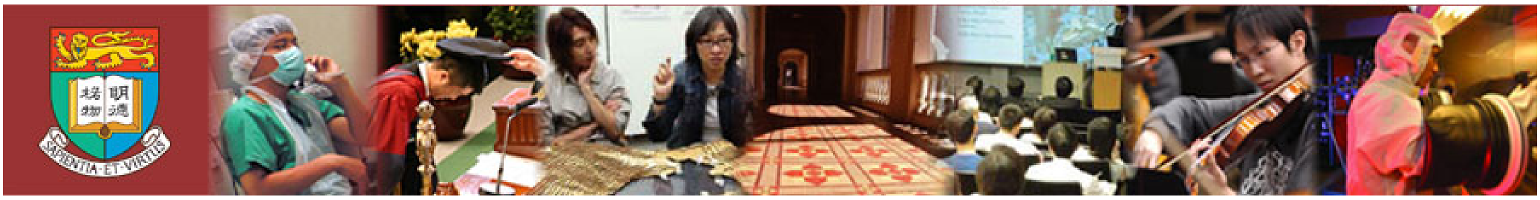

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Author(s)	Hu, PJH; Chau, PYK; Liu Sheng, OR
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Adoption of Telemedicine Technology by Health Care Organizations: An Exploratory Study

Paul Jen-Hwa Hu
Accounting and Information Systems
David Eccles School of Business
University of Utah

Patrick Y. K. Chau
School of Business
Faculty of Business and Economics
University of Hong Kong

Olivia R. Liu Sheng
Department of Management Information Systems
College of Business and Public Administration
University of Arizona

Recent advances in information and biomedicine technology have significantly increased the technical feasibility, clinical viability, and economic affordability of telemedicine-enabled service collaboration and delivery. Health care organizations around the world have become increasingly interested in acquiring and implementing telemedicine technology to improve or extend existing patient care and services. The ultimate success of telemedicine in an adopting organization requires adequate attention to both technological and managerial issues. This study examined organizational technology adoption, an essential management issue facing many health care organizations interested in or currently evaluating telemedicine. On the basis of a framework proposed by Tornatzky and Fleischer [1], we developed a research model for targeted technology adoption and empirically evaluated it in a survey study that involved most of the public health care organizations in Hong Kong. Results from our exploratory study suggest that the model exhibits reasonable significance and explanatory utility to differentiate between adopting and nonadopting organizations. Specifically, the collective attitude of medical staff and perceived service risks were found to be significant determinants of targeted technology adoption. Several research and management implications that emerged from our study findings are also discussed.

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Correspondence and requests for reprints should be sent to Patrick Y. K. Chau, School of Business, Faculty of Business and Economics, University of Hong Kong, Pokfulam, Hong Kong. E-mail: pchau@business.hku.hk

organizational technology adoption, telemedicine,
information technology in health care

1. INTRODUCTION

In essence, telemedicine is about use of information and biomedicine technology to support, facilitate, or improve health care service delivery and collaboration among geographically dispersed parties, including general practitioners, specialists, and patients [2, 3]. Having become increasingly aware of telemedicine and knowledgeable about its potential applications, many health care organizations have adopted or exhibited considerable interest in adopting the enabling technology to support member physicians' practices or to extend existing services. As a result, a fast growing number of telemedicine programs have been established around the world [4].

The ultimate success of telemedicine as a viable alternative service delivery or collaboration mode requires that adopting organizations address challenges pertaining to both technology and management [5]. Among these, organizational technology adoption is critical and usually has profound implications for subsequent technology utilization and the resultant service level and organizational competitiveness. At the organizational level, the process for adopting telemedicine technology can be conceptually delineated into several distinct phases, ranging from individuals' informal technology assessments to actual technology acquisition and implementation. In many cases, the described process, although perhaps not proceeding in a highly linear manner (e.g., there will likely be concurrency and overlapping) [6–8], follows a logical or temporal sequence. In light of this multiphase process, organizational adoption of telemedicine technology should not and cannot proceed in an unplanned manner. Rather, an organization needs to take into consideration relevant contexts and adequately manage important issues when advancing probable technology adoption through these phases so as to lead to a carefully thought out and sound decision.

This exploratory study investigated important factors that differentiate adopting and nonadopting organizations of telemedicine technology, a fundamental technology management issue that has not yet received due attention in prior telemedicine research [5]. The subject of technology adoption in other contexts has been examined extensively by information systems (IS) researchers and practitioners. Linking relevant theories available in the IS literature with an investigation of telemedicine technology adoption by health care organizations allows us to address important organizational management issues in telemedicine and, at the same time, to extend the applicability or empirical validity of the referenced IS theories. Investigations of telemedicine technology adoption by health care organizations will benefit particularly from relevant IS literature in several areas that include conceptualization and framework development.

On the basis of the framework discussed by Tornatzky and Fleischer [1], we developed a research model for explaining or predicting health care organizations' adoption of telemedicine technology. According to the framework, the adoption decision of an organization can be jointly determined by important factors pertinent to three fundamental contexts: environmental, organizational, and technological. This framework conceptually depicts technology adoption at the organizational level, establishing a foundation on which specific factors can be identified within the respective contexts. Anchoring in the described framework, we then proceeded with identification of important adoption factors, which jointly led to the development of our research model. We empirically evaluated the research model using a survey study that involved most of the public health care organizations in Hong Kong. Results from the study suggest that the research model exhibits reasonable and statistically significant explanatory utility, as measured by classification accuracy.

The remainder of the article is organized as follows. In Section 2, we review previous research on both telemedicine and technology adoption to provide the background to our motivation. In Section 3, we describe our research framework and the proposed research model, together with the specific hypotheses to be tested by the study. In Section 4, we detail our research approach, design, and data-collection method. Discussion of data analysis results follows in Section 5. In Section 6, we highlight the important research findings and discuss their implications for telemedicine research and technology management. We conclude the article in Section 7 with a summary of the work, along with a discussion of its contributions and limitations and suggestions for some future research directions.

2. LITERATURE REVIEW AND RESEARCH MOTIVATION

Broadly, *technology adoption* can be understood as an organization's decision to acquire a technology and make it available to its members for supporting or enhancing their task performance [9]. Although ultimate technology adoption decisions are dichotomous, the process leading to a decision may consist of a series of distinct phases that commonly follow a logical sequence with probable overlapping. We focused on telemedicine technology because it is an important and exciting technological innovation that has potential for bringing about a paradigmatic shift in health care service delivery and collaboration.

The concept of telemedicine emerged approximately four decades ago, when forward-looking health care professionals teamed up with technologists to experiment with use of telecommunications technology to support remote patient care or service collaboration [10, 11]. Propelled by long-standing problems in contemporary health care systems in such areas as service accessibility, quality, and costs, recent advancements in information and biomedicine technology have impelled a strong resurgence of interest in telemedicine around the globe [2]. Most prior telemedicine research, however, concentrated on technology developments and their clinical applications [5]. Although a handful of studies have examined issues related to technology adoption [12–15], many of them have been limited in scope (e.g., medical special areas) or scale (e.g., sample size). Also, most of them have either focused on technology adoption (or acceptance) at the individual level [16] or tested hypotheses formulated without an adequate theoretical foundation [17], thus providing limited discussion of telemedicine technology adoption by health care organizations. A recent case study by Liu Sheng et al. [18] reported that not all adoptions of telemedicine technology had proceeded with due consideration of important decision factors. As discussed by Weick [19], an innovation process that takes place in an organizational setting may not be rational. Different barriers to the adoption and use of telemedicine technology have also been examined [20, 21]. In turn, these barriers and others represent essential factors or issues for organizational adoption of telemedicine technology.

Technology adoption in other contexts has received extensive attention by IS researchers and practitioners [22, 23]. Many previous studies have built their theoretical premises around Rogers's innovation diffusion theory [9], which essentially states that an observed adoption is largely prompted and determined by key innovation attributes communicated to potential adopters. This theory has a predominant technological emphasis and, for the most part, has been used to explain or predict technology adoption by individuals. Its applicability or utility in situations where technology adoptions take place in organizational settings is, therefore, questionable [24]. Brancheau and Wetherbe [25] commented that Rogers's innovation diffusion theory does not provide a complete explanation for technology adoption or implementation in organizations. Fichman [26] reviewed previous information technology innovation studies and concluded that classical innovation attributes alone are not likely to be strong predictors of organizational technology adoptions. Additional factors need to be identified and considered. Prior empirical studies based on Rogers's theory have generated inconsistent findings that might have been in part attributable to failures to differentiate individual from organizational adoption and to neglect other essential adoption issues beyond the technology. As summarized by Zmud [27], much prior research failed to recognize that innovation attributes can be perceived significantly differently according to the organizational context involved.

A review of relevant prior research suggests that technological context, although important, may not sufficiently explain or predict technology adoption at the organizational level. Several additional contexts have been identified. For example, Bretschneider [28] compared the implementation of management IS in public and private organizations, emphasizing the importance of the organizational context. Cooper and Zmud [29] investigated information technology implementation in organizations and concluded that both organizational and task considerations were essential. Kimberly and Evanisko [30] examined innovation adoption in health care settings, singling out the importance of individual, organizational, and contextual variables. Furthermore, Tornatzky and Fleischer [1] examined the innovation adoption processes in various organizations and proposed a fairly comprehensive framework that essentially suggests that a technology adoption decision of an organization can be jointly explained by the organizational, technological, and environmental contexts.

In response to the growing importance of telemedicine and the surprisingly limited discussion about its key management issues in prior research, we investigated the organizational adoption of telemedicine technology using a research model adapted from the framework of Tornatzky and Fleischer [1]. The model was then empirically evaluated with a survey study that involved most of the public health care organizations in Hong Kong. The choice of the research framework was based on the following reasons. First, this framework is fairly comprehensive, largely consistent with and supported by results or conclusions of most previous research, including Brancheau and Wetherbe [25], Fichman [26], Zmud [27], Bretschneider

[28], Cooper and Zmud [29], and Kimberly and Evanisko [30]. In the context of telemedicine, this framework encompasses the fundamental knowledge barriers to telemedicine diffusion discussed by Tanriverdi and Iacono [20]. Specifically, the framework appears to include most of the important technology adoption factors identified in a previous case study on telemedicine technology adoption by health care organizations [18]. The particular contexts included in the framework are also congruent with the fundamental technology adoption dimensions commonly identified by the physicians previously interviewed. Detailed descriptions of the research model and hypotheses follow.

3. RESEARCH MODEL AND HYPOTHESES

According to Tornatzky and Fleischer [1], technology adoption that takes place in an organization is jointly influenced by important factors pertaining to the technological context, the organizational context, and the external environment. Essentially, the technological context concerns the technology under discussion and can be characterized by its important attributes, particularly as perceived by users. The consequence anticipated from the intended technology use, as perceived by target users, is another essential locus of the technological context. Together, perceived technology attributes and perceived results from the anticipated technology use largely describe the technological context.

We used organizational readiness to characterize the organizational context discussed by Tornatzky and Fleischer [1]. *Organizational readiness* refers to the availability of the internal conditions necessary for an organization to adopt a technology [31]. An organization usually has considerable influence on or control over its internal conditions with respect to the adoption of a technology. Cultivation and development of the necessary organizational readiness may require considerable time or resources and are often subject to various existing constraints, internal and external.

The external environment, the other context encompassed in the framework, defines the external world in which an organization operates. In most cases, an organization has limited influence or control over its external environment. Thus, the organization needs to take the external context as it is and to strive for a desired fit with the context and rapid adaptability to its changes.

The described framework provided a foundation on which important factors that would potentially differentiate adopting and nonadopting organizations were identified for the respective contexts. Moreover, the effects and significance of each identified factor were also evaluated. Figure 1 depicts our research model.

As shown, the technological context includes perceived technology attributes and perceived results from anticipated technology use. Specifically, perceived ease of use [32] and perceived technology safety are important technology attributes. As a group, physicians might not be particularly known for technology competence or rapid adoption of information technologies. In their investigation of technical barriers to telemedicine, Paul et al. [21] vividly demonstrated the importance of end-user training to health care professionals, who despite their general competence and learning capabilities, often are not technologically savvy. Moreover, physicians may have a strong tendency to consider technology as merely a tool for

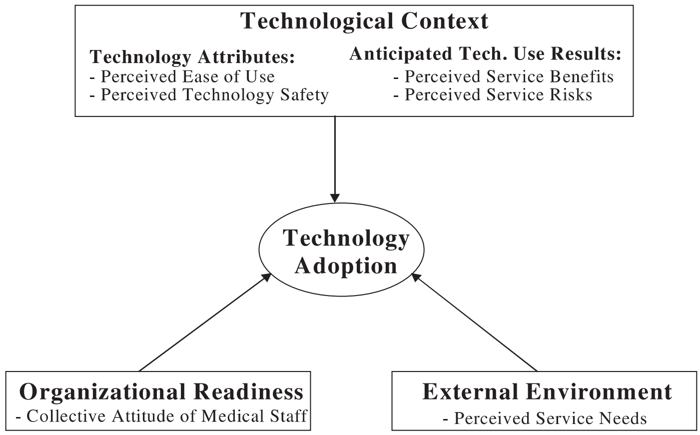

Figure 1. Research model for the organizational adoption of telemedicine technology.

supporting their patient care and services, in part because of professional nature and autonomy. A technology that is difficult to use or operate is not likely to be well received by physicians. As an organization engages in activities along the technology adoption process, this factor (i.e., perceived ease of use) may become increasingly crucial to the ultimate decision making. In this vein, a health care organization needs to evaluate member physicians' perceptions or assessments of the ease of use of the technology and adequately communicate the evaluation results justified by pragmatic or scientific criteria [33]. The exact effects of perceived ease of use on technology adoption have been shown by previous research to be somewhat inconsistent [34–37], suggesting that its influence or significance might be moderate with technology or target users. We hypothesized that perceived ease of use would be a significant adoption differentiating factor and would have positive effects on the likelihood of the adoption of telemedicine technology by an organization. We, therefore, posited that

H1: Perceived ease of use will be a significant technology adoption differentiating factor; specifically, higher levels of perceived ease of use will increase the likelihood of an organization adopting telemedicine technology.

Perceived technology safety is another important technology attribute. Broadly, telemedicine technology has as yet to mature, as suggested by limited efficacy evidence from documented clinical trials. To varying degrees, physicians are cautious about the safety of the equipment and technology used in their patient care and services. This paramount safety consideration can be summarized by the first principle of physicians' practices: Do no harm! Accordingly, we posited that perceived technology safety would be a significant differentiating factor and would have positive effects on telemedicine technology adoption by health care organizations. In other words, we hypothesized that

H2: Perceived technology safety will be a significant technology adoption differentiating factor; specifically, higher levels of perceived technology safety will increase the likelihood of an organization adopting telemedicine technology.

Telemedicine technology supports the patient care and services of individual physicians and, therefore, needs to be evaluated from the service provision and delivery perspective. In this connection, physicians' perceptions or assessments of service benefits and risks resulting from the technology use are essential. Largely comparable to the relative advantages discussed by Rogers [9] and the perceived usefulness discussed by Davis [32], *perceived service benefits,* in this study, refer to the degree to which telemedicine technology is perceived as being better than or superior to existing service arrangements. As discussed by Tanriverdi and Iacono [20], physicians are not likely to be convinced by the value of telemedicine unless its technical feasibility is accompanied by medical (or service) validity. Empirical support for relative advantages or perceived technology usefulness has been fairly strong [31, 38–40]. Accordingly, we hypothesized that perceived service benefits would be a significant discriminator and would have positive effects on organizational adoption of telemedicine technology. On the other hand, health care organizations constantly are concerned about service risks, particularly when assessing the use of a new technology, protocol, procedure, or treatment plan, in our case, telemedicine technology. Specific risk considerations may include service efficacy, outcome effectiveness, physician–patient relationships, and patient (information) privacy. Hence, we postulated that perceived service risks would be a significant differentiating factor and would have negative effects on organizational technology adoption. Accordingly, we test the following two hypotheses:

H3: Perceived service benefits will be a significant technology adoption differentiating factor; specifically, higher levels of perceived service benefits resulting from the use of telemedicine technology will increase the likelihood of an organization adopting the technology.

H4: Perceived service risks will be a significant technology adoption differentiating factor; specifically, higher levels of perceived service risks resulting from use of telemedicine technology will decrease the likelihood of an organization adopting the technology.

Physicians may be the most important users of telemedicine technology and, in effect, are often considered to be the most expensive aspect of a telemedicine program. Based on findings from a recent case study [18] and comments frequently made by several clinical managing physicians in our prestudy interviews, the attitude of medical staff toward telemedicine technology and the services it enables may largely determine the readiness of an organization for the technology adoption under investigation. "The bottom-line is my staff's use of the technology," commented the chief of service of a surgery department where a previously acquired computer-based patient record system had rarely been used by his fellow surgeons. Prior research has also suggested that attitudes of key personnel are an important factor in technology adoption in an organization [41, 42]. Given that the technology adoption under investigation would take place at the organizational level, attitude assessment should proceed at a collective rather than an individual level. We, therefore, hypothesized that the collective attitude of medical staff would be a significant differentiating factor and would have positive effects on the organizational adoption of telemedicine technology:

H5: The collective attitude of medical staff toward telemedicine technology and the services it enables will be a significant technology adoption differentiating factor; specifically, stronger levels of collective attitude will increase the likelihood of an organization adopting telemedicine technology.

Perceived service needs are also an important factor pertaining to the external environment. Because its primary purpose is to provide services to those in need, a health care organization needs to explore and evaluate alternative delivery modes when existing arrangements cannot satisfactorily meet service demands in terms of service access or quality. In many cases, the adoption of a new technology is pulled by existing needs rather than pushed by the technology. Rai and Yakuni [43] examined organizational adoption of computer-aided software engineering technology and concluded that needs-pulled factors were important to adoption decision making in organizations. Similar findings were also reported by Chau and Tam [44]. Accordingly, we posited that perceived service needs would be significant and would have positive effects on telemedicine technology adoption by health care organizations:

H6: Perceived service needs will be a significant technology adoption differentiating factor; specifically, higher levels of perceived service needs will increase the likelihood of an organization adopting telemedicine technology.

4. RESEARCH APPROACH, DESIGN, AND DATA COLLECTION

In this section, we describe our research approach, target organizations, instrument development, and data-collection methods.

4.1 Research Approach

Our overall research approach was characterized by its use of factor modeling for problem conceptualization, key informants for data collection, and a process orientation in technology adoption assessment. We specifically targeted the health care sector in which information technology investments and implementations have increased rapidly. Our choice of industry focus was advantageous. As Kimberly and Evanisko [30] commented,

> Concentration of the research focus can help to identify and isolate factors that clarify the nature of phenomena in a particular sector and, at the very least, can be helpful in in suggesting hypotheses that may be generalizable beyond that sector and tested in others. (p. 691)

We took a factor modeling approach to investigate important factors that affect the adoption of telemedicine technology by health care organizations. Understandably, telemedicine can be applied to support various activities in health care, including service collaboration and delivery and information exchange [45]. A survey of the existing telemedicine programs in Hong Kong suggested a prominent clinical focus, which therefore, was targeted in the study. Specifically, we developed a research model and empirically evaluated its validity and explanatory utility. Results obtained from this exploratory study thus provide a point for departure for continued research, including confirmatory investigations that should further analyze the technology adoption under discussion.

A key-informant approach was employed for data collection. We obtained responses from managing clinical physicians at the various participating organizations to evaluate technology adoption that had taken place in their respective organizations. The target informants included hospital executive officers, clinical department chiefs of service, and long-term care and rehabilitation center directors. Use of key informants to obtain information about their respective organizations is justifiable and common [24, 41, 46–48], and its application in this study was advantageous in several ways. First, the key informant presumably has a fairly comprehensive understanding of both the external environment and the internal conditions of his or her organization. In our case, the target informants had good knowledge about the overall (big) picture and thus were considered to be better or more qualified information sources than others, including individual physicians. Second, these informants held clinical management positions and often had considerable influence on or authority over decisions that would affect their organizations, including the adoption of a new technology. At the same time, most informants were clinically active health care professionals themselves and thus were able to relate and communicate to their peers professionally, including about technology evaluation and use. The dual role of the informants, as both administrators and clinicians, was essential for our investigation of technology adoption at the participating organizations.

We took a process-oriented view to technology adoption assessment. Specifically, we used an adoption continuum to measure organizational technology adoption, our dependent variable. As summarized in Appendix A, this continuum consisted of seven logical and distinct phases that signaled or corresponded to the specific stages in which organizations were currently located in the adoption process. These distinct phases, in turn, could closely approximate the likelihood of the organization adopting the technology. That is, the likelihood of an organization adopting telemedicine technology increased as the organization advanced along the phases on the continuum. For instance, an organization that had already submitted a formal adoption proposal for review by a funding agency was plausibly more likely and closer to adopting telemedicine technology than one that had thought about the adoption but had decided not to pursue it at present. Logically, use of the continuum to depict and, therefore, differentiate organizational adoption provided increasing details because the adoption taking place in an organization may have progressed through several latent but distinct phases before reaching an observable state that was close to the ultimate technology acquisition and implementation. In this vein, the absence of observable adoption activities did not necessarily elucidate the process of an organization for adopting telemedicine technology. Understandably, steady progress through the necessary intermediary (latent) stages may have been made by the organization whose adoption activities would soon become observable and fruitful.

In addition, the use of the described continuum to measure organizational technology adoption also supported the intended dichotomous classification analysis. These phases jointly indicated the likelihood of organizational adoption, which could be dichotomously analyzed with an adequate threshold or criterion. Thus, logistic regression appeared to be appropriate for our hypothesis testing and, therefore, was applied to differentiate the adoptions by the investigated organizations. Use of the adoption continuum was also pragmatically effective for coping with existing constraints. To a large extent, telemedicine developments in Hong Kong are mostly in an early stage; actual technology implementation and use, although currently not widespread, are expected to grow rapidly. Hence, use of the multiphase continuum allowed us to take into consideration various adoption phases of organizations, despite overall limited technology use. Data analysis results obtained from the study, in turn, may shed light on the potential barriers separating organizations in advanced adoption phases and those in primitive ones.

4.2 Target Organizations

We targeted public health care organizations in Hong Kong, including general and acute tertiary hospitals, long-term care and rehabilitation centers, and specialized clinics. Clinical departments were considered independent units of analysis because of medical specialization and departmental autonomy. Choice of the targeted organizations was made primarily because of the likelihood of their involvement and their taking the lead in telemedicine, in addition to accessibility. As a group, these organizations may be more likely to adopt telemedicine technology than their private counterparts for several reasons [18]. First, public health care organizations are the principal, if not dominant, care providers in Hong Kong [49] and usually have considerable service needs that may be effectively addressed by telemedicine [50]. Secondary and particularly acute tertiary care units have considerable underaddressed service demands that may be better served by telemedicine-enabled service delivery, collaboration, and integration. Second, these organizations have relatively greater access to the resources (e.g., financial and others) necessary for technology adoption than most private clinics and hospitals in Hong Kong. Third, most of the public health care institutions have reasonable in-house technology bases and technical support, including that provided by the Hospital Authority (HA), the supreme governing body of Hong Kong's public health care establishments, which has highly sophisticated information technology capabilities. Therefore, our target organizations tended to be more technologically ready for telemedicine than other health care institutions in Hong Kong.

4.3 Instrument Development

To develop the survey instrument, we reviewed relevant prior research to identify appropriate candidate measures. These were supplemented with additional items obtained from findings of prestudy interviews and focus-group discussions that included several chiefs of service from different organizations and specialty areas. The resultant preliminary question items were examined by the same focus group, which assessed their content validity at face value. Based on their feedback, several minor modifications, including wording choices, were made to enhance the communicability of the question items in the targeted health care context.

The question items were then tested with a card-sorting procedure [51] that involved one chief of service, one hospital medical executive, and one director of a long-term care center. Like the focus-group physicians, the physicians who had participated in the pretest study were excluded from the subsequent formal study. The question items were separately printed on 8 × 6 cm index cards that were shuffled and presented randomly to each pretest physician, who was asked to sort the cards into appropriate categories individually. Results from the card-sorting evaluation were generally satisfactory; the physicians were able to categorize the question items correctly with an accuracy rate of 80% or better.

With the exception of question items for measuring pertaining to the dependent variable, a 7-point Likert scale, ranging from 1 (*strongly agree*) to 7 (*strongly disagree*), was used for all question items. To ensure a desirable balance of the items in the questionnaire, we properly negated half of the questions to force respondents to become increasingly alert to manipulated question items. In addition, all question items were randomly arranged to minimize potential ceiling or floor effects that could induce monotonous responses to question items designed to measure the same construct. To anchor participants' responses adequately [52], we provided a specific working definition of *telemedicine* in the questionnaire and included in each survey packet selected general references to telemedicine and common introductory information about the enabling technology.

The dependent variable, technology adoption level, was defined at seven distinct phases, each of which conceivably could have served as a logical precursor to or a foundation for the succeeding adoption phase. The minimum requirement for adopting organizations was the submission of a formal adoption proposal under review by the funding agency. That is, *adopters,* as we defined them, also included organizations that had located and secured the funding and technology source necessary for the technology adoption as well as those that had already implemented the technology and actually used it. On the other hand, organizations not yet reaching the described threshold were considered to be *nonadopters* in our data analysis. Choice of formal proposal submission and review as the classification criterion (or threshold) was based on the following reasons. First, a proposal under review by the funding agency, in most cases, would succeed eventually. Judged from the perspective of remaining distance, these organizations literally were closely approximate to technology acquisition. Proposal submission is documented and observable, singling the strong intention of an organization for and commitment to telemedicine. In addition, the differential between proposal submission and its immediate preceding phase ("have or about to complete an adoption plan") was relatively more noticeable, distinguishable, and clearly defined than that between this preceding phase and its intermediate precursor ("have designated a task force or individual to investigate potential adoption").

4.4 Data Collection

We collected responses from the key informants using a self-administered questionnaire survey. Contact information for these individuals that included hospital executive officers, clinical department chiefs of service, and long-term care and rehabilitation center directors was obtained from an internal directory published by the HA. Before the questionnaire distribution, each target respondent was sent a faxed letter that briefly stated the purpose of the study and its anticipated results and significance. Survey packets were sent by postal mail. Each contained a cover letter explicitly describing the purpose of the study and the intended use and management of the data to be collected, endorsement letters from the Hong Kong Telemedicine Association and the HA Information Technology division, selected general references on telemedicine and exemplar technology, the questionnaire, and a self-addressed stamped envelope. Use of the HA internal directory facilitated coding and tracking of individual respondents, which allowed us to identify nonrespondents to be contacted in the subsequent follow-up process.

Each informant was given approximately 2 weeks to complete the questionnaire, dated from the estimated arrival of the packet. A reminder letter was faxed to each respondent a week after his or her estimated receipt of the questionnaire. A second reminder letter was faxed to each respondent's secretary 2 or 3 days before the indicated response-time window expired, asking him or her to remind the participant to complete the questionnaire and return it using the provided stamped return envelope. Reminders and additional questionnaires were sent by mail to those who failed to return completed questionnaires within the initial response period. Late respondents were given another 10 days to complete the questionnaires, and their secretaries were telephoned to notify them about the questionnaires that would arrive. A second reminder and another questionnaire were faxed to the respondents who had not yet responded at the end of the extended response period. A final 1-week response window was explicitly specified in a subsequent faxed reminder to the remaining nonrespondents, who were asked a final time to mail in their completed questionnaires.

5. DATA ANALYSIS RESULTS

In this section, we summarize the respondent profile and highlight data analysis results in terms of instrument validity and logistic regression, described as follows.

5.1 Respondent Profile

Of the 188 questionnaires distributed, 113 were completed and returned, showing a 60.1% response rate. Among the responses, 19 were partially completed and thus were excluded from the subsequent data analysis, making the effective response rate 50.0%. The responding organizations had an average of 34.8 member physicians (or specialists) and employed 142.1 nurses and 34.3 technicians. As shown in Table 1, most of the responding informants were male (85.1%), held the post of chief

Table 1
Summary of Respondent Profiles

Dimension	*No. of Respondents*	*%*
Post		
Chief of service	63	67.0
Center director	19	20.2
Hospital medical executive	12	12.8
Gender		
Male	80	85.1
Female	14	14.9
Country where respondent attended medical school		
Hong Kong	76	80.8
United Kingdom	8	8.5
Australia	4	4.2
Others (including the United States)	6	6.5

of service (67.0%), and had received their basic medical education in Hong Kong (80.8%). On average, these informants were 43.5 years of age and had had 17.7 years of postinternship clinical practice.

Distribution of medical specialty areas among the responding organizations was fairly diverse and balanced. Among the total of 18 medical specialties represented by the data collected, internal medicine, pediatrics, radiology, oncology, surgery (particularly neurosurgery), obstetrics and gynecology, and pathology appeared to show relatively higher levels of participation. Primary care, long-term, and rehabilitation care were also included, accounting for 3.2, 1.1, and 6.4% of responding organizations, respectively.

A total of 62 responses were completed and returned within the initial response window, accounting for 66.0% of the effective responses. These respondents were considered early respondents, whereas the remaining ones were classified as late respondents. A comparative analysis between the early and the late respondents suggested no significant differences in organization size and informant profile. As a group, the early responding organizations included a comparable number of physicians or specialists, nurses, and technicians to their late counterparts. Similar comparability was also found in the informants, as measured by age, postinternship clinical experience, and gender distribution; post; and country of medical school attendance. Jointly, these comparative analysis results suggest that nonresponse bias might have been insignificant.

5.2 Instrument Validity Assessment

Instrument validation is essential to the validity of research results and, therefore, has to be examined. Specifically, we evaluated instrument validity in terms of content validity, measurement reliability, and construct validity, all of which were suggested by Straub [53] as essential dimensions for instrument validation. As described, we examined content validity using both face-value evaluation and card-sorting methods, and the results were largely satisfactory.

Reliability was evaluated by examining the internal consistency among alternative items used to measure the same underlying construct. As discussed by Straub [53], high correlation between or among alternative measures designated for the same construct or large Cronbach alpha values are common signs of measurement reliability. Accordingly, we examined both the measurement correlation and the Cronbach alpha values derived from the question items intended for the respective constructs. As depicted in Appendix B, measures designated for the same construct demonstrated higher correlation than those measuring different constructs. In addition, all investigated constructs exhibited an alpha value of close to or greater than .7, a common reliability threshold for exploratory research (as shown in Table 2) [54]. The correlation analysis results together with observed Cronbach alpha values suggest that the measurements included in the study had exhibited reasonable reliability.

Construct validity is an operational issue, concerned with whether or not the question items designed truly describe the underlying construct of interest. We evaluated the construct validity of the instrument by examining its convergent and discriminant validity [53]. Both correlation and factor analyses were performed. As shown in Appendix B, the correlation coefficients were considerably higher among question items designed to measure the same construct than among those designated for different constructs. The observed higher levels of correlation among measurements for the same construct suggest that our instrument had demonstrated adequate convergent and discriminant validity.

We further examined the construct validity of the instrument by performing a principal component factor analysis. Based on the Varimax rotation method with Kaiser normalization, a total of six components were extracted, precisely matching the number of constructs included in the research model. As shown in Table 3, question items designated for the same construct exhibited distinctly higher factor loadings on a single component, signaling satisfactory convergent and discriminant validity encompassed by the instrument. Jointly, the correlation and factor analyses results suggest that the instrument used in the study exhibited adequate construct validity, as manifested by its satisfactory convergence and discriminant validity results.

Finally, Harmon's one-factor test was performed to evaluate the potential effects of common method variance [40]. The one-factor test restricts the items presumably designated to measure different constructs to a single-factor analysis. When the dominance of a single factor is observed, these items are considered to be re-

Table 2
Analysis of Measurement Reliability

Construct	*Cronbach's* α
Perceived service benefits (5 items)	.75
Perceived service risks (4 items)	.80
Perceived service needs (2 items)	.85
Collective attitude of medical staff (3 items)	.78
Perceived ease of use (2 items)	.70
Perceived technology safety (2 items)	.68

Table 3
Factor Analysis Results: Convergent and Discriminant Validity

	Component					
	1	*2*	*3*	*4*	*5*	*6*
Perceived service risks						
PSR4	0.798					
PSR2	0.774					
PSR1	0.736					
PSR3	0.650					
Perceived service benefits						
PSB3		0.698				
PSB4		0.697				
PSB1		0.650				
PSB5		0.638				
PSB2		0.634				
Collective attitude of medical staff						
CAMS2			0.843			
CAMS1			0.800			
CAMS3			0.735			
Perceived service needs						
SN1				0.916		
SN2				0.816		
Perceived ease of use						
PEOU2					0.880	
PEOU1					0.703	
Perceived technology safety						
PTS1						0.893
PTS2						0.603
Eigenvalue	2.495	2.069	1.903	1.758	1.639	1.558
Variance explained (%)	15.59	12.93	11.90	10.00	10.25	9.74

lated because of the use of a common method, in our case the self-reporting method. Our analysis result shows that the single most dominant factor accounted for only 16% of the total variance, suggesting that the underlying common method variance may not have been significant.

5.3 Research Model Evaluation and Hypothesis Testing With Logistic Regression

Logistic regression was used to evaluate the research model and test our research hypotheses. Choice of the data analysis technique was based primarily on its flexibility in assumption requirements [55] and the intended dichotomous classification of the dependent variable. In particular, we examined the significance and classification accuracy of the research model. Regression results show that our research model was not significantly different from a perfect model, which could correctly classify all organizations to the appropriate adopter or nonadopter category. The observed nondistinction from a perfect model is significant, as suggested by its goodness-of-fit statistic having a chi-square of 73.17 and a level of significance of .85.

The research model was also examined in terms of classification accuracy or discriminant power. Based on the discussed adoption threshold, our data included 19 adopting and 75 nonadopting organizations. Random guesswork, in theory, would result in a classification accuracy of 67.74%, that is, $(19/94)^2 + (75/94)^2 = .6774$. On the other hand, the classification accuracy achieved by the research model was 84.04%, considerably higher than that of random chance and thus suggesting the reasonable discriminant power of the model.

We evaluated support for individual hypotheses by examining the respective regression coefficients and the associated statistical significance. As summarized in Table 4, collective attitude of medical staff, perceived service risks, and perceived ease of use appeared to be significant factors differentiating adopting and nonadopting organizations, as suggested by *p* values of .005, .006 and .013, respectively. Surprisingly, perceived service benefits, perceived service needs, and perceived technology safety seemed to be insignificant adoption differentials.

5.4 Analysis of Adoption Phases

We examined the specific adoption phase of each investigated organization. Among the 94 organizations included in the data analysis, 11 had implemented the technology and used it to provide patient care and services. A total of 6 organizations had secured the funding and technology source necessary for technology acquisition. Meanwhile, another 2 organizations had submitted formal proposals currently under review by the funding agency. As shown in Figure 2, most of the organizations included in the study either had thought about technology adoption but decided not to pursue it at present or had informally discussed potential adoption within the organization but had taken no concrete actions. The skewed distribution toward preliminary adoption phases suggested the early stage of telemedicine development in Hong Kong. To varying degrees, all the investigated health care institutions nevertheless were aware of telemedicine. In effect, many of them had considerable knowledge about its applications and had exhibited interest in acquiring the technology and incorporating it into existing services.

Table 4
Hypothesis Testing Results: Logistic Regression Analysis

Differentiating Factor	*Coefficient*	*Wald Statistic*	*p*
Perceived service benefits	–0.42	1.66	.1975
Perceived service risks	–0.99	7.72	.0055
Perceived service needs	0.46	2.30	.1292
Collective attitude of medical staff	1.48	8.00	.0047
Perceived ease of use	–0.71	6.12	.0133
Perceived technology safety	0.38	1.37	.2421

Note. Underlined values = significant at a 5% level.

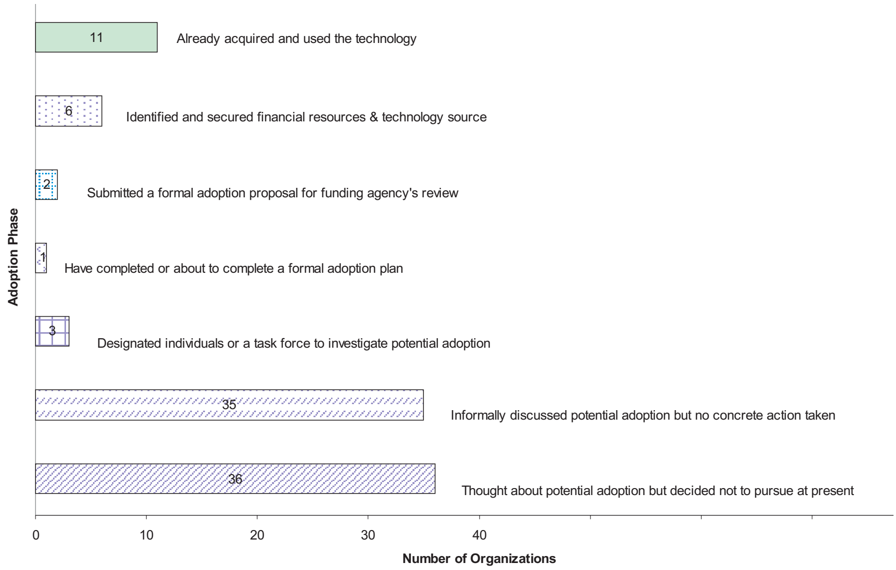

Figure 2. Analysis of technology adoption phases.

6. IMPLICATIONS FOR ORGANIZATIONAL TELEMEDICINE MANAGEMENT

Results from our data analysis support the hypotheses on collective attitude of medical staff and perceived service risks. Perceived ease of use was found to have a significant effect on technology adoption, but the direction of impact was surprising. Support of the remaining hypotheses was not of statistical significance. A similar pattern of research findings was also reported by Paul et al. [21], who categorized these findings into "expected and supported," "expected and supported in unexpected manner," and "expected but not supported," respectively.

Collective attitude of medical staff toward telemedicine technology and the services it enables is essential to technology adoption. Based on our findings, collective attitude appeared to be the most significant factor differentiating adopting and nonadopting organizations, as we defined them in the study. Specifically, the stronger the collective attitude was, the more likely an organization was in an advanced adoption phase and, intuitively, the more likely it was to acquire, implement, and actually use the technology. The observed significance of collective attitude may in part have resulted from the professional nature of medicine, in which physicians have relatively high autonomy in determining whether or not to accept (or use) a technology. Compared with end users commonly found in ordinary business settings, physicians may have more influence on the organizational adoption of a technology that would affect their practices and services. The described autonomy may make attitude management increasingly important for organizational technology adoption in the health care context.

Several implications for telemedicine management can be derived from this finding. First, management may need to be cautious in evaluating the attitudes of member physicians toward telemedicine technology and its inclusion into their practices before committing resources for technology acquisition and implementation. Second, proactive attitude management is essential. Understandably, attitudes are fluid and may dynamically evolve over time as new information or experiences are acquired and assimilated. That is, favorable attitudes can be managed through proper cultivation and reinforcement. In this connection, an organization interested in telemedicine-enabled service delivery and collaboration should consider proactively educating member physicians about the application frontiers of telemedicine and communicating to them the benefits of the technology, including documented efficacy or clinical results available in the literature. Third, professional workshops and seminars are effective vehicles for facilitating and fostering the communication about telemedicine technology and applications. Furthermore, peer influence is also important and may effectively address a physician's concerns about telemedicine technology and its inclusion into his or her practice. Peer influence may take place in several forms, including through opinion leaders and change agents who can supplement the top-down hierarchical communications initiated by management or an internal champion for telemedicine.

Consideration of perceived service risks also is essential. As suggested by our study results, perceived service risks appeared to be another significant factor differentiating adopting and nonadopting organizations. The propensity for resistance to change can be considerable in health care settings, especially when changes are likely to bring about significant uncertainty or adverse effects on individual physicians' patient care and services. Understandably, a physician may have concerns about incorporating telemedicine technology into his or her practice in the light of potential service risks, degradation, or disputes, which in some cases, might have considerable legal ramifications. Not all perceived service risks are substantial or legitimate. In effect, some perceived risks are not warranted and can be reduced or removed by evidence-based information exchanges based on first-hand experiences or accounts from trusted sources known in the professional networks. Hence, an implication for telemedicine management is that an organization should identify the primary risks perceived by member physicians, followed by proactive verification, clarification, and mitigation of their potential occurrence and effects. The described proactive intervention, at a minimum, may lead to removal of unwarranted concerns by physicians. Toward this end, one intuitive strategy is to facilitate physicians' interactions with internal or external peers experienced in routine telemedicine services.

Perceived ease of use also appeared to be an important factor differentiating adopters and nonadopters, but its effects may need further evaluation. On the basis of our findings, perceived ease of use exhibited a significant negative regression coefficient with the technology adopting phase of an organization. Hence, perceived ease of use was significantly but inversely correlated with the adoption phase of an organization. That is, organizations in advanced adoption phases appeared not to consider perceived ease of use as important a factor as did organizations in preliminary phases. In our context, this finding might imply that an organization initially having high anxiety about telemedicine the ease of use of the technology may become less concerned about this issue after moving forward to an advanced adoption phase (i.e., beyond formal technology assessment). That is, organizations not familiar with telemedicine technology are likely to emphasize unduly the difficulty or complexity associated with its use, whereas organizations relatively familiar with the technology may consider its use to be increasingly manageable over time. The speculated overemphasis or appraisal might in part have resulted from knowledge barriers [56, 57] that can be reduced by trial use and user-end training, which when adequately provided, would produce scientific evidence and justification necessary for underpinning essential technical knowledge. Effects of trial use and training may be enhanced with detailed technology assessment and adequate communication of evaluation results to individual physicians.

Perceived service benefits appeared to be an insignificant discriminator for adopters and nonadopters. One plausible explanation might be that telemedicine largely remains a novelty to many organizations whose potential adoption or intention for adoption is primarily driven by considerations other than specific service benefits, including clinical feasibility, technology exploration, and professional status enhancement. Alternatively, the observed insignificance might also in part have resulted from a mismatch between technological capabilities and user requirements. As discussed by Paul et al. [21], a mismatch can result from overly complex and sophisticated rather than insufficient technological capabilities, thus diminishing the user's perception of the benefits of technology in relative terms. The discussed effects of undue technological sophistication, in turn, may explain or reinforce the observed overemphasis or appraisal of perceived ease of use by organizations in preliminary adoption phases. Likewise, the observed insignificance of perceived service needs might be similarly explained. As shown by Paul et al. [21], one technical barrier to telemedicine adoption was that the sophistication of the equipment appears to have advanced faster and further than expected by the users (p. 287). Together, these findings may suggest that telemedicine has not been properly positioned by health care organizations as a solution for unmet or underaddressed service needs.

Neglecting the described mismatch may jeopardize service sustainability. At the time of study, all telemedicine programs in Hong Kong were operated in the form of experimental projects or pilot programs. To be sustainable, these programs, like any other, have to become financially self-sufficient. Service positioning is critical to self-sufficiency and requires adequate assessment of service needs and benefits. Hence, an organization that has adopted or is about to adopt telemedicine technology needs to define explicitly the targeted services and position them with respect to its existing services, market segment(s), and competing services by other organizations. Providing new services and extending existing services to new market segments are exemplar service positions.

Similarly, technology safety also appeared not to be an important factor. The observed lack of significance may partially reflect the overall early stage of telemedicine development in Hong Kong as well as the organizations' intentions for experimenting with the new technology or conducting clinical trials for efficacy assessment. Beyond the experimental or trial stage, technology safety will become compulsory and, therefore, should be duly considered and addressed in advance. Acquiring the technology that has met or is likely to meet safety requirements mandated by the government authority or using industry standards adopted by governing professional societies or advanced medical systems represents a reasonable strategy to ensure a necessary safety level.

7. CONCLUSIONS

Telemedicine is an exciting technological innovation that has great potential to bring about paradigmatic changes to health care, an increasingly important service sector in both the national and the global economy. In response to the significance of telemedicine technology and the far limited discussion concerning its adoption by health care organizations, we developed a research model and evaluated its empirical validity and explanatory utility by using a survey study that involved most of the public health care organizations in Hong Kong. Our overall data analysis results support the research model, which exhibited reasonable classification accuracy and statistical significance. Furthermore, our findings suggest that the collective attitude of medical staff and perceived service risks appear to be significant discriminators between adopting and nonadopting organizations. Perceived ease of use of telemedicine technology may also be significant but its appraisal could be unduly overemphasized or overestimated by organizations in early adoption phases. Collective findings from our exploratory study seemingly suggest that most of the investigated organizations might have considered the technological context and the organizational readiness more relevant to or important for their technology adoption than the external environment. The observed lack of support for several hypotheses also demands continued efforts for identifying and including in the research model additional factors pertaining to the respective contexts.

The study has contributed to both the research and the practice of telemedicine technology management. On the research front, we examined organizational technology adoption, a fundamental research issue that has not yet received due investigative attention. Specifically, we proposed and empirically evaluated a research model, which appears to exhibit reasonable explanatory utility and statistical significance. Furthermore, our study bridged IS literature and technology management in health care and generated findings that may benefit continued IS research in technology adoptions in health care settings, particularly those taking place at the organizational level. Contributions were also made to the organizational management of telemedicine technology. Conducting an empirical investigation that included most health care institutions in Hong Kong, we identified several factors that are potentially important for technology adoption and explored their plausible implications for organizational technology management. Based on the findings of our study, promising strategies and methods for addressing these determining issues were also discussed.

With this exploratory study, we intended to provide a point of departure for continued research on organizational adoption of telemedicine technology. Several inherent limitations need to be noted. First, the study was limited in scope and was confined to public health care organizations in Hong Kong. Hence, cautions need to be taken when generalizing its findings across other health care organizations and/or geographical or cultural characteristics. Imaginably, health care organizations elsewhere (e.g., in the United States or China) might consider a subtly different set of factors important for their technology adoption decisions; so may private health care institutions in Hong Kong. Data collection is another source of limitation. Our use of a single method (i.e., self-reporting) to obtain responses cannot rule out the threats of common method bias [58]. This limitation can be mitigated by data triangulation supported by additional data-collection methods that may include interviews and field observations. Typical telemedicine services span across organizational boundaries. This interorganizational nature requires technology adoption investigations to include multiple organizations simultaneously. However, in this study, we concentrated on examining adoptions taking place in the service-providing organization and thus did not investigate that at the service-recipient organization. Similarly, the interaction between the organizations was also not examined.

In turn, these limitations and others point out some of the areas that need continued research attention. Several possibilities for moving this research forward are promising. For instance, reexamining the research model with health care organizations from the private sector or from different geographic regions or cultures may enhance the empirical validity and applicability of the model, hence, increasing the generalizability of the research results.

Continued examination of organizational adoption of telemedicine technology that includes multiple and complementary methodologies is also important. In this connection, the case study method may be desirable because it would overcome the potential common method bias (as in this study) and, at the same time, would yield rich insights to the technology adoption process of interest. Understandably, an organization's process for adopting a technology may not proceed in a rational manner. Van de Ven et al. [59] reviewed a series of innovation adoptions and concluded that the adoption process may be a messy and complex progression of events (p. 23).

An interorganizational or network-based approach for examining the technology adoption of interest is also important. Most telemedicine-enabled service deliveries and collaborations connect multiple organizations. Hence, technology adoption activities are likely to take place simultaneously at all connecting organizations, each of which has its distinct role and, to varying degrees, may influence the technology adoption that takes place in other connecting organizations. Therefore, an interorganizational or network-based approach that examines technology adoption in multiple participating organizations concurrently may be interesting and adequate.

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Appendix A
Listing of Question Items Used in the Study

Construct	*Question Items*
Perceived service benefits (PSB)	PSB1: Improving the timeliness of patient care
	PSB2: Reducing patient care and service costs
	PSB3: Improving service productivity of medical staff
	PSB4: Reducing unnecessary patient transfers or admissions
	PSB5: Improving overall effectiveness of patient care
Perceived service risks (PSR)	PSR1: Hindering physician–patient relationship
	PSR2: Reducing patient care effectiveness
	PSR3: Jeopardizing patient privacy
	PSR4: Bringing psychological harm
Perceived service needs (SN)	SN1: Unmet patient service needs
	SN2: Existing service gap
Collective attitude of medical staff (CAM)	CAMS1: Collective attitude toward technology-empowered virtual patient care
	CAMS2: Collective attitude toward technology assisted consultation
	CAMS3: Collective attitude toward increased use of IT in patient care
Perceived ease of use (PEOU)	PEOU1: Easy to become skillful in using the technology
	PEOU2: Finding the technology is flexible to interact with
Perceived technology safety (PTS)	PTS1: Technology certification by related government authority
	PTS2: Technology endorsement by medical professional societies
Adoption phase	1. Already adopted telemedicine technology and used it for clinical purposes
	2. Have located and secured financial resources and technology source
	3. Have put together a formal proposal that is currently under external review
	4. Have or are about to complete adoption plan to be submitted to a funding agency
	5. Have designated a task force or individuals to investigate potential adoption
	6. Informally discussed potential adoption but have taken no concrete actions
	7. Thought about potential adoption but decided not to pursue at present time

Appendix B
Analysis of Correlation Coefficients

	PSR1	*PSR2*	*PSR3*	*PSR4*	*PSB1*	*PSB2*	*PSB3*	*PSB4*	*PSB5*	*CAMS1*	*CAMS2*	*CAMS3*	*SN1*	*SN2*	*PEOU1*	*PEOU2*	*PTS1*	*PTS2*
PSR1	1.0000																	
PSR2	0.5360	1.0000																
PSR3	0.4900	0.5349	1.0000															
PSR4	0.5462	0.4926	0.3747	1.0000														
PSB1	0.2221	0.2540	0.1664	0.1114	1.0000													
PSB2	0.0228	0.1252	–0.0394	–0.1296	0.3731	1.0000												
PSB3	0.2466	0.1133	0.0481	0.0969	0.3749	0.3055	1.0000											
PSB4	0.0584	0.0449	–0.0827	0.0816	0.3227	0.3545	0.3613	1.0000										
PSB5	0.2104	0.1281	–0.0293	0.1159	0.4683	0.3947	0.3004	0.4179	1.0000									
CAMS1	0.2556	0.0632	–0.0367	0.1713	0.1288	0.2011	0.0863	0.1088	0.2251	1.0000								
CAMS2	0.2027	0.1875	0.0364	0.2342	0.2717	0.3132	0.1075	0.1264	0.2672	0.5951	1.0000							
CAMS3	0.0766	0.2303	0.1433	0.2450	0.1052	0.2593	0.0342	–0.0454	0.1787	0.4482	0.5654	1.0000						
SN1	0.1571	0.0859	0.0941	0.0656	0.2918	0.2944	0.0782	0.2471	0.4072	0.1794	0.3488	0.2442	1.0000					
SN2	0.2679	0.3149	0.1685	0.2402	0.2985	0.3153	0.2417	0.2770	0.4052	0.2087	0.3987	0.2778	0.7540	1.0000				
PEOU1	0.1901	0.2100	0.2115	0.2394	0.3896	0.2416	0.1062	0.1779	0.3199	0.3322	0.4149	0.4755	0.2606	0.4097	1.0000			
PEOU2	0.0966	0.1013	0.2343	0.0820	0.1724	0.0663	–0.0598	–0.1593	0.0806	0.1872	0.1241	0.2973	0.0919	0.1171	0.5326	1.0000		
PTS1	0.2533	0.1435	0.2585	0.0997	0.1769	0.0350	0.1559	0.0122	–0.0070	0.2714	0.1508	0.1658	0.1796	0.1999	0.2704	0.1879	1.0000	
PTS2	0.3401	0.3720	0.2921	0.2942	0.1551	0.1477	0.1071	0.0562	0.1297	0.2190	0.2999	0.4523	0.2493	0.2530	0.2443	0.1601	0.5169	1.0000

Note. PSR = perceived service risks; PSB = perceived service benefits; CAM = collective attitude of medical staff; SN = perceived service needs; PEOU = perceived ease of use; PT = perceived technology safety.