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Quality Predictors and Clinician Performance in Using Health Information Systems: A Test of Mediating Effect

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ABSTRACT

Medical errors are prevalent barriers that negatively affect clinicians' productivity when using a health information system (HIS). In Malaysia, medication errors have critically increased in the past few years and this phenomenon requires immediate academic and managerial attention. This study aimed to determine whether the effective use of HIS could predict the effects of the system, records, service, and knowledge qualities on the performance of clinicians. A total of 1200 surveys were administered to clinicians in different health institutions with HISs. The mediation effects based on 817 usable data were analyzed using partial least squares (PLS). In the path model, results demonstrated that effective use had a positive effect on the outcome variable and partially mediated the positive effects of quality predictors towards enhanced user performance. In other words, effective use of HISs increased the performance of clinicians through the ease of system functions and features, well-organized contents, and minimal data entry errors in EHRs, onsite technical support, and efficiency of drug order entry and decision support tools usage. Future evaluation studies of HIS should integrate effective use, and hospitals must strongly consider this predictor for the system upgrade or new implementation to avert medical errors when the use of the system is compulsory.

Keywords: Clinician performance, electronic health records, health information systems, information management, partial least squares

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INTRODUCTION

Hospital computerisation through the implementation of a health information system (HIS) can minimise and overcome

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human errors obtained from traditional and manual systems (El-Kareh et al., 2013; Khajouei et al., 2018). System implementation has been shown to improve patient safety and the efficiency of care delivery worldwide (Strudwick et al., 2016). For instance, the successful HIS implementation in Africa saved millions of lives and improved the citizen's quality of life, considering the accuracy and reliability of health statistics that influenced sound decision making in health care systems (Musa et al., 2016).

The effective use of HIS can improve clinical workflows and prevent unnecessary care and medical errors (Bae & Encinosa, 2016; Walsh et al., 2018). Unfortunately, medical errors in Malaysian health facilities have significantly increased by 35% from 1427 cases in 2016 to 1923 cases in 2017 even though HIS was in place (Abu Bakar et al., 2017), which determined its ineffective use (Yusof & Sahroni, 2018). Furthermore, surgeons refused to use the system due to the incomplete data field pertaining to the provided notes and considerable typing mistakes, which could lead to medication errors that could harm patients (Salahuddin et al., 2018; Yusof, 2015). When these errors occur during treatment, they can cause patient dissatisfaction with the quality of the patient safety (Salahuddin & Ismail, 2018), which then produces low productivity of doctors. Hence, these situations require the effective implementation of HIS to enhance the performance of clinicians, ensure patient safety and maintain public trust towards the government health system (Rajasekar, 2015).

The current study tries to explain the quality of HIS, records, support service, and knowledge towards clinician performance that are predicted by effective use. Clinicians are the health care providers who deal directly with the patient care or services rather than being involved with non-surgical diagnostic and treatment like physicians (Bossen et al., 2013). Specifically, the objective is to understand how effective use of HIS significantly affects the relationship between system quality, records quality, service quality, and knowledge quality on the performance of clinicians in the developing country of Malaysia to improve the past theoretical model and to recommend new criteria for HIS upgrades in an effort to avert medical errors.

LITERATURE REVIEW

System quality is employed to measure the effective use and performance of clinicians against the technical characteristics of HIS functions (Yusof et al., 2008). A survey of 235 nurses in Canada reported that the use of HIS was effective in preventing medication errors, increasing patient safety and supporting medication administration, which contributed to the significant satisfaction in reducing many drug prescription errors (Smith et al., 2016). Similarly, adequate computers and high performance of nursing HIS positively changed the workflows and medication management safety of nurses, thus increasing their satisfaction and task benefits after six months of implementation (Tsai et al., 2016). Therefore, the effective use of HIS positively mediates the system quality and performance of clinicians (H1).

The quality of records depends on the timely access, consistency, standardised, accuracy, duplication prevention, and comprehensiveness of health records (patient notes, reports, prescriptions, images, laboratory test results, and discharge summaries) generated from an HIS that is employed to measure the effective use and performance of clinicians (Salleh et al., 2017). Based on a survey of 281 clinicians in Iran, the effects of integrated and standardised electronic health records (EHRs) generated from HIS accelerated diagnoses and treatments, increased productivity by minimising errors and repetition of clinical and lab work and enabled the doctors to produce considerable medical studies (Sadoughi et al., 2016). In South Africa, the simplified analysis of EHR is the main priority for user satisfaction and productivity outcomes, which allowed nurses to allocate considerable time for patient communication (Cohen et al., 2015). Therefore, the effective use of HIS positively mediates the quality of records and the performance of clinicians (H2).

Service quality refers to the overall technical support of the internal or external HIS vendor, and is used to measure the effective use and performance of clinicians (Yusof et al., 2008). The quality of IT support service has predicted high user satisfaction and intention to use HIS, which in turn, positively affected the quality and efficiency of work and patient safety in Netherlands (Kuipers, 2016). Service quality, which is obtained from the dedication and commitment of IT staff, has decreased error rates and produced many skilled physicians who can use HISs, thus leading to high quality care (Li, 2014). Therefore, the effective use of HIS positively mediates the service quality and performance of clinicians (H3).

Meanwhile, knowledge quality is defined as the degree to which a clinician perceives that the use of HIS will aid in increasing his/her medical knowledge and applying such knowledge in making the right decision in solving the problems of patients (Chang et al., 2012). In Sweden, the efficiency of a decision support system tool via HIS provided accurate recommendations that increased the knowledge of physicians on drug dosage for patients with renal problems (Shemeikka et al., 2015). The use of HIS, which complements nursing practice, improved the knowledge and skills of nurses on using IT as well as reduced time, work efforts and clinical errors (Adams, 2015). The quality of knowledge generated from medical research and clinical practice via the use of HIS also contributed to the high quality of care and productivity of clinicians (Shimizu et al., 2018; Tsai & Hung, 2016). Therefore, the effective use of HIS positively mediates the quality of knowledge and performance of clinicians (H4).

In most quantitative research, a mediator provides an effect to denote several causes by independent variables towards a dependent variable. In the proposed mediation model (Figure 1), Effective Use as a mediating variable (MV), refers to the achievement of accomplishing clinical tasks by clinicians

without significant medical errors (Salleh et al., 2017), and is used to measure their performance. Meanwhile, Clinician Performance as the dependent variable (DV) refers to the level used to determine whether the use of HIS contributes to either high or low performance of clinicians, which is predicted by independent variables [System Quality(IV1), Records Quality(IV2), Service Quality(IV3), and Knowledge Quality (IV4)], and a mediator of Effective Use (MV). Specifically, Effective Use mediated the positive effects of H1, H2, H3, and H4 on the performance of clinicians. The proposed model in the current study was adopted from the conventional theoretical framework for IS evaluation namely DeLone and McLean model (DeLone & McLean, 2003), and improved Actual Use with Effective Use due to mandatory HIS utilisation in local study sites rather than introducing a new variable called Knowledge Quality. Unfortunately, the User Satisfaction variable from the DeLone and McLean model was removed because it had high correlation with system quality, information quality, and individual effect variables (McGill et al., 2003), which generated a low descriptive power (Sedera & Gable, 2004).

MATERIALS AND METHOD

Convenience sampling was applied to select the samples from hospital populations situated in different states; this was due to hectic schedules of clinicians serving in a busy clinical environment (Salleh et al., 2017; Salleh et al., 2016). The study protocol was approved by the Medical Research and Ethics Committee of the Ministry of Health in Malaysia. The survey draft was first reviewed by the National Institute of Health (NIH) before approval. Then, the draft was pre-tested through a focus group interview with several heads of clinical departments (Paediatrics, General Surgery, Anaesthesiology, General Medicine, Ward, Orthopaedic, Emergency and Trauma, and Nursing) arranged by the Clinical Research Centres of Kedah, Johor, and Pahang Hospitals as they had considerable experience in using HISs. Feedbacks were provided for further improvement to create

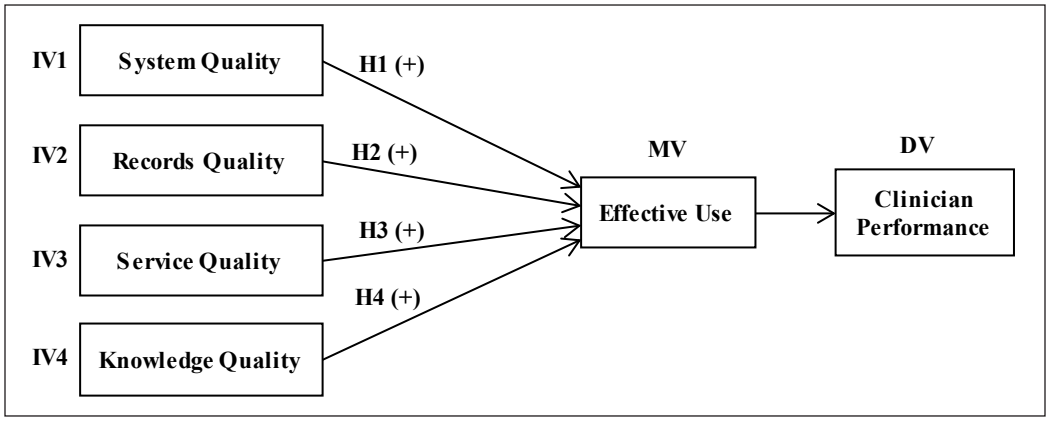

Figure 1. Mediation model

the final survey. Related comments are issued, including technical or complex IT terms and repetitive questions with similar meanings. They recommended restricting the number of questions to fewer than 50 items by refining three to five questions measuring each variable to promote accurate responses.

Subsequently, a total of 1200 printed surveys were distributed to medical officers and nurses in three large government hospitals with more than 500 beds and HISs in their clinics during their participations in the continuing medical education (CME) programs to ensure high response rates. An equal proportion was not assumed as non-probability convenience sampling was concerned because of clinicians' busy schedules and demanding workloads that limited the use of random sampling (Balappanavar et al., 2011). The questionnaire consisted of 25 adopted items from previous studies and 12 new untested items. Among the 817 completed responses, Kedah Hospital had the highest response rate with 41% (n = 334; 201 medical officers and 133 nurses), followed by Johor Hospital with 35% (n = 283; 122 medical officers and 161 nurses) and Pahang Hospital with 25% (n = 200; 101 medical officers and 99 nurses). Harman's one-factor test was performed using IBM SPSS Statistics Software to determine whether the survey data explained more than 50% of the total variance. The factor analysis results revealed that the measured survey items only explained about 32.6% of the total variance, indicating that common method bias did not affect the dataset (Conway & Lance, 2010).

RESULTS

For sample profiles based on 817 usable responses gathered from the three surveyed hospitals, 28% (229) of the participants were male and 72% (588) of them were female (375 nurses were female and about 213 medical officers were also female). More than half of the samples (66% or 542) were between 25–35 years old, followed by 15% (121) aged below 25 years old, 13% (109) aged between 36–45 years old, and 6% (45) aged above 46 years old. A total of 424 (52%) samples were medical officers who had a Medical Degree, and 393 (48%) were nurses who had a Diploma in Nursing. In using HIS, about 75% (619) of the samples had less than 5 years of experience, whereas 25% (198) had more than 5 years of experience.

Formative Model Analysis

In the formative measurement model, the System Quality variable consisted of four different components, such as Adequate IT Infrastructure with two indicators/ question items, System Interoperability with three indicators, Perceived Security Concerns with four indicators and System Compatibility with four indicators. Two System Interoperability items (sysi_1 and sysi_3), three Perceived Security Concerns items (secc_2, secc_3, and secc_4), and two System Compatibility items (syscom_1 and syscom 4) were adopted from the past related study (Salleh et al., 2016). Partial least squares-structural equation modeling (PLS-SEM) was used to analyse the formative and reflective models at the

same time (Hair et al., 2017). The first assessment started with the convergent validity in SmartPLS software 3.2.6 version for measured items. The results revealed that each System Quality item obtained a variance inflation factor below than 3.5, indicating that the items did not highly correlate with each other (Hair et al., 2011). The second assessment proceeded with the bootstrapping nonparametric procedure for outer weights. The results indicated that the items of adin_2, secc_1, secc_2, secc_3, and syscom_4 were not significant but that their loadings were significant at the 1% level, as depicted in Table 1. The results were justified by theoretical and empirical support to retain these items (Hair et al., 2017; Hair et al., 2011). Hence, the formative model was validated.

Reflective Model Analysis

In the reflective measurement model, knowqual_4 item was deleted because of low loading (0.584), which was below 0.7; recqual_2 and effuse_1 items were retained because their loadings were close to 0.7 (Hair et al., 2017), as tabulated in Table 2. The value of composite reliability (CR) for every variable was above 0.7, and the value of average variance extracted (AVE) for each measuring variable was higher than 0.5 (Hair et al., 2017), indicating sufficient convergent validity (Hair et al., 2011).

The assessment continued with the discriminant validity in Heterotrait–Monotrait, which showed that every variable scored below a threshold of 0.85 (Table 3), thus confirming no highly correlated variables to indicate no discriminant validity problem (Hair et al., 2017; Henseler et al., 2014). Hence, the reflective model was validated.

Analysis of Mediation Effects

The analysis of mediation effects was performed with and without the mediator for every proposed hypothesis in the PLS-SEM. Using the same bootstrapping procedure (5000 subsamples, no sign changes and complete bootstrapping settings), the results indicated that the indirect effects among the measured independent variables, mediator, and dependent variable were statistically significant (Table 4).

The estimated path model suggested that Effective Use mediated the positive relationship between System Quality, Records Quality, Service Quality, Knowledge Quality and Clinician Performance at the 1% level (Figure 2). This mediation had a partial effect when three direct effects among the variable relationships were statistically significant (Hair et al., 2017). The predictive power (R^2) of clinician performance increased when a mediator of Effective Use was included in the analysis. Two variables that had the strongest effect on EHR system user performance in the path model with the presence of mediator were records quality (path = 0.087, $p < 0.01$) and service quality (path = 0.084, $p < 0.01$). Overall, all proposed hypotheses (H1, H2, H3, and H4) were empirically supported.

Table 1
Significance assessment for outer weights and loadings

Component	Item/Indicator & Source	Outer Weights	*t*-Value	Sig.	Outer Loadings	*t*-Value	Sig.
Adequate IT Infrastructure	adin_1: Faster network access is critical for me to use HIS (Gray, 2014).	0.160	1.937	*	0.558	10.099	***
	adin_2: Adequate computer hardware is critical for me to use HIS (Gray, 2014).	0.085	1.127	NS	0.501	9.042	***
System Interoperability	sysi_1: I only need to enter and save data once, then use the system with multiple HIS (Salleh et al., 2016).	0.083	1.802	*	0.481	9.875	***
	sysi_2: The cost for patient's treatment is reduced with the use of HIS (Mansoor & Majeed, 2010).	0.123	2.555	**	0.456	9.110	***
	sysi_3: The connection between different HISs is critical to enable coordinated patient care (Salleh et al., 2016).	0.091	1.774	*	0.477	8.832	***
Perceived Security Concerns	secc_1: I believe my HIS does not allow unauthorized access (Yousafzai et al., 2009).	-0.021	0.354	NS	0.460	9.203	***
	secc_2: I believe my HIS protects patient's information (Salleh et al., 2016).	0.078	0.955	NS	0.536	11.539	***
	secc_3: I believe my HIS has a robust security control (Salleh et al., 2016).	0.038	0.480	NS	0.561	12.099	***
	secc_4: I feel secure and safe using HIS (Salleh et al., 2016).	0.174	2.206	**	0.653	14.959	***
System Compatibility	syscom_1: HIS fits my workflows (Salleh et al., 2016).	0.197	2.414	**	0.786	20.227	***
	syscom_2: HIS fits the way I work and my work styles (Tulu et al., 2006).	0.266	3.135	***	0.820	24.014	***
	syscom_3: HIS fits my clinical practices (Tulu et al., 2006).	0.133	1.722	*	0.780	22.208	***
	syscom_4: HIS fits my patients' needs (Salleh et al., 2016).	0.115	1.545	NS	0.736	17.504	***

Note. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$, NS = Not Significant

Table 2
Convergent validity for reflective measures

Variable	Item/Indicator and source	Loadings	CR	AVE
Records quality	recqual_1: Access to EHRs is timely (DeLone & McLean, 2003).	0.728	0.875	0.539
	recqual_2: EHRs are consistent when viewing from other computers (DeLone & McLean, 2003).	0.668		
	recqual_3: EHRs are available in a standardized format (Self-developed).	0.788		
	recqual_4: EHRs are accurate (DeLone & McLean, 2003).	0.780		
	recqual_5: EHRs avoid duplication of diagnostic tests (Self-developed).	0.735		
	recqual_6: EHRs are complete (DeLone & McLean, 2003).	0.700		
Service quality	servqual_1: IT support staff/vendor provides quick assistance when I face problems with HIS (DeLone & McLean, 2003).	0.834	0.900	0.691
	servqual_2: IT support staff/vendor is always able to solve my problems with HIS (Self-developed).	0.847		
	servqual_3: IT support staff/vendor provides follow-up service to HIS users like me (DeLone & McLean, 2003).	0.832		
	servqual_4: IT support staff/vendor provides adequate training for me to use HIS (Self-developed).	0.813		
Knowledge quality	knowqual_1: HIS is useful for learning new medical knowledge (Chang et al., 2012; Wu & Wang, 2006).	0.821	0.911	0.597
	knowqual_2: HIS is useful when researching or creating new medical knowledge (Chang et al., 2012; Wu & Wang, 2006).	0.819		
	knowqual_3: HIS is helpful when applying medical knowledge to my tasks (Chang et al., 2012; Wu & Wang, 2006).	0.850		
	knowqual_5: HIS provides knowledge that increases my ability to make clinical decisions (Self-developed).	0.728		
	knowqual_6: HIS provides knowledge that improves my ability to solve clinical problems (Self-developed).	0.781		
	knowqual_7: HIS provides a complete medical source that I can refer to for more information (Chang et al., 2012; Wu & Wang, 2006).	0.793		
Effective use	effuse_1: HIS enables me to complete my tasks successfully in a few easy steps (Self-developed).	0.694	0.845	0.648
	effuse_2: HIS allows me to prevent misdiagnosis (Self-developed).	0.864		
	effuse_3: HIS allows me to provide the right medications to patients (Self-developed).	0.845		
Clinician performance	clperf_1: HIS increases my time with patients (Self-developed).	0.810	0.902	0.698
	clperf_2: HIS enhances the safety of patient care (Self-developed).	0.816		
	clperf_3: HIS increases my work productivity (DeLone & McLean, 2003).	0.884		
	clperf_4: HIS increases my chances of obtaining better annual performance marks (Self-developed).	0.830		

Table 3
Discriminant validity for reflective measures

Variable	*Clinician performance*	*Effective use*	*Knowledge quality*	*Records quality*	*Service quality*
Clinician performance					
Effective use	**0.540**				
Knowledge quality	0.834	**0.476**			
Records quality	0.721	0.545	**0.698**		
Service quality	0.598	0.341	0.545	**0.464**	

Note. AVE values are on the bolded diagonal.

Table 4
Bootstrapping results for mediation effects

Hypothesis/ Relationship	**Direct effect without mediator *(IV -> DV)***	***R²***	**Direct effect with mediator *(IV -> MV)***	**Direct effect with mediator *(MV -> DV)***	***R²***	**Indirect effect with mediator *(IV -> MV -> DV)***	**Effect size**
H1: System Quality -> Effective Use -> Clinician Performance	0.559 (16.756***)	0.408	0.489 (15.600***)	0.153 (4.624***)	0.420	0.075 (4.322***)	Partial
H2: Records Quality -> Effective Use -> Clinician Performance	0.524 (16.304***)	0.375	0.421 (12.810***)	0.206 (6.253***)	0.408	0.087 (5.605***)	Partial
H3: Service Quality -> Effective Use -> Clinician Performance	0.427 (11.721***)	0.262	0.267 (6.896***)	0.313 (9.513***)	0.352	0.084 (5.752***)	Partial
H4: Knowledge Quality -> Effective Use -> Clinician Performance	0.688 (25.114***)	0.563	0.384 (11.255***)	0.161 (5.577***)	0.584	0.062 (5.067***)	Partial

Note: *** $p < 0.01$.

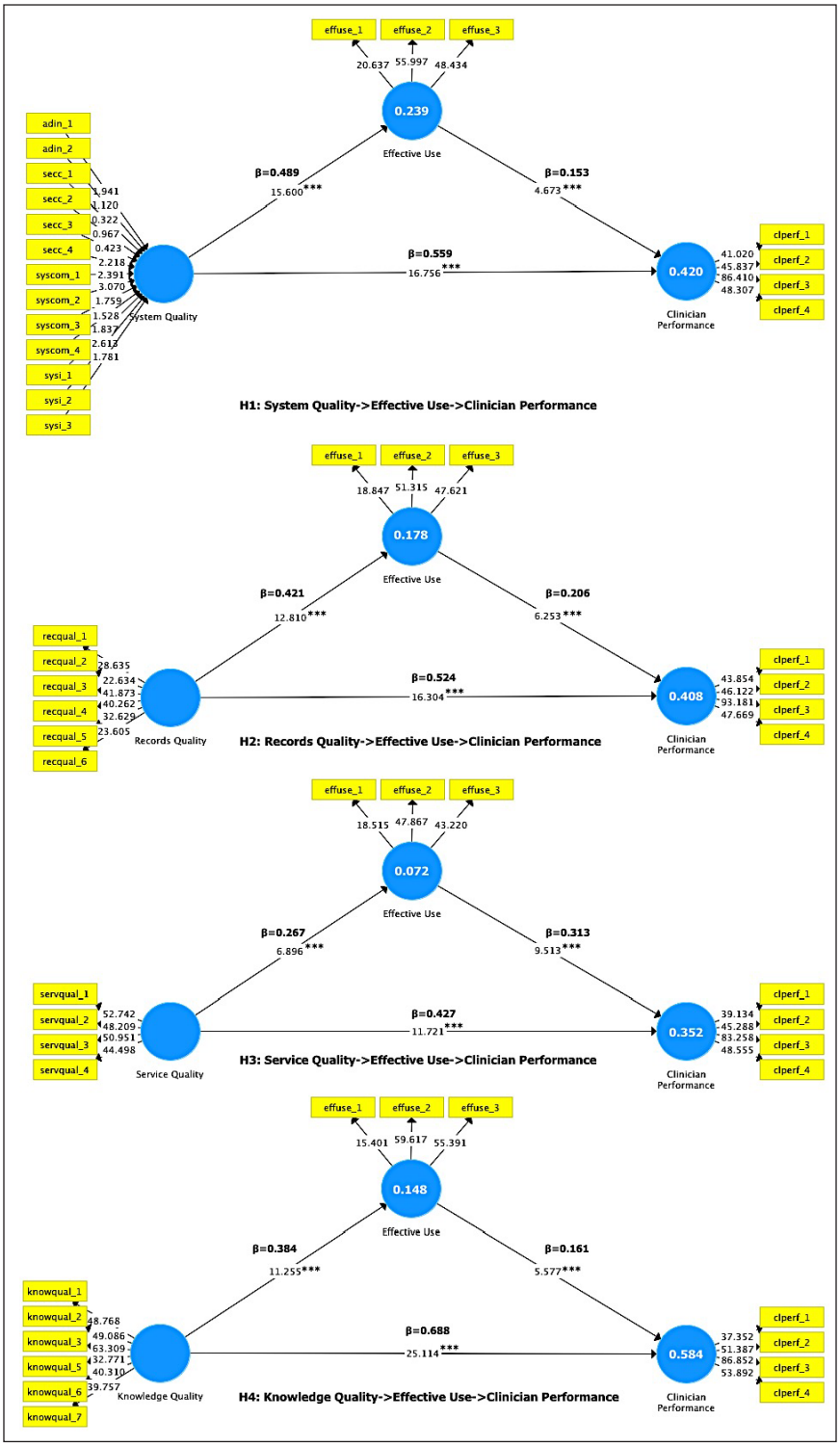

Figure 2. Path models of mediation analysis

DISCUSSION

The findings revealed that Effective Use of HIS became the trigger that caused a positive effect on system quality, records quality, service quality, and knowledge quality in driving clinician performance. In other words, system quality, records quality, service quality, and knowledge quality caused high clinician performance through the effective HIS usage, which increased the predictive power of this outcome variable. Based on the survey outputs, clinicians reported that HISs enabled them to complete their tasks successfully by following a few easy steps. The benefits gained from the system included simplified search and retrieval of patients' medical histories, well-structured contents and reduced spelling errors in data entry with the autocomplete feature, which increased the quality of EHRs and effective use.

By contrast, the quality of technical support service increased due to the efficient follow-up activities of HIS vendors, thus confirming that user-reported problems like faulty computers and printers were fully resolved. In addition, HIS was easily customised with the creation of new fields, note templates and reports, combined with timely access to various types of health records with a single-click and the integration of computerised drug order entry and decision support tools. These tools assisted clinicians in making sound clinical decisions by preventing misdiagnosis and inaccurate prescriptions. These knowledge tools automatically generated alerts for allergies of patients to certain drugs or any reactions to clinical procedures when the HIS stored a complete medical history in an EHR. In turn, the use of such tools increased effective use and eventually improved the task productivity of clinicians.

The results are also consistent with those of the relevant past studies. Efficient HIS utilisation is predicted by functional coverage, significant investigation, and ease of use, which are associated with the performance benefits of physicians (Handayani et al., 2018; Raymond et al., 2015). Effective HIS use also decreases the time required to perform clinical tasks, reduced operational costs, and increased the productivity of care providers by preventing medical errors, thus ensuring the quality of medical services (Bawack & Kamdjoug, 2018; Sultan et al., 2014). Effective system use increases the productivity and satisfaction of individual staff requirements, motivated the staff to fully utilise system capabilities and fosters collaboration among interdisciplinary working groups, including clinicians, non-clinicians, and patients (Hoerbst & Schweitzer, 2015). Besides, clinical staffs with positive experiences in HIS are highly satisfied with its operational reliability, response time, login, and support. Acceptable performance is expected from staff with positive experiences in HIS; such experiences included high satisfaction, changes in work processes and future benefits, such as increased loyalty of patients and good hospital reputation (Bossen et al., 2013). In one Malaysian tertiary care centre, clinicians showed effective and high task performance by

using time-saving tools in HIS, such as auto-charting and rapid decision making with analytical aids. System usage also enhanced the efficiency of clinicians by reducing resource consumption and enabling health records access, capture, and management with automated tools. The quality of patient care increases when clinicians devote time with patients and become much IT savvy in system configuration (Salahuddin et al., 2018; Yusof, 2015). In addition, good quality staff training, constant technical assistance, and support service for computers and networks are critical IS services to promote EHR adoption and significant user performance (Nguyen et al., 2014).

CONCLUSION

This study investigates and tests an improved model that contains five contributing predictors of HIS user performance (system quality, records quality, service quality, knowledge quality, and effective use). In the local clinical context, the model focuses the importance of measuring predictors for contributing to an effective use of HIS. This is because of the facts that ease of HIS usage, fast records access and retrieval, better quality of EHR presentation and consistency, efficient technical support, and able to learn and research from HIS have enabled clinicians to complete their tasks timely and accurately thus, minimizing diagnosis and prescription errors. PLS is employed for data analysis that offers special uniqueness to the empirical work. In this sense, effect size between the measuring independent variables with the presence of a mediator is demonstrated, suggesting the importance of effective use as the main function and feature of HIS when its adoption is mandatory.

The present study provided theoretical implications to academic scholars and researchers. Effective Use as an improved dimension with new items should be integrated into the existing DeLone and McLean model in the mandatory setting because it can assist in preventing diagnosis and medication errors that eventually increased the task performance of clinicians. In the hypothesized research model, two variables have been validated empirically as the strongest predictors of clinicians' performance are records quality and service quality. Higher performance can be expected from those clinicians who are benefits from the quality of EHR usage and technical support from vendors when they faced problems with the systems. Overall, the findings show that system quality, records quality, service quality, and knowledge quality significantly improve the effective use of HISs that eventually increase clinicians' performance and therefore, effective use should be integrated into the future theoretical framework for any HIS evaluation or critical success factors study.

This study also provided practical implications for hospitals and clinicians. In particular, the findings can provide insights for the Ministry and hospitals with HISs to consider effective use functions concerning user-friendly interface with intelligent tools to assist better diagnosis and medication for future upgrades or a new implementation at

other health facilities. Hence, HIS vendors should design system functions and features in both patient and pharmacy modules that can support clinicians in performing their tasks successfully without any data entry errors, apart from improving drug order entry and decision support tools to prevent misdiagnosis and medication errors efficiently. Since EHR quality and service quality were singled out as the most contributing factors for HIS user performance, it is critical for the vendors to provide onsite or personal training to newly graduated clinicians as well as to appoint more experienced system users from senior clinicians or specialists to instruct the junior clinicians in writing EHR documentation completely and accurately that will allow for better patient care. If seniors train juniors effectively in the use of EHR systems and demonstrate the best practices aligned with clinical workflows, they will continue to use the systems and promote to their colleagues at other hospitals without systems. For beginners, the interactive video tutorial, which supplies only required clinical functions and features to be used by clinicians for EHR documentation can be provided in the systems. Thus, taking into account the importance of knowledge quality, further upgrades can be improved by installing data analytics tool so that the incidence reporting and statistics by different clinics can be easily generated in real-time that will enable clinicians to learn and improve their diagnosis and examination. When they can learn and conduct research via the use of EHR systems, the Ministry should provide more clinical research grants to produce more medical scholars.

The study however is not without limitations. Firstly, the mediation model did not include the clinicians' profiles like years of clinical practice and experience using HIS that could predict the mediating effect of user performance between quality predictors (system quality, records quality, service quality, knowledge quality) and effective use. Secondly, the study data was gathered using a cross-sectional survey at a particular point in time. Thirdly, the research was conducted in a single country. Fourthly, there were only two clinician groups engaged as the respondents. To address these, future research can replicate the current study by conducting a longitudinal full-scale HIS evaluation study that extends the samples to specialists, pathologists, pharmacists, imaging officers, laboratory technologists, and radiologists in other Asian health systems because they are also HIS users with different demographic groups with different perceptions and levels of performance. To increase mediation effects for future models, effective HIS use can be further investigated to enhance the performance of clinicians in terms of task completion, misdiagnosis prevention, and accurate medication by different clinical specialties. Considering that the generalization of study results and limited access to clinics have also been identified as the study limitations, future researchers should plan a much effective strategy, such as the distribution of surveys during HIS training or medical education programs that are commonly attended by

large groups of clinicians from various professions, in conducting random sampling from busy hospital environments. To the best of our knowledge, our study was the first to investigate the effects of high-quality HIS, EHRs, IT support service, and clinical knowledge on enhancing the performance of multiple clinicians in different Malaysian health institutions by integrating effective use.

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REFERENCES

Abu Bakar, N. 'Aishah, Khalid, K. H., Abu Bakar, A. M., & Nahar, N. (2017). *e-IR Report 2017*. Putrajaya, Malaysia: Patient Safety Unit, Ministry of Health Malaysia. Retrieved May 15, 2018, from http://patientsafety.moh.gov.my/v2/?page_id=486

Adams, S. L. (2015). *Nurses knowledge, skills, and attitude toward electronic health records (EHR)*. Retrieved October 28, 2016, from http://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=1874&context=dissertations

Bae, J., & Encinosa, W. E. (2016). National estimates of the impact of electronic health records on the workload of primary care physicians. *BMC Health Services Research*, *16*(1), 172-182. https://doi.org/10.1186/s12913-016-1422-6

Balappanavar, A. Y., Sardana, V., Nagesh, L., Ankola, A. V., Kakodkar, P., & Hebbal, M. (2011). Questionnaire vs clinical surveys: The right choice-A cross-sectional comparative study. *Indian Journal of Dental Research*, *22*(3), 494. https://doi.org/10.4103/0970-9290.87081

Bawack, R. E., & Kamdjoug, J. R. K. (2018). Adequacy of UTAUT in clinician adoption of health information systems in developing countries: The case of Cameroon. *International Journal of Medical Informatics*, *109*(October 2017), 15-22. https://doi.org/10.1016/j.ijmedinf.2017.10.016

Bossen, C., Jensen, L. G., & Udsen, F. W. (2013). Evaluation of a comprehensive EHR based on the DeLone and McLean model for IS success: Approach, results, and success factors. *International Journal of Medical Informatics*, *82*(10), 940-953. https://doi.org/10.1016/j.ijmedinf.2013.05.010

Chang, I.-C., Li, Y.-C., Wu, T.-Y., & Yen, D. C. (2012). Electronic medical record quality and its impact on user satisfaction - Healthcare providers' point of view. *Government Information Quarterly*, *29*(2), 235-242. https://doi.org/10.1016/j.giq.2011.07.006

Cohen, J. F., Coleman, E., & Kangethe, M. J. (2015). An importance-performance analysis of hospital information system attributes: A nurses' perspective. *International Journal of Medical Informatics*, *86*, 82-90. https://doi.org/10.1016/j.ijmedinf.2015.10.010

Conway, J. M., & Lance, C. E. (2010). What reviewers should expect from authors regarding common method bias in organizational research. *Journal of Business and Psychology*, *25*(3), 325-334. https://doi.org/10.1007/s10869-010-9181-6

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, *19*(4), 9-30. Retrieved July 23, 2015, from http://www.tandfonline.com/doi/abs/10.1080/07421222.2003.11045748

El-Kareh, R., Hasan, O., & Schiff, G. D. (2013). Use of health information technology to reduce diagnostic errors. *BMJ Quality & Safety*, *22 Suppl 2*(August), ii40-ii51. https://doi.org/10.1136/bmjqs-2013-001884

Gray, C. (2014). *Electronic health record systems in a centralized computing services environment: Critical success factors for implementation* (Doctoral dissertation, Robert Morris University, USA). Retrieved March 11, 2015, from http://www.proquest.com (UMI Number: 3628910)

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). Thousand Oaks, USA: SAGE Publications, Inc.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *The Journal of Marketing Theory and Practice*, *19*(2), 139-152. https://doi.org/10.2753/MTP1069-6679190202

Handayani, P. W., Hidayanto, A. N., & Budi, I. (2018). User acceptance factors of hospital information systems and related technologies: Systematic review. *Informatics for Health and Social Care, 43*(4), 401-426. https://doi.org/10.1080/17538157.2017.1353999

Henseler, J., Ringle, C. M., & Sarstedt, M. (2014). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43*(1), 115-135. https://doi.org/10.1007/s11747-014-0403-8

Hoerbst, A., & Schweitzer, M. (2015). A systematic investigation on barriers and critical success factors for clinical information systems in integrated care settings. *IMIA Yearbook*, *10*(1), 79-79. https://doi.org/10.15265/IY-2015-018

Khajouei, R., Abbasi, R., & Mirzaee, M. (2018). Errors and causes of communication failures from hospital information systems to electronic health record: A record-review study. *International Journal of Medical Informatics*, *119*(January), 47-53. https://doi.org/10.1016/j.ijmedinf.2018.09.004

Kuipers, B. (2016). *Evaluation of a hospital information system (HIS) implementation success from a users' perspective: A mixed method research* (Master's thesis, University Utrecht, Netherlands). Retrieved February 26, 2017, from https://dspace.library.uu.nl/handle/1874/327512

Li, F. (2014). *A framework for examining relationships among electronic health record (EHR) system design, implementation, physicians' work impact* (Doctoral dissertation). Available from University of Southern California Digital Library. (Filename etd-LiFei-2408)

Mansoor, M. M. E., & Majeed, R. (2010). *Achieving interoperability among healthcare organizations* (Master's thesis, Blekinge Institute of Technology, Sweden). Retrieved July 23, 2015, from https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A831672&dswid=-164

McGill, T., Hobbs, V., & Klobas, J. (2003). User developed applications and information systems success: A test of DeLone and McLean's model. *Information Resources Management Journal*, *16*(1), 24-45. Retrieved March 14, 2015, from http://www.igi-global.com/article/information-resources-management-journal-irmj/1235

Musa, P. F., Mwangi, R., & Key, S. (2016). A research outline to explore the benefits of health information systems on outcomes for cardiovascular diseases in Sub-Saharan Africa: Focus on Kenya. *AshEse Journal of Health and Social Care*, *1*(1), 001-015.

Nguyen, L., Bellucci, E., & Nguyen, L. T. (2014). Electronic health records implementation: An evaluation of information system impact and contingency factors. *International Journal of Medical Informatics*, *83*(11), 779-796. https://doi.org/10.1016/j.ijmedinf.2014.06.011

Rajasekar, H. (2015). An evaluation of success of electronic health records in reducing preventable medical error rates in the United States: A detailed report. *Journal of Health & Medical Informatics*, *6*(6), 1-6. https://doi.org/10.4172/2157-7420.1000210

Raymond, L., Paré, G., de Guinea, A., Poba-Nzaou, P., Trudel, M.-C., Marsan, J., & Micheneau, T. (2015). Improving performance in medical practices through the extended use of electronic medical record systems: A survey of Canadian family physicians. *BMC Medical Informatics and Decision Making*, *15*(1), 1-15. https://doi.org/10.1186/s12911-015-0152-8

Sadoughi, F., Karami, M., Mousavi, G. A., & Karimi, A. (2016). The effect of information technology on healthcare improvement from clinicians' perspective. *Global Journal of Health Science*, *9*(3), 128-137. https://doi.org/10.5539/gjhs.v9n3p128

Salahuddin, L., & Ismail, Z. (2018). Hospital information systems (HIS) in the examination rooms and wards: Doctors perceived positive impact on quality of care and patient safety. *International Journal of Engineering & Technology*, *7*(2.29), 871-875.

Salahuddin, L., Ismail, Z., Hashim, U. R., Ikram, R. R. R., Ismail, N. H., & Mohayat, M. H. N. (2018). Sociotechnical factors influencing unsafe use of hospital information systems: A qualitative study in Malaysian government hospitals. *Health Informatics Journal*, 336-343. https://doi.org/10.1177/1460458218759698

Salleh, M. I. M., Abdullah, R., & Zakaria, N. (2017). Extending Health Information System Evaluation with an Importance-Performance Map Analysis. In U. Comite (Ed.), *Advances in Health Management* (pp. 3355). InTech Open. https://doi.org/10.5772/68122

Salleh, M. I. M., Zakaria, N., & Abdullah, R. (2016). The influence of system quality characteristics on health care providers' performance: Empirical evidence from Malaysia. *Journal of Infection and Public Health*, *9*(6), 698-707. https://doi.org/10.1016/j.jiph.2016.09.002

Sedera, D., & Gable, G. (2004). A factor and structural equation analysis of the enterprise systems success measurement model. In *Twenty-Fifth International Conference on Information Systems Proceedings* (pp. 449-464). Association for Information Systems. Retrieved March 14, 2015, from http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1124&context=icis2004

Shemeikka, T., Bastholm-Rahmner, P., Elinder, C.-G., Vég, A., Törnqvist, E., Cornelius, B., & Korkmaz, S. (2015). A health record integrated clinical decision support system to support prescriptions of pharmaceutical drugs in patients with reduced renal function: Design, development and proof of concept. *International Journal of Medical Informatics*, *84*(6), 387-395. https://doi.org/10.1016/j.ijmedinf.2015.02.005

Shimizu, T., Nemoto, T., & Tokuda, Y. (2018). Effectiveness of a clinical knowledge support system for reducing diagnostic errors in outpatient care in Japan: A retrospective study. *International Journal of Medical Informatics*, *109*, 1-4. https://doi.org/10.1016/j.ijmedinf.2017.09.010

Smith, O., Santiago, C., Butorac, E., Bell, K., Diston, M. T., Lewis, E., & Wannamaker, K. (2016). Nurse satisfaction with medication management before and after introduction of an electronic medication system in the intensive care unit. *Canadian Journal of Critical Care Nursing*, *27*(2), 42-43.

Strudwick, G., Booth, R., & Mistry, K. (2016). Can social cognitive theories help us understand nurses' use of electronic health records? *CIN: Computers, Informatics, Nursing*, *34*(4), 169-174. https://doi.org/10.1097/CIN.0000000000000226

Sultan, F., Aziz, M. T., Khokhar, I., Qadri, H., Abbas, M., Mukhtar, A., … Yusuf, M. A. (2014).

Development of an in-house hospital information system in a hospital in Pakistan. *International Journal of Medical Informatics*, *83*(3), 180-188. https://doi.org/10.1016/j.ijmedinf.2013.12.004

Tsai, H. H., Chiou, S. F., Wang, T. C., Wu, M. P., & Feng, R. C. (2016). An empirical study of the successful implementation of nursing information system. *Studies in Health Technology and Informatics*, *225*, 846-847. https://doi.org/10.3233/978-1-61499-658-3-846

Tsai, J., & Hung, S. (2016). Determinants of knowledge management system adoption in healthcare. *Journal of Organizational Computing and Electronic Commerce*, 2-58. https://doi.org/10.1080/10919392.2016.1194062

Tulu, B., Burkhard, R., & Horan, T. (2006). Information systems and health care xiv: Continuing use of medical information systems by medical professionals: Empirical evaluation of a work system model. *Communications of the Association for Information Systems*, *18*(1), 641-656. Retrieved August 18, 2016, from http://aisel.aisnet.org/cgi/viewcontent.cgi?article=3102&context=cais

Walsh, J. N., Knight, M., & Lee, A. J. (2018). Diagnostic errors: Impact of an educational intervention on pediatric primary care. *Journal of Pediatric Health Care*, *32*(1), 53-62. https://doi.org/10.1016/j.pedhc.2017.07.004

Wu, J.-H. J.-. H., & Wang, Y.-M. Y.-. M. (2006). Measuring KMS success: A respecification of the DeLone and McLean's model. *Information & Management*, *43*(6), 728-739. https://doi.org/10.1016/j.im.2006.05.002

Yousafzai, S., Pallister, J., & Foxall, G. (2009). Multi-dimensional role of trust in Internet banking adoption. *The Service Industries Journal*, *29*(5), 591-605. https://doi.org/10.1080/02642060902719958

Yusof, M., & Sahroni, M. N. (2018). Investigating health information systems-induced errors. *International Journal of Health Care Quality Assurance*, *31*(8), 1014-1029. https://doi.org/10.1108/IJHCQA-07-2017-0125

Yusof, M. M. (2015). A case study evaluation of a critical care information system adoption using the socio-technical and fit approach. *International Journal of Medical Informatics*, *84*(7), 486-499. https://doi.org/10.1016/j.ijmedinf.2015.03.001

Yusof, M. M., Kuljis, J., Papazafeiropoulou, A., & Stergioulas, L. K. (2008). An evaluation framework for health information systems: Human, organization and technology-fit factors (HOT-fit). *International Journal of Medical Informatics*, *77*(6), 386-398. https://doi.org/10.1016/j.ijmedinf.2007.08.011