover which social media platforms the CBOs clientele is familiar with and which ones they trust. Delivering services across multiple platforms may add burden to CBOs, but it will improve access and acceptance of web-based programming, thus providing the opportunity to extend reach and support more older adults and their families.

Limitations and Future Studies

Although the timing of the survey limits this study in part owing to recall consideration, this is an important step. We conducted the survey in the second year of the COVID-19 pandemic, in 2022 [38]. Community-academic partners originally planned to implement the study starting in July of 2021, but this was not possible owing to concurrent Asian American immigrant community needs driven by the COVID-19 pandemic. We honored the need to pivot, so that AHSC could focus on addressing staffing, vaccinations, and other needs in response to the virus and the increasing anti-Asian hate. AHSC community leaders expressed that the ability to recall psychosocial impacts based on ratings from 1 to 10 may have influenced the ability for some older adult participants to differentiate between 2 numbers that are next to one another (eg, 5 vs 6). Often, in health technology studies focused on individuals of Asian descent, the research data of subgroups within the large Asian population are aggregated. We examined our study data as a large group of older Asian American immigrant adults and among Chinese, Korean, and Vietnamese participants. However, further studies are needed to examine at a large scale and longitudinally and to examine additional Asian subgroups, for example, Taiwanese and multiracial groups, as they may have different needs. The response rate and completion rate were high in our study, even though a small portion of clients declined to participate. Reasons for rejection included survey length and not having experience with technology or telehealth, and, according to AHSC leaders, some may have declined because of not having a need to use a technology to access health care or having had a bad experience with technology. Although the instruments that we adapted from the PhenX Toolkit [19] have not been formally tested and validated, we pretested them with community partners for face validity and technical functionality before use in this study. We recommend further studies for additional psychometric testing and continuing engagement of older Asian American immigrants in co-designing for adoption research and building upon a CBPR approach using both quantitative and qualitative methods. This may increase meaningful use and sustainability [9,13,39]. Further studies need to address continuing engagement of older immigrant clients in building and sustaining a senior center, completely web-based versus hybrid—combination of web-based and in-person services, and essential trust in web-based continuity of health care and social service. We also recommend further examination of technology accessibility, technology literacy, and complexity of interventions as barriers to or facilitators of uptake [40] and the ethics and utility of using different types of technologies in service and clinical care from the perceptions and experiences of older Asian American immigrant adults, CBO leaders, and health care providers.

Conclusions

Results from our community-academic partnership study inform the rebuilding of an efficacious web-based senior center, where more older Asian American immigrant adults who need can obtain access to the internet and education about using technology-enabled communication devices. Differences in psychosocial needs and the effects of the COVID-19 pandemic were reported among Chinese, Korean, and Vietnamese groups. The strength of the participating older adults was observed and honored. There is a need to engage clients and culturally diverse CBOs in technology access and telehealth as a part of bridging care. This includes uplifting the communication about clients' health and extending the reach of providing care remotely through distance learning and distance integrative health care and social service delivery. There are different psychosocial needs and effects of the COVID-19 pandemic that a web-based senior center could be positioned to meet. Consideration should be given to intragroup and intergroup needs across older Asian American immigrant adults such as among Chinese, Korean, and Vietnamese groups within the large older group. Our study results illuminate the conventional challenges in delivering health care since the COVID-19 pandemic and a pathway forward for improving care and advancing health equity for culturally diverse, older, Asian immigrants.

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Authors' Contributions

The following are individual contributions from authors who have contributed substantially to the work reported. CKYNT and RLF were the 2 senior authors for this study. CKYNT, RLF, and HL were involved in conceptualization. CKYNT, RLF, HL, C Chiu, C Chac, MP, and KW contributed to the methodology. KW dealt with the software. KW, CKYNT, C Chiu, C Chac, MP,

and RLF were involved in validation. KW and CKYNT were involved in formal analysis. CKYNT, KW, HL, C Chiu, C Chac, MP, and RLF contributed to analysis review. CKYNT, KW, HL, C Chiu, C Chac, MP, and RLF contributed to the investigation. CKYNT, HL, KW, C Chiu, C Chac, MP, and RLF dealt with the resources. KW and CKYNT were involved in data curation. CKYNT and KW contributed to the original draft preparation. CKYNT, KW, HL, C Chiu, C Chac, MP, and RLF were involved in reviewing and editing the draft. CKYNT and KW contributed to visualization. CKYNT, HL, and RLF were involved in supervision. CKYNT and HL were involved in project administration. CKYNT and RLF were involved in funding acquisition.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Combined consent; eligibility; and technology access, telehealth, and psychosocial health impacts survey—Microsoft Word document version.
[DOCX File , 224 KB - apinj_v8i1e49493_app1.docx]

Multimedia Appendix 2
Combined consent; eligibility; and technology access, telehealth, and psychosocial health impacts survey—PDF version.
[PDF File (Adobe PDF File), 410 KB - apinj_v8i1e49493_app2.pdf]

Multimedia Appendix 3
Sociodemographics and background characteristics of older Asian American immigrant adults and Chinese, Korean, and Vietnamese groups.
[PDF File (Adobe PDF File), 196 KB - apinj_v8i1e49493_app3.pdf]

Multimedia Appendix 4
Psychosocial needs of and effects of the COVID-19 pandemic on older Asian American immigrant adults and Chinese, Korean, and Vietnamese groups.
[PDF File (Adobe PDF File), 340 KB - apinj_v8i1e49493_app4.pdf]

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Abbreviations

AHSC: Asian Health & Service Center
CBO: community-based organization
CBPR: community-based participatory research
CHW: community health worker
PI: principal investigator
WSU: Washington State University

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Original Paper

Association Between Gestational Weeks, Initial Maternal Perception of Fetal Movement, and Individual Interoceptive Differences in Pregnant Women: Cross-Sectional Study

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Abstract

Background: Interoception encompasses the conscious awareness of homeostasis in the body. Given that fetal movement awareness is a component of interoception in pregnant women, the timing of initial detection of fetal movement may indicate individual differences in interoceptive sensitivity.

Objective: The aim of this study is to determine whether the association between the gestational week of initial movement awareness and interoception can be a convenient evaluation index for interoception in pregnant women.

Methods: A cross-sectional study was conducted among 32 pregnant women aged 20 years or older at 22-29 weeks of gestation with stable hemodynamics in the Obstetric Outpatient Department. Interoception was assessed using the heartbeat-counting task, with gestational weeks at the first awareness of fetal movement recorded via a questionnaire. Spearman rank correlation was used to compare the gestational weeks at the first awareness of fetal movement and heartbeat-counting task scores.

Results: A significant negative correlation was found between the gestational weeks at the first fetal movement awareness and heartbeat-counting task performance among all participants (r=–0.43, P=.01) and among primiparous women (r=–0.53, P=.03) but not among multiparous women.

Conclusions: Individual differences in interoception appear to correlate with the differences observed in the timing of the first awareness of fetal movement.

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KEYWORDS

fetal movement; gestational weeks; gestation; gestational; heartbeat counting task; interoception; pregnancy; pregnant; maternal; fetus; fetal; association; associations; correlation; correlations; obstetric; obstetrics; interoceptive; perception; perceptions; awareness; sense; sensing; senses; internal stimulus; internal stimuli

Introduction

A pregnant woman typically first senses fetal movement at approximately 18-20 weeks of gestation in primipara and approximately 16-18 weeks in multipara. However, there is variability in the gestational week when this awareness occurs, with some experiencing it earlier or later [1,2]. The factors contributing to these variations remain unknown. Interestingly, this awareness tends to occur at approximately 16 weeks or after 20 weeks of gestation. Fetal movements begin in the eighth week of pregnancy, initially subtle and imperceptible to pregnant women. In the absence of maternal or fetal complications, differences in fetal development up to 20 weeks of gestation are minimal [3]. Therefore, fetal development is unlikely to influence a pregnant woman's initial awareness of fetal movement.

Recently, interoception has attracted attention in the fields of psychosomatic medicine and psychology [4]. The term "interoception" was first coined by the British physiologist Sherrington [5] in 1906. It refers to awareness related to changes inside the body, such as the movement of the heart and internal organs, signifying a crucial aspect of overall bodily homeostasis [6]. However, the measurement of interoception is complicated by the need to use questionnaires or a heartbeat-counting task.

Considering that the awareness of fetal movement is considered a component of interoception in pregnant women, variations in the gestational weeks at which initial detection occurs may indicate individual interoceptive disparities. These deviations may lead to mental and physical illnesses, such as mood and metabolic disorders [7]. During pregnancy, mood disorders related to anxiety and depression often develop. However, there is no easy way to detect mental problems in pregnant women [8].

Therefore, establishing the correlation between the gestational week of first fetal movement awareness and interoception could serve as an evaluation index for interoception in pregnant women and may predict mental problems. However, to our knowledge, no previous study has examined the association between interoception and the gestational week at the first fetal movement awareness in pregnant women. Thus, in this study, we aimed to clarify this noteworthy association.

Methods

Study Design

A cross-sectional study was conducted among the recruited 32 pregnant women aged 20 years or older at 22-29 weeks of gestation with stable hemodynamics in the Obstetric Outpatient Department of Kyushu University Hospital. The study was conducted between July and September 2019. Mothers with obvious fetal morphological abnormalities or maternal complications were excluded from recruitment.

Procedure

The data sampling was conducted in a quiet outpatient private room to avoid outside noise, as described in the previous study [9]. First, a wearable heart rate sensor (WHS-1, Union Tool Co.) was attached to the left precordial area, and the participants were allowed to sit and rest for 5 minutes. Then, the heartbeat-counting task was conducted.

Clinical Characteristics

The pregnant women's health status and personal information (including age, gestational period in weeks, educational background, past and current medical history, obstetric history, height, weight, drinking status, smoking status, fertility treatment status, employment status, and financial status) were obtained from the medical records and questionnaires. BMI was calculated using the above data.

Measurement of Interoception

There are different methods for measuring interoception. In the heartbeat-tracking task [10], the participant is asked to press a button on the experimental device synchronous with their heartbeat. In the heartbeat discrimination task [11], the participant is asked to discriminate a sound that matches the heartbeat from a sound that deviates from the heartbeat. In the heartbeat-counting task [10], the number of heartbeats felt by the participant is compared with the actual number of heartbeats measured using an electrocardiogram (ECG) within a certain period. In this study, we used the heartbeat-counting task developed by Schandry [12] to measure interoception, which can be performed in an outpatient setting.

For the measurement procedure, the participants were asked to sit on a chair in the laboratory and were instructed not to touch their bodies to avoid obtaining cues by touching their pulse points. In this state, the participants were asked to count the number of times they felt a heartbeat at 3 intervals of 25, 35, and 45 seconds and to complete a preprepared form after each interval. The absolute value of the difference between the participants' reported heartbeats and the actual ECG-measured heartbeats during each interval was calculated. This absolute difference was divided by the actual number of heartbeats separately for each of the 3 intervals to obtain the ratio of deviation in heartbeats. This value was subtracted from 1, and the mean of all 3 intervals was calculated. This value was used as the heartbeat-counting task score. The heartbeat-counting task score ranged from 0 to 1. The closer the score was to 1, the more accurately the participant felt her heartbeat [4,12].

Statistical Analysis

Descriptive statistics were calculated, and the Mann-Whitney *U* and Kruskal-Wallis tests were used to compare the data between the groups. Spearman rank correlation was used to compare the gestational weeks at the first awareness of fetal movement and the heartbeat-counting task scores. All analyses were performed using SPSS (version 27; IBM Corp). The significance level was set at 5% or $P<.05$.

The sample size calculation was performed using G*Power 3.1.9.7 [13]. Assuming a 2-tailed test for the population correlation coefficient with an expected correlation coefficient of 0.5, a significance level of 5%, and a power of 80%, the required sample size was calculated to be 26 cases.

Ethical Considerations

The Ethics Committee of Kyushu University Hospital (No. 22071-00) approved this study, and all participants provided written informed consent. All the research procedures were conducted following the tenets of the Declaration of Helsinki.

Information on the participants and the data used in this study were collected from a previous report [9], which showed an association between interoception and anxiety. Additionally, data regarding the gestational week at the first awareness of fetal movements in pregnant women were added. Permission was obtained from the authors of the previous study.

Results

Among the 32 participants, the mean gestational week at the first fetal movement awareness was 18.3 (SD 2.6). Table 1 compares the gestational weeks at the first fetal movement awareness based on the participants' characteristics. There were

no significant differences in the gestational weeks of the first fetal movement based on participant characteristics (all $P>.05$).

A significant negative correlation ($r=–0.43$, $P=.01$) was found between the gestational weeks at the first fetal movement awareness and heartbeat-counting task performance among all the participants (Figure 1A).

In primiparous women, a significant negative correlation ($r=–0.53$, $P=.03$) was found between the gestational weeks at initial fetal movement awareness and the heartbeat-counting task performance (Figure 1B). However, for multiparous women, there was no significant association between the gestational weeks at initial fetal movement awareness and heartbeat-counting task performance ($r=–0.35$, $P=.18$; Figure 1C).

Table 1. Participant characteristics and gestational weeks at the first awareness of fetal movement (N=32).

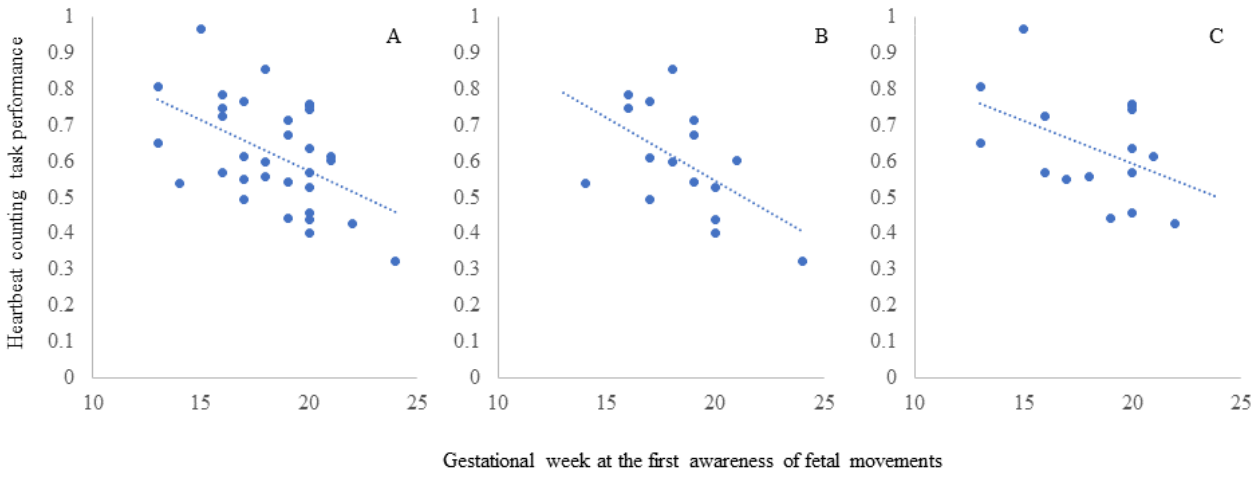
Characteristics	Participant, n (%)	GWs[a] at the first awareness of FM[b], mean (SD)	*P* value
Mother's age (years)			.39
<35	21 (65.6)	18.5 (2.8)	
≥35	11 (34.4)	17.8 (2.2)	
Parity			.32
Primipara	16 (50)	18.4 (2.4)	
Multipara	16 (50)	18.1 (2.8)	
BMI			.44[c]
<18.5	4 (12.5)	17.5 (3.0)	
18.5-25	24 (75)	18.1 (2.4)	
≥25	4 (12.5)	20.3 (2.6)	
Fertility treatment during this pregnancy			.55
No	24 (75)	18.1 (2.8)	
Yes	8 (25)	18.9 (1.7)	
Employment status			.74
Working	18 (56.3)	18.2 (2.9)	
Not working	14 (43.8)	18.4 (2.2)	
Smoking			.14
Previously smoked	3 (9)	20.0 (0.0)	
No smoking	29 (91)	18.1 (2.6)	

[a]GW: gestational week.

[b]FM: fetal movement.

[c]Kruskal-Wallis test.

Figure 1. Correlation between the gestational weeks at the first fetal movement awareness and heartbeat-counting task performance: (A) all participants, (B) primiparous women, and (C) multiparous women.



Discussion

Principal Findings

We found a significant association between the gestational week at initial fetal movement awareness and performance on the heartbeat-counting task. In terms of parity, the association between the gestational week at the first awareness of fetal movement and heartbeat-counting task performance was found in primiparous women but not in multiparous women. Although the reasons for the individual differences in fetal movement awareness remain unclear, our results indicate a link between these differences and individual variations in interoception.

The average number of weeks at which fetal movement was first detected in the participants of this study was 18.3 weeks. *Williams Obstetrics* estimated it to be around 18-20 weeks for primiparous women and around 16-18 weeks for multiparous women [1]. Other studies reported that most pregnant women experience the onset of fetal movement at 16-20 weeks [2,14,15]. Therefore, we posit that the number of weeks at which fetal movements are first noticed in the participants of this study is approximately the same as the average number of weeks.

Primiparous women have difficulty distinguishing fetal movements from stomach and bowel movements, as fetal movements represent an unfamiliar sensation to them [14,15]. Regarding awareness of fetal movements, Tuffnell et al [16] stated that awareness of fetal movements is caused by pressure on the pregnant woman's body wall structure. Interoceptive sensations are sensations related to the internal environment of the body and its changes, such as the heartbeat, and internal organs, such as the stomach and intestines. Pressure on body wall structures is also a part of interoceptive sensation. Furthermore, the accuracy of interoceptive sensation is a value that objectively measures how accurately a person can grasp the internal situation through the senses [17]. Therefore, it is thought that the more accurately a person can detect fetal movements, the more accurate is their interoceptive sense.

Few studies have explored interoception in pregnant women, highlighting the need for further investigation in this area. Furthermore, as it has been reported that deviations in interoception may lead to mental and physical illnesses, such as mood and metabolic disorders [6], it is necessary to examine whether the gestational week at initial fetal movement awareness correlates with maternal mental characteristics and challenges during the peri- and postnatal periods.

Limitations

The generalizability of this study's findings may be limited when restricted to primiparous or multiparous women because of the small sample size. Moreover, the method used, which relied on pregnant women recalling and describing the gestational week of their first fetal movement experience, introduces the possibility of recall bias, which cannot be excluded.

Conclusions

Individual differences in interoception are related to individual differences in the first awareness of fetal movement and can be a crucial evaluation index for interoception in pregnant women.

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Authors' Contributions

MF, Y Suetsugu, and SM were involved in the conception and design of the study. MF, MN, and Y Sato acquired, analyzed, and interpreted the data. MF, Y Sato, and SM drafted and revised the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

None declared.

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Abbreviations

ECG: electrocardiogram

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Ethical Dilemmas Among Oncology Nurses in China: Cross-Sectional Study

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Abstract

Background: Effective communication about cancer prognosis is imperative for enhancing the quality of end-of-life care and improving patient well-being. This practice is sensitive and is heavily influenced by cultural values, beliefs, and norms, which can lead to ethical dilemmas. Despite their significance, ethical challenges in nursing related to prognosis communication are understudied in China.

Objective: This study aimed to examine the ethical dilemmas relating to cancer prognosis communication and their associated factors.

Methods: A cross-sectional design was employed to survey 373 oncology nurses in mainland China. Data were collected on ethical dilemmas, attitudes, barriers, experiences with prognosis communication, sociodemographics, and practice-related information. Ordinary least squares regressions were used to identify factors contributing to ethical dilemmas.

Results: Participants reported a moderate level of ethical dilemmas in prognostic communication (mean 13.5, SD 3.42; range 5 - 20). Significant predictors of these dilemmas included perceived barriers (P<.001), experiences with prognosis communication (P<.001), and years of work experience (P=.002). Nurses who perceived greater communication barriers, had more negative experiences with prognosis communication, and had less work experience were more likely to encounter ethical dilemmas in prognosis-related communication.

Conclusions: Chinese oncology nurses frequently encounter ethical dilemmas, as well as barriers, in communicating cancer prognoses. This study's findings emphasize the importance of culturally tailored communication training. Collaborative interprofessional training, particularly through physician-nurse partnerships, can perhaps enhance the proficiency of cancer prognosis-related communication.

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KEYWORDS

prognosis-related communication; ethical dilemmas; oncology; ethics; China; beliefs; nursing; cultural values; prognosis

Introduction

Background

Prognosis-related communication, also known as truth-telling or breaking bad news, is a continuous process that encompasses discussing life expectancy, symptom progression, and functional abilities with patients, their families, and health care professionals [1]. Effective discussion about a prognosis facilitates informed decisions for patients and enhances patient-reported outcomes [2]. Despite the expectation that prognosis communication should be a standard practice and a universal communication ideal in health care, health care professionals, including nurses, experience discomfort and concerns in breaking bad news. Health care professionals are concerned about providing prognostic information that could contribute to emotional distress in patients and families. This raises questions about their professional roles in alleviating suffering and concerns about the potential impact on relationships [3].

Insufficient training, unclear nursing roles, inadequate communication skills, time constraints, and concerns about diminishing the patient's hope [4-6] can impact prognosis communication. Interpersonal factors such as the patient's and family's lack of support, the family's request to withhold

information from their loved one, and lack of communication from physicians can influence this process [7,8]. Nurses often face ethical dilemmas when there is a disparity between their professional duties and the complex circumstances surrounding family beliefs and cultural norms, making it extremely difficult to proceed [7,9]. Such conflicts can yield negative consequences, including increased burdens, moral distress, emotional burnout, anxiety, and guilt [7,10].

Practices in prognosis disclosure vary by country and cultural groups, influenced by unique cultural beliefs and values [11-13]. In Western cultures, informing patients about their cancer diagnosis and prognosis is deemed vital for promoting patient autonomy and is routinely integrated into palliative care. However, in Eastern countries like China, individual autonomy is often considered secondary to family-centered decision-making [11,14]. Cultural values that prioritize family-centeredness lead health care professionals to defer disclosure of the prognosis to the family, who then decide whether to inform the patient [15]. It is common for families to withhold prognostic information to protect patients from emotional distress [15]. In addition, death and dying are taboo subjects, making it challenging for health care professionals to facilitate timely and effective prognosis-related communication due to concerns about potential adverse outcomes such as emotional distress, diminished hope, and acceleration of the dying process [12,16].

In countries where honest disclosure is not well recognized, health care professionals' challenges and conflicts are greater. Chinese nurses often experience a conflict between personal dimensions influenced by traditional cultural norms versus professional dimensions of adhering to nursing values and principles [12]. Withholding end-of-life (EOL) communication from patients and relying solely on family members for EOL decision-making raises concerns, as families may not fully understand the patient's prognosis or their EOL wishes [15,17]. Recent studies indicate that the majority of cancer patients in China want to be informed of their prognosis [8,18,19]. For example, a meta-analysis of studies in China revealed that 81.8% of patients with cancer, compared to 32.4% of the family, prefer being informed of the prognosis, but only 19.9% of patients are actually informed [8,15]. Although health care professionals aim to maintain hope through nondisclosure, they experience conflicts in balancing hope preservation with truth-telling [16]. The disparities between the professional duty to uphold patient autonomy and the cultural and traditional norms that define what is beneficial for patients give rise to ethical dilemmas and moral distress among health care professionals [17,20].

Aim of the Study

In China, there were 4,546,400 new cancer cases and 2,992,600 cancer deaths in 2020, accounting for 25.1% and 30.2% of global incidences, respectively [21]. Despite the increasing rates of cancer diagnosis and mortality and the significant implications for nursing, there is limited knowledge about the ethical dilemmas and other factors related to prognostic communication among oncology nurses in China. Although several studies in China have examined the complexities of prognosis communication within a sociocultural context, most focus on the nurses' attitudes and preferences for diagnosis or prognostic disclosure [22-24]. Addressing ethical dilemmas in nursing practice is imperative for upholding patient advocacy, promoting patient-centered care, navigating complex moral issues, and maintaining professional integrity and accountability. This study aims to explore the ethical dilemmas in prognosis-related communication among Chinese oncology nurses and to identify their influencing factors.

Methods

Study Design and Sample

This study employed a cross-sectional design using a web-based survey conducted with oncology nurses. Convenience sampling was used to recruit participants from 4 hospitals in Wuhan City, Hubei Province, mainland China. The 4 hospitals were tertiary hospitals, which are designated based on a 3-tiered system (primary, secondary, and tertiary). A tertiary hospital has more than 500 beds, offers specialized health care services, and plays a significant role in medical education and research. The inclusion criteria were registered nurses currently practicing in oncology units and working with patients with advanced cancer. The exclusion criteria included nurses with less than 1 year of practice in oncology, intern nurses, rotating nurses, and those working in pediatric oncology.

Data Collection and Procedure

Our research team contacted nursing directors at 4 hospitals with oncology units in Wuhan and explained the purpose and procedures of the study. The nursing directors and the head nurse distributed the web-based survey to the oncology department's WeChat (Tencent) group, inviting all oncology nurses to participate. The survey was administered from September 17, 2018, to October 24, 2019. A total of 410 eligible nurses enrolled in the study, but 37 did not fully complete the survey, resulting in a final sample of 373 participants.

Ethical Considerations

This study was approved by the Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology, IEC(S198), and all procedures followed ethics standards. Before taking the survey, nurses were informed about the study's purpose, risks and benefits, and their right to withdraw, and then they provided consent to participate the study. Surveys were anonymous and the data were kept confidential. No compensation was given to the study participants.

Measures

Overview of Measures

We developed measures by adapting items from a questionnaire used in previous studies [25,26]. The questionnaire was translated from English to Chinese and back translated to English by different postdoctoral staff independently to avoid bias. Some wordings and phrases were modified to enhance clarity in translation. Discrepancies were resolved with the help of a bilingual nursing faculty member. The content of the survey was validated by an expert panel consisting of 2 administrators with nursing backgrounds, 2 head nurses from an oncology

department, and 2 oncologists with extensive knowledge and clinical experience in the study topic. These experts evaluated the clarity and relevance of the survey's components for the study population and verified the translation of the survey. Their feedback was integrated to refine the items and translation. The translated questionnaire was pilot-tested with 25 oncology nurses to make further improvements. Item responses were summed to calculate 4 composite (scale) scores: dilemmas, communication experiences, attitudes, and barriers.

Dilemmas in Prognosis-Related Communication

This scale (4 items) assessed experiences with dilemmas in prognosis-related communication such as discomfort with discussions and social and cultural conflicts. Responses were rated on a 5-point Likert scale (1=never/almost never; 5=always/almost always). The total scores for ethical dilemmas ranged from 4 to 20, with higher scores indicating more dilemmas. The Cronbach α for this scale was 0.82.

Prognosis-Related Communication Experiences

This scale (3 items) measured experiences involving (1) patients not wanting their family members to be informed of their diagnosis, (2) family members or relatives requesting that patients not be told bad news, and (3) nurses not being encouraged to participate in prognosis-related communication. Responses were rated on a 5-point scale (1=never; 5=always/almost always). The total scores ranged from 3 to 15, with higher scores indicating more negative experiences in prognosis-related communication. The Cronbach α for this scale was 0.70.

Attitudes Toward Prognosis-Related Communication

This scale (6 items) measured attitudes toward engaging in prognosis communication using a 4-point scale (1=strongly disagree; 4=strongly agree). Sample items were "patients can make timely decisions about their treatment if they understand their prognosis" and "answering questions about prognosis-related information is within the scope of nursing practice." The total scores ranged from 6 to 24, with higher scores indicating more positive attitudes. The Cronbach α for attitudes was 0.87.

Barriers to Prognosis-Related Communication

This scale (4 items) assessed perceived barriers to engage in prognosis communication, such as role uncertainty, lack of time, and fear of diminishing hope. Responses were rated on a 4-point scale (1=strongly disagree; 4=strongly agree), with higher scores indicating greater barriers. The total scores ranged from 4 to 16. Higher scores indicate greater levels of barriers in communicating prognosis. The Cronbach α for barriers was 0.80.

Prognosis-related practice questions included: (1) preference for disclosing prognosis (yes/no), (2) the person responsible for disclosing prognosis (physician, family, nurse, or other), and (3) the extent of previous prognostic information disclosure to patients and family (fully, partially, or avoid of disclosure). Lastly, sociodemographic and practice-related questions included age, sex, marital status, education level, years of oncology nursing experience, and formal training on prognosis communication (1=none/almost none; 4=a lot).

Data Analysis

Descriptive statistics were used to demonstrate the distributions of participants' sociodemographic characteristics and other study variables. For continuous variables, mean and SD were calculated, while for categorical variables, the count and frequency were reported. To identify factors associated with increased or decreased dilemmas when engaging in prognosis communication (outcome variable), an ordinary least squares regression was performed. Predictors included attitudes, barriers, and experiences in prognosis-related communication. This analysis controlled for several covariates, including participants' age, sex, marital status, and education level to ensure an unbiased assessment of each predictor's independent impact on the dependent variable—dilemmas in prognosis communication. All analyses were conducted using SPSS 23.0 (IBM Corp), and statistical significance was determined at an α level of .05.

Results

Sociodemographic and Practice-Related Characteristics

Table 1 presents the sociodemographic information about the study sample. The median age of the participants was 30 (IQR 28 - 33) years. The majority were female (352/373, 94.4%), married (274/373, 73.5%), and had a bachelor's degree (219/373, 58.7%). The median years of working as an oncology nurse was 5 (IQR 3 - 8) years, with 65.6% (238/373) reporting that they had received little or no formal training in prognosis communication.

Table . Participant demographic and practice-related data.

Characteristics	Participants (n=373)
Age (years), median (IQR)	30 (28 - 33)
Sex, n (%)	
Female	352 (94.4)
Male	21 (5.6)
Education, n (%)	
Secondary specialized school of nursing	50 (13.4)
Junior college nursing degree	97 (26)
Bachelor's degree	219 (58.7)
Master's/PhD[a] degree	7 (1.9)
Marital status, n (%)	
Married	274 (73.5)
Separated/divorced	19 (5.1)
Widowed	4 (1.1)
Never married	76 (20.4)
Years working as an oncology nurse, median (IQR)	5 (3 - 8)
Formal training for prognosis-related communication, n (%)[b]	
None/almost none	77 (21.2)
Little bit	161 (44.4)
Moderate	90 (24.8)
A lot	35 (9.6)

[a]PhD: doctoral degree in nursing.

[b]n (%) is based on 363 respondents due to missing values.

Regarding prognosis-related practice, 51.1% (228/373) of the participants believed that physicians should be responsible for delivering prognostic information, compared to 10.2% (38/373) who believed nurses should take on this role (see Table 2). Approximately 86.9% (324/373) of the participants engaged in prognosis communication, providing either full or partial disclosure to patients or their families. Only 20.1% (75/373) of the participants reported providing full disclosure to patients, 50.1% (187/373) provided partial disclosure, and 29.8% (111/373) avoided disclosure. In contrast, 43.7% (163/373) of the participants reported providing full disclosure to patients' families, while 37.3% (139/373) provided partial disclosure.

Table . Prognosis-related practice.

Variables	Participants (n=373)
When patients have a poor prognosis, should this be disclosed to the patient? n (%)	
Yes	254 (68.1)
No	119 (31.9)
Who should inform about the prognosis? n (%)	
Physician in charge	228 (51.1)
Family member	90 (24.1)
Nurse in charge	38 (10.2)
Other	17 (4.6)
Prognosis communication to patients, n (%)	
Fully informed patients	75 (20.1)
Provided only partial information	187 (50.1)
Avoided informing prognosis/never disclosed prognosis to patients	111 (29.8)
Prognosis communication to families, n (%)	
Fully informed families	163 (43.7)
Provided only partial information	139 (37.3)
Avoided informing prognosis/never discussed prognosis to the families	71 (19)

Ethical Dilemmas, Experiences, Attitudes, and Barriers Toward Prognosis-Related Communication

Table 3 presents study measures and response distributions regarding dilemmas and experiences with prognosis-related communication. In regard to ethical dilemmas, the most frequently reported items included participants reporting that they always or often felt pressure not to provide information due to a concern of contradicting what doctors said (180/373, 48.3%) and that social custom and cultural barriers prevent them from sharing prognostic information (167/373, 44.8%). Oncology nurses in our study reported that they experienced a relatively moderate level of ethical dilemmas in prognosis communication (mean 13.5, SD 3.43; range 5 - 20). For prognosis-related communication experiences, 71% (265/373) of the participants reported that families always or often requested withholding communication from patients, and 53.4% (199/373) indicated that nurses were always or often not encouraged to participate in prognosis communication. The mean score of prognosis-related communication experiences was 10.64 (SD 2.49).

Table . Study measures (dilemmas and experiences with prognosis-related communication) and response distributions (n=373).

Items	Never/ almost never	Rarely	Sometimes	Often	Always/almost always
Dilemmas in prognosis-related communication, n (%)					
Feel pressure to not provide information about prognosis to patients to avoid contradicting what the doctors have said	16 (4.3)	49 (13.1)	128 (34.3)	110 (29.5)	70 (18.8)
Avoid talking with patients about prognosis-related information due to the discomfort in giving bad news	19 (5.1)	49 (13.1)	149 (39.9)	95 (25.5)	61 (16.4)
Social customs/cultural barriers prevent you from sharing prognosis-related information	17 (4.6)	50 (13.4)	139 (37.3)	105 (28.2)	62 (16.6)
Ethically conflicted when patients or family ask about prognosis-related communication	19 (5.1)	59 (15.8)	148 (39.7)	85 (22.8)	62 (16.6)
Prognosis-related communication experiences, n (%)					
Patients do not want their family members to be told of their prognosis	22 (5.9)	72 (19.3)	118 (31.6)	106 (28.4)	55 (14.7)
Families/relatives request that the patient is not told bad news	8 (2.1)	26 (7.0)	74 (19.8)	171 (45.8)	94 (25.2)
Nurses are not encouraged to be involved in breaking bad news in my area	27 (7.2)	57 (15.3)	90 (24.1)	130 (34.9)	69 (18.5)

Table 4 presents study measures and response distributions regarding attitudes toward and barriers to prognosis-related communication. In terms of attitudes, the majority of participants were positive toward prognosis-related communication. For example, the majority agreed or strongly agreed that oncology nurses were responsible for helping patients prepare for their EOL care (330/373, 88.5%) and that prognosis communication can help patients make a timely decision about their treatments (328/373, 87.9%). The mean score for attitudes toward prognosis-related communication was 18.84 (SD 3.65). In regard to barriers for prognosis-related communication, the items that the participants mostly agreed or strongly agreed with included worries about taking away patients' hope (317/373, 85%), followed by feeling uncertain about their roles (309/373, 82.8%). The overall mean barrier score was 12.0 (SD 2.50).

Table . Study measures (attitudes toward and barriers to prognosis-related communication) and response distributions (n=373).

Items	Strongly disagree	Disagree	Agree	Strongly agree
Attitudes toward prognosis-related communication, n (%)				
Patients can make timely decisions about their treatments if they understand their prognosis.	10 (2.7)	35 (9.4)	158 (42.4)	170 (45.6)
Patients can make timely decisions about hospice enrollment if they understand their prognosis.	24 (6.4)	24 (6.4)	159 (42.6)	166 (44.5)
I feel it is my responsibility to initiate a discussion with physicians about a patient's prognosis if the patient has questions about his or her prognosis.	13 (3.5)	43 (11.5)	213 (57.1)	104 (27.9)
I feel that oncology nurses have a responsibility to help patients prepare for their end of life.	21 (5.6)	22 (5.9)	154 (41.3)	176 (47.2)
I am willing to initiate a discussion with patients regarding prognosis-related information.	22 (5.9)	57 (15.3)	193 (51.7)	101 (27.1)
I feel that answering questions about prognosis-related information is within the scope of nursing practice.	25 (6.6)	77 (20.6)	187 (50.1)	84 (22.5)
Barriers to prognosis-related communication, n (%)				
Uncertainty about my role in communicating prognosis-related information is a major barrier to helping patients and families understand their prognosis	22 (5.9)	42 (11.3)	219 (58.7)	90 (24.1)
Lack of time is a major barrier to discussing prognosis-related information with patients and families.	17 (4.6)	72 (19.3)	173 (46.4)	111 (29.8)
Fear of taking away patients' hope is a major barrier to discussing prognosis-related information with patients and families.	15 (4)	41 (11)	199 (53.4)	118 (31.6)
Physician discomfort with giving bad news is a major barrier to helping patients and families understand their prognosis.	18 (4.8)	102 (27.3)	174 (46.6)	79 (21.2)

Factors Impacting Ethical Dilemmas in Prognosis-Related Communication

Table 5 summarizes the results of the ordinary least squares regression analysis. Previous experience with prognosis communication (β=0.46; *P*<.001), perceived barriers (β=0.40; *P*<.001), and years of work experience (β=–0.14; *P*=.002) were significant predictors of experiencing ethical dilemmas when engaging in prognosis-related communication. These findings suggest that participants who had more negative experiences or perceived more barriers to prognosis communication encountered more dilemmas. Participants with fewer years of experience as oncology nurses were more likely to experience a dilemma. All other variables, including attitudes, formal training, and demographic covariates did not significantly predict dilemmas in prognosis-related communication. This model explained a substantial portion of the variance in ethical

dilemmas in prognosis communication (R=0.79; R^2=0.62; adjusted R^2=0.61; $F_{9,353}$=63.13; P<.001).

Table . Predictors for dilemmas in prognosis-related communication (N=373).

Predictor	b^a	SE	β^b (95% CI)	P value
Barriers	0.55	0.07	0.40 (0.41-0.69)	<.001
Experiences with prognosis communication	0.62	0.06	0.46 (0.50-0.73)	<.001
Attitudes	–0.02	0.05	–0.02 (–0.12 to 0.07)	.66
Marital status	–0.10	0.07	–0.05 (–0.25 to 0.05)	.18
Age	0.04	0.03	0.05 (–0.03 to 0.10)	.23
Sex	–0.80	0.50	–0.05 (–1.80 to 0.19)	.11
Level of education	–0.27	0.17	–0.06 (–0.60 to 0.06)	.10
Years of working as an oncology nurse	–0.11	0.03	–0.14 (–0.18 to –0.04)	.002
Formal training	–0.20	0.13	–0.05 (–0.45 to 0.06)	.13

[a]Regression coefficient.

[b]Standardized regression coefficient.

Discussion

Prognosis-Related Practice

Our study suggests that prognosis disclosure is not a simple dichotomy of telling versus not telling, but rather it varies by the degree of information provided. In this study, about 89% (332/373) of the participants reported either fully or partially engaging in prognosis communication with patients or their families, which is higher than a previous study in Taiwan where about 71% of nurses reported doing so [27], but it is lower than another study in China where 97.2% of oncology nurses engaged in truth-telling [28]. However, consistent with a previous study [8], our study revealed that full disclosure of a prognosis was more frequently given to families (163/373, 43.7%) rather than to patients (75/373, 20.1%). Disclosure of a patient's prognosis to the family before the patient may be intended to protect the patient from the potential harm associated with receiving negative news [29]. Although the frequency of full prognosis disclosure to families was twice the frequency of disclosure to patients, only 43.7% (163/373) of participants fully informed the family about the patient's prognosis. Further analysis revealed that 21.5% (80/373) of the participants provided only partial information to both patients and family members, while 11% (41/373) avoided engaging in prognostic discussions with either group. This hesitation may stem from various factors, including personal discomfort, lack of training, and institutional policies or protocols that affect information delivery [30]. Future studies exploring the reasons behind the varying degrees of prognosis disclosure would be valuable.

Ethical Dilemmas in Prognosis-Related Communication

Oncology nurses in our study experienced a relatively moderate level of ethical dilemmas in cancer prognosis-related communication. Ethical dilemmas in health care arise from various factors, including the influence of sociocultural values and traditions on professional practice, as well as personal attitudes [12,31]. In China, it is traditional for physicians to take primary responsibility for informing patients and their families of the diagnosis and prognosis, which may cause nurses to hesitate when it comes to challenging authority or stepping beyond their professional roles. Nurses may also fear providing inaccurate information without a complete understanding of the patient's prognosis. Furthermore, sociocultural values rooted in Confucianism, which emphasize protecting patients, maintaining family harmony, and prioritizing family-centeredness, can create conflicts for health care professionals in promoting patient-informed decision-making [16,17]. This may lead to situations where patient autonomy is compromised to honor cultural and social traditions and expectations.

Predictors of Ethical Dilemmas in Prognosis-Related Communication

One significant predictor for ethical dilemmas about prognostic communication was the perceived barriers to communication. Nurses who perceived a greater level of barriers were more likely to experience dilemmas. This finding aligns with previous studies indicating that health care professionals' discomfort and the burden of breaking bad news stem from their concerns about patients' inability to cope and relational distress [3]. Our study participants' uncertainty about their role might stem from the hierarchy in the health care system in China, where physicians are traditionally expected to lead discussions about prognosis [15,27]. Nevertheless, conflicting informed consent laws and regulations in China, which emphasize a patient's right to know but discourage health care professionals from truth-telling if it could cause adverse events, create fear of lawsuits and conflict with the family [16]. Consequently, the discomfort and lack of engagement among health care professionals in communicating a prognosis may impose additional burdens and challenges on nurses when patients or family members seek information.

Another significant predictor of dilemmas surrounding prognosis-related communication was the nurses' experience

with prognosis communication. Negative experiences, such as families requesting that the prognosis be withheld from patients, were positively associated with experiencing dilemmas. Previous studies also supported that family requests to withhold prognosis information hinder health care professionals' disclosure of this information to patients [8,14,20]. However, deciding whether to disclose a prognosis is complex, requiring a balance between the patient's wishes and family's concerns. Family members' preferences might not align with the patient's preferences, creating conflicts with health care professionals. Health care professionals' assessment of both patients' and families' prognostic information preference is important to reduce conflicts associated with their discordant views [32]. Regardless, family is an important source of support and patients value positive relationships with their family members. Hence, integrating family into palliative and EOL care is important [14].

In addition, engaging the entire health care team in the communication process and decision-making serves as a collective approach to address ethical dilemmas [10]. Physicians are primarily tasked with delivering unfavorable news yet often evade this duty due to personal discomfort, concerns regarding patients' psychological well-being, time constraints, and inadequate communication training [17,28]. This perhaps compels nurses to feel responsible for filling the informational voids. A recent study with oncology nurses in China highlighted the benefits of an interdisciplinary approach, especially collaborations between physicians and nurses, such as sharing patient information [28]. An interprofessional approach to prognosis communication can effectively empower nurses to communicate truthfully and foster enhanced collaboration with physicians.

The number of years of employment as an oncology nurse was another significant factor associated with experiencing dilemmas surrounding prognosis-related communication. Previous studies have shown that years of nursing experience has a significant association with communication [33] and confidence in palliative and EOL care [34]. Oncology nurses with limited experience encountered uncertainty when addressing prognosis-related inquiries, which engendered apprehension about inadvertently imparting inaccurate information to the patients [35]. Conversely, oncology nurses with extensive experience are likely to have developed advanced communication skills, attributed to their heightened exposure to patients with advanced cancer. Therefore, involving experienced nurses in communication training might be beneficial. Previous studies with Chinese nurses indicated a lack of education in death, dying, and palliative and EOL care [12,30]. Although formal communication training increases health care professionals' engagement in disclosing a diagnosis and prognosis [36], it was not statistically significant in our study. This may be due to the lack of an established formal curriculum on prognosis communication, particularly culturally tailored and adapted skill training in which health care professionals, regardless of receiving formal training, may still be unsure about how to facilitate such challenging communications. In addition, the relatively young age of the study participants suggests that they may switch to other types of nursing units over the course of their careers. Therefore, providing recurring training opportunities led by experienced nurses could help improve communication skills and better equip them to address dilemmas related to challenging topics like prognosis communication.

Nurse communication training is still relatively new, and few training programs provide comprehensive skill training for palliative care. One example is the COMFORT (Connect, Options, Making Meaning, Family Caregivers, Openings, Relating, Team) framework, which outlines communication pathways for palliative care [37,38]. COMFORT incorporates communication theory into clinical research, providing a solid framework for palliative nursing communication with patients and families. Its "train-the-trainer" model has been found to improve nurses' attitudes, comfort levels, perceived self-efficacy, and confidence in engaging in challenging topics with family caregivers [37]. Despite its promising approach, it is crucial to culturally tailor its components for successful adoption. Health care organizations should adapt the curriculum to meet the unique needs and expectations of oncology nurses while accounting for Chinese cultural nuances.

Limitations and Future Studies

This study has several limitations that need to be acknowledged. This study included only 4 hospitals in Wuhan, China, which may limit the generalizability of the findings to oncology nurses in other provinces. Different provinces may have varying regulations and protocols regarding prognosis-related communication. In addition, the 4 hospitals where participants were recruited were tertiary hospitals, which may lead to different experiences for nurses compared to those working in primary or secondary hospitals or smaller regional hospitals. Future studies expanding study sites to include hospitals of different levels can broaden our understanding of this topic. Additionally, the psychometric properties of the measures used in this study were not empirically confirmed. Hence, future research is needed to develop reliable and valid measures.

Conclusion

Communicating a cancer prognosis is a complex process, and ethical dilemmas that nurses encounter need to be understood within their social and cultural contexts. Strategies to address ethical dilemmas require ongoing training and interdisciplinary collaboration. Communication training tailored to specific cultural contexts is indispensable within health care settings. Without uniform or unified policies, gaps and dilemmas in practice inevitably arise, potentially compromising patient care. Given the diverse preferences of patients and their families, communication about prognosis must be individualized and sensitive to their unique needs and backgrounds. Effective communication about cancer prognosis requires a collaborative effort centered around the patient. By harnessing their expertise and using tools that guide the understanding of patient preferences, health care professionals can ensure that discussions are informative, respectful, and supportive. Ultimately, emphasizing teamwork and ethical awareness enhances the quality of prognosis discussions and promotes the well-being of both patients and providers.

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Conflicts of Interest

None declared.

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Abbreviations

COMFORT: Connect, Options, Making meaning, Family caregivers, Openings, Relating, Team
EOL: end-of-life

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Original Paper

Exploring Nursing Research Culture in Clinical Practice: Qualitative Ethnographic Study

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Abstract

Background: Cultivating a positive research culture is considered the key to facilitating the utilization of research findings. In the realm of clinical nursing research, nurses conducting research may find the utilization of findings challenging due to the lack of a positive research culture.

Objective: This study aims to identify and describe the sociocultural context of nursing research in a clinical setting at a Korean tertiary hospital.

Methods: We included participant observation and ethnographic interviews with 6 registered nurses working in a medical-surgical unit in a Korean tertiary hospital who had experience conducting nursing research in clinical settings in this qualitative ethnographic study. The study was conducted from April 2022 to May 2022. Data analysis was conducted using Spradley's ethnographic approach, which includes domain analysis, taxonomic analysis, componential analysis, and theme analysis, and occurred concurrently with data collection.

Results: The overarching theme identified for nursing research culture in clinical practice was the development of a driving force for growth within the clinical environment. This theme encompasses (1) balancing positive and negative influences in the research process, (2) fostering transformational change for both nurses and patients, and (3) promoting complementary communication among nurses.

Conclusions: Clinical research plays a vital role in nursing practice that requires a balance of supportive elements, such as patient-driven research questions and hospital research support, with practical challenges such as shift work and high work intensity. This study found that a positive clinical nursing research culture can serve as a unifying bridge, connecting researchers, patients, who serve as both the origin and ultimate beneficiaries of research, and hospitals that facilitate research endeavors. Future research should explore whether the themes derived from this study fully reflect a clinical nursing research culture comprising patients, nurses, and the hospital environment and determine what requirements are needed to establish such a nursing research culture.

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KEYWORDS

clinical nursing research; ethnography; evidence-based nursing; nursing research; qualitative research

Introduction

Overview

Nurses are increasingly expected to understand and actively participate in research endeavors and to use emerging research evidence as a foundation for their professional practice [1]. This expectation is highlighted by the International Code of Ethics for Nurses, a widely esteemed code of ethics in the nursing profession that explicitly stipulates that nurses should engage in research as an integral aspect of their profession, cultivate research-driven professional acumen, and implement evidence-based findings into their practice [2]. Similarly, the Korean Code of Ethics for Nurses underscores the responsibility of professional nurses to contribute to the development of nursing standards and the advancement of nursing research [3].

Nursing research is defined as a systematic inquiry designed to develop evidence-based information about issues important to the nursing profession, including nursing practice, education, administration, and informatics [1]. Clinical nursing research is a subset of nursing research that focuses specifically on nursing practice to promote and support patients' health, well-being, and quality of life [1,4]. Because nurses constitute the largest group of frontline providers of health care, clinical nursing research has increasingly gained recognition as a vital path to implementing practical, efficient, and economically viable strategies that reduce hospital errors, minimize unnecessary expenditures, and enhance patient outcomes [5].

Research utilization, also referred to as knowledge translation, is a pivotal component of the clinical nursing research process; it involves the generation, distribution, and integration of research findings into clinical practice [4]. Research utilization entails not only the implementation of evidence into practice but also the continuous monitoring and evaluation of changes in practice [6]. Given their role as frontline caregivers in clinical settings, nurses are crucially responsible for translating research findings into clinical nursing practice [7]. Nurses must be motivated and prepared to synthesize the results of existing studies, apply them to clinical practice, and formulate research questions directly within the clinical setting to generate new evidence, yet nurses may remain unengaged in research activities due to a lack of capacity or support to implement research findings into their daily clinical practice [4,8].

The effective utilization of research findings relies on three essential factors: (1) fostering a positive research culture, (2) garnering interest from individuals capable of applying these findings in practice, and (3) securing comprehensive support from governmental bodies, managers, and peers [9]. This study posits that fostering a positive research culture inherently encompasses the other 2 factors because a thriving research culture naturally generates interest and encourages support to translate research findings into practice. We posit, therefore, that a positive research culture is foundational to enhancing individual research interests and garnering organizational support.

Cultivating a positive research culture is essential because research utilization can prove challenging for clinical nurses due to a lack of time, knowledge, research supervision, and support [8]. This study seeks to explore the culture of clinical nursing research in Korea to provide substantive insights for cultivating a positive research culture.

Background

Defining culture poses a formidable challenge due to its inherent complexity; however, adopting a cultural perspective enables an understanding of why certain phenomena may occur in specific ways [10]. Consequently, to understand the essence of any phenomenon, it is necessary to explore the specific culture to which it belongs. A comprehensive understanding of clinical nursing research requires a deep familiarity with the culture of nursing research within specific clinical settings.

In the United Kingdom, because nursing functions within the National Health Service framework, government-led health care changes have seldom been research-based, and few studies have investigated the nature of clinical nursing research culture [9]. The United Kingdom has two distinct nursing subcultures: one for nurses and another for researchers, each characterized by differing values and language use [9]. Despite efforts to bridge these cultural differences, an explicit definition of a nursing research culture in clinical practice in the United Kingdom remains elusive [9]. The United Kingdom has encountered challenges in fostering a nursing research culture due to such factors as a shortage of adequately qualified research-active personnel, underdevelopment of research culture in many departments, limited dedicated research funding, and recurring competing demands on nurse academics [11].

A recent study in Denmark explored nurse researchers' experiences in clinical roles and their perceptions of the nursing research culture in clinical practice [12]. In their case study of nurse researchers' experiences of the presence of a nursing research culture in clinical practice, Berthelsen and Hølge-Hazelton [12] described nursing research culture as "caught between a rock and a hard place," reflecting the dual pressures arising from a limited academic tradition among nurses and a lack of recognition from physicians. In Australia, the authors of a survey of interdisciplinary researchers concluded that an enabling research culture should comprise research productivity, positive collegial relationships, inclusivity, noncompetitiveness, and effective research processes and training [13], but notably, all participants in this study were researchers rather than clinical nurses. Given that clinical nurses are increasingly tasked with involvement in clinical nursing research [14,15], relying solely on nursing researchers to depict the entirety of the clinical nursing research culture presents inherent limitations.

In South Korea, nursing research has been active since the 1980s [16], with clinical nursing research primarily conducted at the tertiary hospital level [14,17-19]. Studies conducted in Korea have explored facilitators and barriers to nursing research in clinical practice, including clinical nurses' knowledge and skills, acknowledgment of the importance of nursing research, organizational support, resource and facility constraints, time limitations, lack of leadership interest, challenges in statistical analysis, and the generalization of research results [14,20-22]. Although these studies have identified factors influencing the

research performance of clinical nurses, the specific nature of the clinical nursing research culture in Korea remains largely unexplored.

To gain a nuanced understanding of the sociocultural context surrounding nursing research in clinical settings, it is essential to explore the culture of the nursing research environment from both observer (etic) and insider (emic) perspectives. Our theoretical framework emphasizes the central role of research utilization in clinical nursing research and has guided each step of our inquiry. In alignment with this framework, our research questions were designed to explore the interplay between the prevailing research culture and the practical utilization of research findings within clinical settings. The selection of participants, the structure of the interviews, and the focal points of our observations were carefully aligned with our framework's emphasis on discerning the sociocultural nuances inherent to nursing research.

Purpose

This study aims to identify and describe the sociocultural context of clinical nursing research within a Korean tertiary hospital. The guiding research questions are the following: (1) what is the sociocultural context of clinical nursing research in a Korean tertiary hospital, and how does it impact clinical nurses' research activities? (2) How do clinical nurses perceive the research environment's culture, and what shared values and beliefs do they hold regarding nursing research in this context? (3) What are the facilitating and hindering factors impacting clinical nurses' research activities? Through participant observation and ethnographic interviews, we sought to uncover shared values and beliefs inherent in the visible phenomenon of the research environment culture of clinical nurses.

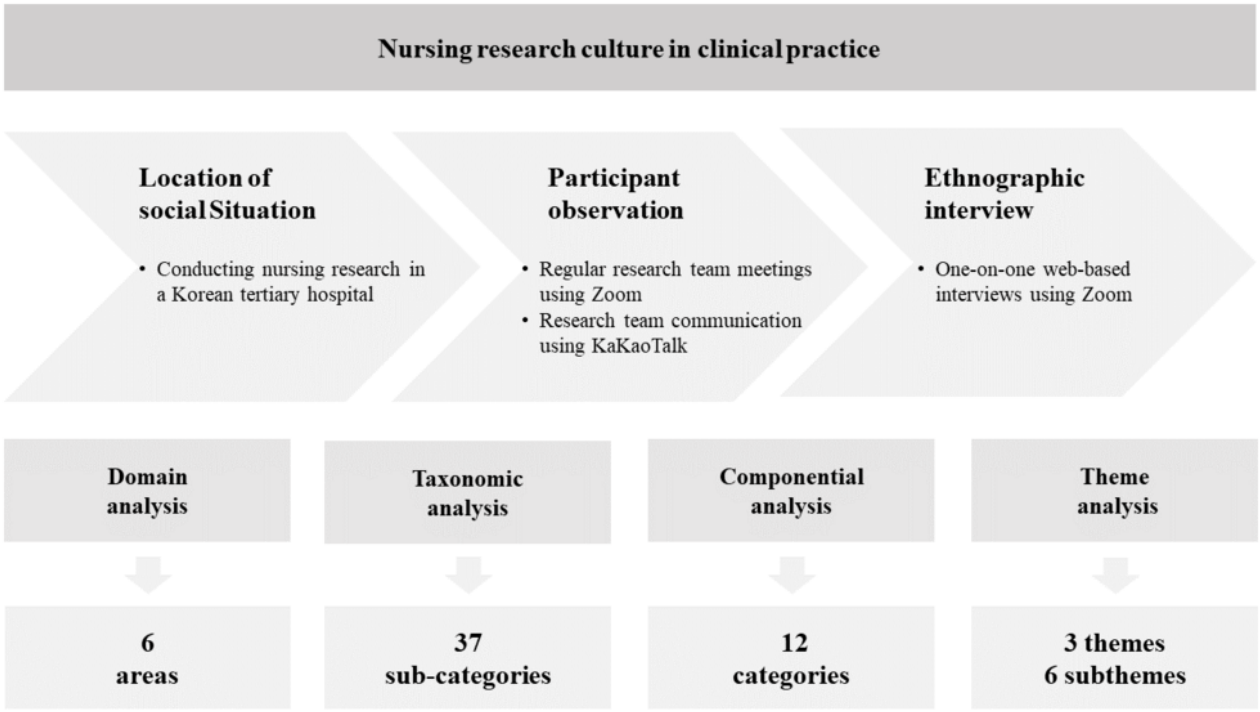
Methods

Overview

Ethnography facilitates the understanding of cultural phenomena, enabling in-depth comprehension of the subject culture from the vantage point of its native participants [23,24]. Therefore, Spradley's [23,24] ethnographic method is aptly suited for this study as it focuses on conducting in-depth interviews with clinical nurses and gaining understanding of the context from both internal and external perspectives.

Our analytical approach, deeply rooted in the emphasized theoretical framework, enabled us to interpret our findings in the broader context of research utilization in clinical nursing. This harmonious amalgamation of theory and method allowed us to unearth insights deeply rooted in the lived experiences of clinical nurses, illuminating the multifaceted nature of research engagement in clinical practice. By detailing the application and influence of our theoretical framework explicitly at each research stage, we aimed to provide a clearer and more comprehensive picture of how theoretical underpinnings shaped this study, addressing any potential concerns regarding the role and application of the theoretical framework in our research. An overview of the method is presented in Figure 1.

Figure 1. An overview of research methods.



Design

Initially, social situations were identified based on Spradley's [23] participant observation, analyzing places, actors, and activities. Participant observation and ethnographic interviews explored and described the research environment and culture of clinical nurses. This study adhered to and was reported according to the Standard for Reporting Qualitative Research (SRQR) [25]. The result of SRQR is presented in Multimedia Appendix 1.

Setting

In a tertiary hospital in South Korea, nurses submit clinical questions annually, and those whose questions are deemed valuable are given opportunities for advancement in clinical nursing research. In a participating medical-surgical unit of this hospital, clinical nursing research is underway that explores the following clinical question: "Is high-dose bowel preparation necessary before colonoscopy?" The research study compares bowel cleanliness, patient compliance, and side effects arising from different bowel preparations for patients undergoing colonoscopy.

Participant observation occurred both within the hospital's actual clinical environment and in cyberspace. Spradley's [23] definition of participant observation entails observing people's activities, the physical attributes of the social context, and experiencing the scene as a participant. This term was chosen as 1 author actively participated in the entire research process, while the remaining 4 authors observed solely in cyberspace, utilizing the mobile messenger app Kakao Talk (Kakao Games) and the video communication platform Zoom (Zoom Video Communications). Consequently, the use of the term adequately aligned with Spradley's approach.

Participants

The selection of research participants and social situations followed the ethnographic research methodology [23,24] to accurately describe clinical nurses' research environment and culture. Participants were purposefully selected based on factors that potentially influence research cultures, including position, research experience, education, and clinical experience. To attain a representation that resonates with the research culture of clinical nurses, recruitment focused on nurses with research experience, particularly those who had completed nursing research-related courses at a university hospital. Furthermore, as the research meetings were primarily conducted through Kakao Talk and Zoom, the inclusion criterion was the ability to use cell phones and computers.

Ethnography acknowledges that the required number of research participants varies depending on the cultural context [23]. Drawing from previous qualitative research [22] that focused on similar research topics and participants, a blend of purposive and snowball sampling strategies was used to recruit nurses engaged in nursing research in a hospital. The sample comprised 5 staff nurses and 1 nurse unit manager affiliated with the medical-surgical unit of a Korean tertiary hospital. One participant (who is a member of the hospital nursing research team and a contributing author to this ethnographic study) was actively involved in both participant observation and the ethnographic interview; this dual role allowed for close and continuous observation of the progress of unit-based nursing research from an actual internal perspective, enriching the study with insight from active engagement in research subjects.

Data Collection

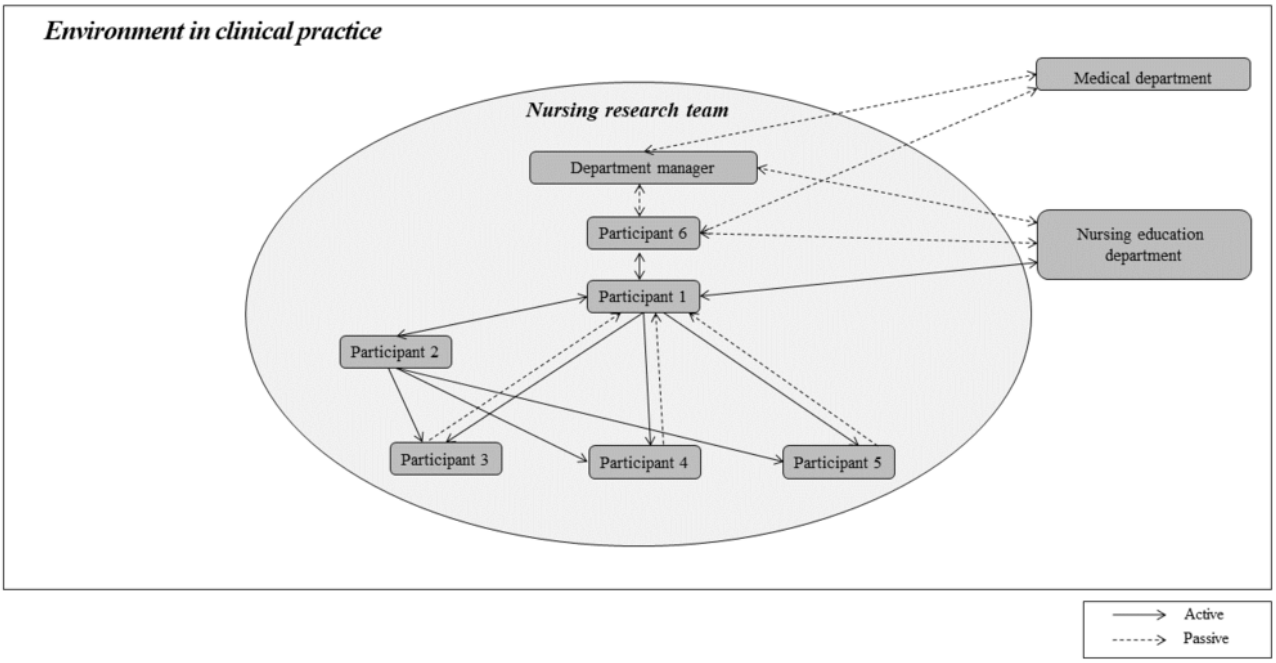
Data collection for this study was executed from April to May 2022, involving several methods, namely participant observation and ethnographic interviews. These diverse methodologies enabled researchers to garner rich data, obtain a deeper understanding of the cultural context, and address the study's queries effectively.

Participant Observation

Participant observation encompassed interactions both within the actual clinical environment of the hospital and in web-based spaces during video research conferences. One of the authors, who was also a participant in the research, conducted in-depth observations, involving monitoring of the research process in the clinical setting and active involvement as a member of the hospital's nursing research team. The remaining 4 authors observed remotely through video meetings on Kakao Talk and Zoom to oversee the research process.

The focus of both forms of participant observation was on noting participants' activities and cultural and environmental characteristics, as well as identifying various aspects such as space, actors, activities, objects, behaviors, events, time, purpose, and emotions. The relationships between research participants, as identified through participant observation, are illustrated in Figure 2.

Figure 2. Interaction of the research participants.



Ethnographic Interviews

Ethnographic interviews were conducted as one-on-one web-based sessions through Zoom in adherence to COVID-19 regulations. These interviews were facilitated by a single, experienced qualitative research interviewer who was not a part of the hospital nursing team. The interviews involved a mix of open-ended and semistructured questions, commencing with the following initial question designed to engage participants with the research topic: “What is the topic of your current hospital research?” Subsequent questions were aimed at eliciting in-depth, voluntary explanations from participants.

The structure and content of the interview questions and guidelines were informed by previous research on clinical nursing research in Korea [14,21,22,26] and were aligned with Spradley’s [24] ethnographic interview approach. Following the outlined interview guide (Multimedia Appendix 2), the interviews were conducted individually and typically lasted between 35 and 50 minutes, with the average duration being 40 minutes.

Data Analysis

In this study, 5 authors acted independently as data coders, each coding the collected data. Discrepancies in the coding results were discussed in research meetings and subjected to a consensus process until an agreement was reached. Word (Microsoft Corp) and Excel (Microsoft Corp) were used for data analysis. Initial transcripts of reported activities were compiled in Word, and meaningful data related to the topic were identified and listed in Excel, with each sentence recorded in a separate row. Subsequently, related sentences were grouped to derive themes.

Data analysis was conducted iteratively alongside data collection, using Spradley’s [24] 4-step method consisting of domain analysis, taxonomic analysis, componential analysis, and theme analysis. In the domain analysis, we reviewed ethnographic interviews and transcripts of reported activities to identify meaningful domains related to the culture of clinical nursing research. These domains were categorized into six areas of clinical nursing research culture: (1) clinical application of nursing research, (2) research role assignment, (3) shift work, (4) hospital research resources, (5) interaction between researchers, and (6) purpose of nursing research.

Taxonomic analysis led to the construction of meaningful terms within the identified domains, resulting in 37 subcategories. Componential analysis distinguished the characteristics of terms used by participants in each classification, leading to the derivation of 12 categories. All authors revised and integrated these categorizations through meticulous review. Subsequent to the categorization and integration, we performed a theme analysis and selected the final meaningful data to provide insight into the culture of clinical nursing research. Contents with similar meanings were classified and categorized, revealing 6 subthemes related to the culture of the nursing research environment among clinical nurses. These subthemes were then synthesized into 3 overarching themes that offered a comprehensive and integrated understanding of the culture of nursing research in the clinical setting.

Rigor

The rigor of this study was bolstered by using a variety of strategies recommended by Lincoln and Guba [27]. To ensure the accuracy of the interview content and methodology, the trained interviewer engaged in discussions with the other authors. All authors maintained transparency through critical reflection on their own beliefs, documented self-critical memos, and participation in deliberative discussions. Dependability was assured by integrating data collection and analysis in a simultaneous, cyclic approach. Additionally, a nursing professor well-versed in qualitative research continuously reviewed the processes of data collection and analysis to maintain the integrity of the study. Lastly, to assess their transferability, the findings

were presented to other clinical nurses to gauge their applicability in varied settings.

Ethical Considerations

This study received approval from the institutional review board of Ewha Womans University (202204-0002-01) and adhered to ethical guidelines. Potential participants were adequately informed about the study's purpose, methods, and incentives, and voluntary participation was emphasized. Sufficient time was provided for potential participants to consider their involvement. Interested participants provided written informed consent and were assured of their right to withdraw from the study at any time. Participants were informed that the collected data would be used only for research purposes and that they could discontinue participation at any time during the study. Access to the collected data was restricted to the authors of the study. To maintain confidentiality, any identifying information and files that could link data to individual participants were securely discarded upon the completion of the study.

Results

Participant Characteristics

This study included 6 participants, all female, comprising 5 staff nurses and 1 unit manager from a ward. The participants were aged between 26 and 53 years and had clinical experience ranging from 2 to 30 years. The number of research experiences among the participants varied from 1 to 7 instances. Additional details on the participants' characteristics are provided in Table 1.

The findings of the study are subsequently presented, supplemented by excerpts from the observations and interviews conducted with the participants.

Table 1. Demographic characteristics of the participants.

Number	Position	Number of research experiences	Education	Age (years)	Clinical experience (years)
1	Staff nurse	6	Doctoral student	34	6
2	Staff nurse	2	Master's student	30	4
3	Staff nurse	2	BSN[a]	26	2
4	Staff nurse	1	BSN[a]	28	3
5	Staff nurse	1	BSN[a]	27	3
6	Unit manager	7	MSN[b]	53	30

[a]BSN: Bachelor of Science in Nursing.

[b]MSN: Master of Science in Nursing.

Balancing Positive and Negative Influences in the Research Process

Shift Work and High Workload Negatively Impacting Research Progress

Nurses working in shifts and experiencing high workloads expressed feeling too exhausted to balance their work and research responsibilities. Most participants viewed research as a separate entity from their clinical roles and expressed that they found the research process arduous and challenging to juggle alongside their work duties. Nurses' varying schedules resulting from shift work made finding a suitable meeting time challenging. Participants in this study used web-based meetings as a solution that allowed maximal participation, and they provided recordings for those who could not attend due to scheduling conflicts. Nonetheless, some participants found it difficult to discuss and share progress updates due to shifting work schedules and reported feeling too drained to attend research-related training sessions given their substantial workload. Consequently, the demands of high workloads and shift work often resulted in deprioritization and postponement of research activities.

> *The process of moving forward seems very arduous. Balancing work and research is challenging, and maintaining focus is difficult.* [Participant 2, observation]

> *Due to shift work, only a few nurses discuss and are informed about the progress of the research. This sometimes leaves others struggling to understand and keep up with the research's progress, which can be embarrassing.* [Participant 3, interview]

> *Sometimes, I feel so tired and overwhelmed by the high workload that I cannot afford to participate in research-related training.* [Participant 4, interview]

Positive Utilization of Hospital's Research Support Resources

The research support resources provided by the hospital positively impacted the progress of the research. Nurses shared that they were able to submit clinical questions about which they were curious through a hospital program, leading to the formation of a research team and the initiation of research. The hospital provided various research support resources, such as research-related education and academic services, support for educational expenses, and dedicated human resources to assist with research. During meetings, participants referenced books provided by the hospital that contained essential information for advancing research. The accessibility of these resources cultivated a supportive environment that enabled participants

to conduct more efficient and effective research, which could be translated into positive outcomes.

> *Every year, our hospital holds an event encouraging nurses to formulate research questions stemming from their clinical curiosities. I found myself jotting down sporadic thoughts, and these activities naturally evolved into nursing research.* [Participant 4, interview]

> *The Nursing Education Department collaborates with our research team leader, offering support including statistical consulting.* [Participant 2, interview]

> *Detailed information useful for assessing the "Risk of Bias" of the selected literature can be found on page 62 of the book provided by the hospital.* [Participant 1, observation]

Fostering Transformational Change for Both Nurses and Patients

Selection of Research Topics Derived From Clinical Settings

Participants acknowledged the need for change to enhance the working environment for nurses and create a safer hospital environment for patients. They engaged with questions emerging from their daily practices and evolved these inquiries into research topics. They perceived that addressing these topics could trigger significant changes that would benefit both nurses and patients. This approach seemed to deepen their understanding of the prevalent issues and elevate the relevance of the research to clinical practice.

> *This research topic came about because nurses noticed issues while doing their jobs. They were thinking about other possible solutions since patients were having a hard time taking a lot of laxatives, causing them discomfort and making nursing tasks take longer.* [Participant 6, interview]

> *The issue we chose as our research topic was something I often pondered over during work. It was a mutual concern among all nurses and patients in our unit, and it's intriguing to see it evolve into a research question.* [Participant 4, interview]

> *I firmly believe the clinical setting is the optimal environment for nursing research. Numerous topics are inherently connected to nursing practices and patient care, highlighting the immense value of conducting research in such settings. Given the chance, I aspire to continue pursuing research in clinical environments.* [Participant 1, interview]

Meaningful Outcomes Obtained Through the Research Progress

All participants regarded the knowledge obtained through research as a common, meaningful outcome, signifying that the acquisition of new knowledge was a significant and shared benefit experienced by the entire group. In addition to the shared benefit of knowledge, participants anticipated obtaining various individual benefits from their research process, including the development of leadership and followership skills, expertise in their field, tangible rewards, increased satisfaction, improved confidence, reinforced trust within the team, and a sense of group unity. The participants expressed that they enjoyed the research process and that the array of rewards it offered led to positive experiences for all involved.

> *Even if the results of our research don't align with our hopes, I think our nurses have already grown personally during the process and can act as positive influences for our younger colleagues.* [Participant 6, interview]

> *I studied article search and analysis techniques in nursing school, but doing research in a clinical environment has allowed me to realize the importance of these skills firsthand, enhancing my learning confidence. I'm also thinking about attending graduate school, and I feel that my current research experience will be beneficial then.* [Participant 5, interview]

> *If our research is published in a scholarly journal, it would be a personal achievement, so I'm even more motivated to work harder.* [Participant 2, interview]

Promoting Complementary Communication Among Nurses

Varied Research Participation Based on Research Competency

The level of involvement of nurses in the research varied, influenced by their previous research and postgraduate course experiences. This involvement was also correlated with the relationships among participants, as depicted in Figure 2. In essence, team members who were actively engaged in the research demonstrated more active relationships within the team, while those who were less active exhibited more passive relationships. Participants with research experience actively shared their opinions; however, as the research progressed, they felt the burden of the uneven distribution of tasks. Conversely, those without previous research experience performed only the roles assigned to them by their more experienced peers and felt apologetic toward other participants.

> *Having engaged in similar research during my master's program, I find the current research less challenging. However, colleagues lacking research experience may find it somewhat hard to keep pace with the progress of the research.* [Participant 2, interview]

> *As the research becomes more complex, the team is finding it difficult, increasing my workload. I feel that if I don't keep at it, the research might halt, so I'm pushing through. Honestly, it's somewhat overwhelming.* [Participant 1, interview]

> *My team leader assigns tasks to members. Since I lacked knowledge about research, my participation has been more passive. So, these days, when I observe some team members struggling with the research, I feel a profound sense of guilt. It's challenging for me*

to decide what to do initially. [Participant 5, interview]

Differences in Researcher Roles Depending on Research Participation

Participants' roles in the research process were diversified, reflecting individual research capabilities and experience, which correlated with the level of their involvement in research. Those actively involved, particularly individuals with previous research experience or a master's degree, autonomously delineated their roles, aligning them with the team members' strengths and competencies. This strategy fostered a cooperative environment and optimized the unique skills of each member. Conversely, participants engaged more passively, typically those lacking research or a relevant educational background, conformed to the leaders' opinions, and concentrated solely on assigned tasks, expressing that they found this approach to be less burdensome. To mitigate the disparities in research capabilities and experiences, participants maintained consistent meetings and endorsed reciprocal, complementary communication. Participants expressed that this emphasis on open dialogue and collaboration imbued them with a sense of preparedness to tackle challenges arising during the research process.

> *I believe that fostering learning and robust teamwork can simplify the research process. I often contemplate the optimal distribution of types and volumes of work, respecting individual researchers' competencies and workload.* [Participant 1, interview]

> *I appreciate our task assignment approach. Given our shared workspace, we understand each other's strengths, which, coupled with my professional and research commitments, makes focusing on my strengths less burdensome.* [Participant 3, interview]

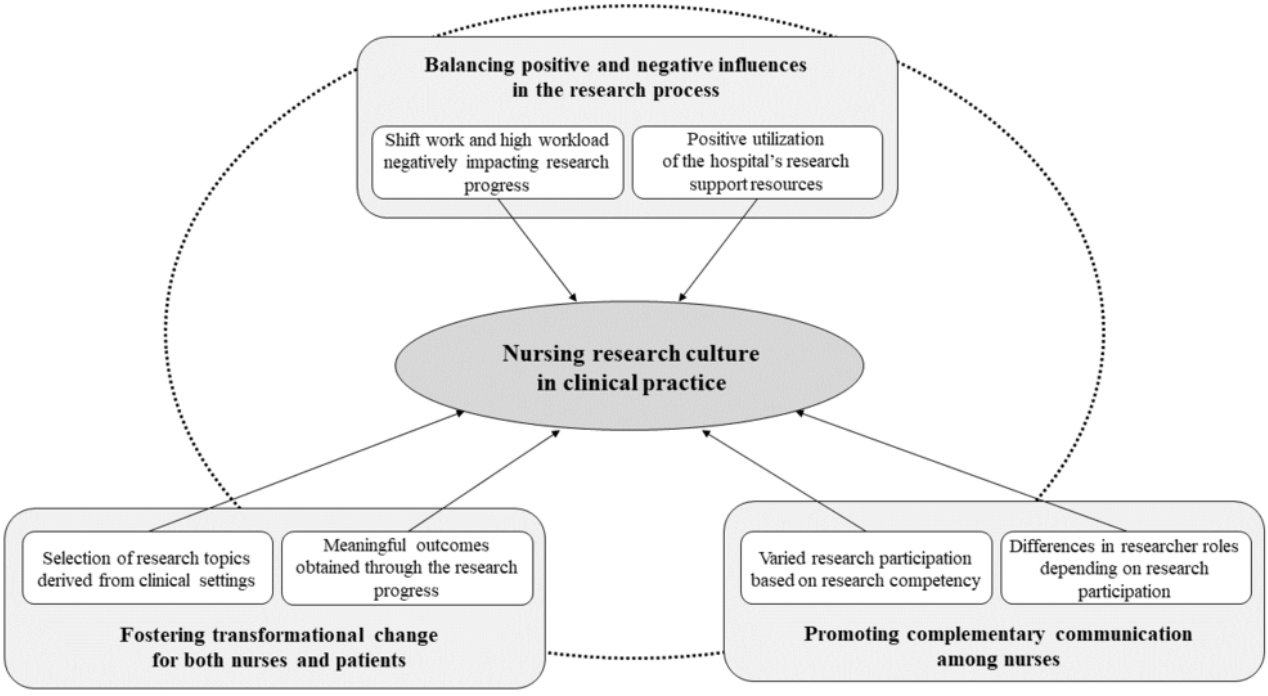
> *Maintaining regular communication is pivotal. The nature of our shift work complicates assembling everyone for research meetings, but I am confident that persistent communication can deepen our understanding of individual roles in research and enable us to offset each other's limitations.* [Participant 5, interview]

Discussion

Overview

The findings of this qualitative study offer insights into the culture of nursing research in clinical settings, showcasing its potential to empower nurses to bring about positive transformations in patient care and their professional practice while bolstering collaborative efforts. The 3 identified themes are balancing positive and negative influences in the research process, fostering transformational change for both nurses and patients, and promoting complementary communication among nurses with different research competencies and roles. Figure 3 provides a visual representation of these themes. These findings underscore the crucial ability of nursing research to enhance nurses' working environments, foster a safer atmosphere for patients, and facilitate overall progress and development in the clinical context.

Figure 3. Essential themes of nursing research culture in clinical practice.



Principal Findings and Comparison With Previous Work

The first emergent theme was the balance between positive and negative influences in the research process. The clinical environment may serve as both a facilitator and a barrier for nurses conducting research. The availability of diverse research support resources plays a crucial role as a facilitator in enhancing clinical nurses' research progress. A variety of research support resources can have a positive impact on clinical nursing research, including both material resources (eg, research-related education, academic services, and educational expense support) and human resources (eg, designated departments and personnel to assist with research progress) [28]. In Korea, clinical nurses have exhibited low research competency, a factor significantly correlated with the amount of organizational support [28]. Previous studies have indicated that organizational support and a strong belief in the value of clinical research enable research activity by fostering a culture that encourages the crucial exploration and application of research evidence in everyday practice [29]. Cultivating an organizational culture supportive of research at the institutional level is, therefore, essential to facilitating the clinical utilization of research findings.

Moreover, research participation by clinical nurses was observed to involve navigating between work and research commitments. Shift work creates challenges for scheduling regular research meetings on fixed dates and coordinating times when all research team members can gather. For example, a study in 2017 to describe the infrastructure supporting research in Magnet hospitals found that nearly half (44%) of the 249 hospitals responding required clinical nurses to conduct research activities during their regular clinical hours, and 40% reported nurses conducting research in their personal time; consequently, research activities often take a backseat to patient care priorities, making it challenging to allocate time for nurses away from direct patient care [30]. To encourage research by clinical nurses, dedicated time for research activities should be provided, and enhancements to the nursing working environment are imperative. Hospitals should acknowledge and account for the time invested in clinical nursing research within regular working hours.

The second theme underscored the transformative potential of clinical nursing research for both nurses and patients. Such research serves as a catalyst, allowing nurses to realize personal goals, such as enhancing their research capacity, while simultaneously fostering improved and safer environments for patients and health care providers. Consequently, deriving research questions from the clinical field and applying the research results to actual clinical practice is at the core of clinical nursing research [4].

In this study, participating nurses formulated research questions from their experiences caring for patients who had difficulty taking high-dose bowel cleansing solutions. Because clinical nursing research directly affects nurses' work, specifically patient care, all our participants empathized deeply with the need for this research, and the practical applicability of the research results encouraged their active participation. The predominant themes identified in a previous study conducted with 64 perioperative nurses in a hospital in Korea (ie, learning how to solve problems in practice, facilitating team activities through motivation, barriers to large participation, and rewarded efforts and inflated expectations) [31] were congruent with the insights gained in this study, suggesting that to bolster clinical nursing research, it is essential to create opportunities for field-based question formulation and foster a belief in the capability to induce change. However, the urgency to partake in clinical nursing research should not overshadow the importance of undertaking thorough literature reviews on existing research findings related to clinical issues. Clinical nursing research should be pursued only when there is a paucity of evidence, and it must always adhere to ethical standards. Motivating nurses to engage in research, allowing for continual identification of pertinent research questions, and promoting thorough reviews of relevant existing literature can yield benefits for both nurses and patients and pave the way for research in previously unexplored areas.

The final theme revolves around complementary communication, accommodating the diverse competencies of nurses. The research team in this study encompassed nurses with varied research-related experiences. Differences in research competency among team members, attributable to varying levels of research experience, led them to adopt distinct approaches to research. Participants with extensive research experience had a better understanding of the research progress, which allowed them to take charge compared with those with less experience. Conversely, those with limited research exposure struggled with the unfamiliar content discussed in meetings and were uncertain about participation modalities. These findings are consistent with a previous study indicating that individuals lacking research experience or knowledge exhibit reluctance toward research participation [31]; therefore, research competency, inclusive of experience and knowledge, emerges as a pivotal facilitator in research implementation.

Despite the associated challenges, participants maintained complementary communication through regular web-based meetings to fulfill their research objectives. Successful complementary communication is straightforward, reciprocally advantageous, and reinforces continuous interaction and relationship development [32]. Given the evident benefits of such communication, we posit that fostering it within teams can significantly enhance nursing research in clinical settings. The diversity in research competency and roles among nurses highlighted in this study accentuates the necessity of nurturing complementary communication within research teams, thus ensuring equitable and balanced interactions and contributions among team members. In the research team examined in this study, the team leader allocated tasks, and nurses with less research experience assumed a more passive stance, fulfilling only the minimal tasks assigned. Communication was then leveraged to mitigate any arising discrepancies. We therefore suggest that championing complementary communication to address variances among research nurses while leveraging the individual strengths of nurses not only sustains clinical nursing research but also cultivates a positive research culture in clinical nursing.

Limitations

This ethnographic study explored the nursing research culture in clinical nursing practice by examining the experiences of 6 nurses working at a tertiary hospital in Korea. The small sample size and the single-site setting may affect the transferability of the study's findings, as they may not represent the broader population of clinical nurses. To mitigate this possibility, we amassed data until saturation was reached, with no additional information emerging. To bolster the study's rigor, we shared the findings with nurses from various units and hospitals to assess transferability.

Due to the COVID-19 pandemic, participant meetings were held through Zoom, with scenes recorded for repeated review during analysis. This format hampered direct observation, however, limiting field notes to within-frame elements and omitting potentially significant out-of-frame expressions and movements. The shift to web-based methods challenges the traditional notion of "placeness of ethnography" [33], and some might argue that without physical immersion in the research area, there is no true fieldwork. However, digital platforms are enabling research in spaces where people are active, allowing a re-evaluation of the necessity of physical presence in traditional ethnographic fieldwork [34]. The paradigm that field research mandates physical colocation with participants [35] is undergoing reconsideration, especially given the COVID-19 pandemic, as technological advances redefine the concept of the research field [36].

Conclusions

Clinical nursing research is pivotal in fostering nurse development and refining nursing practices by juxtaposing challenges such as intensive shifts and heightened workloads with facilitators such as patient-centric research questions and institutional research support. The clinical environment may serve dual roles as a facilitator by providing the requisite infrastructure for research and as a barrier when intensive shifts persist and research time is not allocated. Institutionalizing infrastructure for nursing research and earmarking time for such activities is crucial in clinical settings to facilitate continual knowledge circulation, thereby allowing nurses to generate and apply well-substantiated knowledge effectively. Adequate clinical nursing research enhances both professional development and patient care; therefore, nursing education programs should emphasize the importance of pinpointing apt research topics, reviewing existing research, and executing clinical nursing research. Subsequent research should probe whether the themes uncovered in this study accurately represent the nursing research culture in clinical settings and should identify the prerequisites for establishing an exemplary nursing research culture.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Standard for Reporting Qualitative Research (SRQR) checklist.
[PDF File (Adobe PDF File), 130 KB - apinj_v8i1e50703_app1.pdf]

Multimedia Appendix 2
Interview Guide.
[DOCX File , 24 KB - apinj_v8i1e50703_app2.docx]

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Abbreviations

SRQR: Standards for Reporting Qualitative Research

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Original Paper

Emotional Touch Nursing Competencies Model of the Fourth Industrial Revolution: Instrument Validation Study

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Abstract

Background: The Fourth Industrial Revolution is transforming the health care sector through advanced technologies such as artificial intelligence, the Internet of Things, and big data, leading to new expectations for rapid and accurate treatment. While the integration of technology in nursing tasks is on the rise, there remains a critical need to balance technological efficiency with empathy and emotional connection. This study aims to develop and validate a competency model for emotional touch nursing that responds to the evolving demands of the changing health care environment.

Objective: The aims of our study are to develop an emotional touch nursing competencies model and to verify its reliability and validity.

Methods: A conceptual framework and construct factors were developed based on an extensive literature review and in-depth interviews with nurses. The potential competencies were confirmed by 20 experts, and preliminary questions were prepared. The final version of the scale was verified through exploratory factor analysis (n=255) and confirmatory factor analysis (n=256) to assess its validity and reliability.

Results: From the exploratory analysis, 8 factors and 38 items (client-centered collaborative practice, learning agility for nursing, nursing professional commitment, positive self-worth, compliance with ethics and roles, nursing practice competence, nurse-client relationship, and nursing sensitivity) were extracted. These items were verified through convergent and discriminant validity testing. The internal consistency reliability was acceptable (Cronbach α=0.95).

Conclusions: The findings from this study confirmed that this scale has sufficient validity and reliability to measure emotional touch nursing competencies. It is expected to be used to build a knowledge and educational system for emotional touch nursing.

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KEYWORDS

nurse; therapeutic touch; clinical competence; factor analysis; statistical; reliability; scale; tool; nursing; industrial revolution; competencies; health care; emotional; interview; collaborative practice; learning agility; professional commitment; positive self-worth; compliance; ethics; practice ability; relationship ability; nursing sensitivity

Introduction

The Fourth Industrial Revolution, characterized by the technological convergence of existing and new data through the blurring of physical and digital boundaries, is driving exponential changes across various sectors at an unprecedented pace [1]. Anticipated transformations and revolutions in the economic, social, and cultural domains are enabled by the convergence of advanced technologies such as artificial intelligence (AI), the Internet of Things, cloud computing, and

big data [2]. At the core of these changes lie the health care sector, big data, information and communications technologies, and IT devices, facilitating precision diagnosis, telemedicine, and remote monitoring in medical settings [3].

With the advancement of scientific technology, health care recipients now expect rapid and accurate treatment through precise evidence-based medicine, as well as continuous disease management and health maintenance using IT technologies [3,4]. The medical field has evolved beyond uHealth, with diagnostics and certain support for the execution of nursing tasks increasingly being replaced by AI. Additionally, nursing models that use virtual reality for drug administration, as well as nursing robots that assist with tasks like meal delivery and medication, have been developed, leading to improved nursing quality [5]. Moreover, nurses are expected to analyze big data, provide diagnostic interventions tailored to individual needs according to algorithms, and deliver optimal nursing services with the assistance of AI [6]. Thus, the nursing field as a whole anticipates that the use of new technologies will enhance the efficiency of nursing tasks, alleviate work burdens, and pioneer independent activity areas [4].

However, alongside the rapid technological advancements, there is a growing emphasis on the humanistic and emotional aspects of nursing care, highlighting the importance of balancing the scientific and technological aspects of medicine. As nursing service recipients experience dehumanization in the face of digital transformation [4], there is a demand for more humanistic and delicate care. The increasing need for high-tech solutions like big data, AI, and robots underscores the importance of empathy and human touch—areas where nursing uniquely excels in understanding and connecting emotionally with patients [4,7]. In this context, emotional touch nursing can be described as a professional nursing activity that delivers integrated care through direct physical contact and nonverbal communication, using various resources and collaborating with other health care professionals to sensitively address the health problems of nursing recipients [7].

In recent years, there has been a growing consensus on the importance of adapting nursing to the Fourth Industrial Revolution era, with continuous research being conducted on emotional intelligence, person-centered care, and therapeutic touch [8-11]. Emotional intelligence, widely used in Korean nursing, was originally developed for business students and later adapted to South Korea to reflect the sociocultural characteristics of the country. Although its validity and reliability were verified, it was adapted for nursing students, not nurses, and consists of only 4 factors with 4 items each, making it insufficient in terms of the number of items for each subdomain. Furthermore, it was found to be influenced by personal traits such as personality characteristics [8]. Person-centered care tools include the Person-Centered Care Assessment Tool (P-CAT), developed overseas and translated into Korean [9], and tools developed to emphasize specific aspects such as intensive care unit nursing practice, family involvement, and end-of-life care [10], which pose challenges in measuring emotional touch nursing that moves recipients in the domestic, social, and cultural contexts [7]. Therefore, it is necessary to prioritize the development of tools that reflect the concept of emotional touch competency, suitable for the rapidly changing nursing environment in the Fourth Industrial Revolution era.

Competency modeling can be used as a method for constructing a model of nurses' emotional touch nursing competencies. This approach involves developing a competency model that includes complex elements, such as knowledge, skills, personality, attitudes, problem-solving abilities, and interpersonal skills, and visually represents the relationships between these competencies as a multidimensional concept map [12]. The development of competency models through competency modeling can be effectively used in the development of educational programs as it provides specific skills or behaviors that can be developed through education [13]. Competency-based approaches have been reported to be more effective than other approaches in terms of positive psychology and reinforcement [14], with effectiveness verified in competency-based educational programs across various fields [15-18]. In particular, previous studies on nurse competencies emphasize the use of competency models to develop competent and skilled nursing personnel [19], highlighting the need for further research to identify and analyze nurses' competencies from diverse and in-depth perspectives in clinical settings [20]. Therefore, this study aims to construct a model of emotional touch nursing competencies in response to diverse nursing needs in the rapidly changing Fourth Industrial Revolution era, using a shortened competency modeling method based on expert panels commonly used among expert groups [21]. The specific objectives are mentioned in the next sections.

Methods

Study Design

This methodological study used a competency modeling approach to create a model of emotional touch nursing competencies within the context of the Fourth Industrial Revolution.

Competency Model Construction Process

Phase 1: Construction of Potential Competency Model

Emotional Touch Nursing Competencies From a Conceptual Framework

To develop an emotional touch nursing competencies model through competency modeling for nurses, the components of the scale were identified based on a literature review and prior studies on the concept analysis of emotional touch through interviews with nurses and nursing recipients [7]. The identified competencies for emotional touch nursing include a total of 12 competencies: professional nursing skills, nursing sensitivity, interpersonal skills, leadership, educational competency, spirituality, resilience, judgment, learning sensitivity, IT use skills, collaboration with other health care professionals, ethical sensitivity, and humanistic recalibration.

Delphi Survey Using Expert Panel

A Delphi survey was conducted with the same expert group on the 12 emotional touch nursing competencies identified from prior studies [7]. A shortened competency modeling method

[21] was used, which requires securing more than 20 experts in the field. The expert group consisted of 20 members—5 clinical nurses, 5 clinicians, 8 nurse educators, and 2 professors of medical humanities and bioethics. The survey period was from February 1, 2021, to April 30, 2021. In the first Delphi round, experts were asked to provide opinions on additional or deleted items using an open-ended questionnaire based on the competencies identified in the prior study. The first round results indicated the need to expand the conceptual scope to include "patient-centered care" as a new competency. Consequently, "patient-centered care" was added, bringing the total to 13 competencies for the second Delphi round, where experts were asked to evaluate the appropriateness of the definitions and names of the competencies using an open-ended questionnaire. The second round results confirmed that the 13 competencies were evenly distributed among the attributes of knowledge, skills, self-concept, and traits. In the third Delphi round, the appropriateness of the competencies was confirmed using a 5-point Likert scale, with all competencies scoring 4 or above, ensuring expert validity. Thus, a potential competency model was constructed consisting of patient-centered care, professional nursing skills, nursing sensitivity, interpersonal skills, leadership, educational competency, spirituality, resilience, judgment, learning sensitivity, IT use skills, collaboration with other health care professionals, ethical sensitivity, and humanistic recalibration.

Phase 2: Validation and Finalization of the Competency Model

Development of Preliminary Items

Based on the potential competency model construction process, 13 competencies were finalized, and the first set of preliminary items was developed to measure emotional touch nursing competencies. The preliminary items included 11 items on patient-centered care, 15 on professional nursing skills, 12 on nursing sensitivity, 13 on interpersonal skills, 14 on leadership, 15 on educational competency, 17 on spirituality, 22 on resilience, 11 on judgment, 11 on learning sensitivity, 12 on IT use skills, 7 on collaboration with other health care professionals, and 16 on ethical sensitivity and humanistic recalibration, totaling 176 items. The scale was a 5-point Likert scale, with higher scores indicating higher emotional touch nursing competencies.

Content Validity Testing

The initial set of preliminary items underwent content validity testing by the expert group of 20 members for competency modeling. The content validity of the preliminary items and the appropriateness of each competency attribute were assessed using a 4-point Likert scale, where 1 indicated "not at all appropriate" and 4 indicated "very appropriate." Open-ended questionnaires were also used to collect opinions on any necessary revisions, additions, or deletions of items. The content validity testing results, with an Item-Content Validity Index (I-CVI) criterion of 0.78 or higher, led to the identification of 51 items. The second set of preliminary items was structured as a questionnaire, with 2 researchers cross-examining the appropriateness of the items' meaning, language, duplication, or ambiguity, and their relevance to the subfactors of the conceptual framework. A Korean language expert and an education expert reviewed the items, refining the preliminary scale to a final selection of 51 items.

Participants

The study participants were nurses with more than 3 months of experience working in secondary or tertiary hospitals located in the Seoul, Daegu, and Gyeongbuk regions who understood the aim of the study and voluntarily agreed to participate. Considering that the sample size for factor analysis should be 4 to 5 times the number of items developed, and the ideal sample size for item analysis is 2 to 10 times the number of questions [22], in this study, 546 nurses were targeted, accounting for the number of items and potential dropouts. A total of 511 valid responses were obtained after excluding 25 insufficient responses and 10 nonresponses, with 255 used for exploratory factor analysis (EFA) and 256 for confirmatory factor analysis (CFA).

Research Tools

To verify the criterion validity of the preliminary scale, the P-CAT was used. This tool consists of 25 items across 5 factors (7 items for relationship, 4 for totality, 5 for respect, 5 for individualization, and 4 for empowerment) measured on a 5-point Likert scale, with higher scores indicating a higher level of person-centered care. The reliability at the time of development was Cronbach α=0.94, and in this study, the reliability was Cronbach α=0.97.

Ethical Considerations

Data collection was conducted from May 1 to May 31, 2021, after obtaining approval from the Daegu Catholic University Institutional Review Board (CUIRB-2020-0011). The aims of the study, data collection methods, confidentiality of the data, and participants' rights to withdraw from the study were explained to the participants. Participants were provided with a written consent form, which they could read thoroughly before voluntarily agreeing to participate in the study. Data were stored on a password-protected computer, accessible only to the researchers, and the data will be kept for 3 years after the study's conclusion before being destroyed. Participants were given a small gift of 5000 KRW (equivalent to US $4.42) as a token of appreciation for their participation.

Data Analysis

Collected data were analyzed using SPSS Statistics (version 23.0; IBM Corp) and AMOS (version 24.0; IBM Corp) programs. First, the general characteristics of the study participants were analyzed using descriptive statistics, including frequency, percentage, mean, and SD. Second, construct validity was assessed through item analysis, EFA, CFA, and convergent and discriminant validity analysis. Item analysis involved checking the mean, SD, skewness, and kurtosis of each item to confirm normal distribution, as well as calculating item-total correlation and the reliability coefficient when removing specific items. Factor analysis suitability was tested using the Kaiser-Meyer-Olkin (KMO) and Bartlett test of sphericity. EFA used principal component analysis with varimax rotation to extract factors, while CFA evaluated the model fit using indices such as chi-square, chi-square/*df*, root mean square error of

approximation (RMSEA), squared root mean-squared residual (SRMR), the goodness of fit index (GFI), and comparative fit index (CFI). Convergent validity was confirmed by examining standardized regression coefficients, construct reliability, and average variance extracted (AVE). Discriminant validity was verified by ensuring that the square of the correlation coefficients was smaller than the AVE. Third, criterion validity was measured by calculating Pearson correlation coefficients using person-centered care as the criterion variable. Fourth, reliability was assessed using the Cronbach α coefficient to determine internal consistency.

Results

General Characteristics

The average age of the participants was 34.4 years, with 287 (56.2%) out of 511 participants being unmarried. The majority had a bachelor's degree in nursing, accounting for 384 (75.1%) participants. The average total clinical experience was 9.27 years. Regarding income, 211 (41.3%) participants earned between 2.5 million and 3 million KRW (US $1=1130.50 KRW, effective as of May 31, 2021) per month. Most participants worked in general wards (n=285, 55.8%), and the majority held the position of nurse (n=426, 83.4%; Table 1).

Table 1. General characteristics of participants (n=511).

Characteristics and categories	Values
Age (years), mean (SD)	34.4 (9.90)
Marital status, n (%)	
Single	287 (56.2)
Married	221 (43.2)
Others	3 (0.6)
Education, n (%)	
Diploma	73 (14.3)
Bachelor's degree	384 (75.1)
Master's degree	53 (10.4)
Doctoral degree	1 (0.2)
Total clinical career (year), mean (SD)	9.27 (7.53)
Income (KRW[a]), n (%)	
<1,500,000	4 (0.8)
1,500,000 to >2,000,000	7 (1.4)
2,000,000 to >2,500,000	85 (16.6)
2,500,000 to >3,000,000	211 (41.2)
3,000,000 to >3,500,000	96 (18.8)
3,500,000 to >4,000,000	55 (10.8)
≥4,000,000	53 (10.4)
Working unit, n (%)	
General unit	285 (55.8)
Special unit	199 (38.9)
Outpatient clinic	27 (5.3)
Current position, n (%)	
Staff nurse	426 (83.3)
Charge nurse	56 (11.0)
Head nurse (unit manager)	23 (4.5)
Nursing team leader or more	6 (1.2)

[a]US $1=1130.50 KRW, effective as of May 31, 2021.

Item Analysis

In the item analysis conducted for the EFA of the preliminary items, the corrected item-total correlation for each item and the total set of items was examined. The correlation coefficient for item 6, "I believe that most events happen for a reason," was found to be below 0.30. Items with a correlation coefficient above 0.80 may indicate redundancy with other items, while those below 0.30 are considered to contribute less to the tool [22]. Therefore, item 6 was deleted. The correlation coefficients of the remaining 50 items ranged from 0.44 to 0.67, and the Cronbach α value after item removal was 0.96.

Exploratory Factor Analysis

Overview

To determine whether the 50 preliminary items identified in the item analysis were suitable for factor analysis, the KMO test was performed, resulting in a score of 0.93. The Bartlett test of sphericity yielded a value of 7304.34 (degrees of freedom=1176; $P<.001$), confirming that the data were appropriate for factor analysis. The factor analysis extracted 8 factors with eigenvalues greater than 1.0. The scree plot also showed a horizontal change in eigenvalues after the ninth factor, with the cumulative variance explained being 60.4%. Using varimax rotation, items with a factor loading of 0.40 or higher were considered significant, while those with a loading of 0.50 or higher were deemed highly significant [22]. As a result, 11 items with factor loadings below 0.40 and 1 item deemed to have a different attribute by 2 researchers were excluded, leaving 38 items. The communalities of each item ranged from 0.40 to 0.78, meeting the criteria. The factor loadings for the 38 items across 8 factors ranged from 0.45 to 0.82. The factors were composed of 3 to 11 items each, satisfying the basic assumption that each factor should include at least 3 items [22] (Table 2).

Table 2. Result of exploratory factor analysis.

Factors (number of items) and items	Factor loading	Eigenvalues	Accumulative variance, %
F1[a] (11)		17.79	12.1
24. I can lead the patient and family toward active participation in nursing.	0.72		
23. I can apply nonverbal communication (therapeutic touch, positive face, eye gaze, etc) for client centered nursing depending on the individual characteristics.	0.62		
25. I can provide an emotionally comfortable and cozy environment (noise pollution, eliminate odor, adjusting lighting brightness, etc) to the client.	0.60		
35. I can determine priorities for educational needs, goals, and schedules through mutual discussions between the nurse and the client.	0.59		
26. I can discuss with the patient, family, and colleagues about methods to provide client centered nursing.	0.57		
37. I can provide constructive feedback by rechecking educational content after client education is completed.	0.55		
32. I can provide an individual nursing education depending on the client's needs, symptoms, characteristics, learning types (learning preferences or method), and self-care level.	0.52		
34. I can help the client build a positive relationship with other patients, medical personnel, and others through appropriate communication.	0.47		
33. I can provide client with education on available materials and human resources to help them adapt to the hospital environment.	0.46		
45. I can discuss with colleagues and expertise groups (hospital ethics committee, etc) about the ethical issues that could arise when providing best nursing.	0.45		
28. I can communicate with client to help them honest express emotions, thoughts, and opinions.	0.45		
F2[b] (4)		2.55	20.5
49. I can search and evaluate reliable internet-based material (clinical nursing guidelines, related papers, etc) to provide evidence-based practice.	0.81		
48. I can use application programs (Excel, Power Point, Hangul, Zoom, YouTube, etc) to carry out whatever work I want to do.	0.80		
50. I can use information and communication technologies (health care applications and patient education related videos, etc) to educate clients on effective health management.	0.73		
36. I can educate the client's using various methods such as videos, pamphlets, and role-play to elevate the effectiveness of education.	0.55		
F3[c] (4)		2.12	28.2
13. I feel self-esteem and a sense of vocation within the job.	0.82		
12. I sense self-realization and value of life when I provide nursing to the client.	0.79		
11. I believe nursing has a profound meaning in my life.	0.77		
9. I feel pleased when I am learning or self-development in relation to my job.	0.54		
F4[d] (5)		1.83	35.3
1. I can overcome new challenges and adversities well, based on my past experiences and hope for the future.	0.72		
3. I am a person who is needed and important to others.	0.69		
4. I can set my life goals and grow for my own happiness.	0.68		
2. I can make efforts to resolve any issues to achieve my goals.	0.65		
5. When there is a challenging problem, I am able to find positive aspects that could arise in the process of resolving the problem.	0.52		
F5[e] (5)		1.50	42.2
43. I believe the act of caring for the client should be prioritized under any circumstances.	0.71		

Factors (number of items) and items	Factor loading	Eigenvalues	Accumulative variance, %
47. I believe it takes efforts and time to effectively use the hospital information system necessary for providing clinical or nursing services to the client.	0.62		
44. I believe medical personnel should feel responsible if they or other colleagues are committing unethical medical practices, and take further action accordingly.	0.62		
46. I believe good nursing involves equally respecting the human rights and self-determination rights of all individual clients.	0.54		
31. I believe it is the responsibility of a nurse who performs a professional role to sensitively respond to new nursing knowledge and skills or techniques.	0.52		
F6[f] (3)		1.45	48.6
21. I can record the treatment and nursing intervention applied to the client pursuant to the nursing record guidelines.	0.80		
22. I can use necessary emergency medications, medical devices, equipment, and so forth for nursing the patient and manage facilities.	0.79		
20. I can provide expert nursing skills (core nursing skills including nutrition, elimination, medication, blood transfusion, etc) depending on the characteristics of the patient.	0.76		
F7[f] (3)		1.22	55.1
16. When the client expresses negative or positive thoughts and feelings toward me, I can acknowledge such thoughts and feelings.	0.75		
15. When there is a discord between me and the client, I can constructively communicate and convey feelings and thoughts of either party.	0.70		
17. I can exhibit a friendly attitude and maintain good relationships with patients.	0.63		
F8[g] (3)		1.15	60.4
27. I believe it is important to determine the treatment method preferred by the client within a possible scope.	0.65		
30. I believe desirable nursing involves promptly responding to the vulnerable situations and needs of the patient.	0.59		
29. I fully understand what impacts specific behavior of the nurse has on the client.	0.58		

[a]F1: client-centered collaborative practice.

[b]F2: learning agility for nursing.

[c]F3: nursing professional commitment.

[d]F4: positive self-worth.

[e]F5: compliance with ethics and roles.

[f]F6: nursing practice competence.

[g]F7: nurse-client relationship.

[h]F8: nursing sensitivity.

Factor 1

Named “Client-Centered Collaborative Practice,” this factor included 11 items. The eigenvalue was 17.79, explaining 12.1% of the variance, with factor loadings ranging from 0.45 to 0.72.

Factor 2

Named “Learning Agility for Nursing,” this factor included 4 items. The eigenvalue was 2.55, explaining 20.5% of the variance, with factor loadings ranging from 0.54 to 0.81.

Factor 3

Named “Nursing Professional Commitment,” this factor included 4 items. The eigenvalue was 2.12, explaining 28.2% of the variance, with factor loadings ranging from 0.54 to 0.82.

Factor 4

Named “Positive Self-Worth,” this factor included 5 items. The eigenvalue was 1.83, explaining 35.3% of the variance, with factor loadings ranging from 0.52 to 0.72.

Factor 5

Named “Compliance with Ethics and Roles,” this factor included 5 items. The eigenvalue was 1.50, explaining 42.2% of the variance, with factor loadings ranging from 0.52 to 0.71.

Factor 6

Named “Nursing Practice Competence,” this factor included 3 items. The eigenvalue was 1.45, explaining 48.6% of the variance, with factor loadings ranging from 0.76 to 0.80.

Factor 7

Named "Nurse-Client Relationship," this factor included 3 items. The eigenvalue was 1.22, explaining 55.1% of the variance, with factor loadings ranging from 0.63 to 0.75.

Factor 8

Named "Nursing Sensitivity," this factor included 3 items. The eigenvalue was 1.15, explaining 60.4% of the variance, with factor loadings ranging from 0.58 to 0.65.

Confirmatory Factor Analysis

To validate the model structure of the eightfold 8 factors and 38 items derived from the EFA, CFA was conducted using data from 256 participants who were not included in the exploratory analysis. The model fit indices were χ^2/df=2.48 (less than 3), RMSEA=0.07 (less than 0.10), SRMR=0.04 (less than 0.08), GFI=0.92 (greater than 0.90), and CFI=0.92 (greater than 0.90), all of which indicated an acceptable fit (Table 3).

Table 3. Result of confirmatory factor analysis.

	χ^2 (*df*)	*P* value	χ^2/*df*	RMSEA[a]	SRMR[b]	GFI[c]	CFI[d]	β	CR[e]	AVE[f]
ETNCM[g]	573.3 (198)	<.001	2.5	0.07	0.04	0.92	0.92	.60-.85	0.82-0.94	0.62-0.78
Criteria	__[h]	>.05	≤3	≤0.10	≤0.05	≥0.90	≥0.90	≥0.50	≥0.50	≥0.50

[a]RMSEA: root mean square error of approximation.

[b]SRMR: squared root mean-squared residual.

[c]GFI: goodness of fit index.

[d]CFI: comparative fit index.

[e]CR: construct reliability.

[f]AVE: average variance extracted.

[g]ETNCM: Emotional Touch Nursing Competencies Model.

[h]Not applicable.

Convergent Validity

The convergent validity was confirmed, with standardized regression coefficients ranging from 0.60 to 0.85, all exceeding 0.50 (*P*<.05). The construct reliability ranged from 0.82 to 0.94, all exceeding 0.50, and the AVE ranged from 0.62 to 0.78, all exceeding 0.50. The discriminant validity of the factor structure was confirmed by verifying that the squared values of the correlations between latent variables were smaller than the AVE values in all areas (Table 3).

Criterion Validity Verification

To verify the criterion validity of the developed emotional touch nursing competencies model, the Human-Centered Nursing Tool [23] was used. The correlation between Human-Centered Nursing and emotional touch nursing competencies was positively significant (*r*=0.78; *P*<.001). The correlations between subfactors of emotional touch nursing competencies and Human-Centered Nursing were also significant—client-centered collaborative practice (*r*=0.76; *P*<.001), nursing learning agility (*r*=0.48; *P*<.001), nursing professional commitment (*r*=0.49; *P*<.001), positive self-worth (*r*=0.58; *P*<.001), compliance with ethical and role (*r*=0.66; *P*<.001), nursing practice ability (*r*=0.46; *P*<.001), patient relationship ability (*r*=0.57; *P*<.001), and nursing sensitivity (*r*=0.55; *P*<.001), thereby confirming the criterion validity (Table 4).

Table 4. Correlation of the Emotional Touch Nursing Competencies Model (ETNCM) and Person-Centered Care Assessment Tool (P-CAT).

	F1[a]	F2[b]	F3[c]	F4[d]	F5[e]	F6[f]	F7[g]	F8[h]	ETNCM
P-CAT									
r	0.76	0.48	0.49	0.58	0.66	0.46	0.57	0.55	0.78
P value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

[a]F1: client-centered collaborative practice.

[b]F2: learning agility for nursing.

[c]F3: nursing professional commitment.

[d]F4: positive self-worth.

[e]F5: compliance with ethics and roles.

[f]F6: nursing practice competence.

[g]F7: nurse-client relationship.

[h]F8: nursing sensitivity.

Reliability Verification

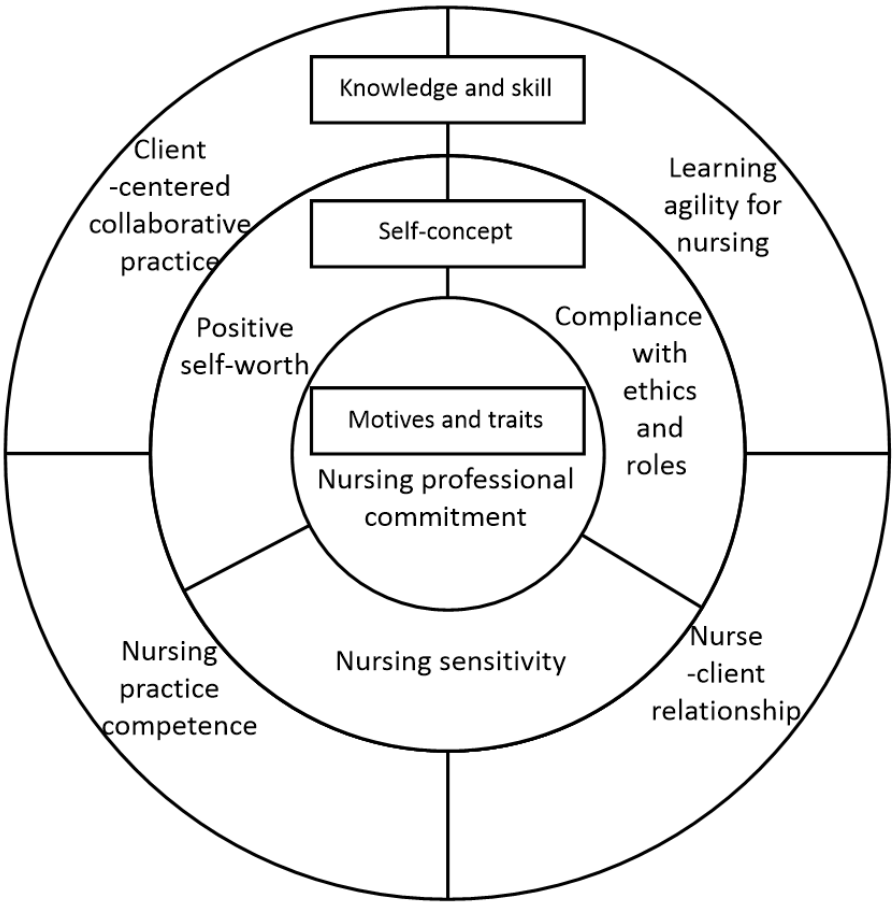
The internal consistency of the scale developed in this study was confirmed, with a Cronbach α of 0.95 for the overall scale. The reliability for each subfactor was as follows: factor 1=0.90, factor 2=0.84, factor 3=0.85, factor 4=0.83, factor 5=0.76, factor 6=0.86, factor 7=0.75, and factor 8=0.75.

Optimization of the Scale and Finalization of the Competency Model

This study constructed an emotional touch nursing competencies model and verified its validity and reliability, resulting in a self-reported questionnaire consisting of 38 items across 8 factors, measured on a 5-point Likert scale. The total score ranges from 38 to 190, with higher scores indicating higher emotional touch nursing competencies.

The construct validity of the competency model was confirmed using the emotional touch nursing competencies scale centered on the Fourth Industrial Revolution, as defined by the competency model. Knowledge and skill competencies were finalized as client-centered collaborative practice, nursing learning agility, nursing practice ability, and nurse-client relationship ability. Self-concept competencies included positive self-worth, nursing sensitivity, and compliance with ethics and roles. Motivation and trait competencies were consolidated under nursing professional commitment (Figure 1).

Figure 1. The competency model for emotional touch nursing.



Discussion

Principal Findings

This methodological study developed a scale for assessing emotional touch nursing competencies based on the concept and competency modeling of emotional touch nursing led by nurses in the Fourth Industrial Revolution. The developed scale consists of 38 items across 8 factors.

The competencies derived from this study include several key factors. The first factor, "Client-Centered Collaborative Practice," consists of 11 items that encompass providing nursing care through collaboration in physical, psychological, environmental, and social aspects centered around the client. In light of the rapid advancements in advanced medical technologies and the increasingly complex and diverse competencies required of nurses to meet various client needs [24], this finding aligns with research by Seomun et al [25], which identified the integration of knowledge and nursing skills as essential core competencies for nurses. Additionally, client-centered care emphasizes the importance of client participation at all stages of health care [26]. Given these results, the factor of client-centered collaborative practice is deemed appropriate for providing diverse and nuanced nursing care,

fostering trust in health care professionals amidst the rapidly evolving medical landscape.

The second factor, "Learning Agility for Nursing," comprises 4 items related to the use of information and communication technologies and various data resources. This finding is consistent with the study by Kwak et al [27], which identified nursing informatics competency as a crucial skill related to nurses' job performance. Furthermore, research by Lee et al [28] highlighted that the area with the lowest performance in nursing informatics subcompetencies pertains to the application of software related to medical information systems. These results reflect the learning vulnerabilities among clinical nurses in using software tools for patient care. As clinical nurses operate in environments deeply intertwined with rapidly advancing technologies in the Fourth Industrial Revolution, the importance of nursing learning agility is underscored for providing systematic, evidence-based nursing care.

The third factor, "Nursing Professional Commitment," includes 4 items related to job pride and self-actualization. Job commitment, a concept similar to professional commitment, refers to the psychological pride, unity, and perceived importance one feels toward their current work [29]. Han and Koo's [30] study found that professional self-concept was the most significant influencing factor on nurses' job commitment, which aligns with our findings. The increase in job commitment stemming from a positive professional self-concept is anticipated to enhance the quality of nursing services, suggesting that when clinical nurses possess high pride, responsibility, and confidence in their profession, they can provide detailed and compassionate care to patients.

The fourth factor, "Positive Self-Worth," encompasses 5 items related to personal values, self-efficacy, and self-esteem. Previous studies have demonstrated a significant negative correlation between positive psychological competencies and burnout [31]. Furthermore, nurses' self-efficacy significantly influences patient safety management activities [32]. In this context, "positive self-worth" is seen as a critical concept for nurses in recognizing their positive value and establishing their self-concept, contributing to the growth of their emotional touch.

The fifth factor, "Compliance with Ethics and Roles," consists of 5 items related to nursing ethics, professional role responsibilities and duties, and respect for clients. This finding supports previous studies that emphasized the importance of ethical competency in general nursing competencies [33]. The Singapore Nursing Board has suggested ethical, professional, and legal nursing practices; care management; leadership; and professional development as competencies for nurses [34], aligning with the results of this study.

The sixth factor, "Nursing Practice Competence," includes 3 items related to various clinical nursing skills applicable to patients. This factor is comparable to clinical performance [35], clinical decision-making abilities [36], and job performance [27] identified in prior studies. However, unlike similar concepts in previous research, the nursing practice competency factor reflects the characteristics of the nursing profession while distinguishing itself through the provision of client-centered nursing care suitable for the Fourth Industrial Revolution. Delivering high-quality care based on nursing practice competency is an essential condition for nurses.

The seventh factor, "Nurse-Client Relationship," comprises 3 items related to relationships, communication, and attitudes toward clients. This aligns with findings from prior studies [37] investigating the professional competencies of nurses in various departments, highlighting the importance of behaviors that foster a close connection between nurses and clients. Furthermore, research analyzing recent data from domestic and international accreditation agencies identified communication competency as a priority for improvement [25], indicating that interpersonal issues among nurses significantly affect the quality of nursing services [38]. Thus, enhancing client relationship competency is crucial for improving patient satisfaction with nursing services.

The eighth factor, "Nursing Sensitivity," includes 3 items concerning respect for client treatment, empathy for vulnerable situations, and prompt responses. This finding is consistent with prior studies emphasizing the immediate provision of individualized patient care as a vital component of nurses' professional competencies [37]. Moreover, recent patient expectations for high-quality nursing care have expanded to include an empathetic understanding of their situations and emotions, reflecting the evolving scope of nursing in a professional context [39].

Based on a literature review, interviews with nurses and nursing clients, and 3 rounds of expert Delphi and content validity verification processes, 13 attributes and 51 items were ultimately derived, with 50 items undergoing factor analysis to confirm the 8 factors comprising 38 items. Additionally, these 8 factors accounted for 60.43% of the total variance. The reliability of the scale was found to be Cronbach α=0.95, with subfactor reliabilities ranging from 0.75 to 0.90. Correlation analysis for criterion validity revealed a positive correlation between person-centered care [23] and emotional touch nursing competencies, with all subfactors also demonstrating positive correlations.

This study developed a scale to measure competencies defined based on the competency model to verify the construct validity of the competency model. Competency modeling for nursing integrates cognitive and noncognitive skills systematically and contextually based on internal structures [20]. Therefore, the results of this study approached from the integrated perspective of knowledge and skills, self-concept, motivation, and traits, provide valuable insights into the emotional touch nursing competencies of nurses.

This research is significant for attempting to build a model of emotional touch nursing competencies based on competency modeling, considering the rapidly changing nursing demands of clients in the Fourth Industrial Revolution and post–COVID-19 era. This scale can be used to assess and evaluate the degree of emotional touch competencies among nurses, providing a foundation and essential data for developing educational programs aimed at enhancing emotional touch nursing competencies.

Conclusions

This study established a model of emotional touch nursing competencies for nurses in response to the Fourth Industrial Revolution through the modeling of the concept and competencies of emotional touch nursing. The model encompasses 8 factors—"Client-Centered Collaborative Practice," "Learning Agility for Nursing," "Nursing Practice Competence," and "Nurse-Client Relationship," which reflect knowledge and skills; "Positive Self-Worth," "Compliance with Ethics and Roles," and "Nursing Sensitivity," which represent self-concept; and "Nursing Professional Commitment," which pertains to motivation and traits. The scale developed for this study consists of a total of 38 items using a 5-point Likert scale, with a possible score range of 38 to 190, indicating that higher scores reflect higher emotional touch nursing competencies. This scale is expected to be useful for assessing nurses' emotional touch nursing competencies and, through the results, for developing and implementing educational programs aimed at enhancing nursing competencies, thereby facilitating the provision of positive emotional touch nursing to clients in the rapidly changing health care environment of the Fourth Industrial Revolution.

Based on the findings of this study, the following suggestions are made—first, as this study targeted clinical nurses in general hospitals or larger institutions, future research is recommended to explore the degree of emotional touch nursing competencies among nurses in hospitals of various sizes. Second, subsequent research is suggested to develop and apply educational programs aimed at enhancing nurses' emotional touch nursing competencies based on the model developed in this study.

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Authors' Contributions

SYJ developed the research questions. SYJ and JHL were responsible for the methodology design and leading the review process. The review process, including resolving discrepancies, screening and selecting studies, and extracting and coding data, was jointly conducted by SYJ and JHL. Descriptive analyses and the preparation of tables and figures for the paper were carried out by SYJ and JHL. All authors were involved in interpreting the findings. The initial drafting of the study was done by SYJ and JHL. The paper was revised and the final version approved by all authors.

Conflicts of Interest

None declared.

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Abbreviations

AI: artificial intelligence
AVE: average variance extracted
CFA: confirmatory factor analysis
CFI: comparative fit index
EFA: exploratory factor analysis
GFI: goodness of fit index
I-CVI: Item-Content Validity Index
KMO: Kaiser-Meyer-Olkin
P-CAT: Person-Centered Care Assessment Tool
RMSEA: root mean square error of approximation
SRMR: squared root mean-squared residual

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