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ORIGINAL RESEARCH

Construction and Evaluation of a Predictive Model for Grassroots Nurses' Risk Perception of "Internet + Nursing Services": A Multicenter Cross-Sectional Study

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Purpose: The development of "Internet + nursing services" can effectively solve the problem of population aging, and grassroots nurses are the primary providers of such services in rural areas. This study aimed to analyze the factors affecting grassroots nurses' risk perception of "Internet + nursing services" and construct a predictive model.

Patients and Methods: A multicenter cross-sectional study of 2220 nurses from 27 secondary hospitals and 36 community health centers in Hubei Province was conducted from August to December 2023 using a multi-stage cluster sampling method. Information was collected through a structured anonymous questionnaire. A Chi-square test, a Welch *t*-test, and binary logistic regression analyses were employed to determine independent risk factors for grassroots nurses' risk perception of "Internet + nursing services", and a nomogram was constructed. Receiver operating characteristic curves, calibration curves, and decision curves were plotted to evaluate the discrimination, calibration, and clinical effectiveness of the nomogram.

Results: A total of 2050 valid questionnaires were collected, demonstrating that 51.95% of grassroots nurses thought that "Internet + nursing services" was a medium-high risk. Age, other sources of income, knowledge about "Internet + nursing services", personal safety, physical function, occupational exposure, social psychosocial, and time risk ($P<0.05$) were independent risk factors for grassroots nurses' risk perception. The area under the receiver operating characteristic curve of the nomogram was 0.939. The calibration and decision curve analyses demonstrated good calibration ability and clinical application values.

Conclusion: The prediction model constructed in this study has good prediction ability. Most grassroots nurses believe that "Internet + nursing services" are risky and influenced by several factors. It is suggested that the government and hospitals should formulate a unified charging standard, improve the safety guarantee, and gradually eliminate the concerns of grassroots nurses.

Keywords: grassroots nurse, Internet + nursing services, risk perception, predictive model

Introduction

Population aging is a critical issue worldwide and a significant challenge for China in particular. According to statistics, by the end of 2023, the population aged 60 years and over in China will reach 296 million, making up 21.1% of the total population.[1] The traditional healthcare model is struggling to meet the long-term care needs of a large aged population.[2] More importantly, while nearly 46% of older adults live in rural areas,[3] most of China's advanced medical resources are

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centralized in urban areas,[4] and insufficient construction of medical facilities and weak capacity to provide medical services in rural areas remain an issue.[5] This mismatch between the availability and requirements of healthcare resources makes the need for nursing services in rural areas more urgent.[6]

To accurately meet older adults' rising needs for nursing services, China is currently implementing the "Internet + nursing services" plan. This plan involves registered nurses providing care for discharged patients or patients with limited mobility through the "online application, offline service" model[7] (nurses who provide this care are termed online nurses).[8] The aforementioned plan is already widely implemented in first-tier cities, such as Tianjin, Jiangsu, and Zhejiang.[9] However, less-developed and rural regions remain in the initial stages.[10] In June 2023, the National Health Commission proposed, in the Action Plan for Further Nursing Services (2023–2025), that it should gradually increase the number of grassroots "Internet + nursing services" medical institutions and balance the allocation of nursing resources.[11] This plan is crucial for implementing quality medical resources in rural areas and improving the accessibility of "Internet + nursing services" in such areas.

As an innovative nursing service model, nurses may face many risks when providing "Internet + nursing services."[12] Earlier studies have demonstrated that age and working years affect nurses' risk perception of "Internet + nursing services."[13] A qualitative interview with 26 nurses demonstrated that nurses worried about personal safety risks and occupational risks when providing "Internet + nursing services", which also impacted their willingness to participate.[14] However, comprehensive and specific research lacks the factors influencing risk perception. Meanwhile, much of the current research on "Internet + nursing services" has focused on urban areas,[14,15] and the risk perception status of grassroots nurses remains unclear. However, as the primary provider of "Internet + nursing services" in rural areas, grassroots nurses are indispensable in promoting the efficient development of this service in rural areas. Analyzing the factors that affect such nurses' risk perception of "Internet + nursing services" will help identify possible difficulties and problems in promoting this policy at the grassroots level. This is of great significance for sustainable policy development.

To increase the motivation of grassroots nurses participating in "Internet + nursing services", it is important to identify and accurately predict the factors influencing their risk perception. Nomograms are well-established risk-assessment tools.[16] By integrating different variables, a nomogram can generate the individual risk probability of clinical events and visualize predictive models.[17] Nomograms have been widely used in clinics such as for predicting disease survival probabilities.[18] However, to our knowledge, relatively few reports of nomograms are being employed to predict the risk perception of grassroots nurses. Therefore, we conducted a cross-sectional study to explore the risk factors of grassroots nurses' risk perception of "Internet + nursing services" and innovatively established a predictive model. This model can maximize the distinction of grassroots nurses' risk perception of "Internet + nursing services" and provide a basis to formulate targeted risk-coping strategies.

This study is the first to develop a nomogram to predict grassroots nurses' risk perception of "Internet + nursing services." The purpose is to accurately identify the factors that affect these nurses' risk perception of "Internet + nursing services" and propose targeted improvement strategies to contribute to the growth of "Internet + nursing services" in rural areas of China.

Materials and Methods

Study Design and Participants

We conducted a multicenter cross-sectional study from August to December 2023. The participants were grassroots nurses with rich clinical experience. These nurses were selected through a multi-stage cluster sampling method. In the first stage, according to the economic development level and population size of each urban area in Hubei Province, Yichang City, Xiangyang City, and Jingzhou City—which are ranked high in terms of GDP and population density—were comprehensively selected as the sample areas for the study. In the second stage, based on the economic level and geographic location of counties within the selected cities, three counties in each city were selected as being more economically developed and closer to the city center (a total of nine counties were selected). In the third stage, three secondary hospitals and four community health service centers were selected as sampling organizations in each county. Finally, grassroots nurses from 27 secondary hospitals and 36 community health service centers were selected as the

sample population. The inclusion criteria were: (1) age > 18 years; (2) nurse practitioner qualification; (3) informed consent and willingness to participate in the study. The exclusion criteria were as follows: (1) absence from work due to leave of absence, out for further studying, etc.; (2) standardized training nurses and practice nurses.

This study was reviewed and approved by the Medical Ethics Committee of Tianyou Hospital affiliated to Wuhan University of Science and Technology (approval number: LL2024032103), and informed consent was obtained from all participants.

Research Tool

By reviewing the literature[13,19,20] and the pertinent policy documents of the National Health Commission regarding the experimental "Internet + nursing services" project and considering the purpose of this study, we designed a questionnaire. The questionnaire comprised three parts: (1) the general information questionnaire, including gender, age, number of children, marital status, education background, employment form, positional title, monthly income, working years, knowledge about "Internet + nursing services", other sources of income and acceptance of "Internet+nursing services"; (2) level of grassroots nurses' risk perception of "Internet + nursing services", which involved determining the said level through the question related to "Whether Internet + nursing services is risky." A 5-point Likert scale was used with options ranging from 1 = hardly to 5 = very high. Choosing "hardly" or "relatively low" is considered low risk, while choosing "medium degree", "relatively high", or "very high" is considered medium-high risk;[21] (3) online nurse risk perception questionnaire, which was compiled by Du[13] and comprises 28 items as well as six dimensions: five items on personal safety risks, four on physical functioning risks, four on occupational exposure risks, five on social psychological risks, four on organizational factor risks, and six items on time risk. In the questionnaire, a 5-level Likert rating method is used to score (1 = "none at all" to 5 = "always"). Higher dimension scores indicate that participants have a heavier perception of risk. The Cronbach's α coefficient for this scale was 0.996 in a prior study,[13] while in this study, it was 0.983.

Data Collection and Quality Control

The study data were collected through an online survey platform. Before conducting the research, the researchers communicated with the directors of the nursing departments to obtain their approval and cooperation. The QR code of the questionnaire was then sent to the clinical nurses by the hospital's nursing directors. The questionnaires were completed anonymously through mobile phones or computers, ensuring participants' privacy and data security. The first page of the questionnaire used unified guidance to explain the research purpose to the participants and obtain their informed consent and cooperation. To prevent repeated filling-in, respondents with the same IP address could submit the questionnaire once only, and the questionnaire could not be submitted unless all items were completed to maintain data integrity.

Before the official distribution of the questionnaire, a pre-survey involving 30 nurses was conducted. The questionnaire took an average of 317 seconds to complete, with a minimum completion time of 154 seconds and a maximum completion time of 486 seconds. Following questionnaire collection, the data were scrutinized by two researchers, and questionnaires with completion times of less than 160 seconds or with identical responses to all items were excluded.

Statistical Analysis

The data were processed using SPSS 25.0 software. The normal distribution of continuous data was expressed as mean ± standard deviation ($\bar{X} \pm S$), and the *t*-test was employed for between-group comparisons. Categorical variables were expressed as percentages ("%") using the chi-squared test for between-group comparisons. To determine the independent risk factors for risk perception among grassroots nurses, variables with statistically significant differences in the univariate analysis ($P<0.05$) were included as independent variables in the binary logistic regression analysis, and the results were used to establish a model.

The "rms, ggplot2, rmda, and pROC" packages in R4.2.3 software (http://www.r-project.org/) were used to draw nomograms, a calibration curve, a decision curve analysis (DCA), and an operating characteristic (ROC) curve. In the model verification phase, the bootstrap method was used for internal verification, and the concordance index (C-index) was used to measure the discrimination of the prediction model. The discriminatory ability of the model was explored by

drawing an ROC curve. Typically, an area under the ROC curve (AUC) >0.75 indicates good discriminant ability.[22] The accuracy of the model was verified using a calibration curve, and its clinical utility was analyzed using DCA. A two-sided *P*-value <0.05 was considered a statistically significant difference.

Results

Characteristics of Participants

A total of 2,220 nurses were investigated in this study; 2,220 questionnaires were distributed, and 2,157 were recovered, with a recovery rate of 97.16%. Moreover, 107 invalid questionnaires were deleted, and 2,050 valid questionnaires were collected, representing an effective response rate of 95.03%. A descriptive analysis of the general demographics of the 2,050 participants is presented in Table 1. The majority were women (97.51%), which is consistent with the traditional social perception of care

Table 1 Characteristics of the Participants (n = 2050)

Variable	Category	n	%
Gender	Female	1,999	97.51
	Male	51	2.49
Age	≤30	782	38.15
	31–40	966	47.12
	≥41	302	14.73
Marriage status	Married	1,635	79.76
	Single	415	20.24
Number of children	0	574	28.00
	1	848	41.37
	2	608	29.66
	≥3	20	0.98
Educational background	Polytechnic school	59	2.88
	Junior college	1,421	69.32
	Bachelor's degree or above	570	27.80
Employment form	Regular staff	342	16.68
	Personnel agency	227	11.07
	Contract system	1,416	69.07
	Labor dispatch	65	3.17
Positional title	Nurse	359	17.51
	Primary nurse	764	37.27
	Supervisor nurse	848	41.37
	Co-chief superintendent nurse or above	79	3.85
Working years	≤5	376	18.34
	6–10	677	33.02
	11–19	739	36.05
	≥20	258	12.59
Monthly income (yuan)	≤3000	230	11.22
	3001–5000	1,033	50.39
	5001–7000	537	26.20
	≥7001	250	12.19
Other sources of income	Yes	104	5.07
	No	1,946	94.93
Knowledge about Internet + nursing services	Yes	1,532	74.73
	No	518	25.27
Acceptance of Internet + nursing services	Totally reject	45	2.20
	Less accepting	54	2.63
	Neutrality	672	32.78
	Relatively accepting	781	38.10
	Fully accept	498	24.29

workers. Most participants were married (79.76%), while more than 60% had a junior college degree (69.32%). Approximately half of the participants (50.39%) earned 3,001–5,000 Chinese Yuan (CNY) per month (A currency exchange rate of ¥1=US $0.14 is applicable), while the majority (74.73%) knew about "Internet + nursing services."

Grassroots Nurses' Risk Perception of "Internet + Nursing Services"

Table 2 illustrates the results of risk perception of "Internet + nursing services" among the participants. In total, 51.95% of the participants believed that the "Internet + nursing services" plan was a medium-high risk.

Analysis of Influencing Factors of Grassroots Nurses' Risk Perception of "Internet + Nursing Services"

Grassroots nurses' risk perception of "Internet + nursing services" (low risk = 0, medium-high risk = 1) was used as the dependent variable. In contrast, gender, age, marriage status, number of children, educational background, employment form, position title, monthly income, and working years, etc., were used as independent variables for the chi-square test and Welch *t*-test analysis. The results demonstrated that there were statistically significant differences between the two groups except for gender and educational background ($P < 0.05$) (Table 3).

Binary Logistic Regression Analysis of Factors Associated with Risk Perception

The variables associated with grassroots nurses' risk perception ($P<0.05$) were selected for binary logistic regression analysis. The findings demonstrated that single grassroots nurses' risk perception of "Internet + nursing services" was 1.840 times that of married grassroots nurses. The risk perception of grassroots nurses with one child was 1.336 times higher than that of those without children. The risk perception of grassroots nurses with working years of 6–10 years was 0.623 times that of those with working years ≤5 years. The detailed analysis results are presented in Table 4. Furthermore, the regression analysis illustrates that eight variables, including age, other sources of income, knowledge about "Internet + nursing services", personal safety risks, physical function risks, occupational exposure risks, and social psychological risks, were independent influencing factors for grassroots nurses' risk perception of "Internet + nursing services" (all $P<0.05$). A forest map of the influencing factors is illustrated in Figure 1.

Constructing and Validating of the Nomogram Prediction Model

We developed a nomogram based on eight independent risk factors derived from the binary logistic regression analysis (Figure 2). The ROC curve of the nomogram is illustrated in Figure 3. The C-index was 0.939 (95% CI: 0.931–0.948), and the AUC value was 0.939, which is greater than 0.75,[22] indicating that the nomogram had a good discrimination ability in predicting grassroots nurses' risk perception of "Internet + nursing services." In the calibration chart (Figure 4), the calibration curve almost coincides with the reference line, indicating that the calibration ability of the nomogram is better. DCA (Figure 5) illustrates that using the nomogram to predict risk perception had the best net benefit. The overall prediction performance of the model was excellent. Unfortunately, this study was not conducted in an external population, so subsequent external validation is needed to assess the validity of the model.

Table 2 Risk Perception Level of "Internet + Nursing Services" for Grassroots Nurses (n = 2050)

Variable	Category	n	%
Whether the "Internet + nursing services" plan is risky	Hardly	287	14.00
	Relatively low	698	34.05
	Medium degree	762	37.17
	Relatively high	213	10.39
	Very high	90	4.39

Table 3 Risk Perception of Grassroots Nurses with Different Demographic Characteristics on "Internet + Nursing Services"

Variable	Low risk (n = 985)	Medium-high risk (n = 1065)	χ^2/t	*P*
Gender			χ^2 = 1.635	0.201
Female	965 (97.97)	1,034 (97.09)		
Male	20 (2.03)	31 (2.91)		
Age			χ^2 = 56.608	<0.001
≤30	300 (30.46)	482 (45.26)		
31–40	499 (50.66)	467 (43.85)		
≥41	186 (18.88)	116 (10.89)		
Marriage status			χ^2 = 38.504	<0.001
Married	842 (85.48)	793 (74.46)		
Single	143 (14.52)	272 (25.54)		
Number of children			χ^2 = 42.648	<0.001
0	210 (21.32)	364 (34.18)		
1	453 (45.99)	395 (37.09)		
2	312 (31.68)	296 (27.79)		
≥3	10 (1.02)	10 (0.94)		
Educational background			χ^2 = 5.947	0.051
Polytechnic school	35 (3.55)	24 (2.25)		
Junior college	661 (67.10)	760 (71.36)		
Bachelor's degree or above	289 (29.34)	281 (26.38)		
Employment form			χ^2 = 17.982	<0.001
Regular staff	196 (19.90)	146 (13.71)		
Personnel agency	110 (11.17)	117 (10.99)		
Contract system	642 (65.18)	774 (72.68)		
Labor dispatch	37 (3.76)	28 (2.63)		
Positional title			χ^2 = 12.833	0.012
Nurse	156 (15.84)	203 (19.06)		
Primary nurse	349 (35.43)	415 (38.97)		
Supervisor nurse	433 (43.96)	415 (38.97)		
Associate chief nurse and above	47 (4.77)	32 (3.01)		
Working years			χ^2 = 39.354	<0.001
≤5	141 (14.31)	235 (22.07)		
6–10	310 (31.47)	367 (34.46)		
11–19	375 (38.07)	364 (34.18)		
≥20	159 (16.14)	99 (9.30)		
Monthly income (yuan)			χ^2 = 26.935	<0.001
≤3000	92 (9.34)	138 (12.96)		
3001–5000	465 (47.21)	568 (53.33)		
5001–7000	283 (28.73)	254 (23.85)		
≥7001	145 (14.72)	105 (9.86)		
Other sources of income			χ^2 = 39.070	<0.001
Yes	81 (8.22)	23 (2.16)		
No	904 (91.78)	1,042 (97.84)		
Knowledge about "Internet + nursing services"			χ^2 = 49.117	<0.001
Yes	805 (81.73)	727 (68.26)		
No	180 (18.27)	338 (31.74)		
Acceptance of "Internet + nursing services"			χ^2 = 101.778	<0.001
Totally reject	18 (1.83)	27 (2.54)		
Less accepting	15 (1.52)	39 (3.66)		
Neutrality	239 (24.26)	433 (40.66)		
Relatively accepting	397 (40.30)	384 (36.06)		
Fully accept	316 (32.08)	182 (17.09)		

(*Continued*)

Table 3 (Continued).

Variable	Low risk (n = 985)	Medium-high risk (n = 1065)	χ^2/t	*P*
Personal safety risks	12.50 ± 3.60	17.95 ± 3.30	*t* = −35.715	<0.001
Physical function risks	8.72 ± 2.73	13.78 ± 2.67	*t* = −42.336	<0.001
Occupational exposure risks	9.19 ± 2.81	14.05 ± 2.69	*t* = −39.993	<0.001
Social psychological risks	11.34 ± 3.27	17.02 ± 3.17	*t* = −39.885	<0.001
Organizational factors	9.58 ± 2.69	13.79 ± 2.50	*t* = −36.648	<0.001
Time risk	13.37 ± 4.09	20.40 ± 3.97	*t* = −39.460	<0.001

Table 4 Binary Logistic Regression Analysis of Grassroots Nurses' Risk Perception of "Internet + Nursing Services"

Variables		B	S.E	*P*	OR (95% CI)
Age	≤30				(Reference)
	31–40	−0.652	0.236	0.006	0.521 (0.328–0.829)
	≥41	−0.858	0.445	0.054	0.424 (0.177–1.014)
Marital status	Married				(Reference)
	Single	0.610	0.318	0.055	1.840 (0.987–3.432)
Number of children	0				(Reference)
	1	0.290	0.283	0.305	1.336 (0.798–2.325)
	2	0.695	0.302	0.872	0.877 (0.177–4.332)
	≥3	0.435	0.851	0.610	1.544 (0.291–8.191)
Employment form	Regular staff				(Reference)
	Personnel agency	0.370	0.527	0.482	1.448 (0.515–4.067)
	Contract system	0.792	0.508	0.119	2.208 (0.816–5.978)
	Labor dispatch	0.540	0.460	0.241	1.716 (0.696–4.229)
Positional titles	Nurse				(Reference)
	Primary nurse	−0.017	0.256	0.946	0.983 (0.595–1.623)
	Supervisor nurse	0.316	0.290	0.276	1.372 (0.777–2.422)
	Associate chief nurse and above	−0.154	0.554	0.782	0.858 (0.290–2.541)
Working years	≤5				(Reference)
	6–10	−0.473	0.289	0.101	0.623 (0.353–1.097)
	11–19	−0.469	0.354	0.186	0.626 (0.313–1.253)
	≥20	−0.684	0.551	0.215	0.505 (0.171–1.487)
Monthly income (yuan)	≤3000				(Reference)
	3001–5000	−0.010	0.255	0.970	0.990 (0.600–1.633)
	5001–7000	−0.218	0.286	0.445	0.804 (0.459–1.408)
	≥7001	−0.428	0.360	0.234	0.652 (0.322–1.320)
Other sources of income	Yes				(Reference)
	No	1.747	0.387	<0.001	5.736 (2.689–12.249)
Knowledge about "Internet + nursing services"	Yes				(Reference)
	No	0.462	0.176	0.009	1.587 (1.125–2.240)
Acceptance of "Internet + nursing services"	Totally reject				(Reference)
	Less acceptable	−0.349	0.835	0.676	0.705 (0.137–3.621)
	Neutral	−0.181	0.718	0.800	0.834 (0.204–3.404)
	Compare accept	−0.790	0.714	0.269	0.454 (0.112–1.841)
	Fully accept	−0.871	0.719	0.226	0.419 (0.102–1.714)
Personal safety risks		0.523	0.171	0.002	1.687 (1.206–2.360)
Physical function risks		2.218	0.242	<0.001	9.188 (5.722–14.752)
Occupational exposure risks		1.282	0.260	<0.001	3.602 (2.162–6.002)
Social psychological risks		2.006	0.283	<0.001	7.436 (4.267–12.958)
Organizational factors		0.200	0.231	0.386	1.221 (0.777–1.919)
Time risk		1.750	0.214	<0.001	5.756 (3.786–8.751)

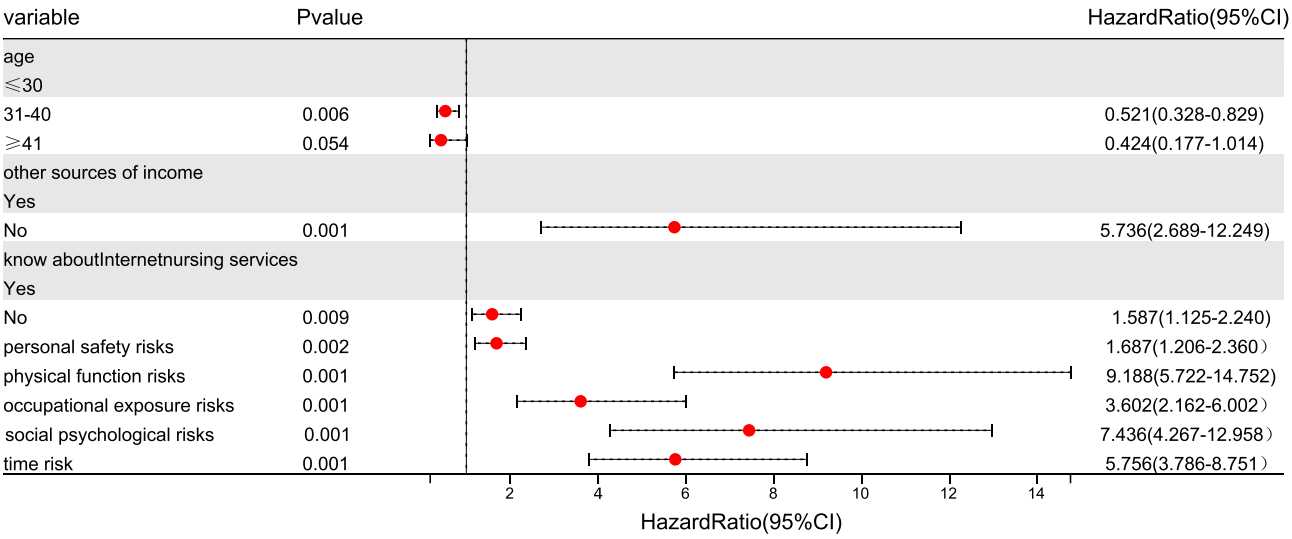

Figure 1 Forest map of influencing factors of risk perception.

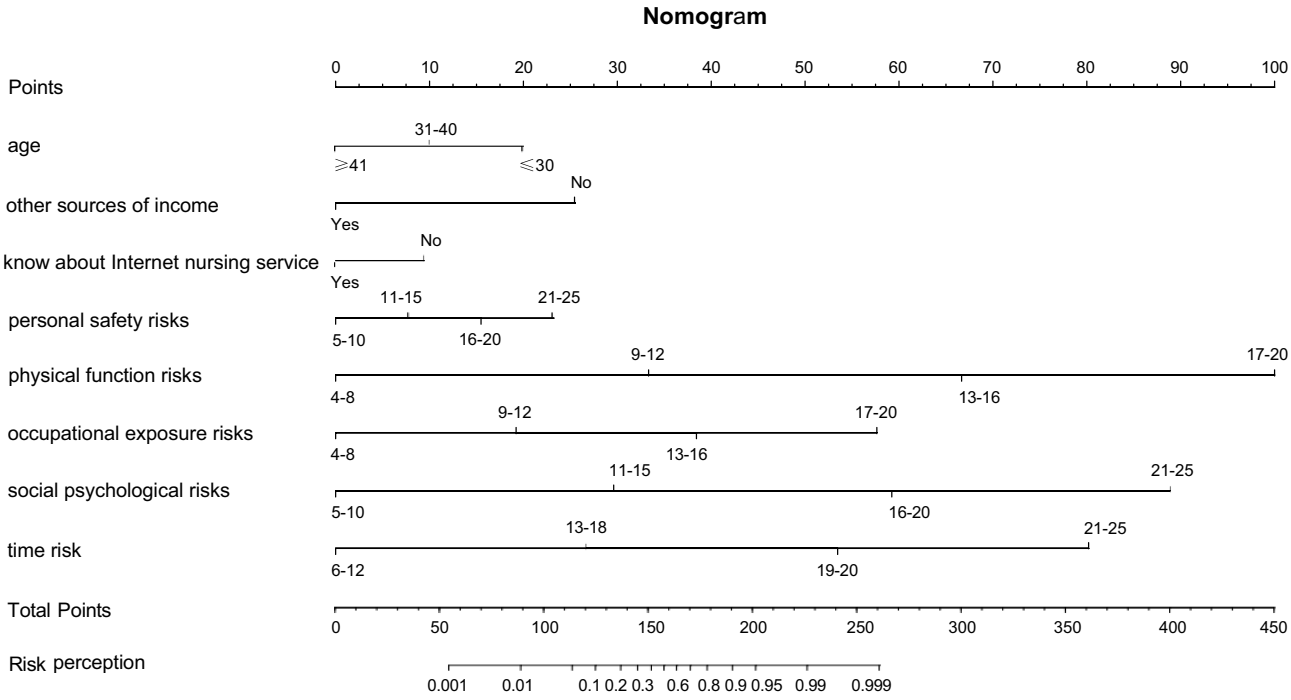

Figure 2 Nomogram for the prediction of risk perception of "Internet + nursing services" among grassroots nurses.

Discussion

Current Situation of Risk Perception of "Internet + Nursing Services" Among Grassroots Nurses

This study investigated grassroots nurses' risk perception of "Internet + nursing services" and established a risk prediction model for the first time. It enriches the research in this field owing to its novel perspective. In this multicenter cross-sectional study, our results indicated that 51.95% of grassroots nurses believed that the "Internet + nursing services" plan is medium-high risk—a figure higher than that noted in a survey of nurses in Jiangsu Province.[23] The

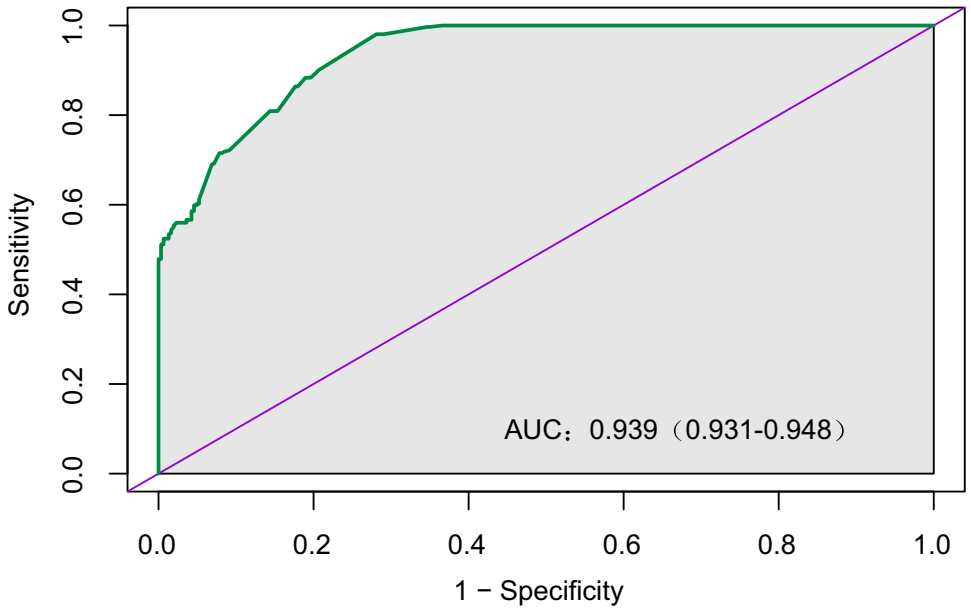

Figure 3 ROC curve for the nomogram.

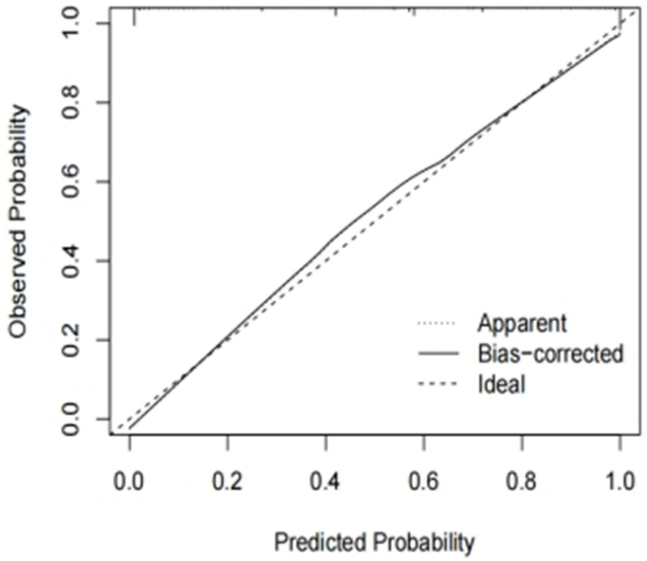

Figure 4 The calibration curve for the nomogram.

reason may be that Jiangsu Province was one of the first cities to implement "Internet + nursing services" in 2019, and the development of such services has been relatively mature.[9] Meanwhile, compared with urban areas, the "Internet + nursing services" plan in rural areas of China is in its infancy.[10] Multiple challenges, such as the lack of nursing staff in rural areas, backward infrastructure, and insufficient resource allocation,[5,24] might have increased grassroots nurses' risk perception of "Internet + nursing services." It is important to identify the factors impacting these nurses' risk perception in a timely manner and implement effective countermeasures to promote the development of "Internet + nursing services" in rural areas.

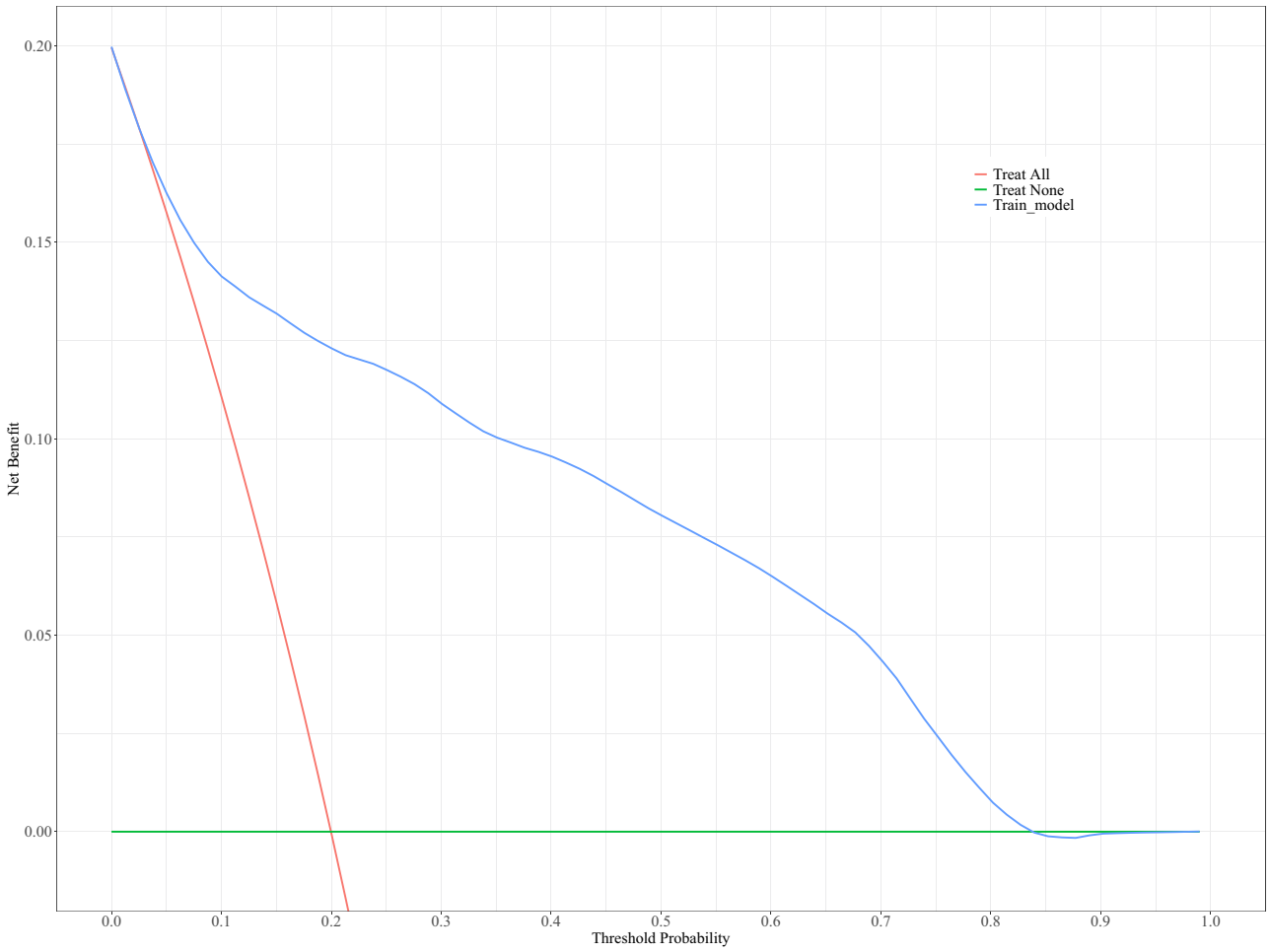

Figure 5 Decision curve for the nomogram.

Influencing Factors of Grassroots Nurses' Risk Perception of "Internet + Nursing Services"

For this study, we developed a simple intuitive graph of a predictive model that quantified grassroots nurses' risk perception of "Internet + nursing services." Eight independent predictors were identified. After verification, the prediction models exhibited satisfactory performance in terms of discrimination, calibration, and accuracy.

In our analysis, age was an independent factor influencing grassroots nurses' risk perceptions (OR = 0.521, 95% CI: 0.328–0.829). Younger grassroots nurses had higher levels of risk perception. This differs from the results reported by Du.[13] It may be that the operational skills of young grassroots nurses are not well developed, their clinical experience is insufficient,[13] and they are more alert to risks in nursing work. Additionally, in our study, the grassroots nurses' educational level was mainly junior college (69.32%), indicating that the educational level of grassroots nurses was generally low, and their basic knowledge was weak. This is consistent with the results of a research project, which surveyed 302 grassroots nurses in Xi'an.[25] Therefore, grassroots medical institutions should focus on knowledge lectures and training for young nurses with low education, enhance nurses' home-based nursing operation skills, and improve their emergency response ability so as to reduce grassroots nurses' risk perception of "Internet + nursing services."

This study demonstrates that grassroots nurses with other sources of income had lower risk perceptions than grassroots nurses without other sources of income (OR = 5.736, 95% CI: 2.689–12.249). Similarly, a previous study reported that nurses with higher incomes were more likely to participate in the services.[26] The reason may be the additional financial benefits of providing "Internet + nursing services",[27] which offset some of the risks; however,

qualitative research demonstrates that some nurses believe that pricing is considerably low and that there is a mismatch between effort and income, which discourages them from participating in the services.[28] Therefore, the relevant departments should formulate reasonable service-charging standards and improve their salary distribution systems. Meanwhile, considering the low income in rural areas,[29] it is recommended that "Internet + nursing services" be included in the scope of medical insurance reimbursement to maximize the benefits for both nurses and patients.

Occupational exposure is an independent factor that affects grassroots nurses' risk perception of "Internet + nursing services" ($P<0.05$). A survey conducted in Chicago revealed that home care workers face varying levels of exposure to blood and bodily fluids risk.[30] Nurses need to take the medical waste generated during services back to the hospital for disposal,[28] and poor sanitation in rural areas can lead to an increased risk of occupational exposure for grassroots nurses. A previous study confirmed that occupational exposure may lead to resistance to the program among online nurses.[14] Therefore, relevant measures should be taken to reduce the occupational exposure risk of grassroots nurses, such as strengthening standardized training on medical waste disposal and improving their awareness of personal protection. Simultaneously, when facing a harsh service environment in rural areas, grassroots nurses should wear appropriate protective equipment to increase their security during participation in the services.

Our findings revealed that grassroots nurses who knew about the "Internet + nursing services" had lower risk perceptions than grassroots nurses who were unaware of the service ($P<0.05$). The reason may be that grassroots nurses who know about this service could have a more accurate judgment of potential risks. In this study, 74.73% of the grassroots nurses surveyed knew about "Internet + nursing services", which is higher than the results of Huang.[31] The discrepancy could be because "Internet + nursing services" had been officially implemented for four years when the survey was conducted, with more than 2,000 medical institutions across the country offering over 60 medical services for older adults.[12] Indeed, the policy has been widely implemented, and has achieved remarkable results,[27] which has improved the awareness rate of grassroots nurses.

Social psychological factors also affected the risk perception of grassroots nurses ($P<0.05$). Consistent with the findings of a qualitative study on grassroots nurses, support and recognition from patients facilitated positive experiences.[32] To better implement the "Internet + nursing services" plan, relevant departments should improve public support for the policy. As rural residents have few information sources and a weak ability to receive information, it may be difficult to promote the plan.[32] Therefore, hospital managers can make use of a combination of online and offline methods, such as WeChat platforms, home visits, or docking with surrounding older adult care institutions, to improve the social support provided to the public in the region, thus increasing the motivation of grassroots nurses to participate.

The results demonstrate that time risk was an independent factor influencing risk perception ($P<0.05$). This is consistent with the results of interviews with 15 online nurses from five cities.[28] According to Kowitlawkul et al, most nurses spend over 80% of their time on work activities, while less than 20% is allocated to their personal lives.[33] Therefore, a time conflict is key for nurses when participating in "Internet + nursing services." The results of an interview with grassroots nurses demonstrated that remote destinations and poor network signals in rural areas led to inaccurate positioning, which prolonged the service process to a certain extent.[24] It is suggested that the service platform be optimized and improved to provide more accurate positioning. Meanwhile, nursing managers can try to set up "Internet + nursing services" as a post. This will ensure that grassroots nurses have the time and energy to provide the services.

The results demonstrate that physical function and personal safety were independent factors influencing grassroots nurses' risk perception of "Internet + nursing services" ($P<0.05$), consistent with previous findings.[14,31] Studies have demonstrated that the incidence of non-physical violence experienced by door-to-door medical service providers is 51.5%.[34] The unique nature of the service location and the unpredictability of the population may lead to increased safety hazards for nurses.[35] Transportation in rural areas is inconvenient, and some grassroots nurses believe that there is a lack of travel safety guarantees when providing services.[24] This discourages grassroots nurses from providing such services. Therefore, it is recommended that hospitals purchase personal accident insurance for grassroots nurses and equip them with assistive devices such as a One-Button Emergency Phone with GPS Tracker.[14] They can also be equipped with special vehicles for greater publicity and to ensure that nurses travel safely. This might gradually eliminate the concerns of grassroots nurses and promote the development of "Internet+nursing services" in rural areas.

Limitations

This study has certain limitations. First, the survey was administered online, so it was not possible to determine whether the participants approached the survey seriously. Second, as all respondents were nurses in grassroots hospitals in Hubei Province, the results may not be applicable to other provinces and higher-level hospitals. Finally, as only internal validation of the predictive model was conducted, its applicability to external datasets could not be determined. Therefore, future studies can consider adopting face-to-face questionnaires and collecting data from different regions. To verify the external reliability of the model and improve the representativeness of the findings, thereby guiding medical institutions can formulate effective risk control strategies.

Conclusion

The predictive model constructed in this study to address grassroots nurses' risk perception of "Internet + nursing services" has good predictive ability and can be used for personalized analysis of grassroots nurses' risk perception. Meanwhile, this study found that grassroots nurses generally believe that "Internet + nursing services" is risky. Age, knowledge about "Internet + nursing services", other sources of income, personal safety risks, physical function risks, occupational exposure risks, social psychological risks, and time risks are the main influencing factors. It is recommended that government and hospitals formulate suitable risk response strategies, strengthen policy publicity efforts, establish uniform charging standards, and improve service security. These measures will help reduce the perceived level of risk for grassroots nurses and facilitate the implementation of "Internet + nursing services" in rural areas.

Data Sharing Statement

The data will be available from the corresponding author.

Ethical Approval

This study was reviewed and approved by the Medical Ethics Committee of Tianyou Hospital affiliated to Wuhan University of Science and Technology (approval number: LL2024032103). The study was conducted according to the Declaration of Helsinki.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

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