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ORIGINAL RESEARCH

Dynamics of Health Technology Diffusion in the Integrated Care System (DHTDICS): A Development and Validation Study in China

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Background: Limited diffusion of health technology has greatly halted the improvement of resource integration and healthcare outcomes. The importance of understanding the dynamics of health technology diffusion is increasingly highlighted. However, the dynamic mechanism of health technology diffusion in the context of the integrated care system (ICS) remained largely unknown.

Purpose: To develop and validate the scale on Dynamics of Health Technology Diffusion in Integrated Care System (DHTDICS) for providing an instrument to investigate the health technology diffusion in the ICS in China, by taking the Des-gamma-Carboxy Prothrombin (DCP) test as an example.

Methods: Based on previous classical theories such as the theory of planned behavior (TPB), technology acceptance model (TAM), and technology-organization-environment framework (TOE), the scale with 34 items was initially developed. It was tested in a cross-sectional questionnaire survey including 246 participants from February to August 2019 in China. Cronbach's alpha, corrected item-total correlation, and factor loadings were used to assess reliability. Exploratory factor analysis and confirmatory factor analysis were applied to evaluate the validity by assessing factor structures and correlations.

Results: Reliability analysis revealed excellent internal consistency. Acceptable validity was confirmed through tests of convergent validity and discriminant validity. Regarding the domains that DHTDICS contributes, the results highlighted 4 domains: personal beliefs (including dimensions of attitudes, subjective norms and perceived behavioral control), technical drivers (including dimensions of ease of use and price rationality), organizational readiness (including dimensions of organizational culture, technology absorptive willingness and technology sharing willingness), and external environment (dimension of industry competition pressure).

Conclusion: The findings confirmed the reliability and validity of the scale on DHTDICS. The scale will be not only a scientific tool in determining the dynamics of health technology diffusion in the ICS, but also a helpful reference for developing future interventions to promote health technology diffusion.

Keywords: health technology diffusion, dynamics, scale development, integrated care system, validity, reliability, China

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Introduction

Integrated care system (ICS) can be defined as a health system that integrates the inputs, delivery, management of various health care services, including health promotion, disease prevention, treatment and rehabilitation.[1] As the importance of

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ICS becoming increasingly highlighted, its growth is accelerating worldwide with various forms of practice.[2–4] For instance, in England, primary care trusts (PCTs) are free-standing bodies to integrate community health services and social services. In America, patient-centered medical home (PCMH) is a model of care in which patients receive integrated care from their designated providers. And in the Netherlands, people-centered and integrated health care services (PCIHC) is to restructure the health service network that composed of interconnected providers at all levels. Similar to these forms, China's regional medical consortium (RMC) is expressed in terms of national conditions under the connotation of ICS. RMC is an important means of integrating medical resources in China, which mainly involves local or cross-regional leading hospitals, as well as other health institutions with a lower level.[5] The most common collaboration between participants in RMC is technical assistance, which is characterized as providing technical cooperation or support to each other. This collaboration model benefits promoting communication and collaboration between different levels of health institutions,[6,7] as well as puts forward higher requirements on the integration ability of health resources and the service quality.[8,9]

Although some achievements have been made in the integration of health resources in the RMC, the problem of under-utilization of health technology still exists in practice, and the value of many health technologies has not been given full play.[10] Des-gamma-Carboxy Prothrombin (DCP) for example, is a tumor marker of primary hepatocellular carcinoma (PHCC), and the security, effectiveness and economy of DCP test in early detection of PHCC have been reported in many clinical practices and studies.[11–14] In addition to large hospitals,[15,16] the role of DCP implementation has also been verified in county hospitals or other health institutions with a lower level in China.[17] However, in terms of coverage even in the context of RMC, the use of DCP in China is far behind Japan, which also has a high incidence of liver cancer but with DCP widely and routinely used to screen for liver cancer.[18]

To further address the problem in the practice of technology diffusion, many theories were applied to define the connotation of technology diffusion. And its facilitators and barriers were also investigated in a large number of studies in the disciplines of sociology, behavior, psychology, and so on.[19–21] The interpretations of technology diffusion vary depending on the disciplines. According to the Innovation Diffusion Theory (IDT) proposed by Rogers,[22] this study defines technology diffusion as the process in which technology is communicated between and within organizations of a social system. In addition to the IDT, many other classical theories have been proposed to guide the adoption practices by exploring the effects of different sets of factors on technology diffusion, such as the Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM), and Technology-Organization-Environment framework (TOE). Among these theories, TPB suggests an individual's behavior is ultimately influenced by behavioral intention, which is a function of attitude toward behavior, subjective norms, and perception of the ease with the behavior that can be performed.[23] TAM implies perceived usefulness and perceived ease of use as two crucial factors, which focuses on the impact of technology natures.[24] IDT demonstrates that the properties of technology and interpersonal communication can affect technology use.[25] TOE infers that the effect of technology, organization and external environment should be considered.[26]

Despite previous theories mostly focused on some stages of technology diffusion and investigate certain sets of potential domains, there were still insufficient explanations in terms of the dynamic mechanism of health technology diffusion from different perspectives and facets. Therefore, by taking the DCP test as an example, this study aims to integrate these theories to provide a comprehensive insight into the health technology diffusion, to develop and validate an instrument for measuring and further investigating the dynamics of health technology diffusion in the ICS.

Materials and Methods

Theoretical Model

Based on the theories mentioned above, we integrated some core elements and proposed a theoretical model for the dynamics of health technology diffusion in the ICS from four domains, namely the domain of personal beliefs, technical drivers, organizational readiness, and external environment (Figure 1).

In this study, personal beliefs referred to the physicians' perceptions of the DCP test and its use, which mainly depend upon attitudes, subjective norms, and perceived behavioral control.[27,28] Attitude has been perceived as one of the most powerful predictors in technology adoption and use, while subjective norms are kind of

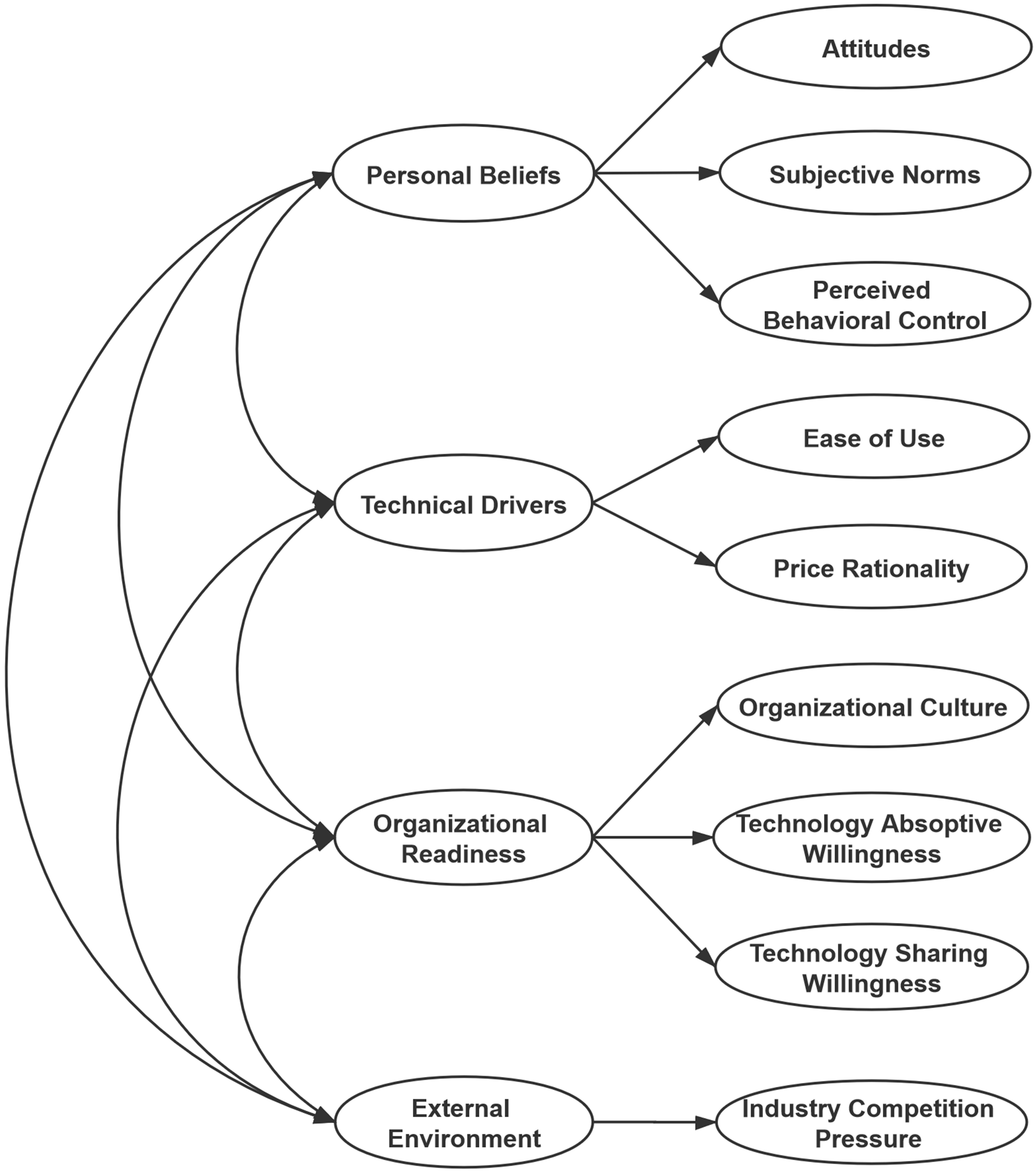

Figure 1 The model of the dynamics of health technology diffusion in ICS.
Note: Double-headed arrows represent correlations between variables and single-headed arrows represent regression relationships between variables.

perceived criteria and pressures from important individuals' judgments. And perceived behavioral control is often based on beliefs concerning access to the necessary resources and opportunities to successfully perform a behavior.

The technical drivers involved the nature of technology including ease of use and price rationality. Taking the DCP test for instance, ease of use is a degree to which the physicians expect the DCP test can be performed with ease, while price rationality is an underlying important source of motivation.[29,30] People are tending to adopt technologies easier to perform with price rationality.

Moreover, studies have mentioned the importance of organizational readiness, which reflects the overall preparedness for health technology of the entire staff.[31] It consisted of organizational culture, technology absorptive willingness, and technology sharing willingness. Organizational culture is the ensemble of values, norms, and operating behaviors shared by members within an organization.[32,33] Technology absorptive willingness shows the willingness and readiness situations of introducing a new health technology into the organization,[34] while technology sharing willingness is a degree of sharing knowledge with the other organizations.[35,36]

The domain of external environment is generally considered as an important factor affecting health technology diffusion, which usually focuses on industry competition pressure.[37,38] Both the trend in the market and the tendency of business partners are the main concerns of the hospital managers while deciding on whether to adopt certain technology.[39]

Measurement

According to the proposed model in Figure 1, the scale of Dynamics of Health Technology Diffusion in Integrated Care System (DHTDICS) was initially structured with 2 parts, 34 items (see supplementary file).

The first part with 28 items was the measurement of the components of DHTDICS, which consists of 9 dimensions in 4 domains: personal beliefs, including dimensions of "attitudes" (ATT), "subjective norms" (SN) and "perceived behavioral control" (PBC); technical drivers, including dimensions of "ease of use" (EOU) and "price rationality" (PR); organizational readiness, including dimensions of "organizational culture" (OC), "technology absorptive willingness" (TAW) and "technology sharing willingness" (TSW); external environment, namely "industry competition pressure" (ICP). All 28 items were measured using a 5-point Likert scale ranging from "strongly disagree" (1) through "neutral" (3) to "strongly agree" (5).

The second part of the questionnaire was used to collect personal socio-demographic characteristics of respondents (physicians), including 8 items of gender, age, education, professional title, administration position, years in practice, the RMC, and the level of the medical institution. Age was recoded into three groups: <35 years old (1), 35~44 years old (2), and ≥45 years old (3). Education was divided into junior college or below (1), bachelor (2), master (3), and doctor (4). The professional title of physicians included three levels: junior (1), intermediate (2), and senior (3). If a physician has a concurrent management position, he/she is considered to have an administration position (1); otherwise, he/she had no administration position (2). Years in practice were classified into five groups: <5 years (1), 15~10 years (2), 11~15 years (3), 16~20 years (4), and >20 years (5). The level of the medical institution included secondary or bellow (1) and tertiary (2).

Sample and Procedure

To validate the scale developed in this study, a cross-sectional questionnaire survey was conducted from February to August 2019 using a multistage random sampling method. Firstly, based on the latest average incidence of liver cancer in China (26.92/100,000),[40] Fujian and Jiangxi provinces were randomly selected from the provinces with a high and low incidence of hepatocellular carcinoma, respectively (the incidence of liver cancer in Fujian and Jiangxi were 32.18/100,000 and 23.80/100,000, respectively[41,42]). Secondly, we listed all RMCs in each province as sampling frame, and two RMCs were randomly selected from each province. Thirdly, a sampling frame was made to list all medical institutions of four RMCs, and 50% of the medical institutions within each RMC were randomly selected to be included in the survey. Finally, the scales were distributed to the physicians who had knowledge of DCP and worked in liver disease-related departments in these medical institutions (including the department of hepatology, oncology, gastroenterology, infection, ultrasound, etc.). With the support of selected medical institutions, each round for filling out the questionnaire was accompanied by a trained coordinator to introduce the study purpose. All responses were anonymous, but participants were invited to submit their contact information if they were interested in this study or wanted to be kept informed of the study results.

Each RMC was expected to investigate 5~8 medical institutions, and four RMCs in two provinces would include 20~30 medical institutions. Each medical institution would investigate 10~20 physicians on average, and at least a total of 200 physicians would participate in the survey, which met the sample size requirement that at least 5 times of the survey question.[43]

Data Analysis

Instrument optimization was in virtue of the corrected item-total correlation (CITC) and the Cronbach's alpha if item deleted. Items would be deleted if their results satisfy both of two conditions: 1) the CITC less than 0.6; 2) Cronbach's alpha would be improved if this item was deleted.[44] Besides, there was a need to ensure that at least three items per factor were used in order to interpret the results.

Reliability analysis was conducted by calculating Cronbach's alpha, CITC and factor loadings. Generally, internal consistency is adequate if the following criteria were met: 1) Cronbach's alpha >0.7; 2) CITC > 0.6; 3) factor loadings >0.5.[45,46]

The validity was initially examined with exploratory factor analysis (EFA), which can explore the possible factors and factor structure in the pool of items by principal components analysis (PCA) (the method of factor extraction). Kaiser-Meyer-Olkin (KMO) value, Bartlett's test of sphericity, eigenvalues, factor matrix, and correlation matrix were used to verify the factorability. The recommended threshold of the KMO value is 0.7.[47] Factors with eigenvalues greater than 1 in the factor extraction were determined. Confirmatory factor analysis (CFA) was used to further test convergent validity and discriminant validity by structural equation modeling (SEM), including indicators of the average variance extracted (AVE), composite reliability (CR), and the root of AVE. The criteria commonly used are: 1) AVE > 0.5; 2) CR > 0.7; 3) the root of AVE > 0.7, and higher than the correlation with other factors.[48,49]

Data analyses were performed using IBM SPSS software 20.0 version (SPSS, Inc., Chicago, IL, USA) and Amos 17.1 software. Statistical significance was set at $P < 0.05$.

Results

Sample and Data Description

This study included a total of 246 physicians in 23 medical institutions in 4 RMCs. The corresponding sample-to-item ratio of 9.84 was greater than the threshold of 5 [40], it can be considered that sample sizes collected were acceptable. Table 1 demonstrates the demographic characteristics of the 246 participants. Among the participants, 66.26% were males and 33.74% were females. Over eighty percent (83.74%) were in the age group of under 45 years old. In terms of educational level, 90.65% reported having a bachelor's degree or above. The majority of participants had obtained junior (35.37%) or intermediate (36.99%) professional titles. Most of the participants (79.27%) had no administration position. The participants who had 5~10 years in practice accounted for 30.08%, followed by 11~15 years in practice (29.27%). About 66.26% of the participants were from Fujian province, and 33.74% were from Jiangxi province. The majority of participants were in tertiary hospitals (62.60%), and the RMC type of most participants was specialist RMC (64.23%).

Data on each domain are shown in Table 2. In the domain of personal beliefs, more than 70% of the participants agreed (selected "agree" or "strongly agree") with the description of each item. The proportion of disagreement (selected "disagree" or "strongly disagree") ranged from 2.03% to 6.91% for each item. In the domain of technical drivers, for each item, the percentage indicating agreement ranged from 48.37% to 67.88%. In the domain of organizational readiness, about 6.51% to 13.42% of the participants showed their disagreement over the description of the item. In the domain of external environment, more than a quarter of the participants were neutral in each item.

Items Optimization

As demonstrated in Table 3, all CITC values of items were greater than the ideal value of 0.6, and Cronbach's alpha of the factor cannot be improved despite the item deleted. Therefore, no item needs to be eliminated from the instrument.

Instrument Reliability

Table 3 shows the Cronbach's alpha of all factors and the whole questionnaire are much higher than the recommended threshold of 0.7. Also, all CITC values and factor loadings of each item were above the acceptability value of 0.5, suggesting the internal consistency of the questionnaire was fairly well.

Instrument Validity

Exploratory Factor Analysis

A PCA of all the 28 items showed KMO values of 0.920 and Bartlett's test of sphericity was strongly significant ($P < 0.001$), indicating the great suitability of PCA for validity estimate. Four factors appeared with an eigenvalue greater than 1 and cumulatively explained 76.36% of the total variance. To further defined factors included clearly, the varimax rotation method was then used.

Table 1 Demographic Characteristics of the 246 Participants

Variables	Categories	Frequency (n)	Percentage (%)
Gender	Male	163	66.26
	Female	83	33.74
Age	<35 years old	107	43.50
	35~44 years old	99	40.24
	≥45 years old	40	16.26
Education	Junior college or below	23	9.35
	Bachelor	140	56.91
	Master	76	30.89
	Doctor	7	2.85
Professional title	Junior	87	35.37
	Intermediate	91	36.99
	Senior	68	27.64
Administration position	Yes	51	20.73
	No	195	79.27
Years in practice	<5 years	62	25.20
	5~10 years	74	30.08
	11~15 years	72	29.27
	16~20 years	33	13.41
	>20 years	5	2.04
Province	Fujian	163	66.26
	Jiangxi	83	33.74
Type of RMC	Urban RMC	88	35.77
	Specialist RMC	158	64.23
Level of the medical institution	Secondary or below	92	37.40
	Tertiary	154	62.60

Abbreviation: RMC, regional medical consortium.

Table 4 shows all items in each dimension are almost loaded to four different factors, which fits well with the proposed framework and indicates acceptable construct validity. Factor 1 to factor 4 explained 26.34%, 24.32%, 14.42%, and 11.28% of the total variance, respectively. Accordingly, we named factor 1 as "personal beliefs", factor 2 as "organizational readiness", factor 3 as "technical drivers", and factor 4 as "external environment", respectively. Besides, factor scores of the four factors were automatically generated into the last columns of the operation interface.

Meanwhile, we show the correlations between the items and factor scores of each factor. The results are shown in Table 5. Each of the factors was separated from each other on account of having a low correlation with each other. Additionally, items of the same dimension converged on the same factor and discriminated well with other factors.

Confirmatory Factor Analysis

To further validate the research model, we calculated indicators of AVE and CR for each factor through the SEM approach to assessing convergent validity. The results showed that AVE and CR values of all factors were, respectively, above the recommended value of 0.5 and 0.7 (Table 3), which indicates a good convergent validity.

Then, we followed Fornel and Larcker's (1981) suggestion to calculate the square root of AVE to reflect the discriminant validity.[47] As shown in Table 6, the square root of AVE (reported in the diagonal of the correlation matrix) of each factor is higher than its correlation coefficients with other factors, indicating its strong discriminant validity.

Discussion

The diffusion and utilization of many innovative appropriate health technologies (such as DCP test) are limited.[50–52] These health technologies are currently only being implemented in some medical institutions (such as large urban hospitals) and some populations,[53] and their value in preventing disease and improving health has not been fully realized.[54,55] Meanwhile, it also leads to the confusion of functional positioning among medical institutions and the poor effect of health resource integration,[56] that is, the screening function which was originally in charge of primary health care institutions is transferred to large hospitals. This issue has become even more severe and prominent especially under the background of continuous ICS growth worldwide. To bridge the research gap that few is known on the dynamic mechanism of health technology diffusion in the ICS, this study took the DCP test as an example and developed an instrument to measure and evaluate the dynamics of health technology diffusion in the integrated care system (DHTDICS). It will be

Table 2 Items of Perceptions on DCP and Its Diffusion

Items of Each Domain	Frequency (%)				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Personal beliefs					
ATT1. I think it's a right thing to use DCP for early diagnosis of hepatocellular carcinoma	0 (0)	6 (2.44)	51 (20.73)	83 (33.74)	106 (43.09)
ATT2. I think it's a wise choice to use DCP for early diagnosis of hepatocellular carcinoma	1 (0.41)	9 (3.66)	48 (19.51)	83 (33.74)	105 (42.68)
ATT3. I think it's good for all to use DCP for early diagnosis of hepatocellular carcinoma	0 (0)	7 (2.86)	47 (19.11)	81 (32.93)	111 (45.12)
SN1. People who are important to me tend to use DCP for early diagnosis of hepatocellular carcinoma	4 (1.63)	12 (4.88)	52 (21.14)	74 (30.08)	104 (42.27)
SN2. People who are important to me have a positive attitude on using DCP for early diagnosis of hepatocellular carcinoma.	5 (2.03)	12 (4.88)	53 (21.54)	70 (28.46)	106 (43.09)
SN3. People who are important to me think it's a right thing to use DCP for early diagnosis of hepatocellular carcinoma.	1(0.41)	10 (4.07)	57 (23.17)	71 (28.85)	107 (43.50)
PBC1. Using DCP can make me have more choice in diagnosing liver cancer.	1 (0.41)	7 (2.85)	43 (17.48)	78 (31.71)	117 (47.56)
PBC2. Using DCP can increase my confidence in diagnosing liver cancer.	0 (0)	5 (2.03)	46 (18.70)	80 (32.52)	115 (46.75)
PBC3. Using DCP can make my diagnosis more recognized.	0 (0)	5 (2.03)	47 (19.11)	80 (32.52)	114 (46.34)
Technical drivers					
EOU1. We can easily obtain the materials and instruments needed for DCP test	5 (2.03)	11 (4.47)	75 (30.49)	68 (27.64)	87 (35.37)
EOU2. We can get the result of DCP test in a short time after detection	0 (0)	7 (2.85)	72 (29.27)	77 (31.30)	90 (36.58)
EOU3. We can be provided with assistance in clinical diagnosis by the result of DCP test	0 (0)	6 (2.44)	53 (21.54)	82 (33.33)	105 (42.69)
PR1. Compared with the same type of serological tests, the price of DCP is relatively cheaper	7 (2.85)	12 (4.88)	108 (43.90)	57 (23.17)	62 (25.20)
PR2. DCP test has a high cost performance	3 (1.22)	9 (3.66)	92 (37.40)	71 (28.86)	71 (28.86)
PR3. The price of DCP is affordable for most patients	4 (1.63)	5 (2.03)	79 (32.11)	70 (28.46)	88 (35.77)
Organizational readiness					
OC1. The hospital advocates the technical innovation to improve the clinical outcomes for patients.	15 (6.10)	12 (4.88)	51 (20.73)	79 (32.11)	89 (36.18)
OC2. The hospital advocates continuous learning and absorption of new technologies	10 (4.07)	6 (2.44)	44 (17.88)	79 (32.11)	107 (43.50)
OC3. The hospital advocates the exchange and sharing of clinical experience	10 (4.07)	6 (2.44)	48 (19.51)	76 (30.89)	106 (43.09)
TAW1. When DCP test appeared, the hospital is willing to allocate relevant staff to collect information	15 (6.10)	14 (5.69)	70 (28.46)	71 (28.86)	76 (30.89)

(*Continued*)

Table 2 (Continued).

Items of Each Domain	Frequency (%)				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
TAW2. When DCP test introduced, the hospital is willing to provide training for the staff	24 (9.76)	9 (3.66)	68 (27.64)	75 (30.48)	70 (28.46)
TAW3. When DCP test adopted for clinical practice, the hospital is willing to promote its use more widely	22 (8.94)	11 (4.47)	73 (29.68)	72 (29.27)	68 (27.64)
TSW1. The hospital is willing to send the information of DCP test with other institutions	10 (4.07)	9 (3.66)	51 (20.73)	80 (32.52)	96 (39.02)
TSW2. The hospital is willing to discuss the problems of DCP use with other institutions	9 (3.66)	8 (3.25)	52 (21.14)	82 (33.33)	95 (38.62)
TSW3. The hospital is willing to share the experience of DCP use with other institutions	10 (4.07)	7 (2.85)	46 (18.70)	87 (35.37)	96 (39.01)
External environment					
ICP1. DCP has been widely used for early diagnosis of hepatocellular carcinoma in the medical industry	10 (4.07)	6 (2.44)	66 (26.83)	78 (31.71)	86 (34.95)
ICP2. Many surrounding hospitals are using DCP for early diagnosis of hepatocellular carcinoma	14 (5.69)	20 (8.13)	88 (35.77)	61 (24.80)	63 (25.61)
ICP3. Our business partners recommend DCP for early diagnosis of hepatocellular carcinoma	7 (2.85)	9 (3.66)	84 (34.15)	74 (30.07)	72 (29.27)
ICP4. The application of DCP in the early diagnosis of hepatocellular carcinoma has become routinized.	7 (2.85)	10 (4.07)	86 (34.95)	68 (27.64)	75 (30.49)

Abbreviations: DCP, des-gamma-carboxy prothrombin; ATT, attitudes; SN, subjective norms; PBC, perceived behavioral control; EOU, ease of use; PR, price rationality; OC, organization culture; TAW, technology absorptive willingness; TSW, technology sharing willingness; ICP, industry competition pressure.

provided as a scientific tool for investigating the mechanism and further promote health technology diffusion in the ICS.

By analyzing the internal consistency and dimensionality of the DHTDICS, the reliability and validity of this instrument have been confirmed. Results of reliability analysis revealed excellent internal consistency, as the value of Cronbach's alpha all greater than 0.80 for four of the domains in this study. Regarding the validity test, EFA results showed all items in each dimension were loaded to four different factors, which fits well with the proposed framework and indicates good construct validity. CFA results showed AVE and CR values of all factors were above the recommended value of 0.5 and 0.7, which indicated an acceptable convergent validity. Additionally, it demonstrated items of the same dimension converged on the same factor, and discriminate well with other factors.

With respect to the potential domains and dimensions that DHTDICS contributes, the results highlighted the definite existence of 4 domains and 9 dimensions: domain of personal beliefs (individuals' perceptions and impressions on subjective and interpersonal predisposition, including dimensions of attitudes, subjective norms and perceived behavioral control), domain of technical drivers (characteristics of health technology on hardware predisposition, including dimensions of ease of use and price rationality), domain of organizational readiness (context preparedness in spiritual level, including dimensions of organizational culture, technology absorptive willingness and technology sharing willingness) and domain of external environment (the forces that can exert influence on physicians from the outside of the hospitals, including dimension of industry competition pressure), which were in line with assumption of scale design and also consistent with the findings of previous research on health

Table 3 Reliability and Convergent Validity

Items	Cronbach's Alpha	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Factor Loadings	AVE	CR
ATT1	0.960	0.846	0.954	0.918	0.855	0.981
ATT2		0.853	0.954	0.906		
ATT3		0.901	0.952	0.944		
SN1		0.852	0.954	0.925		
SN2		0.812	0.956	0.942		
SN3		0.843	0.954	0.935		
PBC1		0.762	0.958	0.846		
PBC2		0.829	0.955	0.954		
PBC3		0.823	0.955	0.946		
EOU1	0.912	0.708	0.904	0.781	0.736	0.943
EOU2		0.771	0.894	0.879		
EOU3		0.736	0.899	0.864		
PR1		0.740	0.899	0.853		
PR2		0.768	0.894	0.900		
PR3		0.814	0.887	0.864		
OC1	0.957	0.790	0.954	0.864	0.865	0.983
OC2		0.855	0.951	0.946		
OC3		0.864	0.950	0.950		
TAW1		0.776	0.955	0.902		
TAW2		0.744	0.957	0.936		
TAW3		0.749	0.956	0.866		
TSW1		0.898	0.949	0.959		
TSW2		0.896	0.949	0.974		
TSW3		0.897	0.949	0.966		
ICP1	0.899	0.747	0.879	0.791	0.698	0.902
ICP2		0.718	0.892	0.756		
ICP3		0.812	0.856	0.888		
ICP4		0.829	0.849	0.898		
The whole questionnaire	0.957	N/A	N/A	N/A	0.810	0.992

Note: N/A, not applicable.
Abbreviations: AVE, average variance extracted; CR, composite reliability; ATT, attitudes; SN, subjective norms; PBC, perceived behavioral control; EOU, ease of use; PR, price rationality; OC, organization culture; TAW, technology absorptive willingness; TSW, technology sharing willingness; ICP, industry competition pressure.

technology utilization.[57–59] This result reminded us that successful technology diffusion does not depend solely on the technology itself, individual practitioners, the promotion of organizations, or the external environment, but it is the outcome of the joint efforts of all the aspects mentioned above. It emphasized the importance of taking

Table 4 Rotated Factor Matrix

Items	Factors and Loadings			
	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**
ATT1	0.838			
ATT2	0.874			
ATT3	0.874			
SN1	0.837			
SN2	0.809			
SN3	0.833			
PBC1	0.730			
PBC2	0.753			
PBC3	0.743			
EOU1			0.613	
EOU2			0.646	
EOU3	0.555		0.586	
PR1			0.792	
PR2			0.768	
PR3			0.783	
OC1		0.809		
OC2		0.879		
OC3		0.883		
TAW1		0.763		
TAW2		0.744		
TAW3		0.726		
TSW1		0.900		
TSW2		0.893		
TSW3		0.890		
ICP1				0.749
ICP2				0.736
ICP3				0.721
ICP4				0.725

Notes: Factor 1 "personal beliefs", Factor 2 "organizational readiness", Factor 3 "technical drivers", and Factor 4 "external environment".
Abbreviations: ATT, attitudes; SN, subjective norms; PBC, perceived behavioral control; EOU, ease of use; PR, price rationality; OC, organization culture; TAW, technology absorptive willingness; TSW, technology sharing willingness; ICP, industry competition pressure.

Table 5 Pearson Correlation Matrix for the Items and the Factors (Bold Values Indicate the Items of the Same Dimension Converge on the Same Factor)

	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**
ATT1	**0.838****	0.129*	0.169**	0.176**
ATT2	**0.874****	0.101	0.106	0.130*
ATT3	**0.874****	0.163*	0.203**	0.155*
SN1	**0.837****	0.147*	0.185**	0.151*
SN2	**0.809****	0.190**	0.131*	0.135*
SN3	**0.833****	0.126*	0.154*	0.169**
PBC1	**0.730****	0.211**	0.296**	0.060
PBC2	**0.753****	0.194**	0.361**	0.182**
PBC3	**0.743****	0.227**	0.388**	0.156*
EOU1	0.309**	0.140*	**0.613****	0.319**
EOU2	0.461**	0.069	**0.646****	0.259**
EOU3	**0.555****	0.139*	**0.586****	0.205**
PR1	0.154*	0.200**	**0.792****	0.236**
PR2	0.253**	0.191**	**0.768****	0.260**
PR3	0.319**	0.180**	**0.783****	0.202**
OC1	0.223**	**0.809****	0.188**	0.000
OC2	0.245**	**0.879****	0.104	−0.012
OC3	0.214**	**0.883****	0.140*	0.004
TAI1	0.043	**0.763****	0.053	0.371**
TAI2	−0.050	**0.744****	0.089	0.361**
TAI3	−0.040	**0.726****	0.210**	0.382**
TSI1	0.222**	**0.900****	0.086	0.097
TSI2	0.261**	**0.893****	0.115	0.065
TSI3	0.239**	**0.890****	0.150*	0.075
ICP1	0.283**	0.153*	0.254**	**0.749****
ICP2	0.156*	0.170**	0.355**	**0.736****
ICP3	0.283**	0.214**	0.331**	**0.721****
ICP4	0.347**	0.167**	0.284**	**0.725****

Notes: Factor 1 "personal beliefs", Factor 2 "organizational readiness", Factor 3 "technical drivers", and Factor 4 "external environment"; Bold values indicate the items of the same dimension converge on the same factor; **$p < 0.01$, *$p < 0.05$.
Abbreviations: AVE, average variance extracted; CR, composite reliability; ATT, attitudes; SN, subjective norms; PBC, perceived behavioral control; EOU, ease of use; PR, price rationality; OC, organization culture; TAW, technology absorptive willingness; TSW, technology sharing willingness; ICP, industry competition pressure.

concrete measures from a multi-dimensional perspective to integrate the efforts of all involved parties while promoting health technology diffusion in the context of ICS.

Among multiple domains of the dynamics of health technology diffusion, domains of personal beliefs and organizational readiness were illustrated as two of the

Table 6 Discriminant Validity (Bold Values in the Diagonal Indicate the Square Root of AVE of the Corresponding Factor)

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	**0.945**			
Factor 2	0.465***	**0.935**		
Factor 3	0.799***	0.440***	**0.858**	
Factor 4	0.600***	0.436***	0.778***	**0.864**

Notes: Factor 1 "personal beliefs", Factor 2 "organizational readiness", Factor 3 "technical drivers", and Factor 4 "external environment"; Bold values in the diagonal indicate the square root of AVE of the corresponding factor; ***p < 0.001.

most powerful domains in the DHTDICS in this study, which implied that more attention should be paid to these two aspects. For instance, the domain of personal beliefs, namely Factor 1 in this study, revealed three contributors of positive attitudes, strong subjective norms, and perceived behavioral control. Similarly, the domain of organizational readiness, namely Factor 2 in this research, consisted of organizational culture, the willingness of technology absorptive, and technology sharing, highlighted the importance of developing an organizational atmosphere that advocates technology innovation and promotes inter-organizational technology exchange and cooperation. Thus, to promote the diffusion of some appropriate health technology in the RMC, it is recommended to uptake some continuing education and training to raise the awareness of certain health technology and the importance of expanding its use.[60] Besides, the positive role of subjective norms also highlighted the impact of peer and organization as mentioned above.[61] As confirmed by previous researches, organizational norms and values control the way individuals interact with each other within or outside the boundaries of the organization.[28,29] Apart from these domains, the domains of technical drivers and external environment were also significant dynamics components that cannot be ignored in health technology diffusion in the RMC.

This study was strengthened by some features. Firstly, the research model was developed by integrating several previous theories of the IDT, TPB, TAM, TOE, which can combine the strengths of different theories and provide a comprehensive insight into health technology diffusion. Secondly, the findings expanded the knowledge of physicians' DCP use, it will not only directly guide the practice of promoting the utilization of DCP test, but also provide clues for the diffusion of other health technologies in the RMC. Thirdly, the joint application of EFA and CFA ensured the effectiveness and robustness of the results. However, there are also some limitations to this study. Firstly, due to the effect of social desirability, the participants may not tend to voice negative assessment on the actual performance of themselves and the hospitals, which probably lead to overestimation of the responses. Secondly, owing to time and funding constraints, the DHTDICS has only been validated with a specific technology. The generalizability of this instrument needs to be further validated with other technologies. Thirdly, test-retest reliability has not been assessed as the second wave of data collection was not conducted, which may need to be confirmed in future research.

Conclusion

Under the guidance of multiple theories, this study developed a scale on DHTDICS with the domains of personal beliefs, technical drivers, organizational readiness and external environment. By the agency of calculating Cronbach's alpha and applying EFA and CFA, the reliability and validity of the scale were confirmed, and the roles of the four domains in the DHTDICS were also identified. By providing a robust tool for evaluating the dynamics of health technology diffusion in the RMC, this study will contribute to the knowledge of health technology diffusion in the ICS, and will also benefit to tailor future intervention strategies to promote the effective diffusion and allocation of health technology resources.

Abbreviations

ICS, integrated care system; PCTs, primary care trusts; PCMH, patient-centered medical home; PCIHC, people-centered and integrated health care services; RMC, regional medical consortium; DCP, Des-gamma-Carboxy Prothrombin; PHCC, primary hepatocellular carcinoma; IDT, Innovation Diffusion Theory; TPB, Theory of Planned Behavior; TAM, Technology Acceptance Model; TOE, Technology-Organization-Environment framework; DHTDICS, dynamics of health technology diffusion in integrated care system; ATT, attitudes; SN, subjective norms; PBC, perceived behavioral control; EOU, ease of use; PR, price rationality; OC, organization culture; TAW, technology absorptive willingness; TSW, technology sharing willingness; ICP, industry competition pressure; CITC, corrected item-total correlation; EFA, exploratory factor analysis; PCA, principal components analysis; KMO, Kaiser-Meyer-Olkin; CFA, confirmatory factor analysis; SEM, structural equation modeling; AVE, average variance extracted; CR, composite reliability.

Ethical Statement

Ethical permission was granted for this study from the Ethics Committee of Fujian Medical University (No. 2017-17). This study was conducted under the Declaration of Helsinki. A formal letter of cooperation was written to the directors of each selected medical institution and permission was obtained. All participants were informed about the study purpose, participation in the study was voluntary, and all responses were anonymous. If the participants completed and returned the questionnaire, it was considered informed consent.

Consent for Publication

All participants provided written informed consent to publish this study.

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Disclosure

The authors declare that they have no conflicts of interest for this work.

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