Healthcare technology management competency and its impacts on IT–healthcare partnerships development

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Abstract
Objective: This study presents a conceptual model to investigate the healthcare technology management (HTM) competency required by healthcare IS professionals and the impact of such competency in gaining strategic advantages through information technology (IT) by development of partnerships with people from different divisions of healthcare organizations.

Methods: First, a scale to measure HTM competency was developed and validated, then it was used to collect the large-scale survey data. Second, the partial least squares (PLS) method was used to empirically test the conceptual model and hypotheses through the large-scale survey data collected.

Results: The empirical results support the proposed structure for HTM competency encompassing the four skills/knowledge domains: healthcare organization overview, external knowledge networking, healthcare technology integration, and management and interpersonal. The findings indicate that HTM competency positively influences the attitudes of information system (IS) professionals towards their willingness to develop partnerships with healthcare professionals.

Conclusions: The findings improve our understanding of the concept of HTM competency and its influence on IT–healthcare partnerships. The conceptual model of HTM is of particular value to those concerned with skills/knowledge training and competency development for IS professionals in healthcare organizations. Healthcare organizations can develop HTM profiles for individual IS professionals in accordance with their own organization contexts. Executive management can take advantage of such HTM profiles to assist in making succession-planning decisions by evaluating the competency levels and development needs of their employees.

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1. Introduction

As a part of the changing world, the healthcare industry and healthcare system have encountered dramatic changes in information and communication technology (ICT) that will influence the way healthcare services are delivered and used, and the relationship between healthcare provider and consumers. The rapid progress in ICT provides both opportunities and challenges in delivering high-quality and efficient healthcare, curbing the scourge of medical errors, facilitating point-of-care decision support, streamlining workflow, and reducing costs and improving the patient–physician relationship. The influence of electronic healthcare (E-healthcare) will increasingly affect the very roots of our current healthcare system [1].

As healthcare innovation relies more strongly on ICT, information system (IS) professionals in healthcare organizations should be more entrepreneurial in focusing on innovation through information technology (IT). In addition, the complexity of IS/IT implementations in healthcare integrated delivery systems requires the coordination of diverse efforts including manpower, medical materials, and relevant technical components. Therefore, it is critical for healthcare organizations to figure out how to create effective team relationships between the IS departments and medical units to enhance capabilities and maintain competitiveness. An effective partnership between IS professionals and their business partners is a primary determinant of success in gaining advantage through IT in today's business environment [2]. The partnership-building ability of IS professionals can thus be a core capability of organizations [3]. To develop sound partnerships with healthcare professionals and identify opportunities for innovation, it is necessary for IS professionals to understand, participate in, and support their healthcare partners’ critical professional activities [4–6].

With accelerated healthcare competition and the popularity of ICT usage, there is a need to understand what factors are most important in enabling healthcare IS professionals to develop and foster collaborations with healthcare professionals. Comprehending these factors with respect to the proactive attitude of IS professional to develop partnerships can potentially provide management insights in determining effective strategies to enable health care organizations to be competitive and better able to retain their customers and/or patients [7]. The need to effectively communicate with healthcare professionals requires that IS professionals develop some commonality of vocabulary and conceptual knowledge, as well as experience working with healthcare professionals.

Most healthcare and IT/IS-related research has focused on the technology developments and clinical applications essential to successful implementation in the healthcare environment [8, 9]. For instance, considerable effort is devoted to characterizing broad knowledge areas concerning leadership and business knowledge/skills in healthcare administration (e.g., [10–13], health/medical informatics training and education (e.g., [11, 14–16]), leveraging of health IT for business value and strategy (e.g., [17–19]) and healthcare information resource management (e.g., [20, 21]) as aspects of the training and expertise of healthcare practitioners in the disciplines of medical informatics and healthcare management [22–24]. However, little attention has been paid to investigating the healthcare technology management-related skills/knowledge required by healthcare IS professionals and the impact of such skills/knowledge in gaining strategic advantages through IT by development of partnerships with people from different divisions of healthcare organizations. The purpose of this research is therefore, to address two research questions: (1) What are the areas of knowledge/skills that characterize healthcare technology management competency of IS professionals? and (2) What is the contribution of healthcare technology management competency in IS professionals to improving their proactive attitudes to develop partnerships with healthcare professionals?

2. Theoretical foundation and conceptual model

2.1. Social cognitive theory and empowerment theory

In this study, two theories provide a useful explanatory framework for addressing the above research problems. First, social cognitive theory, from Bandura [25], serves as an initial foundation for exploring IS professionals’ self-efficacy beliefs of healthcare technology management (HTM)-related skills/knowledge and the influence on their attitudes towards IT–healthcare partnerships development. Second, empowerment theory (ET) provides the rationale for the formation of HTM competency.

Social cognitive theory is rooted in a view of human agency in which individuals are agents proactively engaged in their own development and can make things happen by their actions. Self-efficacy beliefs, standing at the very core of social cognitive theory, affect human functioning. Bandura defined perceived self-efficacy as “people’s judgments of their capabilities to organize and execute courses of action required to attain designated types of performances.” It can enhance human accomplishment and well-being, help determine how much effort people will expend on an activity, how long they will persevere when confronting obstacles, and how resilient they will be in the face of adverse situations. Self-efficacy measures should be tailored to the targeted domain context [25].

Many empowerment theorists have identified empowerment as the construct of self-efficacy or self-determination/autonomy. For instance, Thomas and Velthouse [26] conceptualized empowerment as four cognitions including a sense of meaning, competence, self-determination, and impact. Among them, competence (i.e., self-efficacy) is a belief that one possesses the skills and knowledge necessary to perform a job or task well [27] and is analogous to agency beliefs, personal mastery, or effort–performance expectancy in one’s capability to perform work activities with skills/knowledge [28, 29]. This personal efficacy belief has been found to be related to a variety of proactive behaviors and a necessary condition to produce certain behavioral outcomes in the workplace. In that sense, for professionals to enhance empowered outcomes of others, it is necessary for them to improve their efficacy beliefs through the empowering process to collaborate with their partners in the development, implementation, and evaluation of involved community; whereby profession-
als become members of the community to some extent, working with community members as coequal partners, and creating opportunities for community members to develop skills/knowledge, so that they do not have to be dependent on professionals.

To effectively develop healthcare technology partnerships, IS professionals must possess strong healthcare and interpersonal knowledge and skills other than their technical skills. Building collaborative partnerships with other departments in a healthcare organization depends on the capability of IS professionals to convince their healthcare partners that they understand their goals, concerns, language, and processes and are trying to help them achieve their goals. It is a measure of IS professionals’ capacity for healthcare organization understanding. When IS professionals and healthcare professionals understand each other’s reality, they are more likely to work towards common goals and be willing to share risks and responsibilities in their common activities to form a sound collaborative community in the workplace [27]. This organization-level competency is termed IS professional’s HTM competency or self-efficacy beliefs in the healthcare sector. This competency can be expected to contribute to better IT–healthcare partnerships among IS professionals and provide the reason for collaborating with business partners to put IT into effective use to create competitive advantage. Therefore, based on the social cognitive theory and empowerment theory the following hypothesis is proposed.

**Hypothesis.** A higher level of healthcare technology management competency possessed by IS professionals will positively associate with a higher level of proactive attitudes to develop partnerships with their healthcare partners.

### 2.2 Developing a framework for HTM competency

It is widely recognized that higher business acumen, i.e., business competency, is needed for IS professionals to develop more effective partnerships with their business partners [2,30]. However, the set of skills/knowledge that essentially comprise such healthcare technology management competency and the structure of this construct are not clearly identified in the healthcare management field. For the past two decades, various studies (e.g., [2,5,10,13,31]) have offered different frameworks, categories, coverage, and labeling as shown in Table 1. Among them, Bassellier and Benbasat [2] offered a somewhat comprehensive taxonomy of IS professionals’ business competency in the general business domain.

Based on empowerment theory, the empowering process to enhance professionals’ self-efficacy beliefs might include improvements in developing a critical understanding of their own environments, expanding their social support networks, and gaining knowledge about critical resources acquisition, as well as developing and practicing leadership and management skills/knowledge to work with others on a common goal [27,32]. Therefore, in this study, we adopted the concept of business competency proposed by Bassellier and Benbasat [2] and empowerment theory and tailored it to the healthcare sector. We induced four broad categories of skills/knowledge, including (1) healthcare organization overview, (2) external knowledge networking, (3) management and interpersonal skills, and

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Healthcare organization overview</td>
<td>Organizational overview</td>
<td>Organizational overview</td>
<td>Organizational overview</td>
</tr>
<tr>
<td>External knowledge networking</td>
<td>Knowledge network</td>
<td>Knowledge network</td>
<td>Knowledge network</td>
</tr>
<tr>
<td>Healthcare technology integration</td>
<td>IT-business integration</td>
<td>Technical integration skills/analytic reasoning</td>
<td>Technical integration skills/analytic reasoning</td>
</tr>
<tr>
<td>Management and interpersonal skills</td>
<td>Interpersonal communication</td>
<td>Leadership</td>
<td>Leadership</td>
</tr>
</tbody>
</table>

Table 1 – The proposed taxonomy of HTM competency for IS Professionals
2.2.1. Healthcare organization overview
Healthcare organization overview (HOO) stands for the understanding by IS professionals of the holistic healthcare organizational settings in which IT is deployed and of the connections between IT and healthcare organizations. This knowledge represents the capability of IS professionals for healthcare understanding, enabling them to see the big IT picture in their healthcare organizations and to make a linkage between different hospital divisions and tasks, ensuring that benefits are realized from the potential fit between IT and the specific healthcare organizational setting [10]. It includes understanding the healthcare delivery processes supported by IT and the connections and interdependencies among different divisions [33]. IS professionals also need to understand the healthcare environment as workers in other functional areas would, and participate in making functional areas successful in the same way. Healthcare organization overview knowledge implies knowing an organization’s goals, objectives, core capabilities and critical success factors [2].

2.2.2. External knowledge networking
External knowledge networking (EKN) is an important personal capability which is necessary for IS professionals in a healthcare environment. It refers to the abilities of IS professionals to understand where the critical external knowledge resources (e.g., customers, suppliers, and other external collaborators) concerning the healthcare organizations originate and how they are acquired [2,34,35]. IS professionals in healthcare settings should effectively develop their own social and knowledge networks concerning the knowledge regarding both technology and business fields to communicate clearly and concisely with internal and external clients, establish and maintain relationships, and facilitate constructive linkages with individuals and groups [10]. Skyrme [36] argued the importance of knowledge networking concerning people, processes and practices to effectively achieve collaboration and team-working.

2.2.3. Management and interpersonal skills/knowledge
The competency of management and interpersonal (M&I) skills/knowledge taps into the capability for execution of management practices and formation of sophisticated personal interactive relationships. It refers to the capability of an IS professional to act as a technology leader in dealing with organizational renovation/innovation and risk management, to work in a team environment, and to communicate in non-technical language within a healthcare context [37,38]. Although management and interpersonal skills/knowledge required by IS professionals could be quite diverse, the practical skills/knowledge required for dealing with organizational innovation adoption and change management are most important [11,12,14,17]. As key figures for information service delivery and change agents, IS professionals have to participate in interpersonal interactions and deal with group dynamics more than ever before. They are increasingly asked to develop overall strategy and tactics for creating broad-based understanding as well as to act as exceptional team players and effective, jargon-free communicators throughout the organization [2,39].

2.2.4. Healthcare technology integration
Healthcare technology integration (HTI) refers to the ability to visualize the ways in which various kinds of technologies can contribute to healthcare organization performance and help to provide synergies among IS/IT, healthcare professionals’ knowledge, and organization performance. IS professionals need to act as healthcare problem solvers and to integrate healthcare development with IT capability. Healthcare organizations use lots of advanced technologies, such as picture archiving and communication systems (PACSs), cardiac catheterization records, mobile/ubiquitous computing technology [40–42], and interactions with personal health records (PHRs) [43–47]. These technologies have diverse contents needing various media types and data formats [48]. IS professionals with healthcare technology integration capability need to be good at applying these technologies to support an existing healthcare delivery service or to create a new one.

2.3. The causal effects among the constructs of HTM competency
In our study, the questions explored include whether an IS professional has adequate experience in recognizing potential ways to exploit new healthcare opportunities using IT, analyzing healthcare organization problems in order to identify IT-based solutions, and evaluating the impacts of IT solutions. IS professionals should not only count on their IT skills but also equip themselves with the above specific healthcare environment domain knowledge. Healthcare IS personnel need to act as healthcare problem solvers and to integrate healthcare development with IT capability. The way IS contributes to the value, and its alignment with the healthcare domain and functional unit should be considered thoroughly.

Empowerment theory-related research (e.g., [27–29]) indicates that individuals will feel empowered when they can comprehend the organization’s structural characteristics and see their working environment as providing opportunities for, rather than constraints on, individual behavior. In the healthcare sector, knowledge of healthcare organizations also includes a critical understanding of the whole healthcare environment and the constraints imposed by customers (patients), government, suppliers and competitors (other hospitals). Thus, it is necessary to evaluate whether a healthcare IS professional has sufficient knowledge concerning the external environment, the objectives of his or her own institution, the core capabilities, and the critical success factors of healthcare organizations. In addition, to support healthcare processes effectively, IS professionals need to understand what the divisions of their healthcare organizations are, including their objectives, problems and the language they speak. Thus, it is necessary to evaluate whether an IS professional has sufficient knowledge for this purpose.

To support various sorts of healthcare processes effectively and efficiently IS professionals also need to develop unimpaired knowledge linkage networks. Doing this can help them to obtain initial aid easily, to facilitate timely information
sharing, and enable consistent coordination between different functional divisions [49]. This knowledge includes finding the right people to contact outside their healthcare institution (e.g., consultants, vendors, and strategic partners) and relevant sources of healthcare-related information (e.g., Internet sites, magazines, and trade journals), as well as understanding the personal connections and interdependencies among various external information/knowledge resources while they swamp in questions or problems in practices that cannot be unraveled on their own. This knowledge is linked to the specific organization, as it not only refers to a more active role taken by IS professionals, but also to a sense of commitment, empowerment, personal involvement, and organizational pride [30,34,50]. In this study, the confidence of IS professionals in their ability to find the right internal and external contacts and the relevant sources of information was examined.

Moreover, in previous research concerning empowerment theory [27–29] for professionals to feel empowered in the workplace, they need to practice management and utilize interpersonal skills/knowledge, to work with counterparts on a common goal, to develop leadership skills, to learn about resources development and management, and to stretch their social support network. Longest [51] argued the importance of management and interpersonal skills/knowledge for IS professionals to motivate other people, articulate visions and preferences and communicate them to others, handle negotiations with other people and manage conflicts. Other studies (e.g., [35,37,52–54]) also posited requirements for management and interpersonal-related skills and knowledge to achieve effective healthcare administration practice.

Indeed, management and interpersonal skills/knowledge can help IS professionals to coordinate IS professional activities in ways that support other functional units, suppliers, and customers, manage relationships and build overarching social networks [55]. Such skills can empower them to identify the relationship with colleagues and subordinates, define the milieu in which they work, motivate them, probe into their activities to keep them alert, and take responsibilities for implementing and sustaining empowerment in their interactions with business partners [56]. In this study, the effectiveness of an IS professional was evaluated with respect to working in a team environment, communicating in non-technical language within a healthcare context, acting in a leadership role, dealing with innovation, and offering problem-solving solutions based on his or her experience when the organization or department is mired in emergencies [30,32,57].

Given the emphasis on integration in healthcare technology integration skills/knowledge, the first three categories of IT–healthcare-related skills/knowledge constructs, HOO, EKN, and M&I skills/knowledge, are further hypothesized to be helpful for IS professionals for HTI. This suggests that IS professionals in healthcare facilities have to cultivate higher levels of HOO, EKN, M&I skills/knowledge to gain higher levels of HTI skills/knowledge. Therefore, the following hypotheses are proposed.

**H1.** A higher level of healthcare organization overview skills/knowledge possessed by IS professionals will positively associate with a higher level of healthcare technology integration skills/knowledge.

**H2.** A higher level of external knowledge networking skills/knowledge possessed by IS professionals will positively associate with a higher level of healthcare technology integration skills/knowledge.

**H3.** A higher level of management and interpersonal skills/knowledge possessed by IS professionals will positively associate with a higher level of healthcare technology integration skills/knowledge.

### 2.4 Influence of HTM competency on IT–healthcare partnership development

Based on social cognitive theory and empowerment theory as discussed in the previous sections, IS professionals should be willing to share certain responsibilities with other healthcare staff and their business partners in healthcare organizations, during the processes of developing and executing a project, if these processes are to be done effectively and efficiently [58]. Furthermore, the healthcare technology management competency required by IS professionals in the healthcare sector and their willingness to develop sound IT–healthcare partnerships will affect the success of the project [4,6]. Explicitly, the higher the level of HTM competency possessed by IS professionals, the more they would be expected to pursue development of sound partnerships with other healthcare staffs.

IS professionals with greater HTM competency would collaborate more effectively and efficiently with their healthcare colleagues in the healthcare sector. The concept of HTM competency comprises organizational, managerial and technological skills/knowledge and, considered together, can well reflect healthcare IS professionals’ overall HTM capability to sustain IT innovation and respond to changing healthcare surroundings through focused IT applications. We therefore regard HTM competency as a holistic concept reflected by an IS professionals’ skills/knowledge portfolio. Thus, the following hypotheses are proposed.

**H4.** A higher level of healthcare organization overview skills/knowledge possessed by IS professionals will positively associate with a higher level of proactive attitudes to develop partnerships with their healthcare partners.

**H5.** A higher level of external knowledge networking skills/knowledge possessed by IS professionals will positively associate with a higher level of proactive attitudes to develop partnerships with their healthcare partners.

**H6.** A higher level of management and interpersonal skills/knowledge possessed by IS professionals will positively associate with a higher level of proactive attitudes to develop partnerships with their healthcare partners.

**H7.** A higher level of healthcare technology integration skills/knowledge possessed by IS professionals will positively associate with a higher level of proactive attitudes to develop partnerships with their healthcare partners.
Based on the foregoing discussion, we propose a conceptual model which suggests that HTM competency of IS professionals influences their attitudes to develop partnership with healthcare professionals, as shown in Fig. 1.

3. Research methodology

3.1. Instrument development

At the outset, we developed the constructs of healthcare technology management competency and the associated measures. A number of prior relevant studies were reviewed to ensure that a comprehensive list of measures was included. To construct a deliberate questionnaire to achieve the research goal, initial design and subsequent refinement of the instrument was done by researchers via several rounds of in-depth personal interviews with IS practitioners in healthcare organizations and academic experts in healthcare management departments of universities/colleges in Taiwan using the questionnaire to structure their questions. This process was continued until no further modifications to the questionnaire were necessary. Feedback from the in-depth personal interviews served as the basis for refining the experimental scales of the survey instrument. The researchers tested and revised the questionnaire several times before starting to gather the large-scale survey data.

The questionnaire contained two major parts including a portion for the respondent's basic data and another for the responses to our research constructs. The basic data portion requested IS professionals to give the names of their hospitals/healthcare institutes and their own demographic characteristics job title, and main tasks. The second part contained 25 questions including 22 items relating to the four skills/knowledge constructs in accordance with the skills/knowledge classifications and three items aimed at healthcare IS professionals' collaborative-attitude measurement. Data were collected using a seven point Likert-type scale.

3.2. Data collection

The empirical data were collected using a questionnaire survey administered from May to September, 2005. The initial mail-out list for questionnaires included all medical centers (14) and regional hospitals (99) in Taiwan. The MIS department of each healthcare institution received an initial phone call explaining the purpose of our project and inquiring whether the organization would be willing to participate in the study. Due to the conventional expectation of low survey response rates in healthcare organizations, a contact person was identified at each organization; this person was asked to distribute the self-administered questionnaires to IS professionals and/or managers. Several reminders were sent to the contact person from the late June to August, 2005 to increase the response rate in this study. Overall, we sent out 528 questionnaires and 182 completed questionnaires were returned. Twenty-three responses were considered incomplete and had to be discarded. This left 159 valid responses for the statistical analysis, and a valid response rate of 30.11% of the initial sample. To assess non-response bias, we have collected the data of related healthcare organizations from the Department of Health of Executive Yuan, Taiwan. Using a t-test and Chi-square tests to compare the responding and non-responding healthcare organizations' type, number of beds, and geographic location, the results indicated no significant differences (p > .05). In addition, the potential non-response bias was also assessed by comparing the early versus late respondents that were weighed on several demographic characteristics. The results indicated that there are no statistically significant differences in demographics between the early and late respondents. These results suggest that non-response bias was not a serious concern. The profile
Table 2 – Respondents profile and non-response bias analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Classification</th>
<th>Total (%) (N = 159)</th>
<th>Early respondents (%)</th>
<th>Late respondents (%)</th>
<th>( \chi^2 ) (Sig.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational position</td>
<td>Executive level</td>
<td>11 (6.9)</td>
<td>3 (3.6)</td>
<td>8 (10.5)</td>
<td>4.64 (0.20)</td>
</tr>
<tr>
<td></td>
<td>Middle level</td>
<td>24 (15.1)</td>
<td>15 (18.1)</td>
<td>9 (11.8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supervisory level</td>
<td>29 (18.2)</td>
<td>13 (15.7)</td>
<td>16 (21.1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical level</td>
<td>95 (59.7)</td>
<td>52 (62.7)</td>
<td>43 (56.6)</td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td>Information management</td>
<td>57 (35.8)</td>
<td>30 (36.1)</td>
<td>27 (35.5)</td>
<td>2.11 (0.55)</td>
</tr>
<tr>
<td></td>
<td>Software engineering</td>
<td>24 (15.1)</td>
<td>11 (13.3)</td>
<td>13 (17.1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Computer science</td>
<td>32 (20.1)</td>
<td>20 (24.1)</td>
<td>12 (15.8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>46 (28.9)</td>
<td>22 (26.5)</td>
<td>24 (31.6)</td>
<td></td>
</tr>
<tr>
<td>Level of hospital</td>
<td>Medical center</td>
<td>76 (47.8)</td>
<td>42 (50.6)</td>
<td>34 (44.7)</td>
<td>0.55 (0.46)</td>
</tr>
<tr>
<td></td>
<td>Regional hospital</td>
<td>83 (52.2)</td>
<td>41 (49.4)</td>
<td>42 (55.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Senior high school</td>
<td>2 (1.3)</td>
<td>1 (1.2)</td>
<td>1 (1.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>College/University</td>
<td>108 (67.9)</td>
<td>52 (62.7)</td>
<td>56 (73.7)</td>
<td>2.31 (0.31)</td>
</tr>
<tr>
<td></td>
<td>Graduate school</td>
<td>49 (30.8)</td>
<td>30 (36.1)</td>
<td>19 (25.0)</td>
<td></td>
</tr>
<tr>
<td>Types of jobs</td>
<td>IS maintenance and management</td>
<td>37 (23.3)</td>
<td>20 (24.1)</td>
<td>17 (22.4)</td>
<td>1.13 (0.57)</td>
</tr>
<tr>
<td></td>
<td>Program/SA&amp;D/implementation</td>
<td>86 (54.1)</td>
<td>47 (56.6)</td>
<td>39 (51.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strategic planning/needs assess</td>
<td>36 (22.6)</td>
<td>16 (19.3)</td>
<td>20 (26.3)</td>
<td></td>
</tr>
<tr>
<td>Average years of work experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.18</td>
</tr>
</tbody>
</table>

of respondents and the results of non-response bias analysis are shown as in Table 2.

3.3. Analysis methods

The empirical data collected were analyzed using the partial least squares (PLS) method, which is particularly suitable for identifying the variance and validating the causal relationships between latent variables comprising complex theoretical and measurement models [59]. The hypotheses, proposed for the predictive and nomological structure of healthcare technology management competency and the influences on healthcare IS professionals’ attitudes on partnership development, were validated at the same time. The PLS method allows the validations of the measurement model and the estimation of the structural model. The questionnaire administered in the large-scale questionnaire survey included items worded with proper negation and a shuffle of the items to reduce monotony of questions measuring the same construct. The statistical analysis strategy involved a two-phase approach in which the psychometric properties of all scales were first assessed through confirmatory factor analysis (CFA) and the structural relationships were then validated by bootstrap analysis.

4. Results

4.1. Measurement properties

All of the constructs in the conceptual framework were modeled as reflective and were measured using multiple indicators. The measurement model relating the IT–healthcare skill/knowledge and attitudes-to-develop-collaboration scale items to their latent constructs was analyzed by PLS-Graph 3.0. The assessment of item loadings, reliability, convergent validity, and discriminant validity was performed for the latent constructs through a confirmatory factor analysis. Reflective items should be uni-dimensional in their representation of the latent variable, and therefore correlated with each other. Item loadings should be above .707, showing that more than half of the variance is captured by the constructs [60]. As shown in Table 3, all items of the instrument have significant loadings higher than the recommended value of .707.

All constructs in the measurement model exhibit good internal consistency as evidenced by their composite reliability scores. The composite reliability coefficients of all constructs in the proposed conceptual framework (Fig. 1) are more than adequate, ranging from 0.87 to 0.93. To assess discriminant validity, (1) indicators should load more strongly on their corresponding construct than on other constructs in the model and (2) the square root of the average variance extracted (AVE) should be larger than the inter-construct correlations [59]. The percent of variance captured by a construct is given by its AVE. To show discriminant validity, each construct square root of the AVE has to be larger than its correlation with other factors. As the results in Table 4 show, all constructs meet this requirement. Finally, the values for reliability are all above the suggested minimum of 0.7 [60]. Thus, all constructs display adequate reliability and discriminant validity. All constructs share more variance with their indicators than with other constructs. Thus, the convergent and discriminant validity of all constructs in the proposed conceptual framework can be assured.

4.2. Test of the structural model

The path coefficients and explained variances for the conceptual model in this study are shown in Fig. 2. T-statistics and standard errors were generated by applying the bootstrapping procedure with 200 samples. All of the constructs in this study
<table>
<thead>
<tr>
<th>Construct</th>
<th>Code</th>
<th>Scale item</th>
<th>Loading</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare organization overview</td>
<td>HOO1</td>
<td>Rate your knowledge level about the overview of healthcare environment (e.g., government, competitors, health systems, and customers) around your healthcare institution.</td>
<td>0.82</td>
<td>4.43</td>
</tr>
<tr>
<td></td>
<td>HOO2</td>
<td>Rate your knowledge level about the objectives of your healthcare institute as a whole.</td>
<td>0.80</td>
<td>4.67</td>
</tr>
<tr>
<td></td>
<td>HOO3</td>
<td>Rate your knowledge level about the core capabilities of your healthcare institution.</td>
<td>0.87</td>
<td>4.46</td>
</tr>
<tr>
<td></td>
<td>HOO4</td>
<td>Rate your knowledge level about the critical successful factors for your healthcare institution.</td>
<td>0.81</td>
<td>4.40</td>
</tr>
<tr>
<td></td>
<td>HOO5</td>
<td>Rate your knowledge level about the main challenges that different divisions in your healthcare institution face in achieving their objectives.</td>
<td>0.80</td>
<td>4.17</td>
</tr>
<tr>
<td></td>
<td>HOO6</td>
<td>Rate your knowledge level concerning the overall performance of your healthcare institution.</td>
<td>0.73</td>
<td>4.17</td>
</tr>
<tr>
<td>External knowledge networking</td>
<td>EKN1</td>
<td>If you have a question or problem in practice that you cannot solve alone, how confident are you about finding the right person in other divisions to contact in your healthcare institution?</td>
<td>0.80</td>
<td>4.74</td>
</tr>
<tr>
<td></td>
<td>EKN2</td>
<td>If you have a question or problem in practice that you cannot solve alone, how confident are you about finding the right contacts outside your healthcare institution (e.g., consultants or vendors)?</td>
<td>0.79</td>
<td>4.27</td>
</tr>
<tr>
<td></td>
<td>EKN3</td>
<td>If you have a question or problem in practice that you cannot solve alone, how confident are you about finding other relevant sources of healthcare-related information including Internet site, magazines, trade journals, and conferences?</td>
<td>0.78</td>
<td>4.67</td>
</tr>
<tr>
<td></td>
<td>EKN4</td>
<td>If you have a question or problem in practice that you cannot solve alone, how confident are you about finding relevant resources through your personal connections and interdependencies between various divisions in your healthcare institution?</td>
<td>0.76</td>
<td>4.21</td>
</tr>
<tr>
<td>Management and interpersonal skills</td>
<td>M&amp;I1</td>
<td>In general, how effective do you think you are at communicating with people at different levels of your healthcare institution (e.g., with your subordinates, peers, superiors)?</td>
<td>0.79</td>
<td>4.74</td>
</tr>
<tr>
<td></td>
<td>M&amp;I2</td>
<td>How effective are you at working in a team environment in your healthcare institution?</td>
<td>0.76</td>
<td>4.69</td>
</tr>
<tr>
<td></td>
<td>M&amp;I3</td>
<td>How well can you communicate about IT matters in non-technical language and within a healthcare context to non-IT specialists in your healthcare institution?</td>
<td>0.81</td>
<td>4.61</td>
</tr>
<tr>
<td></td>
<td>M&amp;I4</td>
<td>In general, how effective do you think you are at managing projects (planning, managing resources, evaluating, etc.) in your healthcare institution?</td>
<td>0.81</td>
<td>4.40</td>
</tr>
<tr>
<td></td>
<td>M&amp;I5</td>
<td>In general, how effective do you think you are at acting in a leadership role (e.g., establishing direction, directing people, motivating and inspiring, etc.) in your healthcare institution?</td>
<td>0.83</td>
<td>4.27</td>
</tr>
<tr>
<td></td>
<td>M&amp;I6</td>
<td>Rate your knowledge level concerning the existing practices for the management of change in your healthcare institution.</td>
<td>0.79</td>
<td>4.26</td>
</tr>
<tr>
<td>Healthcare technology integration</td>
<td>HTI1</td>
<td>How experienced are you at analyzing business problems in order to identify IT-based solutions (understand situations, getting the “big picture”, identifying underlying root problems, etc.) in your healthcare institution?</td>
<td>0.82</td>
<td>4.48</td>
</tr>
<tr>
<td></td>
<td>HTI2</td>
<td>How experienced are you at evaluating the impacts of IT solutions on your healthcare institution?</td>
<td>0.81</td>
<td>4.34</td>
</tr>
<tr>
<td></td>
<td>HTI3</td>
<td>Rate your knowledge level concerning the development of a technical platform that responds to current and future organization needs in your healthcare institution.</td>
<td>0.84</td>
<td>4.55</td>
</tr>
<tr>
<td></td>
<td>HTI4</td>
<td>Rate your knowledge level concerning the integration IS and new work flow of your healthcare institution.</td>
<td>0.82</td>
<td>4.46</td>
</tr>
<tr>
<td></td>
<td>HTI5</td>
<td>Rate your knowledge level concerning the way IS contributes to the value of your healthcare institution.</td>
<td>0.81</td>
<td>4.72</td>
</tr>
<tr>
<td></td>
<td>HTI6</td>
<td>Rate your knowledge level concerning the alignment between healthcare organization goals and information systems goals in your healthcare institution as a whole.</td>
<td>0.85</td>
<td>4.61</td>
</tr>
<tr>
<td>Attitudes to develop partnerships</td>
<td>ADP1</td>
<td>To what extent are you willing to commit to the sharing of responsibilities with your colleagues in different divisions for the development and implementation of future projects?</td>
<td>0.91</td>
<td>4.74</td>
</tr>
<tr>
<td></td>
<td>ADP2</td>
<td>How comfortable would you be to getting involved with your colleagues in different divisions on the projects that may require more innovative technologies, with the risk it may imply?</td>
<td>0.92</td>
<td>4.82</td>
</tr>
<tr>
<td></td>
<td>ADP3</td>
<td>In the future, to what extent do you intend to develop strong partnerships with your colleagues in different divisions of your healthcare institution?</td>
<td>0.80</td>
<td>5.04</td>
</tr>
</tbody>
</table>
Table 4 – Inter-correlation among reflective constructs

<table>
<thead>
<tr>
<th>Construct</th>
<th>No. of items</th>
<th>Composite reliability</th>
<th>Construct</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOO</td>
<td>6</td>
<td>0.92</td>
<td>0.81a</td>
</tr>
<tr>
<td>EKN</td>
<td>4</td>
<td>0.87</td>
<td>0.75</td>
</tr>
<tr>
<td>M&amp;I</td>
<td>6</td>
<td>0.92</td>
<td>0.73</td>
</tr>
<tr>
<td>HTI</td>
<td>6</td>
<td>0.93</td>
<td>0.78</td>
</tr>
<tr>
<td>ADP</td>
<td>3</td>
<td>0.91</td>
<td>0.78</td>
</tr>
</tbody>
</table>

a Diagonal elements are the square roots of average variance extracted (AVE).

Fig. 2 – Results of PLS analysis. Note: Path coefficients are indicated in the path diagram. *Path is significant at the 0.05 level. n.s. means insignificant at the 0.05 level.

were modeled as reflective and were measured using multiple indicators, rather than summated scales. A test of the structural/inner model was used to assess the structure of HTM and its effects on the construct of "attitudes to develop partnerships". As can be seen from Fig. 2, the direct and indirect effects from all of the HTM constructs, EKN, HOO, HTI, and M&I skills/knowledge, totally account for 47% of the variance explained in healthcare IS professionals' attitudes to develop partnerships (ADP). For the intrinsic part of the HTM model, the constructs of HOO, EKN and M&I skills/knowledge together explain 70% of the variance explained in the construct of healthcare technology integration. An F test was further applied to test the significance of the effect size of the overall model. Both of the two dependent variables are significant (HTI, p = .000, F-value = 121.33; ADP, p = .000, F-value = 34.58). Therefore, the model has strong explanatory power for the constructs of HTM and ADP. The significant path coefficients, effect size, and the value of the $R^2$ reinforce our confidence in the results of hypotheses testing and provide support for the structure of HTM and the association with IT–healthcare collaboration.

Hypotheses, H1, H2, and H3, effectively drawn from HOO, EKN, and M&I to HTI, are supported by the significant path coefficients. That is, the 3 categories of skills/knowledge, HOO, EKN, and M&I do apparently influence the healthcare technology integration capability of healthcare IS professionals. This would suggest that healthcare organizations need to support their IS professionals with more healthcare knowledge, facilitate the culture of knowledge sharing, and emphasize the importance of management practice and interpersonal relationships in peers. On the other hand, with the significant path coefficients, the analysis results also provide support for hypotheses H5, H6, and H7, effectively drawn from EKN, M&I, and HTI to ADP. Contrary to our predictions, the path from HOO to ADP (H4) is not significant. The possible reason might be due to the large number of IS professionals (non-managers)
in our study group, who may express proactive attitudes and interests in collaboration on their projects but who do not have a large-scale organizational overview that is more likely to be present in management level. These interesting findings are worth pursuing in our future studies to clarify the insignificant predicting effect of “healthcare organization overview” to “attitudes to develop partnerships” and the indirect influence through the mediator, “healthcare technology integration”, to ADP.

5. Discussions and conclusions

This study proposed a comprehensive model of healthcare technology management competency of healthcare IS professionals, identified four broad categories of constructs concerning IT–healthcare-related skills/knowledge of IS professionals in the healthcare industry, developed measures of these constructs, and validated the conceptual model through a rigorous PLS analysis. The nomological structure of HTM competency encompassing the four skills/knowledge domains, namely, “healthcare organization overview”, “external knowledge networking”, “healthcare technology integration”, and “management and interpersonal”, are well validated by the empirical data. All the four major components of HTM competency are found to be directly and indirectly influential in contributing to IS professionals’ proactive attitudes to develop sound collaborative relationships with their healthcare clients.

Specifically, the test results indicate that three domains of IT–healthcare-related skills/knowledge, say, “external knowledge networking”, “healthcare technology integration”, “management and interpersonal” skills/knowledge have direct influences on IS professional attitudes to develop partnerships. Although “healthcare organization overview” knowledge has no direct effect, through the mediation of “healthcare technology integration”, it will have indirect effects on IT–healthcare partnership. Besides, for the inherent part of the HTM structure, higher levels of “external knowledge networking”, “healthcare organization overview”, and “management and interpersonal” skills/knowledge possessed by healthcare IS professionals will have salient contributions for IS professionals’ “healthcare technology integration” proficiency. Thus, these three domains of skills/knowledge are critical antecedents for IS professionals to cultivate “healthcare technology integration” capability. Among them, healthcare organization overview has the most contribution (total effect) on healthcare technology integration. These factors imply that in practice healthcare organization overview is the most significant antecedent for healthcare technology integration and must be taken into account while healthcare organizations educate and train their IS professionals.

The conceptual model of HTM competency is of particular value to those concerned with skills/knowledge training and competency development for IS professionals in healthcare organizations. It provides a systematic structure to help train program instructors to identify the necessary skills/knowledge for their trainees. Healthcare organizations can further develop HTM profiles that accurately account for the tailored set of knowledge and skills required for individual IS professionals in accordance with their own organization contexts. Once the profiles for the IS professionals have been identified, a well-defined program of required training responses can be identified. The resulting portfolios of HTM competency requirement can then guide the relevant training activities. Executive management can also take advantage of such HTM profiles to assist in making succession-planning decisions by evaluating the competency levels and development needs of their employees. In addition, it also provides evidence to suggest that biomedical informatics (MI) curricula, e.g., as suggested by prior literature [61–66] and the working group of the International Medical Informatics Association (IMIA) might consider HTM competency as one of their recommendations for learning outcomes on modeling biomedical and health informatics education.

In this study, we follow a rigorous procedure of research model design, instrument development, sampling, and statistical analysis. Therefore, good internal validity can be assured. However, the current study has several limitations that also represent opportunities for future research. First, the model was validated using sample data gathered in Taiwan, as a result of which interpretation of the findings should be made with caution when generalizing to other systems or countries. Other samples from different nations, cultures and technology environments should be gathered to confirm and refine the findings of this study. It is worthy to provide more insightful and interesting implications through the comparison of required healthcare technology management-related skills/knowledge (competency) and IS professionals’ attitude to IT–healthcare partnerships among advanced countries, developing countries, and underdeveloped countries with different technology levels, healthcare policies and national structures of healthcare systems.

Second, test–retest reliability should be also evaluated to examine the model’s stability because the umbrella term HTM competency is still in its infancy, and its implications are limited. Refinement of the factor structure of HTM competency and assessment of its reliability and validity are required. Third, since the proposed model variables only explained 47% of the variance in IS professionals’ proactive attitudes to develop IT–healthcare partnerships, further study is needed to explore additional significant influencing antecedents other than HTM competency. For example, maturity of healthcare technology assimilation, organizational culture, trust, and the relationships between chief medical officers and IT management may be other interesting factors underlying attitudes of healthcare informaticians to proactively develop IT–healthcare partnerships.

Acknowledgments

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Authors’ contributions: JH Wu had the idea of the study and designed it. YC Chen helped in design and had full access to all of the data in the study and takes the integrity of the data and the accuracy of the data analysis. JH Wu and YC Chen wrote
Summary points

What is already known on this subject?

- The healthcare industry has encountered dramatic changes in information and communication technology that will influence the way healthcare services are delivered and used, and the relationship between healthcare providers and consumers.
- Healthcare organizations need to learn how to create effective team relationships between the IS departments and medical units to enhance capabilities and maintain competitiveness.
- It is critical to understand what factors are most important in enabling healthcare IS professionals to develop and foster collaborations with healthcare professionals. However, little attention has been paid to investigating the healthcare technology management-related skills/knowledge required by healthcare IS professionals for this purpose, and the impact of such skills/knowledge on IT–healthcare partnerships.

What the study has added to the body of knowledge?

- The study develops a conceptual model to explore the healthcare technology management competency required by healthcare IS professionals and its impacts on IT–healthcare partnership development.
- The empirical results support the proposed structure for HTM competency encompassing the four skills/knowledge domains: healthcare organization overview, external knowledge networking, healthcare technology integration, and management and interpersonal.
- The results indicate that HTM competency significantly influences the attitudes of IS professionals towards their willingness to develop partnerships with their healthcare partners.

the first draft of the manuscript. RA Greenes helped in design and critically revised the manuscript. All authors interpreted the empirical results and read and approved the final version of the manuscript.

References
