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Perceived acceptance, intention to use and actual use behavior of digital information technologies among nursing professionals in Shanghai: a cross-sectional study

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Abstract

Background Digital information technologies (DITs) can contribute to optimizing the quality and efficiency of healthcare delivery. However, profiles of awareness and use behavior of DITs among Chinese nursing professionals remained limited. This study aimed to investigate the profiles of perceived acceptance, intention to use and use behavior of DITs and identify influencing factors among nursing professionals in hospitals in Shanghai.

Methods A total of 1421 nursing professionals from 20 hospitals across Shanghai were selected as participants between August and October 2021. After excluding missing values, 1395 participants were included in the analyses. Using the technology acceptance model, perceived acceptance of general DITs was measured as perceived ease of use (PEU) and perceived usefulness (PU). Intention to use and use behavior were measured using two single 5-point Likert scales. Linear and logistic regression models and mediation analyses were developed to examine influencing factors.

Results All of the PU and PEU items received affirmative responses (agree or strongly agree) among over 50% of participants. Of all participants, 1101 (78.9%) expressed intention to use DITs; 626 (44.9%) were frequent users. Age, bachelor's degree, in-house training on DITs, school-based training, and out-of-hospital training were associated with perceived acceptance. Licensed practical nurse, deputy chief nurse, working years, in-house training, and school-based training were significant predictors of intention to use. Vocational college diploma, bachelor's degree, in-house training, school-based training, out-of-hospital training, tertiary level 1 and tertiary level 2 hospitals, and specialized hospitals were associated with frequent use. Intention to use mediated 42.6% (95%CI: 10.3%~60.4%) of the total effects of perceived acceptance on frequent use of DITs.

Conclusions This study suggests that although nursing professionals in Shanghai have positive perceived acceptance and strong intention to use DITs, they rarely use DITs in their practice. Therefore, policies and interventions should be developed to enhance the integration of DITs into nursing professionals' daily practice.

Keywords Intention, Information technology, Nursing staff, China

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Background

Digital information technologies (DITs) are now widely applied in clinical care, optimizing the efficiency and safety of healthcare utilization and delivery [1–4]. Broadly speaking, DITs encompass digitally collected data, technical software and artificial intelligence (AI). For instance, electronic health records (EHRs) contribute to enhancing the completeness, structure, and legibility of medical data [5]; AI-powered decision support systems benefit both medical professionals and patients by improving diagnostic accuracy and expediting the diagnostic process [6, 7]; mobile health applications have proven to be effective tools for improving quality of care and enhancing nurses' learning and knowledge [8]. Furthermore, DITs also contribute to gains in medical education and the cultivation of leadership skills among medical professionals [9].

In China, the general digital technology innovation surges in scale and vitality, impacting social and economic development [10]. When looking at the DITs and their application in healthcare settings, national policy calls for a strong emphasis on promoting DITs as a strategic pillar of national health reform [11]. Currently, the primary stage of construction and deployment of DITs has been completed in China's tertiary hospitals [12]. The basic EHR application has been gaining increasing recognition in China's hospitals [13].

Although DITs are gaining momentum today, their real-world adoption and application rely heavily on the attitude and acceptance of DITs among healthcare professionals [14]. As the primary practitioners in daily clinical practice, nursing professionals have extensive interactions with patients, consistently providing care and ensuring patient safety [15]. Furthermore, nursing professionals can influence practice by implementing best practices [16, 17]. Consequently, the extent to which DITs are widely adopted in healthcare settings largely depends on nursing professionals' perception of and behavior towards these technologies.

Previous studies demonstrated that health professionals, including nursing professionals, faced significant organizational-level and individual-level barriers to adopting DITs in their practice [9, 18–20]. However, these studies also emphasized that a positive perception of the effectiveness and usefulness of DITs can facilitate their adoption. Particularly, a study focusing on nursing professionals found that the characteristics and preferences of nurses and their voluntariness were prerequisites for the successful adoption of DITs [21]. Conversely, another study revealed that negative attitudes and decreased productivity due to the use of DITs were reported barriers to adoption [22].

Accordingly, gaining insights into the perceived acceptance and attitude towards DITs may shed light on promoting their adoption in clinical settings. In particular, the Technology Acceptance Model (TAM) can serve as a classic and easily understandable framework for understanding the factors that shape the ultimate adoption of a technology [23]. As stipulated by TAM, technology adopters initiate the adoption process by developing a cognitive perception of the technology, followed by forming an affective perception, and ultimately shaping their adoption behavior.

However, although several studies have investigated similar topics, they may not be informative due to using a small sample size [24, 25], investigating non-general DITs [26] and focusing excessively on latent influencing factors (e.g., social norm, culture) [27]. Additionally, data and evidence regarding this topic remain limited in the Chinese context. Therefore, this study aimed to investigate the perceived acceptance, intention to use, and use behavior of DITs among nursing professionals, and examine associated influencing factors and mechanisms.

Methods

Settings and participants

This study was a cross-sectional investigation conducted in hospital settings across Shanghai from August to October 2021. This study was exempt from ethical review by the Institutional Review Board of the International Peace Maternity and Child Health Hospital in March 2021. The reason for the exemption was that our study does not belong to biomedical research that collects biological samples and health records. A non-probability convenience sampling method was employed to recruit participants. Hospitals located in 13 out of the 16 districts in Shanghai were approached to ascertain their potential agreement to participate in this study. A total of 20 out of 26 hospitals responded positively and were ultimately selected. This resulted in a response rate of 76.92% at the organizational level. Since the exact total number of nursing staff in each participating hospital cannot be obtained due to reasons including privacy and direct decline by heads of nursing departments, a response rate at the individual level cannot be calculated. In each of the selected hospitals, all nursing professionals were invited to join this study. Among those who agreed to join, an online questionnaire was administered (via https://www.wjx.cn/). The administration mode was self-report. A total of 1421 complete questionnaires were returned. Listwise deletion was applied to handle missing values. After excluding 26 observations with missing values on the working years variable, 1395 participants were finally included in the analyses.

Overall questionnaire

Based on inputs from literature research [24, 26–29] and expert consultation meetings (Appendix), a structured

questionnaire was developed to collect information. This questionnaire consisted of demographic items asking about age, education, working areas, working years, professional titles, involvement in night shifts, hospital tiers and hospital types. Additionally, it included items asking about training on DITs, perception of DITs, intention to use DITs and use behavior of DITs. At the end of the questionnaire, an item was set to ask participants to select barriers to the adoption of DITs.

To ensure clarity and comprehension, a concise description of DITs was provided at the outset of the questionnaire. A pre-testing phase involving ten nursing professionals was conducted to refine the wording and minimize cognitive load (Appendix).

Perceived acceptance

Based on the TAM, eight items were developed to measure the perceived usefulness (PU) and perceived ease of use (PEU) of DITs (Appendix). Participants were asked to indicate their level of agreement or disagreement on the PU and PEU statements using a 5-point Likert scale, ranging from "strongly agree" (assigned 5 points in the analysis) to "strongly disagree" (assigned 1 point). The perceived acceptance was determined as the sum of the scores from the PU and PEU items, with a theoretical range of 8 to 40. Higher scores indicated a higher level of perceived acceptance.

Reliability tests were conducted on the perceived acceptance items. Consistency reliability was evaluated using Cronbach's α. The Cronbach's α was 0.98, which indicated good consistency. Structure reliability was assessed using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity. The KMO value was 0.96, and Bartlett's test result was significant ($p < 0.001$), indicating satisfactory structure reliability.

Intention to use DITs

The intention to use DITs was measured by asking participants if they were willing to use DITs. Responses were strongly willing, willing, fair, unwilling, and strongly unwilling. Participants were deemed to have the intention to use if they responded strongly willing or willing.

Use behavior of DITs

Asking a binary question about whether participants use DITs in their daily practice would be problematic, as nearly all nursing professionals in Shanghai's hospitals would know and use DITs more or less. However, it was anticipated that there would be variations in the frequency of their use. Hence, the use behavior of DITs was assessed by asking participants to what extent they were involved in using DITs in their practice. Responses were very much, much, fair, little, very little. Participants were deemed frequent users of DITs if they responded very much or much.

Covariates

Covariates included age (a continuous variable), education (secondary vocational school diploma/vocational college diploma/bachelor's degree/master's degree and above), professional titles(early-stage nurse/ licensed practical nurse/supervisor nurse/deputy chief nurse, listed in order of increasing qualification levels), working years (a continuous variable), night shifts (yes/no), hospital tiers(secondary level 1/secondary level 2/tertiary level 1/tertiary level 2, listed in order of increasing tier levels), hospital types(general/specialized), working areas (ward/intensive care unit/operating room/delivery room/outpatient and emergency department/others), hospital in-house training(yes/no), school-based training(yes/no) and external training(yes/no).

Statistical analysis

The sample size was calculated for three primary regression models (detailed below). For the linear regression model, a conservative R squared value of 0.20 and 15 variables were assumed, which yielded 108 samples with 90% power and a 5% significance level. For two logistic regression models, the events per variable (EPV) rule was applied. With 15 variables assumed in the model and an EPV value of 20, the required number of events was 300. Assuming a prevalence of 50% for intention to use DITs and 30% for frequent use, the required sample size was 600 and 1000, respectively.

Due to a limited number of observations with missing values (26 observations), the analysis was carried out on a complete-case basis. Mean (standard deviation, SD) or frequency (percentage) was used to describe sample characteristics. The significance of difference between two groups was determined using a Chi-squared test or a t-test where applicable.

Three multivariable models were developed to examine the socio-economic factors influencing perceived acceptance, intention to use and frequent use of DITs. Perceived acceptance was modelled using a multivariable linear regression with robust estimator. Intention to use and frequent use of DITs were each modelled using a multivariable logistic regression with robust estimator. Since perfect separation occurred in the group with a Master's degree and above for the education variable, the Bachelor's degree and the Master's degree and above groups were merged in the model predicting intention to use DITs. Predictors were introduced in the models without selection processes as we aimed to explore the effects of all observed socio-economic variables.

To gain further insights into the relationship among perceived acceptance, intention to use, and frequent use

of DITs, a regression-based mediation analysis was conducted. It was hypothesized that the effects of perceived acceptance on frequent use would be partly mediated by intention to use. Therefore, a mediator model was first developed, regressing intention to use on perceived acceptance. An outcome model was then fitted with frequent use as the dependent variable and both intention to use and perceived acceptance as the independent variables. Mediator and outcome models were controlled for the same set of covariates. The total effects, mediation effects and proportion of effects mediated were the measures of interest. The bootstrapping method was used to obtain 95% confidence intervals for statistical inference in the mediation analysis. The bias-corrected and accelerated confidence interval was used. Plots of distributions of bootstrapped samples can be found in Appendix.

Table 1 Summary statistics for sample profile (N = 1395)

Variables	Overall	Frequent use of DITs		*p*
		No	Yes	
Age, mean (SD)	33.51 (7.78)	33.95 (7.75)	32.96 (7.78)	0.017
Education				
Secondary vocational school	22 (1.6)	9 (1.2)	13 (2.1)	0.152
Vocational college diploma	415 (29.7)	220 (28.6)	195 (31.2)	
Bachelor's degree	932(66.8)	529 (68.8)	403 (64.4)	
Master's degree and above	26(1.8)	11 (1.4)	15 (2.4)	
Professional titles				
Early-stage nurse	1116 (80.0)	609 (79.2)	507 (81.0)	0.312
Licensed practical nurse	130 (9.3)	81 (10.5)	49 (7.8)	
Supervisor nurse	129 (9.2)	67 (8.7)	62 (9.9)	
Deputy chief nurse	20 (1.4)	12 (1.56)	8 (1.3)	
Working years, mean (SD)	8.79 (7.58)	9.14 (7.72)	8.36 (7.39)	0.055
Night shifts				
Yes	959 (68.7)	536 (69.7)	423 (67.6)	0.427
No	436 (31.3)	233 (30.3)	203 (32.4)	
Hospital tiers				
Secondary level 1	80 (5.7)	52 (6.8)	28 (4.5)	0.017
Secondary level 2	664 (47.6)	380 (49.4)	284 (45.4)	
Tertiary level 1	134 (9.6)	78 (10.1)	56 (8.9)	
Tertiary level 2	517 (37.1)	259 (33.7)	258 (41.2)	
Hospital types				
General	696 (49.9)	402 (52.3)	294 (47.0)	0.055
Specialized	699 (50.1)	367 (47.7)	332 (53.3)	
Working areas				
Ward	871 (62.4)	478 (62.2)	393 (62.8)	0.173
ICU	118 (8.5)	54 (7.0)	64 (10.2)	
Operating room	47 (3.4)	28 (3.6)	19 (3.0)	
Delivery room	145 (10.4)	89 (11.6)	56 (8.9)	
Outpatient and ED	130 (9.3)	76 (9.9)	54 (8.6)	
Others	84 (6.0)	44 (5.7)	40 (6.4)	

DITs = Digital Information Technologies; ED = Emergency Department; ICU = Intensive Care Unit; SD = Standard Deviation

Model fit statistics were calculated (Appendix). The regression-based mediation analysis was performed using the glm function in the base package and the boot function in the boot package in R. Statistical significance was determined at an alpha level of 0.05. All analyses were performed in R version 4.4.1.

Results

Sample profile summary

The mean age of the included participants was 33.51 years, and all were women. The majority of participants had bachelor's degree (66.8%) and professional titles of early-stage nurse (80.0%). The average working years was 8.79. Over half of participants worked in ward (62.4%). Frequent users of DITs were more likely to be younger (p = 0.017) and employed at tertiary level 2 hospitals (p = 0.017). Additional details on the sample summary are provided in Table 1.

Descriptive analysis of TAM dimensions

Figure 1 showed that all of the PU and PEU items received affirmative responses (agree or strongly agree) among over 50.0% of participants. The mean PU and PEU scores were 11.17 (SD 2.59) and 18.74 (SD 4.17) respectively. The overall mean score for perceived acceptance was 29.91 (SD 6.66).

Among all participants, 1101 (78.9%) expressed intention to use DITs; 626 (44.9%) were frequent users of DITs.

Factors associated with TAM dimensions

The regression model for perceived acceptance showed that perceived acceptance scores decreased on average by 0.10 for every one-year increase in age (p = 0.008). Participants who achieved a bachelor's degree had scores that were 2.87 points lower than those who only completed a secondary vocational school diploma (p = 0.037). Participants who received hospital in-house training, school-based training, or out-of-hospital training on DITs had scores that were 3.67, 1.91, and 1.58 points higher, respectively, compared to their counterparts who did not (all p values < 0.050). No significant associations were found between other variables and perceived acceptance. Complete results can be found in Table 2.

Results for the model examining intention to use DITs showed that compared with early-stage nurses, licensed practical nurses and deputy chief nurses were more likely to intend to use DITs (all p values < 0.050). For every additional year of work experience, the odds of intending to use DITs decreased by 3.0% (p = 0.013). Participants who received hospital in-house training or school-based training on DITs were associated with higher odds of intending to use DITs than those who did not (all p values < 0.05). The effects of other variables showed no statistical significance in the model (Table 2).

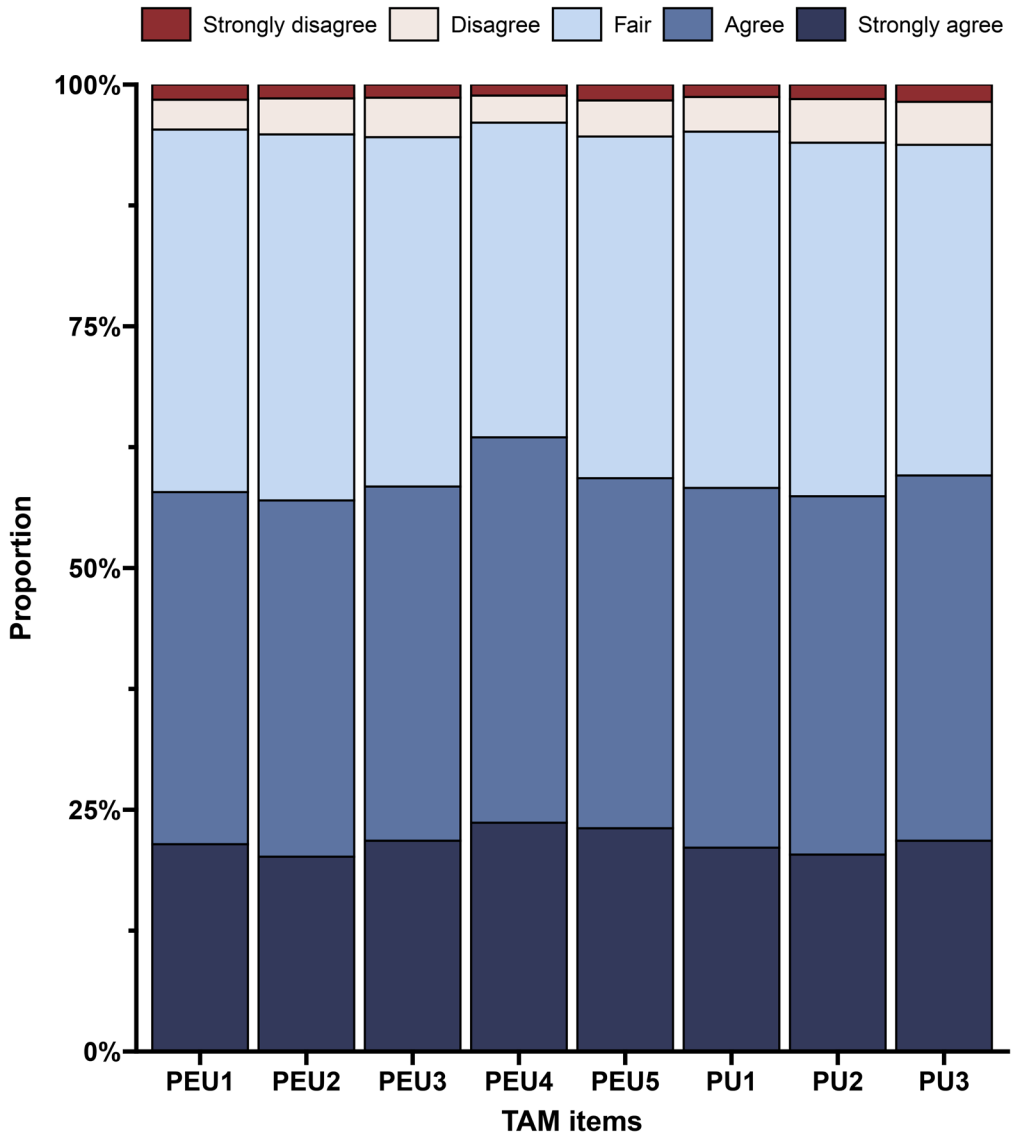

Fig. 1 Descriptive statistics for nursing professionals' response to TAM items. TAM = technology acceptance model; PEU = perceived ease of use; PU = perceived usefulness. Details of the 8 items and numeric results can be found in appendix

The use behavior model results showed that participants with a vocational college diploma or a bachelor's degree were less likely to be frequent users of DITs compared to those who achieved a secondary vocational school diploma (all p values < 0.050). Participants who received training on DITs, whether in-hospital, at school, or outside of hospital, had higher odds of being frequent users compared to those who did not receive such training (all p values < 0.001). Participants who worked in tertiary level 1 or tertiary level 2 hospitals had higher odds of being frequent users compared to those working in secondary level 1 hospitals (all p values < 0.05). Participants working in specialized hospitals were more likely to be frequent users than those who worked in general hospitals (p = 0.038). More details can be found in Table 2.

Mediation analysis of TAM dimensions

The mediation model results showed that the total effects of perceived acceptance on frequent use of DITs were estimated at 0.21 (95%CI: 0.14 ~ 0.29). The mediation effects of intention to use between perceived acceptance and frequent use were estimated at 0.09 (95%CI: 0.01 ~ 0.17). The proportion of total effects mediated was estimated at 42.6% (95%CI: 10.3% ~ 60.4%). Details can be found in Table 3. Results of mediator and outcome models can be found in Appendix.

Mentioned barriers that impact the adoption of DITs

The top three barriers mentioned were poor internet access (reported by 59.7% of respondents), hardware insufficiency (51.5%), and incompatibility between

Table 2 Regression model results of socio-economic factors associated with perceived acceptance, intention to use, and frequent users of DITs among nursing professionals in Shanghai (N = 1395)

Variable	Perceived acceptance		Intention to use		Frequent users[a]	
	Coef. (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)	*p*
Age	−0.10(−0.17 ~ -0.02)	0.008	1.00(0.97 ~ 1.03)	0.907	0.98(0.95 ~ 1.01)	0.116
Education						
Secondary vocational school diploma	Reference		Reference		Reference	
Vocational college diploma	−2.59(−5.33 ~ 0.15)	0.064	0.68(0.23 ~ 2.06)	0.497	0.31(0.13 ~ 0.78)	0.013
Bachelor's degree	−2.87(−5.56 ~ -0.17)	0.037	0.65(0.22 ~ 1.92)[b]	0.432	0.31(0.13 ~ 0.75)	0.010
Master's degree and above	−0.76(−4.26 ~ 2.75)	0.672			0.32(0.09 ~ 1.12)	0.075
Professional titles						
Early-stage nurse	Reference		Reference		Reference	
Licensed practical nurse	0.38(−0.71 ~ 1.47)	0.495	2.47(1.39 ~ 4.38)	0.002	0.86(0.55 ~ 1.33)	0.503
Supervisor nurse	−0.91(−2.11 ~ 0.29)	0.139	1.66(0.97 ~ 2.84)	0.064	1.28(0.79 ~ 2.07)	0.309
Deputy chief nurse	−1.38(−4.92 ~ 2.17)	0.447	10.76(1.46 ~ 79.56)	0.020	0.55(0.16 ~ 1.82)	0.324
Working years	−0.03(−0.10 ~ 0.04)	0.385	0.97(0.94 ~ 0.99)	0.013	1.01(0.99 ~ 1.03)	0.407
Night shifts						
Yes	Reference		Reference		Reference	
No	0.65(−0.17 ~ 1.47)	0.122	0.88(0.62 ~ 1.25)	0.482	1.29(0.94 ~ 1.79)	0.119
Working areas						
Ward	Reference		Reference		Reference	
ICU	1.06(−0.01 ~ 2.12)	0.052	1.28(0.73 ~ 2.27)	0.388	1.39(0.88 ~ 2.18)	0.155
Operating room	0.53(−1.21 ~ 2.26)	0.553	1.47(0.68 ~ 3.19)	0.334	1.16(0.58 ~ 2.30)	0.681
Delivery room	0.13(−0.93 ~ 1.19)	0.814	1.49(0.91 ~ 2.43)	0.117	0.90(0.60 ~ 1.37)	0.636
Outpatient and ED	−0.85(−2.11 ~ 0.41)	0.184	0.97(0.62 ~ 1.52)	0.891	1.18(0.76 ~ 1.82)	0.469
Others	0.58(−0.82 ~ 1.97)	0.418	0.72(0.40 ~ 1.31)	0.287	1.51(0.84 ~ 2.69)	0.167
Hospital in-house training						
No	Reference		Reference		Reference	
Yes	3.67(2.97 ~ 4.36)	<0.001	2.38(1.72 ~ 3.30)	<0.001	3.53(2.72 ~ 4.58)	<0.001
School-based training						
No	Reference		Reference		Reference	
Yes	1.91(1.22 ~ 2.60)	<0.001	1.72(1.25 ~ 2.35)	0.001	1.60(1.23 ~ 2.08)	<0.001
External training						
No	Reference		Reference		Reference	
Yes	1.58(0.58 ~ 2.57)	0.002	1.56(0.96 ~ 2.52)	0.072	2.55(1.80 ~ 3.60)	<0.001
Hospital tiers						
Secondary level 1	Reference		Reference		Reference	
Secondary level 2	−0.26(−1.55 ~ 1.03)	0.693	0.87(0.48 ~ 1.56)	0.634	1.27(0.75 ~ 2.15)	0.374
Tertiary level 1	−0.33(−1.89 ~ 1.23)	0.681	0.94(0.45 ~ 1.94)	0.864	2.02(1.06 ~ 3.84)	0.033
Tertiary level 2	0.82(−0.48 ~ 2.13)	0.217	1.11(0.60 ~ 2.04)	0.740	1.84(1.07 ~ 3.16)	0.026
Hospital types						
General	Reference		Reference		Reference	
Specialized	−0.22(−0.95 ~ 0.51)	0.557	0.82(0.59 ~ 1.13)	0.222	1.35(1.02 ~ 1.79)	0.038

Coef. = Coefficient; OR = Odds Ratio; ED = Emergency Department; ICU = Intensive Care Unit

[a]Frequent users were defined as participants who respond very much or much to the question "to what extent are you involved in using DITs in your practice?"

[b]This coefficient estimate pertains to the education group: Bachelor's degree and above. This is because master's degree and above group exhibited perfect separation and hence, the bachelor's degree group and the master's degree and above group were combined in the model predicting intention to use

Table 3 Mediation analysis results (N = 1395)

	Mediation effects	Direct effects	Total effects	Proportion mediated
Estimate (95%CI[a])	0.09(0.01 ~ 0.17)	0.12(0.09 ~ 0.15)	0.21(0.14 ~ 0.29)	42.6% (10.3% ~ 60.4%)

95%CI = 95% confidence interval

[a] The bias-corrected-accelerated confidence interval was used

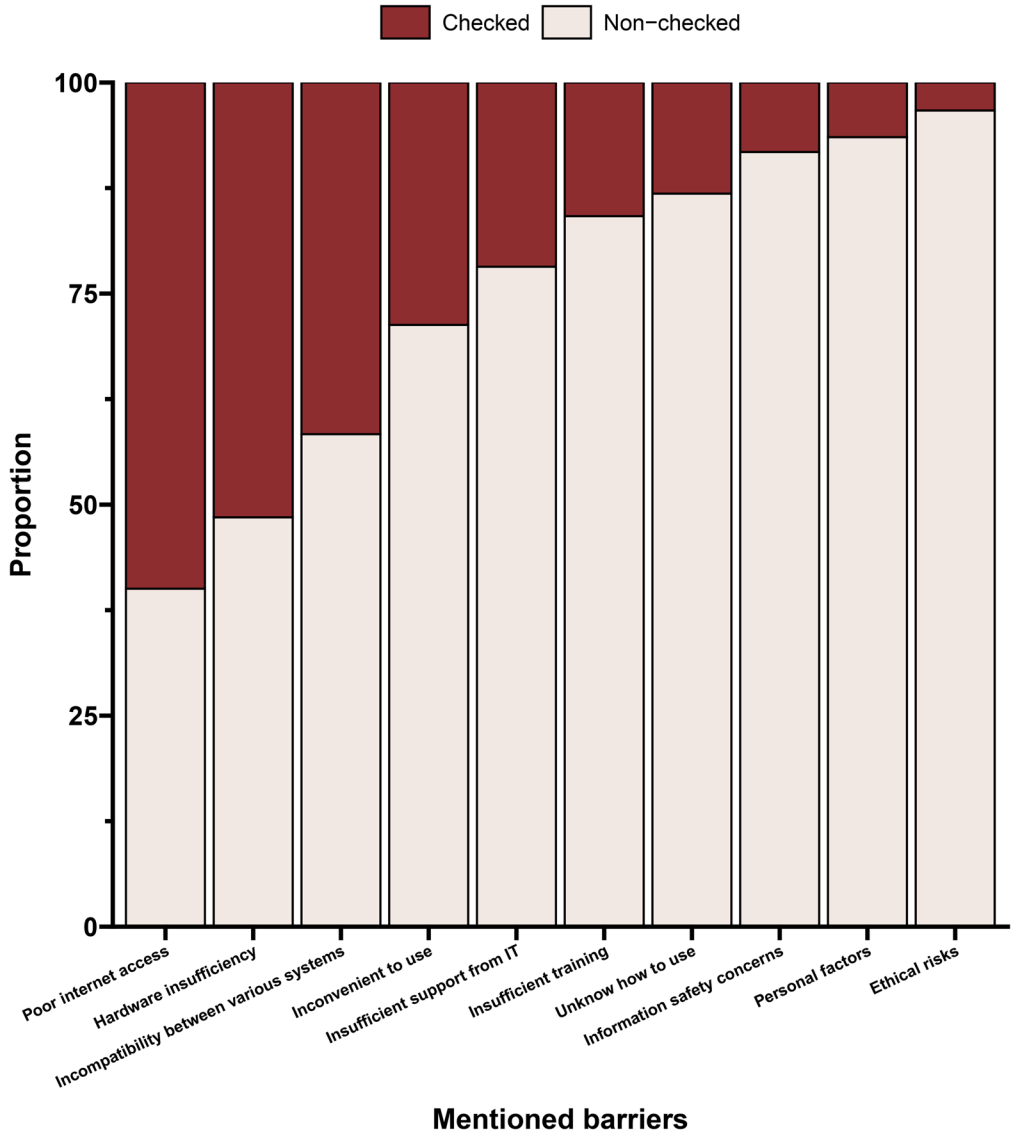

Fig. 2 Selected barriers to the adoption of DITs among nursing professionals. DITs = digital information technologies. Numerical results can be found in appendix

various systems (41.7%). The complete ranking can be found in Fig. 2.

Discussion

Primary findings

As clinical practice transitions into the digital era, it is beneficial for nursing professionals to learn and incorporate DITs into their practice. Our study examined the perceived acceptance, intention to use, and use behavior of DITs among a cohort of nursing professionals working in hospitals in Shanghai. Our findings revealed a positive perception of DITs, with half of the participants showing affirmative responses to each PEU and PU item. While most nursing professionals demonstrated intention to use, they were not frequent users. Also, intention to use DITs mediated the correlation between perception and frequent use of DITs.

Explanations for unsatisfied utilization of DITs

Early similar studies have demonstrated a positive perception of DITs among nursing professionals. For example, a study conducted in South Africa found a high degree of PEU and PU of DITs among nurses [25]. A U.S. qualitative study reported positive experiences and perceptions of DITs, including EHRs, large databases and bio-surveillance, among nurses using the TAM framework [30]. Similarly, a study in Saudi Arabia found positive attitudes towards DITs among nursing students [31].

DITs have the potential to enhance healthcare delivery efficiency, ensure patient safety and reduce medical

errors. These advantages were also perceived by healthcare professionals in a previous qualitative study [32]. However, in our study, the PEU items "It is comfortable using DITs in daily practice" and "It is convenient to use DITs in daily practice" received the lowest proportion of affirmative responses. A systematic review identified infrastructure and technical barriers as the most commonly reported barriers to utilizing DITs among health professionals [20]. Given the demanding schedules of nursing professionals, they may have limited time to spend learning and integrating DITs into practice.

Our study demonstrated that frequent use of DITs was not common. In China, the infrastructure of DITs is still in the early stage of development [12]. Despite a satisfactory EHR adoption rate [13], advanced DITs are not widely deployed in Chinese hospitals. A previous study highlighted that the use of advanced DITs may increase health professionals' empowerment and reduce their stress, but using basic DITs did not show these effects [33]. This could serve as one explanation for the less frequent application of DITs. Additionally, there is an overwhelming patient volume in China's hospitals, particularly in Shanghai where the hospitals admit patients from nationwide. Therefore, nursing professionals' focus would be placed on interactions with patients, sparing limited time on how to learn and use DITs, which could lead to this reduced level of use. For successful integration of DITs into practice and contribution to efficient care delivery, there is still a long way to go.

Effects of training on perception, intention and behavior of DITs

Receiving training was associated with a greater level of involvement in DITs, including a higher level of perceived acceptance, a greater likelihood of intending to use and being frequent users. This finding might underscore the importance of training programs in promoting the adoption of DITs among nursing professionals. However, it must be acknowledged that DIT training is often provided outside of healthcare professionals' working hours, leading to it being overlooked and resulting in poor effectiveness. A previous study revealed that significant barriers to the adoption of DITs among U.K. general practitioners included a required high level of training and familiarization effort, as well as additional working hours [34]. The study proposed that incentives and the integration of training into medical education could enhance the effectiveness of DITs among medical professionals.

Effects of education on perception, intention and behavior of DITs

Our study revealed that a higher level of education was associated with a lower level of perceived acceptance and a lower likelihood of being a frequent user of DITs. This finding was somewhat surprising. Previous studies showed that more educated health (nursing) professionals tended to have higher levels of digital competency and digital literacy [35–37], which might imply that they would have more positive perceptions and use behavior. We believed that there would be some explanations for this discrepancy. First, our participants who had a higher level of education may have a greater abundance of knowledge of DITs. They may have a raised standard in rating the ease of use and usefulness of DITs, which could lead to low ratings for the surveyed hospitals that lacked adequate DITs [38]. Second, a more educated nursing professional would be more likely to be involved in advanced or complex practices, thereby limiting their time spent on becoming familiar with and learning DITs [20].

Effects of hospital characteristics on perception, intention and behavior of DITs

We also discovered that nursing professionals employed in hospitals of a higher tier exhibited a greater tendency to be frequent users of DITs. However, this finding was not surprising, as hospitals of a high tier in China are typically equipped with advanced digital infrastructures. These advanced facilities may enhance the opportunities for healthcare professionals to engage with DITs, including training, education, and practical applications. As to hospital type, our study results showed that nursing professionals who worked in specialized hospitals were more likely to be frequent users relative to those in general hospitals. Earlier studies reported that hospitals with a larger number of beds tended to be equipped with more digital technologies [39, 40]. In China, specialized hospitals are generally smaller in size than general hospitals within the same tier and have relatively lower workload. In the model, we controlled for hospital tier which could serve as a proxy for hospital size. Accordingly, the observed higher frequency of DIT use in specialized hospitals might result from a relatively lower workload and better organizational behavior [41].

Mediation analysis

The mediation analysis showed that the intention to use DITs partially mediated the association between perceived acceptance and frequent use of DITs, aligning with the classic TAM framework [23, 30]. Roughly 43.0% of the association was mediated, indicating that the intention to use was a potential intervention target for promoting frequent use of DITs. While intention to use was a contributing factor, the direct effects of perceived acceptance cannot be overlooked. Inducing the sense and perception of DITs may play a more critical role than merely focusing on enhancing the intention to use

to shape the final use behavior [42]. By simultaneously examining the socio-economic factors and the interplay relationship among the three study outcomes, we may be able to identify a targeted population among which promotion of adoption of DITs can be effectively carried out.

Implications for practice and research

Our study findings may have implications for practice and research. First, the needs and perspectives of nursing professionals should be integrated during the development of DITs. Involving nursing professionals, who are the end-users, in the decision-making process would enhance the usability of DITs, which could promote acceptance among them [43]. Second, incentives, along with training programs or sessions on DITs, should be considered for nursing professionals. For example, participating in DIT training sessions can be integrated into continuing medical education programs and corresponding certification credits can be awarded. Third, since our participants rated poor internet connection, insufficient hardware and system incompatibility as the top three barriers, secured budgets should be planned to improve internal hardware and software facilities at the organizational level. Fourth, future research is warranted to explore interventions or policies that can transform the positive perception and intention of DITs into actual use behavior. Also, methodological studies are needed to facilitate a reasonable and scientific estimation of the confidence interval for statistics that have no defined distribution in a mediation analysis.

Regarding the generalizability of our study, we acknowledge that Shanghai, as an economic and technological hub in China, may have a different healthcare system and DIT development trajectory compared to other regions. However, with the acceleration of digital transformation globally, many countries and regions are actively promoting digital reforms in their healthcare systems. Therefore, we speculate that the identified factors associated with the perception, intention and use behavior of DITs, as well as the interplay among the three outcomes, may have some universality in other countries and regions undergoing digital transformation of healthcare.

Limitations

The limitations of our study cannot be ignored. First, we failed to collect data on participants' workload. The omission of this variable in the models could detect the artifact effects of some variables, like hospital grades and hospital types. Second, although we tried to recruit over 1300 participants, using a non-probability sample may compromise the validity of the descriptive statistics calculated with the hope of presenting the whole group of nursing professionals in Shanghai. Particularly, we want to highlight the volunteer bias that could arise from non-responders. Since our survey was delivered in an electronic format, the invitees who declined to participate could inherently exhibit less interest in DITs, which could reflect a lower level of perceived acceptance and reduced use frequency of DITs than those who did respond. Third, our data collection period fell within the COVID-19 pandemic timeframe, which could impact our study regarding how our participants rated their perception and intention towards DITs. Therefore, this contextual factor could reduce our study's generalizability. Finally, we might have limited confidence in employing mediation analysis with our cross-sectional data. However, we refrained from drawing causal inferences and making causal descriptions throughout the study. We expect that our research could serve as an exploratory foundation for more rigorously designed studies on similar topics. For example, comprehensive variables at both the individual and organizational levels can be collected to statistically and clinically infer true effects. Also, we would recommend using a random sampling strategy and a longitudinal design to accommodate representativeness and the assumptions of mediation analysis.

Conclusions

Based on a sample of over 1300 nursing professionals practicing in hospitals in Shanghai, this cross-sectional study suggests that nursing professionals in Shanghai have positive perceived acceptance and strong intention to use DITs, yet their actual use of DITs remains limited. Therefore, actions or interventions should be carried out to enhance the transformation of the satisfied perception and intention into actual frequent use of DITs in nursing practice.

Abbreviations

DITs	Digital information technologies
AI	Artificial intelligence
EHRs	Electronic health records
TAM	Technology acceptance model
PU	Perceived usefulness
PEU	Perceived ease of use
KMO	Kaiser-Meyer-Olkin
EPV	Events per variable
SD	Standard deviation

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12912-025-03078-w.

Supplementary Material 1

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None.

Author contributions

W.Z. and H.X. conceived the study. H.X and P.Z. wrote the original manuscript. H.X. and P.Z. were responsible for methodology. W.Z. and P.Z. were responsible for manuscript revision and validation. H.X. and P.Z. were responsible for

project management, data collection, and proofreading of the manuscript. W.Z. supervised the entire process and provided grant support. All authors read and approved the final manuscript.

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Data availability
The dataset used in the current study is available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was exempt from ethical review by the Institutional Review Board of the International Peace Maternity and Child Health Hospital in March 2021. By confirming their willingness to participate in the online survey, participants gave their informed consent. This study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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