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ABSTRACT

Background: One of the most important factors for the success of health information technology (IT) implementation is users’ acceptance and use of that technology. Thailand has implemented the national universal healthcare program and has been restructuring the country's health IT system to support it. However, there is no national data available regarding the acceptance and use of health IT in many healthcare facilities, including community health centers (CHCs). This study employed a modified Unified Theory of Acceptance and Use of Technology (UTAUT) structural model, to understand factors that influence health IT adoption in community health centers in Thailand and to validate this extant IT adoption model in a developing country health care context.

Methods: An observational research design was employed to study CHCs' IT adoption and use. A random sample of 1607 regionally stratified CHC's from a total of 9806 CHCs was selected. Data collection was conducted using a cross-sectional survey by means of self-administered questionnaire with an 82% response rate. The research model was applied using the partial least squares (PLS) path modeling.

Results: The data showed that people who worked in CHCs exhibited a high degree of IT acceptance and use. The research model analyses suggest that IT acceptance is influenced by performance expectancy, effort expectancy, social influence and voluntariness. Health IT use is predicted by previous IT experiences, intention to use the system, and facilitating conditions.

Conclusions: Health IT is pervasive and well adopted by CHCs in Thailand. The study results have implications for both health IT developmental efforts in Thailand and health informatics research. This study validated the UTAUT model in the field context of a developing country's healthcare system and demonstrated that the PLS path modeling works well in a field study and in exploratory research with a complex model.

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1. Background

More than 40% of information technology (IT) developments in various sectors including the health sector have failed or been abandoned [1–5]. One of the major factors leading to the failure is the inadequate understanding of the socio-technical aspects of IT, particularly the understanding of how people and organizations adopt information technology [6–8].

The Ministry of Public Health (MOPH) of Thailand has been restructuring the country's health information system to support the country's universal healthcare coverage scheme, which has been implemented since 2001 and is still evolving [9–12]. The goal is to have an information system that integrates health-related information from the village level in community health centers to hospitals and local administrative organizations up to the central administration at ministry [9,13]. Multiple levels of health-related information systems including community health center (CHC) information systems are being planned and developed using IT to support the universal healthcare system. Lessons learned from previous major health IT implementation projects in the country [14,15] suggest that user acceptance of technology is one of the major determinants of the project success. The knowledge of how people who work in the health sector accept and use health IT, their basic IT knowledge, and factors that influence their IT acceptance and use not only helps health information system designers but also enables more efficient implementation and evaluation processes.

We conducted a national survey to study Thailand CHC's Health IT penetration and adoption in 2005. The results show that health IT is pervasive in Thailand CHCs across the country and is prevalent in all regions. CHCs have adopted health IT, but several perceived barriers associated with IT use were evident. These results have been described elsewhere in detail [16]. This paper reports the analyses of the research model employed in the survey which aims to understand factors that influence health IT acceptance and use. Section 2 of paper is the brief review of IT acceptance and use model, and describes our research model. Sections 3 and 4 describe the methodology and the results of the model analysis. The final two sections discuss the validity of the model, its implications for health informatics research and health IT development in developing countries.

2. IT acceptance and use models

Research on IT users’ acceptance and use has been done extensively since computer and information technology have been in wide use and several models have been developed to explain users’ acceptance and use. The models originated from different theoretical disciplines such as psychology, sociology and information systems. These are the Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), the Motivation Model (MM), the Theory of Planned Behavior (TPB), the Combined TAM and TPB (c-TAM-TPB), the Model of PC Utilization (MPCU), Innovation Diffusion Theory (IDT) and Social Cognitive Theory (SCT). In 2003, Venkatesh et al. proposed a new IT acceptance and use model which aimed to unify eight prominent competing IT acceptance and use models [17]. The model is named the Unified Theory of Acceptance and Use of Technology (UTAUT). The authors contend that the new model successfully integrates all constructs in previous models and can explain variance in IT behavioral intention and use behavior better than the previous models. The UTAUT model was able to explain 69% of intention to use IT (technology acceptance) while other previous models explained approximately 40% of technology acceptance [17].

Our study adapts the UTAUT model to study factors that predict the intention to use health IT and IT use in community health centers in Thailand. The UTAUT model was developed in a western industrial developed country's (USA) business context (banking, accounting, entertainment and telecommunications services) [17]. Applying the model to a study of health IT acceptance and use in a developing country's public health context, such as Thailand, will expand the understanding of the model's robustness in explaining acceptance and use.

The basic UTAUT model (see Fig. 1) consists of several components or constructs that are hypothesized to relate to the intention to use IT. In turn intention to use IT predicts IT use. Performance expectancy (PE) is defined as the degree to which an individual believes that using health IT will help him or her to attain gains in job performance. Venkatesh et al. [17] integrated similar concept from other models, namely, perceived usefulness [18], outcome expectancy [19], relative advantage [20], job-fit [21] and extrinsic motivation [22] into this construct. In several previous acceptance studies, performance expectancy was shown to be a strong predictor of intention to use IT [17,18,23–25].

Effort expectancy (EE) is defined as the degree of ease of use associated with health IT. The concept is similar to the perceived ease of use construct in TAM and the IDT model and the complexity of technology construct in the MPCU model. Although many previous studies have shown that effort expectancy was a significant influence on intention to use behavior [18,20,21,23,26,27], some did not [28].

Social influence (SI) is defined as the degree to which an individual perceives that important others believe he or she should use health IT. The construct contains a notion that an individual’s behavior is influenced by the way in which one believes others will view him/her as a result of having used health IT. Venkatesh et al. integrated subjective norms in TRA, TAM2, and TPB, social factors in MPCU, and image in IDT to this construct [17]. The effect of social influence on intention to use technology has been shown to be significant in several previous acceptance studies [23,25,29], but some studies exhibited a non-significant effect, especially studies in professionals with high autonomy such as physicians [27,28,30]. However, the people in our study who were working in CHCs were health workers, nurses and public health specialists. They do not generally act as autonomously as physicians, so it is possible that

For a comprehensive review of information technology adoption theories and models, the interested reader is referred to Venkatesh et al. [17].
social influence has a positive influence on their intention to use IT.

Voluntariness (VO), defined as the degree to which an individual perceives that he or she has a choice to use or not use health IT, is an important concept that also influences the intention to use information technology and is included in the explanatory model. Moore’s dissertation (1989) showed that the degree of perceived voluntariness of use affects attitudes toward usage and the attitudes toward usage predicted use. The less voluntary the behavior, the less one’s attitude toward usage predicts use [29,31]. Perceived voluntariness was treated as a moderating dichotomous variable (voluntary/compulsory) in the original UTAUT model, but it was treated as a determinant variable with ordinal scale in Karahanna et al.’s technology innovation adoption study [29]. Moore and Benbasat (1991) and Agarwal and Prasad (1997) argued that in practice, users may perceive different degrees of voluntariness in using technology and suggested that it might be empirically ordinal [20,32].

The construct labeled facilitating conditions (FC) is defined as the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system. The UTAUT’s facilitating conditions construct captures the perceived behavior control concept from the TPB and c-TAM-TPB models, the facilitating conditions concept from the MPCU model and compatibility from the IDT model [17]. Previous technology adoption studies exhibited a positive effect of facilitating conditions on innovation use. [17,20,21,23,24,28,33] They found that facilitating conditions significantly predicted technology use but did not predict intention to use IT when both the performance expectancy and effort expectancy constructs are present in the model. Furthermore, we anticipate that the CHC personnel’s basic IT knowledge should have a positive influence on the perception of facilitating conditions because having adequate knowledge to use a computer is one of the operationalized items in the facilitating conditions construct. Consequently we have added a construct of IT knowledge (Knowledge) to the model as a predictor of facilitating conditions.

We also argue that Experience, defined as the past use of health IT, is an important predictor of IT use in addition to a person’s intention to use IT. Thompson and Higgins found that the direct effect of experience on PC utilization was statistically and substantially significant while the indirect effect was present but less profound [34]. The original UTAUT model treats Experience as a moderator between effort expectancy, social influence, and behavior intention, and between facilitating conditions and use behavior. In addi-
tion, the “Experience” construct in the original UTAUT model was operationalized by converting aggregating data from three consecutive time periods [17]. But, our study operationalized Experience as the length of time each respondent reported using health IT and tested only the direct effect of experience on health IT use.

Finally, the intention-behavior relationship is well documented in many research fields including the technology acceptance literature and has been found to be strong [17,24,25,35,36].

Since the inception of the UTAUT model, several works in the healthcare context have employed and modified the model to study IT adoption and IT use. The studies show that the UTAUT model and its modified model are applicable in explaining IT adoption in healthcare settings. However, all these studies were conducted in developed countries [23,27,30]. To the best of our knowledge, there is no study employing the UTAUT model that has been conducted in a developing countries healthcare context.

The latent variable components in Fig. 1 portray this study’s proposed structural model adapted from UTAUT. As shown in the figure, performance expectancy, effort expectancy, social influence and voluntariness are the determinants of intention to use IT. Following the path, IT use is predicted by intention to use, facilitating conditions, and computer experience. Facilitating conditions is predicted by basic IT knowledge that is defined as general knowledge (similar to a college entrant) related to basic personal computer (PC) components and basic functions of PC and the Internet [37]. The IT use construct is hierarchically modeled. Overall IT use is represented by three dimensions of IT use related to CHC’s activities and one dimension of use frequency. Health IT in this study is defined as the information and communication technology that is used for health information systems.

3. Methods

A cross-sectional national survey was conducted in Thailand during July–October 2005. We randomly sampled population weighted provinces. This resulted in the selection of twelve provinces with 1607 CHCs: three from the north with 337 CHCs, four from the central with 376 CHCs, three from the northeast with 708 CHCs, and two from the south with 146 CHCs. At each CHC, we asked an officer who was responsible for the CHC’s information management or the CHC’s administrative officer (the CHC’s head officer) to complete the survey. Research collaborators at the provincial health office in each province distributed the self-administered paper-based survey. Respondents could return the questionnaire either through the provincial collaborators or by mailing the questionnaires direct to the research team at Center for Health Equity Monitoring (CHEM), Naresuan University. The questionnaires collected by the provincial research collaborators were also sent directly to CHEM. Each questionnaire included a pre-paid return envelope. Two to four weeks after questionnaire distribution, the provincial research collaborators reminded the CHCs to complete the questionnaire by phone and/or by an in-person reminder at the monthly meeting of the provincial health office’s director and CHCs’ head officers. The details of this survey process and the survey instrument have already been reported elsewhere [16].

The survey contained a number of questions that were designed to capture information about the constructs in the research model. These are labeled as manifest variables in Fig. 1 and form the outer ring of that model. The questions that measured performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC) and voluntariness (VO), including intention to use IT (IN) construct were adapted from Venkatesh et al. [17]. IT use associated with activities in CHCs, drawn from our previous study [37], was measured with ten questions using a four-point scale ranging from one (never use) and four (always use). These ten items included four for “use for providing care and routine reporting” (Care and Report Use), three for “use for management and administration” (Administration Use) and another three for “use for information searching and collaboration with colleagues” (Communication Use). Table 1 contains a description of each of the items and the constructs that they are intended to measure. All items were minimally modified and translated into Thai language so as to be clearly understood by Thai health center personnel. As previously reported, the study was approved by the University of Minnesota Institutional Review Board and the Ethical Review Committee for Research in Human Subjects, the Ministry of Public Health Thailand. The survey was piloted tested for its understandability in Thai prior to its distribution.

SPSS V15.0 statistics package was used to obtain descriptive statistics for the manifest variables. Partial least square path modeling (PLS-SmartPLS V 2.0 M3) [38,39] was applied to evaluate the predictive research model.

PLS path modeling is one of the statistical methods for structural equation modeling (SEM), a modeling procedure that performs path-analytics modeling with latent variables (unobservable variables). SEM has been used to model the complex relationship of multiple endogenous (independent) and exogenous (dependent) variables. It is considered a second-generation of multivariate analysis and is originated to overcome limitations of those first generation ones including standard regression-based analyses, such as multiple regression, discriminant analysis, logistic regression, and analysis of variance [40–42]. SEM is capable of simultaneously assessing the reliability and validity of the measures of theoretical constructs and estimating the relationships among these constructs [43]. There are two approaches to SEM analysis. The first approach is covariance-based analysis which typically uses maximum likelihood (ML) and was popularized by LISREL, AMOS and EQS statistics software. The second approach is variance-based analysis, or component-based analysis, which uses least square (LS) functions and is called partial least squares path modeling.

PLS path modeling is sometimes known as “soft modeling” [43–45] whereas ML is a covariance-based SEM approach, known as “hard modeling.” This is because ML “aims at optimality in statistical inference, and is designed for testing hypotheses that are sharp and pure; accordingly, ML is sensitive to the inaccuracies of real-world models and impurities of real data. PLS is distribution-free (employing nonparametric statistics), and aims only at (predictive) consistency, and is therefore insensitive to impurities in the model and the data”
Table 1 – Mean scores and standard deviations of each item in the questionnaire related to the research model constructs (N = 1323).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>SD</th>
<th>Construct (LV) definition/Item (MV) in questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Expectancy (PE)&lt;sup&gt;a&lt;/sup&gt; = the degree to which an individual believes that using the system will help him or her to attain gains in job performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE1</td>
<td>6.28</td>
<td>1.30</td>
<td>I would find the computer system useful in my job.</td>
</tr>
<tr>
<td>PE2</td>
<td>6.34</td>
<td>1.23</td>
<td>Using the computer system enables me to accomplish tasks more quickly.</td>
</tr>
<tr>
<td>PE3</td>
<td>6.17</td>
<td>1.27</td>
<td>Using the computer system increases my productivity.</td>
</tr>
<tr>
<td>PE4</td>
<td>5.73</td>
<td>1.43</td>
<td>If I use the computer system, I will increase my chances of getting a raise.</td>
</tr>
<tr>
<td>Effort Expectancy (EE)&lt;sup&gt;a&lt;/sup&gt; = the degree of ease associate with use of system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE1</td>
<td>5.66</td>
<td>1.31</td>
<td>My interaction with the computer system would be clear and understandable.</td>
</tr>
<tr>
<td>EE2</td>
<td>5.68</td>
<td>1.29</td>
<td>It would be easy for me to become skillful at using the computer system.</td>
</tr>
<tr>
<td>EE3</td>
<td>5.68</td>
<td>1.29</td>
<td>I would find the computer system easy to use.</td>
</tr>
<tr>
<td>EE4</td>
<td>5.22</td>
<td>1.40</td>
<td>Learning to operate the computer system is easy for me.</td>
</tr>
<tr>
<td>Social Influence (SI)&lt;sup&gt;a&lt;/sup&gt; = the degree to which an individual perceives that important others believe he or she should use the system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI1</td>
<td>5.47</td>
<td>1.46</td>
<td>People who influence my behavior think that I should use the computer system.</td>
</tr>
<tr>
<td>SI2</td>
<td>5.51</td>
<td>1.42</td>
<td>People who are important to me think that I should use the computer system.</td>
</tr>
<tr>
<td>SI3</td>
<td>5.30</td>
<td>1.63</td>
<td>The senior health administration has been helpful in the use of the computer system.</td>
</tr>
<tr>
<td>SI4</td>
<td>5.71</td>
<td>1.46</td>
<td>In general, provincial health office has supported the use of the computer system.</td>
</tr>
<tr>
<td>Voluntariness (VO)&lt;sup&gt;a&lt;/sup&gt; = the degree to which use of IT is perceived as voluntary or free will</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO1</td>
<td>4.80</td>
<td>1.72</td>
<td>My boss does not require me to use computer.</td>
</tr>
<tr>
<td>VO2</td>
<td>4.91</td>
<td>1.75</td>
<td>Although it might be helpful, using a computer system is certainly not compulsory in my job.</td>
</tr>
<tr>
<td>Intention to Use (IN)&lt;sup&gt;a&lt;/sup&gt; = the degree to which an individual intends to use IT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN1</td>
<td>6.17</td>
<td>1.11</td>
<td>I intend to use the computer system in the next 2 months.</td>
</tr>
<tr>
<td>IN2</td>
<td>6.17</td>
<td>1.10</td>
<td>I predict I would use the computer system in the next 2 months.</td>
</tr>
<tr>
<td>IN3</td>
<td>6.13</td>
<td>1.16</td>
<td>I plan to use the computer system in the next 2 months.</td>
</tr>
<tr>
<td>Facilitating Conditions (FC)&lt;sup&gt;a&lt;/sup&gt; = the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC1</td>
<td>5.60</td>
<td>1.45</td>
<td>I have the resource necessary to use the computer system.</td>
</tr>
<tr>
<td>FC2</td>
<td>5.26</td>
<td>1.27</td>
<td>I have knowledge necessary to use the computer system.</td>
</tr>
<tr>
<td>FC3</td>
<td>5.73</td>
<td>1.22</td>
<td>The computer system is compatible with other systems I use.</td>
</tr>
<tr>
<td>FC4</td>
<td>5.13</td>
<td>1.56</td>
<td>Health IT persons in province are available for assistance with system difficulty.</td>
</tr>
<tr>
<td>FC5</td>
<td>5.65</td>
<td>1.23</td>
<td>I think that using computer system fits well with the way I like to work.</td>
</tr>
<tr>
<td>FC6</td>
<td>5.21</td>
<td>1.37</td>
<td>I have knowledge sources (e.g. books, documents, consultants) help me learn about computer system.</td>
</tr>
<tr>
<td>Experience&lt;sup&gt;b&lt;/sup&gt; = IT experience</td>
<td>6.69</td>
<td>0.94</td>
<td>How long ago did you first start to use a computer?</td>
</tr>
<tr>
<td>Knowledge</td>
<td>13.20</td>
<td>4.50</td>
<td>There are 20 test statements. The highest score is 20, the lowest score is 0.</td>
</tr>
<tr>
<td>Care and Report Use&lt;sup&gt;c&lt;/sup&gt; = use for providing care and routine reporting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C&amp;R Use1</td>
<td>3.35</td>
<td>0.88</td>
<td>Recording people (individual and family) information in catchments area.</td>
</tr>
<tr>
<td>C&amp;R Use2</td>
<td>3.49</td>
<td>0.87</td>
<td>Recording patients (clients) information.</td>
</tr>
<tr>
<td>C&amp;R Use3</td>
<td>3.24</td>
<td>0.91</td>
<td>Retrieving previously recorded individual information for providing care.</td>
</tr>
<tr>
<td>C&amp;R Use4</td>
<td>3.51</td>
<td>0.77</td>
<td>Generating mandatory reports.</td>
</tr>
<tr>
<td>Administration Use&lt;sup&gt;c&lt;/sup&gt; = use for management and administration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adm Use1</td>
<td>3.53</td>
<td>0.76</td>
<td>Writing (e.g. official letters, reports, etc.).</td>
</tr>
<tr>
<td>Adm Use2</td>
<td>2.89</td>
<td>1.07</td>
<td>Preparing presentation slides or overheads.</td>
</tr>
<tr>
<td>Adm Use3</td>
<td>2.48</td>
<td>0.05</td>
<td>Performing statistical analysis.</td>
</tr>
</tbody>
</table>
Table 1 – (Continued)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>SD</th>
<th>Construct (LV) definition/Item (MV) in questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comm_USE1</td>
<td>1.76</td>
<td>1.01</td>
<td>Use for information search and collaboration with colleagues.</td>
</tr>
<tr>
<td>Comm_USE2</td>
<td>2.28</td>
<td>1.02</td>
<td>Searching for information associating with office tasks (e.g. governmental documents, products prices).</td>
</tr>
<tr>
<td>Comm_USE3</td>
<td>2.24</td>
<td>1.06</td>
<td>Searching for information for personal interest such as knowledge associating with personal continuing education and general knowledge.</td>
</tr>
</tbody>
</table>

Use Frequency^d = frequency of IT use
Use Freq 5.42 1.00 How often do you use computer system hand on?

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[a] Seven-point scale: 1 = strongly disagree, 2 = quite disagree, 3 = slightly disagree, 4 = neither agree nor disagree, 5 = slightly agree, 6 = quite agree and 7 = strongly agree.
[b] Eight-point scale: 1 = never use, 2 = experience <1 month, 3 = experience 1–6 months, 4 = experience 7–12 months, 5 = experience >1–2 year, 6 = experience >2–5 years, 7 = experience >5–10 years and 8 = experience >10 years.
[c] Four-point scale: 1 = never use, 2 = sometimes use, 3 = frequent use and 4 = always use.
[d] Six-point scale: 1 = don not use at all, 2 = use < once a week, 3 = use about once each week, 4 = use several times each week, 5 = use about once a day and 6 = use several times each day.

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4. Results

4.1. Respondent characteristics

The survey response rate was 82% with 1323 out of 1607 CHCs responding. Of the 1323 respondents, male and female were represented in essentially equal proportions (54% and 46%) and average age was 36 years old (SD = 7, range 17–59). Three quarters (74%) of the respondents had a bachelor degree and one-third (32%) held the position of a public health administration officer. On the whole, respondents were not new employees but rather had worked in centers for several years, and had worked their way up through the position classification system. They spent approximately 40% of their work hours providing health services and almost equal proportion of work hours in data management and report production. The detailed results of the rest of the survey have been described elsewhere [16]. For the manifest variables in the research model, Table 1 provides the item descriptions and descriptive statistics of the measured items from the survey.

Examination of all 1323 responses revealed that ten percent (136) were inconsistent cases. They abnormally shifted the predicting effects of other variables [50]. These responses were from subjects who declared very low intention but reported a high degree of IT use, which conflicted with the Theory of Reasoned Action (TRA) where intention has a positive effect on behavior. Comparisons of the characteristics of inconsistent cases with the rest of the respondents showed no differences in terms of respondents’ demographic information, CHCs’ characteristics, IT resources or among the other model variables. Because we could not distinguish the two groups with using any other characteristics, we concluded that they were outliers who did not conform to the basic assumptions of the model. Therefore we excluded them from the analysis and reported the results for the remaining respondents (1187).

4.2. Measurement model evaluation

The reliability of construct measurement was evaluated by examining the composite reliability and internal consistency reliability (Cronbach’s alpha) as determined by PLS for each construct (see Table 2). All constructs exhibited composite reliability and Cronbach’s alpha greater than the acceptable level of 0.70 indicating that the measurement errors were relatively small [51,52]. Convergent validity of a set of items with respect to their associated construct is assessed by examining the factor loadings of the items on the model’s constructs.
A high loading of the item on its underlying construct and lower loadings on unrelated constructs indicates convergent validity. Barclay et al. suggested that a heuristic criteria for convergent validity is to accept items with loadings of 0.70 or more [43]. However, Falk and Miller argued that the factor loading might be acceptable at the value of 0.55 [44]. As shown in Table 3, factor loadings of all items on their respective associated constructs are equal or greater than 0.70 while their loadings on unrelated constructs are lower. For the second order construct of IT Use, factor loadings of individual first order constructs on the second order construct met the same criteria with the exception of Frequency on Use which was 0.44 which was slightly less than 0.55. Overall, the results demonstrated reasonable convergent validity of the measurement model with respect to the model’s constructs.

Discriminant validity indicates the extent to which a given construct is different from other constructs. In PLS modeling analysis adequate discriminant validity is demonstrated when a construct shares more variance with its measures (indicators) than with other constructs in the model. A measure of variance shared between a construct and its measures is the Average Variance Extract (AVE) that should be greater than the variance shared between the construct and others constructs in the model [51]. Table 2 also displays the correlation matrix for the constructs. The diagonal of the matrix contains the square roots of the AVEs which provide a metric comparable to a correlation (the square root of the variance shared between two variables). For adequate discriminant validity, the diagonal elements should be greater than the off-diagonal elements in the corresponding rows and columns. It should be noted that in the case of IT Knowledge, Use Frequency, and Experience the diagonal value is 1.0 indicating that there was only one measurement item associated with each of these constructs. The results demonstrated adequate discriminant validity for all constructs in our research model.

### 4.3. Structural model evaluation

Structural model evaluation is the assessment of the predictive or causal relationship between constructs in the model. Fig. 2 exhibits the structural model and the analytical results. It portrays the path coefficients ($\beta$), the explained variance ($R^2$) and the effect size ($f^2$) for each path segment in the model. All path coefficients are significant and in the direction proposed.

The constructs of performance expectancy (PE), effort expectancy (EE), Voluntariness (VO) and social influence (SI) were predictive of Intention to Use (IN) with an R-square of 0.54. IN, facilitating conditions (FC) and Experience (Exp) accounted for a smaller R-square ($0.27$) in predicting IT Use (Use). The ability of IT Knowledge (Knowledge) to predict FC ($R$-square $= 0.02$) was low, even though the path coefficient of Knowledge on FC was statistically significant. Nonetheless, the predicting constructs in the model each accounted for more than 1.5% of the variance in a predicted construct. The R-squares of all predicted constructs in our model were greater than 0.10 except the R-square for FC. The results indicate that our structural model is adequate in that it has met Falk and Miller’s criteria for level of variance explained ($R^2$ $\geq 0.10$ and predictor variable explaining $\geq 1.5\%$ of variance) [44].

Examining the individual effect sizes of predictors ($f^2$) provides further information about the unique and separate contributions of each of the constructs. According to Chin, $f^2$ of 0.02, 0.15 and 0.35 can be viewed as a gauge for whether a predicting construct has a small, medium, or large effect at the structural level [40]. With respect to IN, PE had the largest effect size (0.19) classified as “medium” according to the categories proposed by Chin. EE, SI, and VO all had less of an effect with sizes in the “small” category. This indicates that the majority of the variance was accounted for by the combined effect of these four constructs rather than their separate, independent contributions.
In community health centers in Thailand by applying an extant theoretical model. As a result, the focus of the study was the prediction of two theoretical constructs—the intention to use IT and IT use employing an adaptation of the UTAUT model. The results showed that intention to use health IT is a function of the perception that health IT is useful (performance expectancy), that it exhibits ease of use (effort expectancy), that important others believed that he/she should use health IT (social influence) and the perception that one has a choice in the use of IT (voluntariness). The predictive power of these four factors was substantial and accounted for more than half of the variance in the intention to use IT. Among these four influencing factors, performance expectancy was by far the strongest predicting factor. Our results are consistent with a number of prior studies where performance expectancy has more of an influence than effort expectancy and social influence. The influence of voluntariness on the intention to use is also similar to previous findings that the perception of freedom of choice has positive effect on intention to use.

5. Discussion

This study sought to identify factors that predict the survey respondents’ intention to use and their use of health IT in community health centers in Thailand by applying an extant theoretical model. As a result, the focus of the study was the prediction of two theoretical constructs—the intention to use IT and IT use employing an adaptation of the UTAUT model. The results showed that intention to use health IT is a function of the perception that health IT is useful (performance expectancy), that it exhibits ease of use (effort expectancy), that important others believed that he/she should use health IT (social influence) and the perception that one has a choice in the use of IT (voluntariness). The predictive power of these four factors was substantial and accounted for more than half of the variance in the intention to use IT. Among these four influencing factors, performance expectancy was by far the strongest predicting factor. Our results are consistent with a number of prior studies where performance expectancy has more of an influence than effort expectancy and social influence. The influence of voluntariness on the intention to use is also similar to previous findings that the perception of freedom of choice has positive effect on intention to use.
Model analysis also revealed that for Thai CHCs health IT use, the construct of our ultimate interest, was predicted by previous IT experiences (Experience), intention to use IT (IN) and the perception that organizational and technical support for the use of health IT exists (FC—facilitating conditions). Twenty seven percent of the variance in IT use was explained by these three factors. Recognizing that there are a variety of other factors not include in the study that can influence IT use, the result provides us a better understanding of the factors influencing IT use in the context of this study. The positive effects of facilitating conditions, experience and intention to use are similar to findings from previous IT adoption research. In this study, previous IT experience appeared to have stronger effect on IT use than did facilitating conditions and intention to use. The smaller than expected effect of intention to use may be attributable to the nature of our study methods and population. The Use Frequency question in the survey revealed that the respondents were already frequent users of health IT. According to Triandis (1980), frequently perform behaviors are likely to come under the control of habits, and the impact of intentions on behavior is thereby reduced[53,54]. The theory of plan behavior (TPB) suggests that intention to perform behavior predicts future behavior. This study may not be able to demonstrate the full effect of the intention to use on use behavior because it was a “snap-shot” observation which captured attitudes reflecting intention to use IT and reports of use behavior simultaneously.

The positive relationship between IT knowledge and the facilitating conditions supported the validity of the facilitating conditions construct since one of the manifest variables that reflected the FC construct was “I have knowledge necessary to use the computer system”. The positive relationship indicates that a higher IT knowledge score is reflected in the perception of having necessary IT knowledge. The perception of possessing knowledge is an aspect of the perception of “self-behavior control”. The UTAUT model integrates the concept of self-behavior control into its facilitating condition construct. Therefore, the observed positive relationship provides supporting evidence for the validity of the facilitating condition construct.

The study provides further evidence for the basic validity of the UTAUT model in that it confirmed the relationships among the variables in the model proposed by Venkatesh. The relationships between performance expectancy, effort expectancy, social influence and intention to use IT were confirmed as existing and in the same direction as the UTAUT model proposes. Furthermore there was a positive though weak relationship between Intention to Use and reported IT Use. All this provides evidence that the UTAUT model is applicable in health care settings and in other cultures as represented in this study.

In addition, this study demonstrated the direct effects of effort expectancy, social influence, facilitating condition which are the core constructs of the UTAUT model whereas the original UTAUT model demonstrated these three main constructs effect through the three or four way interaction terms with age, gender, experience and voluntariness. Although our model does not explain IT use to the same extent as the original UTAUT model, our expanded UTAUT model provides a better understanding of the technology adoption in a developing country’s healthcare system. Moreover, our research model has demonstrated the adequate construct validity and
reliability of a measurement model related to the core constructs of the UTAUT model. Rather than measuring IT use in one dimension as was done in previous studies, we expanded the measure to represent three dimensions of use associated with activities and one dimension of use frequency. Modeling IT use in this multi-dimensional way may provide a more comprehensive measure of IT use than previous studies.

Moreover, the study applied the partial least squares path modeling method which is not commonly used in the health/biomedical informatics research studies but which has significant advantages in terms of dealing with complex models and studies with many variables. This study demonstrated that the method works well in a field study and in exploratory research. Based on the fact that PLS works with a complex model, small sample sizes and violations of the normal distribution assumption it could be a powerful tool for many health/biomedical informatics researchers who deal with complex path models, particularly in studying socio-technical aspects of IT.

Knowledge acquired from this study can potentially benefit individuals who currently work with health information systems and health IT implementation in developing country like Thailand. The strong influence of performance expectancy and effort expectancy on the adoption of health IT suggests that work-related benefits of implemented systems must be perceivable, identifiable and substantial, and they should be viewed as relatively easy to use. An awareness of these effects on the system adoption can help develop and accelerate the process of the implementation. Adequate facilitating conditions (continuous training and technical support to users) also play an important role in technology use. Social influence and perception of voluntariness do affect technology adoption. Therefore it is important to identify individuals with strong personal influence (formal and informal) and work with them to become advocates for technology use in order to facilitate the implementation process. Fostering an environment, both from a top down and bottom up perspective, where use of technology is desirable, and that maintains the perception that use is a choice, could do much to facilitate the implementation process.

There are several potential limitations of this study. We assumed that one respondent in a given CHC represented all people who worked in the CHC. If the received response was not representative then the generalizability of our findings would be limited. Nevertheless, given the CHC working context, the potential selection bias was minimized by a reasonably representation of people who work in CHCs: 28% of respondents were health workers, 12% nurses, 26% public health specialists (the higher career for health worker and nurse working in CHCs) and 31% public health administrator (the highest career in CHCs). Regarding the CHC’s working context, a CHC is a sub-district (or “Tambon” in Thai) health service unit. It is a first-line unit, covering a population of 1000–5000, with 3–5 health staff typically a health worker, a midwife and a technical nurse, without full-time doctors. Because of the small office, the main job of every employee is providing healthcare services including information management tasks (data input is embedded in the primary healthcare service tasks). These individuals are highly aware of all situations in their work place and thus the survey results should be reasonable reflective of all CHC personnel.

Another potential limitation related to the representativeness of CHC responses and is related to the sampling method used. Because of limited budget, the need to depend on provincial officials to distribute our surveys to the CHCs and the lack of any existing master list of CHCs with contact information we were unable to use simple random sampling. Rather, we chose to use a cluster sampling approach [55]. We performed a first level cluster sampling via random sampling of provinces in each region. This was followed by random sampling of CHC’s within a region. In terms of representativeness, the number of sampled provinces and CHCs were proportionate to the distribution of population and CHCs in each region. Furthermore, the response rates in all provinces were high and similar. Given all these circumstance, we maintain that the results were not compromised by this sampling strategy.

A third potential limitation was due to the cross-sectional nature of the survey design where causal relationships between model factors due to time precedence could not be claimed. Similar follow up studies in the same cohort could shed the light on the causal relationships. The cross-sectional design introduced a limitation on interpreting the relationship between the measures of intention to use and IT use. Since they were measured at the same time the antecedent relationship of intention to the use behavior was not captured. Therefore the causal link between intention to use IT and IT use is less logically obvious.

A fourth potential limitation has to do with the decision to exclude the inconsistent cases who reported a low Intention to Use and a high Usage rate. These persons did not conform to one of the basic model assumptions that there is a positive relationship between these two constructs. By excluding this group of respondents, the generality of the findings is limited to persons who exhibit a non-inverse relationship which is the vast majority of the responding group. Since we were not able to differentiate this group on any other characteristics or responses we do not know if they represent an important subgroup requiring further study or simply a group that misunderstood the Usage rating scale. In any event, the results of the study do represent 90% of the original respondents.

The fifth potential limitation of the study is associated with the relationship between past experience and IT use. Previous IT experience was modeled to influence IT use in the study, but it may well be a bidirectional relationship. For example, people who frequently use IT may report a high degree of experience and vice versa. This possible bidirectional relationship affects the interpretation of the influence of IT experience on IT use. Nevertheless, at least, the positive correlation between past experience and IT use can be claimed.

Finally the results of this study can only apply to health IT in general, because the focus of the study is not a specific technology artifact. Therefore, results may vary in adoption of a specific technology (e.g. applications, services, machines) because of the differences in characteristics of those artifacts. As a result, adoption studies of specific technology artifacts are still needed but should be guided by the overall results of this study.

Our study can be characterized as one of the studies in the IT adoption research stream that focuses on individual adop-
Summary points

What was known before the study?

- At the national level, there are no studies about health providers' IT acceptance and use and its predicting factors in Thailand.
- The UTAUT model had been employed to study user's IT acceptance and use in many developed countries and many industries including health industry, but there are a few studies employing the UTAUT model to study IT acceptance and use in healthcare system in developing countries.

What the study has added to the body of knowledge?

- Community health centers' personnel in Thailand demonstrated high level of health IT acceptance and use. Their intention to use health IT was the function of performance expectancy, effort expectancy, social influence and voluntariness. CHCs' health IT use was influenced by past IT experience, facilitating conditions and intention to use IT.
- The study confirms the validity of the UTAUT model in the field context of a developing country's healthcare.

6. Conclusions

This study applied the modified UTAUT model to understanding factors that influence health IT acceptance and use in Thailand community health centers. The results show that Intention to use health IT is a function of various concepts including the perception that (1) health IT is useful, (2) it is not too difficult to use, (3) important persons/others believed that he/she should use health IT and (4) the perception of free will to use IT influence the intention to use. Among these factors, performance expectancy exerted the strongest effect. CHCs' IT use was influenced by (1) past IT experience, (2) the personnel's intention to use the system, and (3) the belief that an organization and technical support exists to support the use of health IT. Past IT experience and facilitating conditions were prominent in predicting IT use. This study confirms the validity of the UTAUT model in the field context of a developing country's healthcare system. The study has implications for the development of health IT in developing country and health/biomedical informatics research. Knowledge gained from the study is beneficial to both health IT policy makers and people who work with health IT development and implementation projects.

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