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A Quantitative Study Using the ACC-PH Framework: Factors Affecting Cloud Computing Adoption in Saudi Private Hospitals

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***Abstract*—Private hospitals aim to provide essential healthcare services while focusing on profit and income growth. They are turning to innovative solutions to enhance medical services efficiency while reducing costs. Cloud computing has arisen as an ideal option, allowing private hospitals to access advanced digital health services without heavy infrastructure investments. Yet, in Saudi private hospitals, the adoption of Cloud computing is remarkably low. Therefore, in this study, we surveyed 650 managers and administrative staff from Saudi private hospitals, using our previously proposed ACC-PH framework to assess factors influencing Cloud computing adoption from technological, organisational, and environmental perspectives. The data were analysed using IBM-SPSS and AMOSvr29. The results revealed the positive influence of 12 out of 13 examined factors. The findings are significant in guiding decision-makers in Saudi private hospitals to establish effective strategies for implementing Cloud computing. These strategies can enable easier adoption of Cloud computing in this essential industry.**

***Index Terms*—Cloud computing adoption, Saudi Arabia, private hospitals.**

I. Introduction

THE private healthcare industry in Saudi Arabia, especially private hospitals, is encountering significant challenges. Recent statistics from Saudi's Ministry of Health indicate that approximately 43% of the country's population receives healthcare services from private hospitals [1]. However, despite serving a large segment of the population, Saudi private hospitals grapple with the challenge of maintaining profitable returns while simultaneously providing high-quality medical services [2]. Therefore, Saudi private hospitals should consider creative solutions to balance delivering advanced healthcare and meeting their economic objectives. This pressing need for balance underscores the potential benefits of incorporating technological solutions, such as Electronic Health (E-Health) systems.

E-Health systems play a pivotal role in elevating the quality of healthcare services in private hospitals, but they also raise economic challenges. E-Health systems can streamline patient data management, enhance diagnostic accuracy, and enable more efficient treatment processes [3], [4]. However, the implementation and maintenance of E-Health systems can be financially demanding. The initial investment in technological infrastructure, ongoing operational costs, and the need for specialised technicians to manage these systems contribute to increased expenses [5], [6]. As a result, this can negatively impact the profitability of private hospitals. Consequently, balancing the benefits of improved healthcare quality with the financial implications remains an enormous hurdle for private healthcare institutions. Therefore, cost-effective, innovative technologies such as Cloud computing can ease this hurdle.

Cloud computing offers an innovative solution that boosts private hospitals' performance efficiency at a lower cost. Cloud computing revolves around utilising electronic services from external providers, eliminating the necessity for costly technological infrastructure, maintenance expenses and in-house technical experts [7]. Hence, Cloud computing plays a crucial role in cost reduction and boosting the profitability of private hospitals. In addition to cost-effectiveness, Cloud computing offers superior E-health services compared to traditional E-health solutions. That is due to its greater scalability and enhanced ability to manage large volumes of health data [8]. Thus, Cloud computing can significantly increase the effectiveness of E-health services, leading to improved healthcare service quality. However, does Cloud computing also raise some associated concerns?

Yes, Cloud computing may present data security challenges, yet recommended strategies are available to address these issues. According to [9], patient data stored in the Cloud is considered less secure. The primary concern threatening patient data in the Cloud is unauthorised access, as the data are exposed to various platforms [10]. However, to address these concerns, [11] suggests implementing robust security protocols, which can safely leverage the benefits of Cloud computing in E-Health systems.

Implementing these robust security protocols mitigates risks and paves the way for Cloud computing to revolutionise healthcare delivery. Therefore, with Cloud computing succeeding in addressing high-quality versus low-cost challenges, the ability to provide optimal healthcare services at reduced costs is now within the reach of Saudi private hospitals.

Nevertheless, despite these promising developments, the adoption of Cloud technology in Saudi private hospitals is still behind. The literature shows that among various sectors in Saudi Arabia, the healthcare sector, involving private hospitals, has the lowest usage of Cloud computing [12]. It is a phenomenon that highlights the necessity to investigate the affecting factors.

Prior research has shed light on factors that affect the adoption of Cloud computing across healthcare institutions in Saudi Arabia [13], [14], [15], [16]. Although previous studies reveal important effective factors, there is a gap in the literature that exclusively addresses the Saudi private healthcare sector, particularly private hospitals.

Therefore, focusing research on Saudi private hospitals' unique dual goals of quality healthcare service delivery and economic growth can yield distinctive insights not seen in the public sector. Such targeted research could produce more relevant findings that are vital for enabling decision-makers in these institutions to adopt Cloud computing.

Consequently, our paper aims to assist Saudi private hospital decision-makers in formulating suitable strategies for implementing Cloud computing by determining adoption influencing factors. Initially, the paper presents a review of relevant literature and outlines the foundational framework of this study. Following this, the paper delves into the data collection and analysis methodology. The research then provides details on the study's findings, leading to a discussion section that evaluates these results within the broader research field. Finally, in the conclusion, the paper lays the groundwork for our related future research work.

II. Literature Review

In Saudi Arabia, studies have investigated the impact of factors from various contexts on adopting Cloud computing in the healthcare sector. A study by [16] targeted Saudi public and private healthcare institutions to investigate technological, organisational, environmental, human, and business factors. Another study targeted the same population but only investigated factors from a technological context, which was carried out by [14]. The third study in the research field focused on Saudi university hospitals in Riyadh City, investigating the influence of the contexts of technology, organisation, environment, and decision-making on the adoption of Cloud computing [13]. The last and most recent study targeted Saudi hospitals without specifying public or private, focusing on influences on the adoption of Cloud computing from human, organisational, environmental, and technological contexts [15]. A clear gap can be identified after reviewing the related studies in the literature.

The scarcity of these studies indicates a notable lack of research, specifically research that exclusively targets the private healthcare sector in Saudi Arabia. Traditionally, research may have concentrated more on public institutions due to their accessibility, public funding transparency, and the broader impact on national health policy. That often leaves private sectors less inspected. The lack of specific focus on private hospitals is significant, as these entities frequently implement technology differently than public institutions, potentially leading to varied adoption rates and challenges. That is a substantial gap in the literature which needs to be filled. It underscores the urgency for targeted research; fortunately, the existing studies provide a robust foundation that can guide in-depth exploration of how healthcare institutions in Saudi Arabia can effectively adopt Cloud computing technologies.

Based on these foundations, four key technological factors have emerged as particularly influential in the adoption of Cloud systems within Saudi's healthcare sector: Compatibility, as defined by studies [13], [14], [15], assesses how well the prospective technology aligns with an organisation's existing values and operations. Although not a focus of the study [16], this factor showed a substantial impact in other studies. Security, which relates to the effectiveness of Cloud providers in protecting data, was notably emphasised in studies [14] and [15]. Relative Advantage evaluates the additional benefits a hospital gains through Cloud computing and was highlighted as significant in studies [13] and [16]. Reliability, which involves the system's ability to perform anticipated tasks effectively and securely, was exclusively studied in [14] and found to have a considerable impact.

In addition, factors including Top Management Support, Prior Experience, Organizational Readiness, Attitude towards Change, and Cost Analysis were found in previous studies to be the most impactful from an organisational perspective. Top Management Support was explored in studies [13], [15], [16] with findings indicating that leadership significantly drives Cloud adoption by allocating necessary resources. Also, research [13] showed that the prior technological experiences of top managers in Saudi healthcare organisations (Prior Experience) significantly influenced their decisions to migrate to Cloud-based systems. Moreover, the study [15] noted the critical role of Organizational Readiness, referring to the role of human, technological, and financial resources in facilitating Cloud adoption.

Furthermore, Attitude towards Change and Cost Analysis are key organisational factors confirmed by studies [14], [16]. While the study [14] examined Attitude towards Change under technological factors, we argue that since this factor assesses the impact of employees' beliefs about Cloud computing on adoption, it should be regarded as part of the organisational context, considering employees as human resources. Similarly, the Cost Analysis factor demonstrated its significant impact in the study [16] within a business context. It involves a comprehensive cost versus-benefits analysis of Cloud adoption that influences decision-making. We emphasise that the Cost Analysis factor, as performed by relevant employees within healthcare organisations, should also be classified under the organisational context, underscoring its role in shaping strategic decisions.

The literature review offered insights into these five factors that fall within the organisational context and affect the adoption of Cloud computing in healthcare facilities in Saudi Arabia.

The literature also identified other influencing factors from the environment surrounding Saudi healthcare organisations. One was Competitive Pressure, where decision-makers are urged to match competitors already adopting Cloud computing, as noted in the study [15]. Although the study [13] also examined this factor, it did not find it significantly impactful. Another critical environmental influencer is Rules and Regulations, which was noted considerably in the study [16] as government policies play a decisive role in healthcare centres' decisions to adopt Cloud technologies, unlike in studies [13], [15] where it wasn't as pronounced.

These environmental factors and previously identified technological and organisational ones provide a comprehensive foundation for a new model to evaluate the determinants of Cloud computing adoption in Saudi private hospitals. Building on this, we have developed the ACC-PH framework [17], incorporating these eleven core factors along with two additional critical elements pertinent to technology adoption in developing countries: the availability of Cloud providers and Internet connectivity, which are scarce [18] and limited [19] in Saudi Arabia, respectively. This model consolidates thirteen factors hypothesised to positively influence Cloud adoption in private healthcare settings, as illustrated in Fig. 1.

The ACC-PH model gains its robustness from its foundation on two leading theories of technology adoption: The Model of Diffusion of Innovation (DOI) and The Theory of Technology, Organisation, and Environment (TOE). The ACC-PH theory incorporates two factors from the DOI theory: Relative Advantage and Compatibility. The ACC-PH framework also categorises its factors into the three contexts outlined by TOE: technological, organisational, and environmental. Therefore, the ACC-PH framework is predicted to have a significant theoretical contribution to the research field and practical application in assisting Saudi private hospitals in gaining the benefits of adopting Cloud computing.

To ensure that the theoretical insights of the ACC-PH are effectively translated into practical research actions, the next section will detail the specific approaches and procedures used in the study application. The following methodology section will provide a comprehensive overview of the data collection and analysis techniques for applying the ACC-PH model to our study.

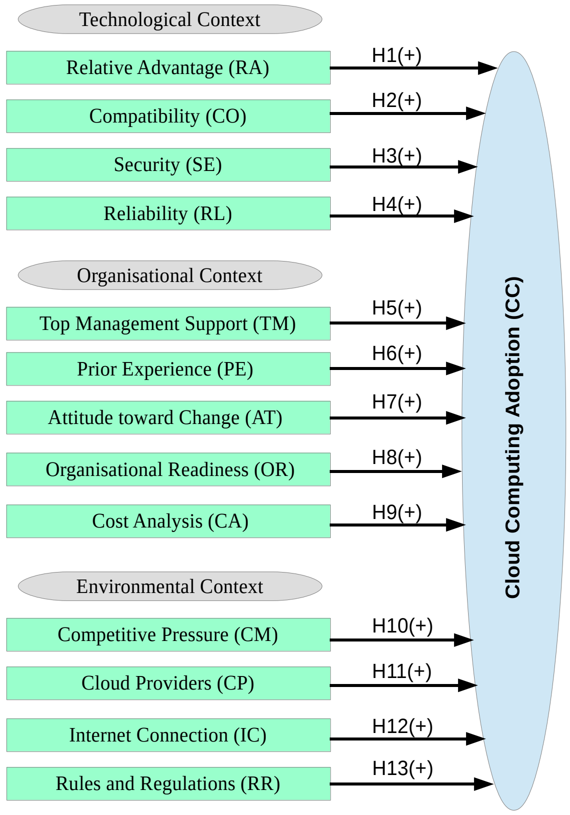

Fig. 1 The Comprehensive Framework for Adopting Cloud Computing in Private Hospitals (ACC-PH) Adapted From [17]

III. Methodology

The research employs a scientific method to thoroughly assess the ACC-PH Framework's suggested factors influencing Cloud computing adoption in Saudi private hospitals. The employed methodology allowed for an efficient exploration of how these factors impact the decision-making processes in healthcare settings.

The approach started with determining the target population. The study targeted managers and administrative staff to ensure a comprehensive evaluation of Cloud computing adoption in Saudi private hospitals. They were specifically chosen as the target population for this study because they are typically the decision-makers regarding implementing new technologies within hospitals. This strategic selection ensures that the survey captures insights from those directly involved in the decision-making process concerning technological adoption. Having identified the key stakeholders for our survey, we next determined the necessary sample size to ensure reliable results.

A standard sample size formula, developed by statisticians, was applied to calculate the sample size, considering the large yet unspecified population size. The available statistics from the Saudi Ministry of Health primarily focused on healthcare professionals like doctors, nurses, and other medical practitioners, without specific details on administrative staff. However, these statistics also revealed that until 2021, there are approximately 115 accredited private hospitals in Saudi Arabia, indicating a substantial population size of administrative employee numbers [1]. Thus, the formula to compute the standard sample size used a confidence level of 95% (Z = 1.96), an error margin of 5% (E = 0.05), and an assumed population proportion, p = 0.5, to ensure the sample size maximisation. The result disclosed the minimum representative sample of administrative staff working in Saudi private hospitals is approximately 384 individuals. As the sample size was firmly established, we carefully crafted the questionnaire to evaluate the various factors influencing Cloud computing adoption.

Comprehensive and transparent questionnaire questions were designed to assess each proposed factor. Four questions (items) were assigned to each factor (latent construct) to prevent the expected exclusion of certain items from affecting the evaluation of the factor in the analysis stage. Various questions were also considered to assess each factor from multiple perspectives. In addition, the survey questions were structured using a 5-point Likert scale, with one representing "Strongly disagree" and five denoting "Strongly agree". After finalising the questionnaire, the focus was on selecting advanced tools for efficient data collection and analysis.

The research methodology included identifying tools for data collection and analysis. Surveys were designed and administered using Qualtrics Core XM software for online data collection. Qualtrics was selected due to its capability to create tailored evaluation instruments and enhance the efficiency of data collection [20]. The surveys were distributed via email, and the collected data were saved in password-protected files on Microsoft OneDrive. In the data analysis phase, we used IBM-SPSS and AMOS version 29. IBM-SPSS and AMOS were explicitly chosen for their advanced capabilities in structural equation modelling, which is essential for effectively analysing the complex interrelations inherent in the comprehensive ACC-PH model. These tools enable precise testing and validation of the model's constructs, ensuring a robust analysis of the data collected [21]. With the data collection and analysis tools set, the next critical step was ensuring all research aspects adhered to the highest ethical standards.

The research was granted ethical clearance by the Sciences & Technology Cross-Schools Research Ethics Committee (C-REC) at the University of Sussex. This approval is documented by the ethical review application number [ER/FA461/2]. The ethical approval came with a guarantee of anonymity and confidentiality for all participants. Participants were assured that their information would be used exclusively for academic purposes and remain confidential. Additionally, the study was designed to ensure that no third parties are involved and that participants' data will not be shared with any external entities. To further protect participant identity, each individual was not asked for personal information but instead assigned a unique identifier, distinguishing their participation while maintaining the anonymity of their contributions.

Following the stringent adherence to ethical standards, the study was well-positioned to proceed into the data analysis phase. The results, derived from the gathered data, are detailed in the following section.

IV. RESULTS

This section presents the study's comprehensive findings. We present the outcomes of the investigation, starting with an exposition of demographic statistical data. It is followed by an evaluation of the construct's reliability and validity. Subsequently, we illustrate the findings derived from the empirical examination of the proposed hypotheses within the ACC-PH framework.

A. Demographic Statistics

Demographic statistics are essential for validating research findings. Describing the characteristics of study participants plays a crucial role in enabling generalisability and ensuring representativeness, thereby improving the overall quality of the research [22]. Demographic statistics provide data like age, gender, education level, and other demographics. Table I. details the demographic results of our study. These details offer a comprehensive breakdown of participant demographics to elucidate the representativeness and diversity observed within the study.

The demographic composition of the 650 participants from Saudi private hospitals surveyed between 15th June 2023 and 15th September 2023 offers insights into the diverse backgrounds represented in the study, including job roles, gender, age, and educational levels. Of these participants, 396 (60.9%) were IT employees, 227 (34.9%) held other administrative roles, and 27 (4.2%) were directors and top managers. Among the participants, 276 (42.5%) were male and 374

TABLE I.
DEMOGRAPHIC STATISTICS FOR THE PARTICIPANTS

Statistic Type	Category	Frequency & Percentage	Statistic Type	Category	Frequency & Percentage
Job Title	IT employees	396 (60.9%)	**Gender**	Male	276 (42.5%)
	Directors	27 (4.2%)		Female	374 (57.5%)
	Other administrative	227 (34.9%)	**Level of Education**	Secondary or less	10 (1.5%)
Age	18-35	468 (72%)		Diploma	66 (10.2%)
	36-45	118 (18.2%)		Bachelor	449 (69.1%)
	46-60	56 (8.6%)		Master	118 (18.1%)
	Over 60	8 (1.2%)		PhD	7 (1.1%)

(57.5%) were female. The age distribution showed a significant majority of younger participants, with 468 (72%) aged between 18 and 35, while 182 (28%) were 36 and above. Educationally, 449 (69.1%) of the participants held a bachelor's degree, followed by 118 (18.1%) with master's degrees, 66 (10.2%) with diplomas, 10 (1.5%) with a secondary school diploma or less, and 7 (1.1%) with Doctoral degrees.

After delineating the demographic profile of the participants, attention was subsequently directed toward verifying the statistical prerequisites necessary for employing Structural Equation Modelling (SEM) in our analysis.

B. *Normality Distribution*

As we utilised Structural Equation Modelling (SEM) to analyse the relationship between observed variables (items) and latent constructs (factors), ensuring the normal distribution of the observed data was crucial. SEM is a parametric statistical technique that yields efficient and reliable estimates when the data are normally distributed [23]. We checked univariate and multivariate outliers, skewness, kurtosis, and standard deviations to verify normality distribution.

Univariate outliers, extreme data points within individual variables, were detected using z-scores; values beyond +/-3.29 are considered outliers. Multivariate outliers were identified across multiple variables using Mahalanobis Distance, with a p-value lower than 0.05 indicative of outliers [24]. The results indicated no univariate outliers, as the maximum z-score was 1.77, and the minimum was -3.11. Similarly, no multivariate outliers were found, as the maximum observed Mahalanobis D-squared value was 23.798, corresponding to a p-value of 0.051.

Additionally, skewness and kurtosis values fell within the acceptable range of +/-2.58, suggested by [25], with the lowest skewness at -0.755, the highest at 0.010, and the maximum and minimum kurtosis values at 0.531 and -0.796, respectively. The standard deviations for all observed variables were close to zero, with a maximum deviation of 1.11 and a minimum of 0.91.

These findings confirmed the normal distribution of the observed data, which was necessary for the SEM analysis of the proposed complex ACC-PH model.

Given the confirmation of data normality, the subsequent analysis moves to examine the model's structural integrity. Specifically, the following section discusses Confirmatory Factor Analysis (CFA), an essential Structural Equation Modelling (SEM) step.

C. *The Confirmatory Factor Analysis (CFA)*

Confirmatory Factor Analysis (CFA) is a crucial initial step in testing hypotheses using the Structural Equation Modelling (SEM) approach. CFA validates proposed models by analysing the interactions between latent constructs and observed variables and provides metrics like standardised factor loadings and latent variable correlations for evaluating the framework's applicability [26]. Therefore, the CFA for our proposed ACC-PH model was designed using AMOS version 29. Thus, with the CFA rigorously set up through AMOS version 29, the following section will detail the outcomes of the measures computed in the CFA, evaluating how well the latent constructs and observed variables align within the ACC-PH model.

D. *Unidimensionality Assessment (Construct Validity)*

Unidimensionality assessment in CFA involves evaluating whether a set of observed variables accurately and appropriately represents a single underlying latent construct, which is essential for maintaining the coherence of measurements related to latent constructs [27]. This verification process is crucial in increasing confidence in the results as the first step in ensuring construct validity [28].

Various methods exist to assess unidimensionality, but standardised factor loading (λ) analysis remains fundamental in confirming that observed variables are sufficient representatives of their respective construct. There is some debate over the standardised factor loading threshold for assessing unidimensionality, with some scholars advocating for a 0.40 threshold (for exploratory studies) [29] while others suggest a stricter 0.60 criterion [28]. This research adopted a more rigorous 0.60 threshold as the standard criterion to accept or reject observed variables.

In implementing these criteria, 14 latent constructs were measured using 56 observed variables in this study, with 55 displaying a standardised loading factor (λ) above 0.60. However, one variable representing the Security (SE) latent construct did not meet the standard criterion with a standardised loading factor (λ) of 0.59 and was therefore omitted from the CFA. This ensured that all remaining variables coherently represent their respective constructs, thereby preserving construct validity. This meticulous approach to variable selection helps preserve construct validity, setting the stage for further validation through additional measures such as Model Fit Indices in CFA.

E. *Model Fit Metrics (Construct Validity)*

Confirmatory Factor Analysis (CFA) is used to further evaluate the construct validity of a measurement model through various model fit metrics/indices. Critical tools such as the Standardised Root Mean Square Residual (SRMR), Chi-Square divided by degrees of freedom (CMIN/DF), Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA) along with its P-Close value, and Goodness of Fit Index (GFI) provide quantitative assessments of how well the model corresponds to the observed data [23], [30]. Each index offers a unique perspective on model fit, addressing different aspects such as discrepancy, incremental fit, and parsimony.

However, interpreting these indices requires caution due to their inherent limitations and potential to yield contradictory outcomes. For instance, indices like CFI and RMSEA are known for their reduced sensitivity to sample size variations, whereas CMIN/DF may be affected by larger sample sizes [23].

TABLE II.
MODEL FIT METRICS

Metric	SRMR		CMIN/DF	IFI	TLI	CFI	RMSEA	P-Close	GFI
Estimate	0.0336		1.372	0.962	0.958	0.962	0.024	1.000	0.901
Threshold	< 0.09 [35]		< 3.0 [25]	> 0.90 [36]	> 0.90 [37]	> 0.90 [37]	< 0.05 [30]	> 0.05 [38]	> 0.90 [39]
Evaluation	Good		Good	Good	Good	Good	Good	Good	Good

Therefore, acknowledging the complexity of accurately capturing a model's fit with a single index is crucial [23]. Thus, a comprehensive evaluation of construct validity necessitates the integration of multiple indices. This study assessed multiple model fit metrics, all remaining within the recommended thresholds, as detailed in Table II.

With the model's fit to the observed data confirmed by multiple indices, the next critical step involves scrutinising Construct Reliability to verify the stability and consistency of our measurement constructs.

F. Construct Reliability

Before further evaluations of construct validity, it is essential to ensure the measurement tool produces stable and consistent results by examining construct reliability. To achieve elevated levels of internal consistency, the variables on a scale must reliably measure the same construct. Specifically, for a construct to be deemed reliable, responses must remain consistent over time [25].

Construct reliability is typically evaluated using two main methods: Cronbach's Alpha (α) and Composite Reliability (CR) [31]. As shown in Table III., the results from these assessments confirmed that both Cronbach's Alpha values and Composite Reliability values exceeded the 0.70 threshold, aligning with [29]'s standards. According to these standards, scores above 0.70 in both Cronbach's Alpha and Composite Reliability indicate adequate construct reliability.

Following the confirmation of construct reliability through Cronbach's Alpha and Composite Reliability, the analysis progresses to assessing Convergent Validity, a critical aspect of Construct Validity, to further validate the coherence and relevance of the constructs within the model.

G. Convergent Validity (Construct Validity)

Convergent validity is a crucial measurement that assesses whether different items or observed variables intended to measure the same construct yield similar outcomes. It aims to confirm that each item accurately measures its intended construct by demonstrating strong correlations with other items that target the same construct [25].

Methods such as the Average Variance Extracted (AVE) and Composite Reliability (CR) are employed to evaluate convergent validity. According to [29], an AVE value of 0.50 or higher indicates good convergent validity. Furthermore, [32] suggests that convergent validity is robust if the CR value exceeds the AVE value, implying that a significant portion of the variance in the items stems from the construct itself rather than from random measurement error.

In this study, as detailed in Table III, the constructs met these stringent criteria, with AVE values exceeding 0.50 and CR values surpassing AVE, thereby affirming the convergent validity of the constructs analysed.

As convergent validity ensures consistency among related items, it is equally crucial to establish the distinctiveness of unrelated items, a measurement to be explored next through Discriminant Validity.

H. Discriminant Validity (Construct Validity)

Discriminant validity is vital for establishing the distinctiveness of constructs within Confirmatory Factor Analysis

TABLE III.
CONSTRUCT RELIABILITY, CONVERGENT VALIDITY, AND DISCRIMINANT VALIDITY

Constructs	α	CR	AVE	MSV	Evaluation
Relative Advantage (RA)	0.869	0.872	0.526	0.081	**Construct Reliability α > 0.70** [29]
Compatibility (CO)	0.798	0.800	0.633	0.023	verified
Security (SE)	0.797	0.799	0.504	0.037	**Construct Reliability CR > 0.70** [29]
Reliability (RL)	0.809	0.810	0.571	0.055	verified
Top Management Support (TM)	0.876	0.877	0.517	0.012	
Prior Experience (PE)	0.806	0.806	0.641	0.023	**Convergent Validity AVE ≥ 0.5** [29]
Attitude toward Change (AT)	0.802	0.803	0.511	0.086	verified
Organisational Readiness (OR)	0.800	0.800	0.506	0.109	**Convergent Validity CR > AVE** [32]
Cost Analysis (CA)	0.806	0.806	0.502	0.080	verified
Competitive Pressure (CM)	0.813	0.814	0.511	0.102	
Cloud Providers (CP)	0.811	0.812	0.524	0.084	**Discriminant Validity AVE > MSV** [32]
Internet Connection (IC)	0.802	0.802	0.520	0.102	verified
Rules and Regulations (RR)	0.815	0.815	0.504	0.081	

(CFA). This form of validity requires that items from unrelated constructs exhibit either no or very low correlations, ensuring that each construct is uniquely captured [25]. There are two primary methods employed to assess discriminant validity.

The first method compares the Average Variance Extracted (AVE) against the Maximum Shared Variance (MSV). To establish discriminant validity, the AVE values for each construct must exceed the corresponding MSV values [32]. Table III. shows that for all latent constructs, the AVE values exceeded the MSV values, thus confirming discriminant validity according to this criterion.

The second method utilises the Fornell-Larcker Criterion, which requires the AVE's square root for each factor to be compared with the correlations or covariances between that factor and others within the model. According to this criterion, discriminant validity is confirmed when the AVE's square root for each factor exceeds any correlation with other factors [33]. The Fornell-Larcker Criterion is typically represented in a correlation matrix, where square roots of AVEs are displayed along the diagonal, and the off-diagonal values denote correlations between constructs. The outcomes of this test, as shown in Table IV, also met the recommended threshold criteria, further validating the discriminant validity of the constructs.

With all measures of Confirmatory Factor Analysis (CFA) affirming the reliability and validity of the constructs, the study now transitions to the next critical phase: building the Structural Equation Modelling (SEM) to thoroughly test the hypotheses.

I. Structural Equation Modelling (SEM)

After completing the Confirmatory Factor Analysis (CFA) for the ACC-PH model, we progressed to developing the Structural Equation Model (SEM). SEM is a renowned multivariate quantitative approach widely utilised for hypothesis testing and offers significant benefits due to its comprehensive nature. This method facilitates the parallel analysis of multiple relationships and effectively handles latent constructs [23].

Consequently, the SEM was constructed to include 13 independent constructs: Relative Advantage (RA), Compatibility (CO), Security (SE), Reliability (RL), Top Management Support (TM), Prior Experience (PE), Attitude towards Change (AT), Organisational Readiness (OR), Cost Analysis (CA), Competitive Pressure (CM), Cloud Providers (CP), Internet Connection (IC), and Rules and Regulations (RR). Cloud Computing Adoption (CC) was designated as the model's dependent construct, central to integrating these various factors.

After establishing the Structural Equation Model (SEM), the next phase of our research focuses on the findings derived from applying SEM to test the hypotheses.

J. Results of Testing Hypotheses within the ACC-PH Framework

In the Structural Equation Modelling (SEM) applied for this study, four key metrics were computed to test the hypotheses of the ACC-PH model: Standardised Regression Weight (β), Standard Error (SE), Critical Ratio (CR), and P-value. These metrics determine the significance of the relationships between the independent variable and the dependent variables.

According to [23], Standardised Regression Weight (β) measures the intensity and direction of a variable's association; larger absolute numbers indicate a stronger connection. Positive values suggest a positive relationship, while negative values indicate a negative relationship. The Standard Error (SE) estimates the variability of the regression weight, with lower values indicating more precision and reliability. The Critical Ratio (CR) is calculated by dividing the regression weight by the standard error, with values beyond ±1.96 typi-

TABLE IV.
DISCRIMINANT VALIDITY (FORNELL-LARCKER CRITERION)

	RR	RA	CO	SE	RL	TM	PE	AT	OR	CA	CM	CP	IC	CC
RR	**0.725**													
RA	0.067	**0.796**												
CO	0.081	0.001	**0.710**											
SE	0.156	0.153	0.055	**0.756**										
RL	0.044	-0.030	0.059	-0.001	**0.719**									
TM	0.107	-0.007	0.015	-0.036	0.002	**0.801**								
PE	0.213	0.060	0.169	0.187	-0.110	0.014	**0.715**							
AT	0.044	-0.031	0.112	0.030	-0.068	0.008	0.117	**0.711**						
OR	0.137	0.022	0.084	0.085	0.035	0.009	0.249	0.245	**0.708**					
CA	0.165	0.014	0.004	0.091	0.045	-0.042	0.068	0.108	0.164	**0.715**				
CM	0.281	0.005	-0.057	0.076	0.032	0.113	0.290	-0.137	0.155	0.074	**0.724**			
CP	0.114	0.114	0.156	0.093	-0.051	-0.050	0.058	-0.018	-0.034	0.320	0.034	**0.721**		
IC	0.285	0.113	0.007	0.071	0.088	-0.018	0.140	0.020	0.102	0.177	-0.071	0.275	**0.710**	
CC	0.281	0.152	0.193	0.234	0.091	0.150	0.293	0.330	0.282	0.248	0.185	0.220	0.282	**0.716**

cally denoting statistical significance at the p-value significant level. The P-value assesses the probability of the observed effect occurring by chance under the null hypothesis, where a value below 0.05 typically denotes statistical significance, suggesting a non-random effect.

Based on these methods, the hypotheses listed in Table V. were tested, with results shown in Table VI. This study assessed four technological factors influencing Cloud computing adoption in Saudi Arabian private hospitals. Security was identified as the most critical factor, followed by Compatibility, Reliability, and Relative Advantage. Additionally, five organisational factors positively influenced Cloud computing adoption, with the employees' Attitude towards Change being the most impactful, followed by Top Management Support. Other significant factors included Prior Experiences, Organisational Readiness, and Cost Analysis.

Furthermore, environmental factors such as Internet Connection, Competitive Pressure, and Cloud Providers were analysed and determined to influence adoption substantially. However, Rules and Regulations have not significantly influenced the adoption of Cloud computing.

Upon detailing the study's findings, engaging in a discussion contextualised within the literature review and a pragmatic framework becomes imperative. The following discussion will ensure that our research's theoretical and practical contributions are achieved.

V. Discussion

Our study investigates several factors influencing the adoption of Cloud computing in private hospitals across Saudi Arabia, focusing on technological, organisational, and environmental aspects. The findings not only corroborate existing theoretical frameworks but also unveil unique insights pertinent to the specific challenges within the Saudi private healthcare sector. By analysing each factor's distinct contributions and their interrelationships, this research provides a nuanced understanding of the dynamics involved in adopting Cloud computing technologies within Saudi Arabia's private healthcare settings.

A. Technological Context

The study investigated the impact of various technological factors on the adoption of Cloud computing in Saudi private hospitals. The findings revealed a positive influence of these factors on Cloud computing adoption, supported by empirical evidence.

Security (SE) was identified as the most influential technological factor. This was indicated by its notable Standardised Regression Weight (β) of 0.121 and the statistically significant P-value of 0.003. The findings align with existing scientific research, such as studies [14], [15], which have similarly highlighted the positive role of Security in adopting Cloud computing within the broader Saudi healthcare context. This agreement underscores the importance of robust security measures, which are crucial for successfully integrating Cloud computing in healthcare environments, especially in private hospitals in Saudi Arabia. The emphasis on security reflects a broader trend in healthcare technology, where protecting sensitive patient data and maintaining system integrity is paramount. It is also essential to consider advanced cyber threats, such as ransomware and advanced persistent threats (APTs), which pose significant risks to Cloud technologies in the health sector [34].

Following Security, ***Compatibility (CO)*** appeared as the second most significant factor, with a Standardised Regression Weight (β) of 0.113 and a P-value of 0.018. This finding is corroborated by studies [13], [14], [15], which have previously drawn similar conclusions. The significance of Compatibility lies in its facilitation of seamless integration and effective use of Cloud computing technologies within existing healthcare systems. Ensuring that new technologies align well with healthcare providers' current practices, workflows, and needs is particularly vital. High levels of compatibility enhance the likelihood of successful adoption and implementation of Cloud computing in Saudi private hospitals.

TABLE V.
LIST OF HYPOTHESES WITHIN THE ACC-PH FRAMEWORK AND THEIR RESULTS ADAPTED FROM [17]

H#	Hypothesis Statement	Result
H1	*"Recognising the relative advantage of Cloud technology enhances the likelihood of adopting Cloud computing in Saudi private hospitals."*	Supported
H2	*"Higher compatibility enhances the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H3	*"Higher security levels enhance the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H4	*"Higher reliability enhances the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H5	*"Top management support enhances the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H6	*"Top managers' sufficient prior technical experience enhances the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H7	*"Positive employees' attitudes towards change enhance the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H8	*"Organisational readiness enhances the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H9	*"Efficient cost analysis enhances the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H10	*"Competitive pressure enhances the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H11	*"Cloud providers' availability within the same country enhances the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H12	*"Internet connection availability and high functionality enhance the likelihood of adopting cloud computing in Saudi private hospitals."*	Supported
H13	*"Flexible rules and regulations enhance the likelihood of adopting cloud computing in Saudi private hospitals."*	Rejected

TABLE VI.
RESULTS OF ANALYSIS OF HYPOTHESIS PATH FOR THE ACC-PH FRAMEWORK

Context	Structural Relation	Regression Weight (β)	Standard Error (S.E.)	Critical Ratio (C.R.)	P-value
Technological	SE → CC	0.121	0.041	2.938	0.003**
	CO → CC	0.113	0.048	2.371	0.018*
	RL → CC	0.096	0.044	2.188	0.029*
	RA → CC	0.071	0.029	2.432	0.015*
Organisational	AT → CC	0.310	0.052	5.905	< 0.001***
	TM → CC	0.118	0.034	3.445	< 0.001***
	PE → CC	0.112	0.048	2.323	0.020*
	OR → CC	0.106	0.052	2.050	0.040*
	CA → CC	0.093	0.045	2.065	0.039*
Environmental	IC → CC	0.166	0.050	3.347	< 0.001***
	CM → CC	0.124	0.050	2.500	0.012*
	CP → CC	0.116	0.053	2.189	0.029*
	RR → CC	0.069	0.050	1.382	0.167

The study also confirmed the core role of the ***Reliability (RL)*** factor, with a Standardised Regression Weight (β) of 0.096 and a P-value of 0.029. In the literature, the study [14] examined the impact of the RL factor in the Saudi healthcare sector and gave equivalent results. The emphasis on Reliability is significant in healthcare, where consistent, dependable, and uninterrupted E-Health services are non-negotiable. The healthcare sector's unique demands, such as the need for constant access to patient records and operational continuity, make Reliability a significant factor influencing the decision to adopt Cloud computing technologies in private hospitals in Saudi Arabia.

Lastly, the study identified the ***Relative Advantage (RA)*** as another significant factor, indicated by a Standardised Regression Weight (β) of 0.071 and a P-value of 0.015. The findings support the outcomes of most of the previous research in the Saudi healthcare sector [13], [16]. These results highlight the importance of recognising the benefits and added value of Cloud computing to private healthcare institutions. The focus on Relative Advantage is particularly relevant in strategic decision-making. Understanding the tangible and intangible benefits of Cloud computing can drive adoption. Our findings suggest that private healthcare facilities are more likely to adopt Cloud computing solutions when they perceive clear advantages over existing systems, such as improved efficiency, cost savings, scalability, and enhanced data management capabilities.

As the technological aspects are thoroughly evaluated, the focus now shifts to the organisational factors. These factors are key to understanding private hospitals' internal readiness to adopt Cloud technologies, highlighting the human and strategic drivers of technology integration.

B. Organisational Context

This research measured five organisational factors potentially impacting Cloud computing adoption in private-sector hospitals in Saudi Arabia, confirming their positive influence.

Attitude towards Change (AT) emerged as the top factor, with a substantial Standardised Regression Weight (β = 0.310) and a highly significant P-value (less than 0.001). These results align with findings from studies [14], [16] although they diverge from [15]. The divergence likely stems from the multifaceted nature of technology adoption across different settings, influenced by cultural, structural, regulatory, and financial elements. In private hospitals, there is often a stronger emphasis on efficiency, innovation, and customer satisfaction due to the competitive nature of the healthcare market. Cultural factors such as the organisational culture towards innovation, structural factors like the flexibility of management structures, regulatory elements including compliance with local and international standards, and financial constraints or incentives play significant roles in shaping technology adoption. These diverse influences can lead to significant differences in how technology is implemented and utilised, explaining the divergent findings. Our study highlights the critical role of a workforce receptive to change, suggesting that adaptability and positive attitudes towards new technologies are significant drivers for successfully integrating Cloud computing in the Saudi private healthcare sector. These findings emphasise the need to cultivate a change-embracing organisational culture, which is vital in the evolving healthcare technology landscape.

Top Management Support (TM) was identified as the second most influential factor, with a Standardised Regression Weight (β = 0.118) and a P-value of less than 0.001, confirming its positive impact. These findings are consistent with previous studies[13], [15], indicating the importance of leadership and strategic guidance in adopting Cloud computing technologies in healthcare. Top management's support, resource allocation, and strategic vision are indispensable for implementing and efficiently utilising Cloud computing in Saudi Arabia's private healthcare facilities.

Prior Experiences (PE) of leaders and decision-makers in private hospitals in Saudi Arabia emerged as the third most influential factor, with a Standardised Regression Weight (β

= 0.112) and a P-value of 0.020. This finding aligns with the study [13] but contrasts with other literature, possibly due to the different sample populations studied. Our study's exclusive focus on Saudi private hospitals may explain these differences. Private hospitals often operate under various constraints and motivations compared to public hospitals. In private healthcare settings, decision-makers may value prior experience more because it directly impacts their ability to innovate and stay competitive in a market-driven environment. In contrast, public sector hospitals, which are often more bureaucratic and have different funding structures, may not prioritise prior experience to the same extent. This distinction highlights how hands-on experience and familiarity with similar technologies can positively affect the readiness and capability of decision-makers in private hospitals to integrate Cloud computing into their operational frameworks.

The study also highlighted ***Organisational Readiness (OR)*** as a significant factor in transitioning to Cloud computing, with a Standardised Regression Weight (β = 0.106) and a P-value of 0.040. These findings support the study [15] but contrast with [13]. The disparity in findings could be due to differences in the scope and focus of the studies, such as variations in sample size, research methodology, or regional healthcare policies. Our analysis suggests that an organisation's readiness, including its human, financial, and technological resources, is vital for successfully adopting Cloud computing in Saudi Arabia's private healthcare sector. Ensuring institutions are adequately prepared at multiple levels—from infrastructure to staff training and financial planning—is crucial for embracing and benefiting from Cloud computing solutions.

Finally, ***Cost Analysis (CA)*** was identified as a positive and direct determinant among organisational factors, with a Standardised Regression Weight (β = 0.093) and a significant P-value (0.039). This finding is consistent with existing literature, such as the study [16]. The results confirm that practical cost analysis influences Cloud computing adoption in Saudi private hospitals. Healthcare administrators and decision-makers need to understand the financial implications and potential advantages of Cloud computing enabling more informed and strategic choices.

Having explored the organisational influences on Cloud adoption, the discussion translates to environmental factors. These external elements play a critical role in shaping the adoption strategies of private hospitals in Saudi Arabia, highlighting the broader market and regulatory conditions that impact technological advancements.

C. Environmental Context

The analysis of quantitative data collected in this study revealed a significant and positive impact of environmental factors such as Internet Connection (IC), Competitive Pressure (CM), and Cloud Providers (CP) on the adoption of Cloud computing in Saudi private hospitals. Conversely, the Rules and Regulations (RR) factor did not significantly impact Cloud computing adoption. These findings contribute to understanding the environmental factors relevant when private healthcare institutions in Saudi Arabia transition to Cloud systems.

Internet Connection (IC) emerged as a primary environmental factor that private hospital managers in Saudi Arabia need to consider during their transition to Cloud computing systems. Structural Equation Modelling (SEM) analysis showed a significant positive association between IC and Cloud Computing Adoption (CC), indicated by a Standardised Regression Weight (β) of 0.166 and a P-value of less than 0.001. These results underscore the criticality of IC in fostering Cloud computing adoption in Saudi private hospitals, emphasising the necessity of robust and reliable Internet connectivity. The complete dependence of Cloud services on the Internet, especially considering its restricted availability in a developing country like Saudi Arabia, highlights the significance of considering this factor in the adoption decision-making process. Moreover, exploring the IC factor provides novel insights into the literature, particularly in the Saudi healthcare sector, where such a relationship has not been previously investigated.

The influence of ***Competitor Pressure (CM)*** on Cloud computing adoption in Saudi private hospitals was also noteworthy, ranking second among environmental factors. SEM analysis confirmed a positive relationship between CM and CC, with a Standardised Regression Weight (β) of 0.124 and a P-value of 0.012. This finding shifts the balance in the literature regarding CM, supporting its positive impact on Cloud computing adoption in the Saudi healthcare sector and reconciling previous mixed results [13], [15]. The finding signifies that the impetus to remain competitive and technologically advanced is a substantial motivator for adopting Cloud computing among private hospitals in Saudi Arabia. This underscores the importance of these healthcare institutions adopting advanced technologies like Cloud computing to sustain competitiveness in the swiftly changing healthcare sector.

Furthermore, the study determined the ***Cloud Providers (CP)*** as another positive influential environmental determinant, ranking third. The SEM results validated this factor with a Standardised Regression Weight (β) of 0.116 and a P-value of 0.029. This finding reinforces the need for geographical proximity and the accessibility of Cloud service providers, suggesting that local availability significantly facilitates Cloud computing integration in Saudi Arabia's private healthcare sector. Additionally, investigating the CP factor enriches the existing literature by offering new perspectives in the context of the Saudi healthcare sector, where this factor has not been extensively explored.

Conversely, the study found that the impact of ***Rules and Regulations (RR)*** had no substantial effect on Cloud computing adoption in Saudi private hospitals, indicated by a Standardised Regression Weight (β) of 0.069 and a P-value of 0.167. This finding aligns with most previous research, particularly studies [13], [15] and underscores the complexities of technology adoption in healthcare. Factors like rules and regulations may have a different impact than initially anticipated. The insignificant impact of RR could be due to a lack of awareness or understanding of related government rules and regulations among hospital administrators and decision-makers. If the implications of these regulations are not fully comprehended, their perceived relevance in decision-making processes related to Cloud technology adoption could be diminished. Therefore, enhancing awareness and understanding of these regulatory frameworks is critical for accurately assessing and leveraging their influence on Cloud computing adoption in the Saudi private healthcare sector.

The in-depth analysis of environmental factors finalises the study of variables affecting Cloud adoption in Saudi private hospitals, setting the stage for an updated ACC-PH framework that incorporates these insights to enhance Cloud computing deployment and use within the sector.

D. The Revised Version of The Comprehensive Framework for Adopting Cloud Computing in Private Hospitals (ACC-PH)

Based on the previous findings, the ACC-PH framework for adopting Cloud computing in Saudi private hospitals has been revised, as illustrated in Fig. 2. This updated framework integrates key insights and factors identified in our research, providing a comprehensive guide for decision-makers in these hospitals. It aims to facilitate a more effective and informed implementation of Cloud computing, addressing the specific needs and challenges of the Saudi private healthcare sector. The revised ACC-PH framework will serve as a valuable tool for hospital administrators and IT professionals, aiding them in navigating the complexities of Cloud computing adoption and ensuring its successful integration into their operations.

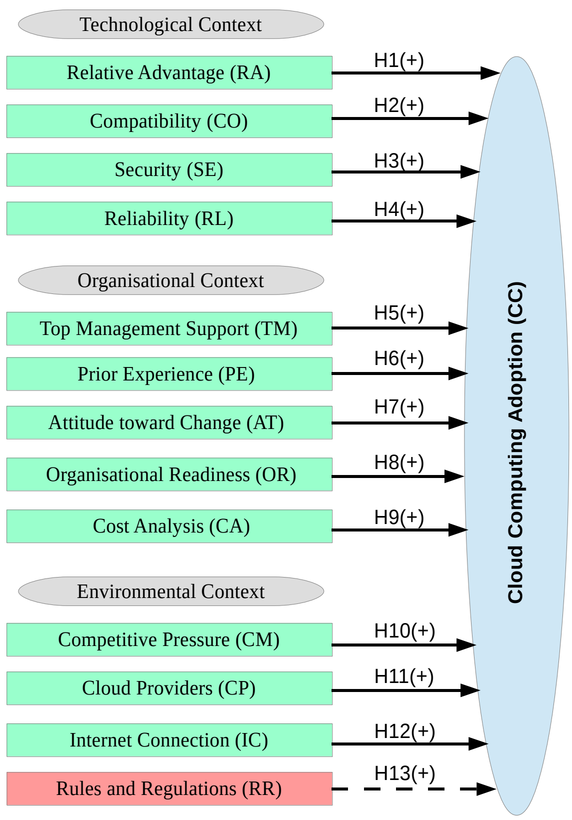

Fig. 2 The Revised Version of The Comprehensive Framework for Adopting Cloud Computing in Private Hospitals (ACC-PH)

VI. Conclusion

Our study thoroughly analyses the factors influencing the adoption of Cloud computing in Saudi private hospitals, exploring technological, organisational, and environmental dimensions. Through surveying 650 managers and administrative staff, we identified several factors that significantly influence Cloud adoption, ranked by their impact: Attitude toward Change (AT), Internet Connection (IC), Competitive Pressure (CM), Security (SE), Top Management Support (TM), Cloud Providers (CP), Compatibility (CO), Prior Experience (PE), Organisational Readiness (OR), Reliability (RL), Cost Analysis (CA), and Relative Advantage (RA). Conversely, Rules and Regulations (RR) did not significantly affect adoption decisions.

The current study holds considerable importance, offering significant contributions, both theoretical and practical. Theoretically, it is groundbreaking as it explores for the first time the roles of factors such as Cloud Providers (CP) and Internet Connection (IC) within the Saudi healthcare sector. It introduces novel insights by highlighting the significant impacts of these and other investigated factors. Additionally, the study contributes confirmatory and contrasting insights on Cloud adoption theories in Saudi healthcare, enriching current discourse in this field.

Practically, the study is further distinguished by its exclusive focus on Saudi private hospitals, a setting previously underexplored in existing literature. This research serves as an essential guide for decision-makers in Saudi private hospitals by outlining strategic approaches for adopting Cloud computing. Implementing these strategies addresses private hospitals' dual challenges of maintaining high-quality healthcare services and enhancing cost efficiency, which are crucial for increasing profits in a competitive market. By clearly delineating the factors influencing Cloud adoption, the study equips Saudi private hospital administrators with the necessary insights to implement Cloud solutions effectively. This guidance is designed to streamline operations and enhance service delivery, leveraging technological advancements to meet operational and financial goals.

Looking ahead, we propose to enrich this research by collecting qualitative data from decision-makers at Saudi private hospitals. This further investigation will deepen our understanding of the factors influencing Cloud adoption and enhance the decision-making process. Such qualitative research will complement this study's findings and provide detailed insights to guide Cloud computing implementation strategies more effectively in the Saudi private healthcare sector.

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