

Factors Influencing the Adoption of Cloud Computing in Healthcare Organizations: A Systematic Review

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Abstract

To analyze and compare the most influencing factors on cloud computing adoption (CCA) in the healthcare organization, a systematic review and meta-analyses of studies was performed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Cochrane collaboration recommendations. A search of PubMed, ScienceDirect, Springer, Wiley Online, and Taylor & Francis Online digital libraries (From inception to January 19, 2022) was performed. A total of 17 studies met the defined studies' inclusion and exclusion criteria. Statistical significance difference favoring most influencing factors on CCA were (MD 0.76, 95% CI -1.48 – 3.01, $p < 0.00001$, $I^2 = 90\%$), (MD 1.40, 95% CI -4.76 – 7.55, $p < 0.00007$, $I^2 = 97\%$) (MD 0.17, 95% CI -2.69 – 3.03, $p < 0.00001$, $I^2 = 96\%$) for technology vs. organizational, technology vs. environmental and business vs. human factors, respectively. Organizational and environmental factors had greater impacts on CCA compared with technological factors. Moreover, business factors were more influential than the human factors.

Keywords: Technology, organizational, environmental, mean difference, survey participants, meta-analysis.

1. Introduction

Cloud computing offers new services and solutions to customers by enabling them to rent information technology (IT) software, platforms, and infrastructure. The definition of cloud computing is widely accepted by the National Institute of Standards and Technology as "a model that enables on-demand network access to the shared pool of configurable computing resources. A minimal management effort is used to release and position the services" [1]. Microsoft, Amazon, and Google are the best cloud service providers [2]. The growth and adoption of cloud computing are evolving worldwide based on their potential of increasing productivity and improving its effectiveness in several developing countries. Organizational, technological, and environmental factors have shown their effects on cloud computing adoption (CCA) [3]. The decision-making for the adoption of cloud computing includes some important factors such as complexity, competitive and trading partner pressure, and technology readiness. Of these factors, pressure from trade partners has greatly influenced the managers' decision-making in the context of the UK industry [4].

Many challenges have been pointed out by researchers regarding the implementation of cloud computing in healthcare organizations. Singh et al. [5] show that the Indian healthcare industry is unable to progress by making vital use of emerging IT technologies. Management of Indian hospitals is interested in using cloud computing services. However, they were concerned about interoperability and security issues. Before this research study, Mezgar and Ruschecker [6] pointed out that handling security, interoperability, privacy, portability, and standardization issues were the real challenges of cloud computing that were not fully solved.

Some review studies were undertaken on the adoption of cloud computing in various industries. One of the reviews highlighted the lock-in problem for corporates in addition to portability and interoperability issues of CCA [7]. Twenty-one factors have been identified in a review paper regardless of their focus on the healthcare industry [8]. Another study shows that CC adoption may enhance the customers' satisfaction by resolving the problems in electronic systems in a short time. In addition to this, CC helps patients to access services by self-service stations in hospitals [9]. However, a survey study reveals that knowledge about CC adoption is not satisfactory in Saudi Arabian organizations. There is a barrier in CC adoption in the public section in KSA, and the education sector was among the leading in CC adoption. Healthcare and financial services were least facilitated by CC adoption. There were no specific barriers reported in this study [10]. Loss of information, security, and privacy were the main concerns in the context of CC adoption in KSA as highlighted in a study. Nonetheless, no meta-analysis was carried out on the research topic of this study. Rest of the paper is organized as follows:

Section 2 highlights the theoretical background of research topic. Section 3 shows us the research methodology used in this paper. Results and their discussion on the reviewed studies are presented in sections 4 and 5, respectively. Section 6 is about the future challenges and section 7 concludes the summary of this paper.

2. Theoretical Background

Population around the world is expecting the effective treatments and quality life that increases pressure on healthcare. Therefore, it has become a social and economic challenge and seeks advanced solutions from science and information technology [11]. Since 1990s, information technology has served positively in response to any process related with the healthcare as well

as meeting social and economic challenges. In fact, healthcare has attracted a great private and public interest and making unprecedented progress in research and funding.

Information technology in healthcare sector has provided potential to enhance the performance, quality and productivity of healthcare services. Therefore, IT is being known as the main pillar and crucial for the success of healthcare organizations [12]. However, traditional IT approaches in healthcare do not provide sufficient support to meet changing and increasing requirements in healthcare sector. Healthcare units in rural areas do not have sufficient IT resources and often suffer from the scarcity of storage and computing capacity [13]. Organizations do not have access to IT resources and also lack the offsite deployment of IT infrastructure. It restricts the organizations in healthcare sector to their abilities for addressing changes in IT demands to meet the medical emergencies.

Due to the enhanced IT services, cloud computing can bring changes in the traditional IT health services. According to a study [1] that provides a precise definition of CC, also listed out three models such as software as a service (SaaS), infrastructure as a service (IaaS), and platform as a service (PaaS). These models can provide support for delivery of IT services in healthcare sector [14]. Based on four CC deployment models such as private, public, hybrid and community infrastructures which are efficient in delivery of IT services.

Cloud computing has several advantages in storing and analysing the large datasets in industry. Therefore, CC is not a new concept. It has relations with grid computing and many of other technologies, including virtualization, distributed systems, computing and clustering. Recent research work highlights the role of CC in improving the healthcare services to benefit the biomedical research. The significant driver behind the CCA in healthcare is to lower the cost on delivery of healthcare services. Due to rise in cost of the healthcare delivery services, many governments have faced the serious funding issues [15]. However, the recognition that CCA can improve the patient care by reducing the cost meant that many countries are willing to push healthcare industry to a faster pace in CC adoption.

Both in Europe and US, healthcare industries offer new healthcare technologies and services in the emerging markets. These technologies and services are as telemedicine, electronic health records (EHRs), prescription and digital imaging. Besides these technologies, CC provides customized services, network access, and remote access [16]. The first kind of services automatically meet the patients' needs for healthcare services and make sure that they are satisfied. The second kind of services are focused on the patients' application that runs on different platforms with the help of electrical devices such as smartphones, laptops, and tablets. The CC resources (hardware and software) remain hidden to patients, and they also use services regardless of their location and data access to storage.

Cloud computing has been studied regarding their impacts on business models in healthcare industry [17]. Cloud computing helps organizations in healthcare industry to improve the use of resources and capabilities by operating in a competitive environment. To manage the sensitive data contents of healthcare organizations, cloud computing and users' devices play a key role in data lifecycle. However, managing different resources used during the creation of a solution has become a central focusing point of researchers [18]. To cope with challenges of COVID-19 pandemic, CC could be a better alternative to meet the challenges in current scenario. Data managing and storing have become easier tasks due to CC adoption that avoids the physical servers' costing as a high amount [19]. However, security issue still has potential to obstruct the adoption of CC in healthcare sector.

3. Research Methodology

The research method advocated by researchers was chosen for this study. It is based on the four phases and each phase further shows us the selection of studies. The first phase, identification is set to identify studies from mentioned data repositories and other relevant sources. The second phase, screening involves the screening of records and exclusion of irrelevant papers. At the third phase, eligibility of each paper is checked by reading it thoroughly, and papers that are not relevant to our research topic are excluded from this paper. In the final phase, included involves the exclusion of studies with reasons. At the end, we receive those papers, which are very close to our research topic (Fig. 1).

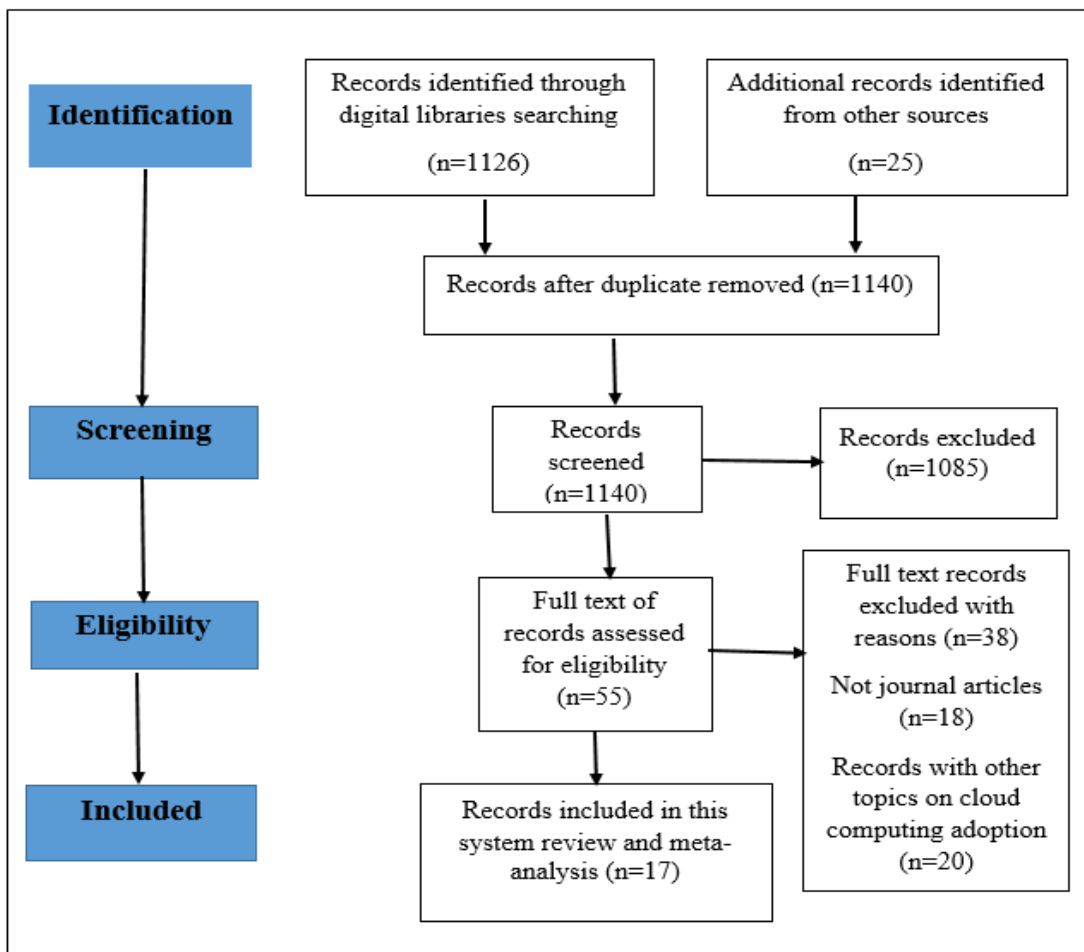


Fig. 1. Process flow of study selection

3.1 Study Design

This study used Cochrane Collaboration recommendations [20] and PRISMA guidelines [21] to perform a meta-analysis.

3.2 Public Involvement

There was no public involvement in this study since it was based on the published literature.

3.3 Inclusion and Exclusion Criteria

This meta-analysis followed studies' inclusion criteria as (1) CCA in healthcare organizations was focused (2) research articles published in Journal venue were considered in this meta-analysis.

The exclusion criteria followed in this meta-analysis were based on: (1) editorials, letters, and commentaries were excluded from this paper: (2) conference papers were also excluded from this paper. Conference papers do not provide comprehensive information about the research topic: (3) duplicate papers were removed from this meta-analysis and extended journal versions of those papers were included in this paper.

3.4 Search Strategy

Most popular digital libraries such as PubMed, ScienceDirect, Springer, Wiley Online, and Taylor & Francis Online were searched for published literature from their inception to 19 January 2022. Subject headings and variations were combined as given follows:

“Influencing factors”, “successful factors”, “cloud computing adoption”, and “healthcare” terms were used with the Boolean operators. **Table 1** presents the use of search keywords or strings to find the relevant research articles.

Table 1. Search keywords

Digital library	Search keywords
PubMed	((((Influencing factors [Mesh]) OR ((successful factors [Mesh]) AND (cloud computing adoption [Mesh]) AND (healthcare [Mesh])))). (factors[All Fields] AND influencing[All Fields] AND ("cloud computing"[MeSH Terms] OR ("cloud"[All Fields] AND "computing"[All Fields]) OR "cloud computing"[All Fields]) AND ("adoption"[MeSH Terms] OR "adoption"[All Fields]) AND ("delivery of health care"[MeSH Terms] OR ("delivery"[All Fields] AND "health"[All Fields] AND "care"[All Fields]) OR "delivery of health care"[All Fields] OR "healthcare"[All Fields])
ScienceDirect	“Influencing factors affecting cloud computing adoption in healthcare”
Springer	“Influencing AND factors AND affecting AND cloud AND computing AND adoption AND in AND healthcare”
Wiley Online	"Influencing factors affecting cloud computing adoption in healthcare".
Taylor & Francis	“Influencing factors affecting cloud computing adoption in healthcare”.

Table 1 is showing us the search keywords used in three digital libraries. Similar search keywords were used in other digital libraries. We performed a manual screening of research articles that resulted from using search keywords.

3.5 Study Selection

The Endnote X9 software was used to manage the references of collected documents. Two reviewers were independently involved in the selection process of research articles. To exclude

the irrelevant articles, abstracts and titles of research articles were assessed. Next, full-length research articles were examined in detail. Any discrepancy for the studies' selection process was resolved with the consensus of the rest of the reviewers.

3.6 Data Extraction

Reviewers (HQ and BS) were involved independently in extracting data from selected studies. The extracted data was based on study id, design, country, influencing factors, sub-influencing factors, and venue as a journal in this meta-analysis.

3.7 Quality Assessment

Newcastle-Ottawa Scale based on three components such as selection, comparability, and the outcome was used to award the quality stars to each study included in this meta-analysis [22]. Two colleague reviewers (YW and YM) were involved in conducting the quality assessment task of included studies.

3.8 Statistical Analysis

Statistical analysis in this meta-analysis was performed using Review Manager 5.4.1 v. Random effect model was used to combine the information from the included research articles. Continuous data were used to calculate the weighted mean difference (WMD) and 95% confidence interval (CI) [23]. I^2 and Chi-squared tests were used to calculate heterogeneity between studies. Subgroup analyses were performed to gauge the effects of influencing factors on CCA in different countries' healthcare systems. Publication bias was tested using the funnel plot.

4. Results

The above-given [Fig. 1](#) is showing us the PRISMA flowchart for the selection of relevant studies after following the studies' exclusion and inclusion criteria in this meta-analysis.

4.1 Search Results

[Fig. 1](#) is the illustration of search results by using search keywords in the most popular digital libraries in the healthcare domain. The initial search for research articles resulted in 1151 documents, including 25 documents from sources. In the next step of the identification phase, 11 duplicate documents were removed. Of the remaining 1140 documents, 1085 articles were excluded at the screening phase, which did not meet the inclusion criteria of studies. A full-text assessment of 55 documents was performed at the eligibility phase that resulted in again an exclusion of 38 documents, which were on topics other than CCA in healthcare. Finally, 17 documents were included that met the eligibility criteria in this meta-analysis.

4.2 Study's Characteristics

The table below is showing the characteristics of included studies such as study id, design, country, main influencing factors during CCA in healthcare organizations, sub-influencing factors, and venue of the papers. Studies included in this review have been thoroughly examined to extract the information in the following table.

Table 2. Studies' characteristics

Sr. #	Study Id	Design	Country	Influencing actors	Sub-influencing factor	Journal
1.	Al-Ruithe et al. [24]	Survey paper	UK	Cultural changes	Not Defined (ND)	Procedia Computer Science
2.	Mekawie and Yehia [25]	Survey paper	Egypt	Change management and technological factors	The budget burden on the renovation of old infrastructure	Procedia Computer Science
3.	Almubarak [26]	Survey paper	Kingdom Saudi Arabia (KSA)	Compatibility, innovativeness, Knowledge, relative advantage, and management support	ND	International Journal of Advanced Computer Science and Applications
4.	Alipour et al. [27]	Survey paper	Iran	Competitive pressure and relative advantage,	ND	Digital Health
5.	Baral and Verma [28]	Survey paper	India	Technological, organizational, environmental, and ethical (TOEE)	ND	FIIB Business Review
6.	Alharbi et al. [29]	Survey paper	India	Five factors (Organizational, business, technological, human, and environmental)	ND	Complex Intelligent Systems
7.	Chang et al. [30]	Survey paper	Taiwan	Cloud management, delivery, and software	ND	<i>Life</i>
8.	Idoga et al. [31]	Survey paper	Nigeria	Eight constructs with several factors	ND	BMC Medical Informatics and decision making
9.	Liao and Qio [32]	Survey paper	Taiwan	Three dimensions with several variables	ND	<i>SpringerPlus</i>
10.	Ratnam et al. [33]	Survey paper	Malaysia	Utilization and dimension	Security and integration	<i>Journal of Medical System</i>
11.	Amin et al. [34]	Survey paper	Malaysia, Pakistan, and KSA	Five variables	ND	<i>Annals of Telecommunication</i>
12.	Lian et al. [35]	Survey paper	Taiwan	Five critical factors (data security, complexity,	ND	International Journal of Information Management

				technical competence, manager support, and cost)		
13.	Alassafi [36]	Survey paper	KSA	Reliability, compliance, data security	Data control	Computer Methods and Programs in Biomedicine
14.	Harfoushi et al. [37]	Survey paper	Jordan	Technology, organization, and environmental (TOE)	Intension to CCA	Communications and Network
15.	Sharma and Sehwat [38]	Research approach	ND	TOE	21 sub-influencing factors	Technology in Society
16.	Lynn et al. [39]	Survey paper	Ireland	Human, technology, and organizational factors	10 sub-influencing factors	Future internet
17.	Nassoura [40]	Survey paper	Jordan	TOE and intention to cloud computing	ND	International journal of scientific & technology research

Table 2 presents the main characteristics or features of the included studies. The first feature as listed in **Table 2** shows us authors' information and reference number in the reference list. Most of studies were based on multiple authors and only a few were authored by single author or two authors. The second feature in column three shows us the design of studies included in this review. The majority of survey studies qualified for the inclusion in this review and meta-analysis. Only one study [38] was based on using a hybrid research approach derived from participants' interviews and Delphi method. Majority of studies were undertaken in Asian countries compared to other region or countries. Taiwan and KSA are the leading countries where research on the topic is widely conducted in recent years. Jordan and India are the second most important countries where this research on the topic is being conducted in a number of last years. TOE as influential factors were investigated in majority of studies. Besides, TOE factors, change management, competitive pressure, delivery of software products, reliability, compliance, security and intention to cloud computing were other factors that influenced the CCA in healthcare organizations.

4.3 Technological vs. Organizational Factors

Comparison between two factors such as technology and organizational regarding their influence on CCA is shown in the following figure. Five studies qualified for the comparison of aforementioned factors.

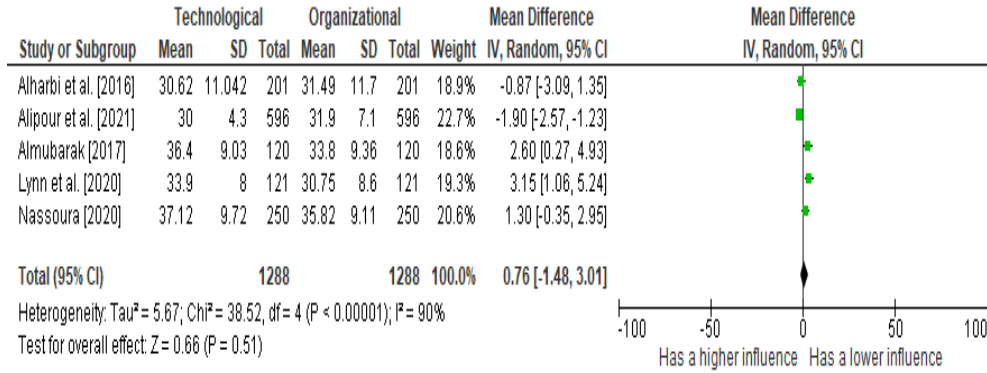


Fig. 2. Technology and organization factors influencing CCA in healthcare organizations

A comparison of technology and organization factors is displayed in **Fig. 2**. Mean, standard deviation (SD), and survey participant statistics were used to perform this meta-analysis. As compared with technology factors, organizational factors have more influence on the CCA in healthcare organizations. Low influencing technology factors results (MD 0.76, 95% CI -1.48 – 3.01, $p < 0.00001$, $I^2 = 90\%$) were received as shown in forest plot (**Fig. 2**).

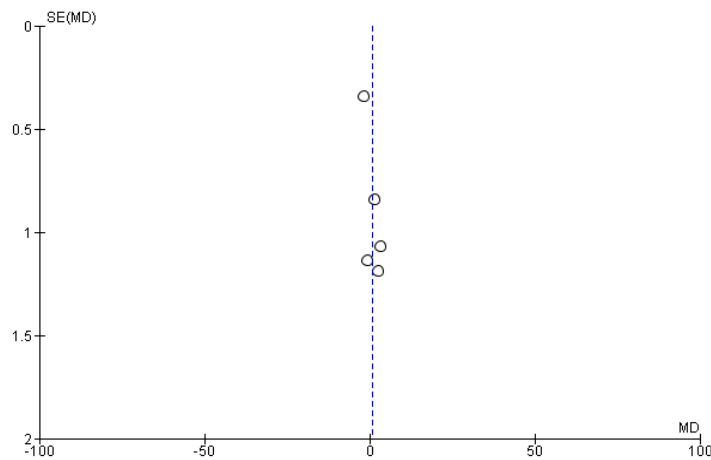


Fig. 3. Funnel plot (Technological vs. Environmental factors)

Fig. 3 shows us the funnel plot of the meta-analysis conducted between two categories of influencing factors.

4.4 Technical vs. Environmental Factors

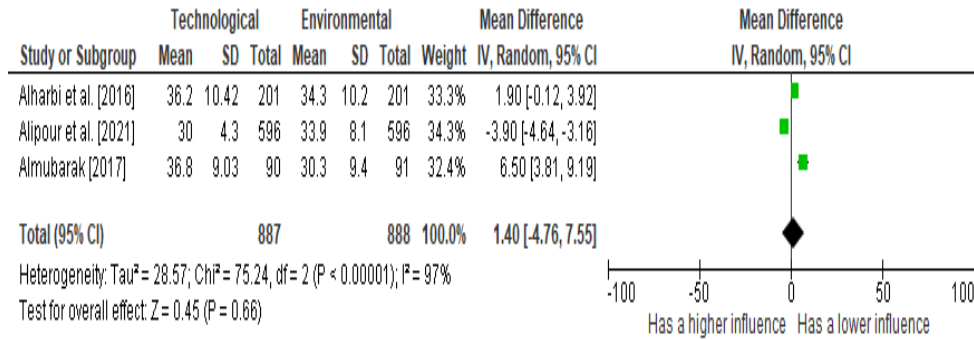


Fig. 4. Technology and environmental factors influencing CCA in healthcare organizations

The second comparison results were obtained between technology and environmental factors with these results such as (MD 1.40, 95% CI -4.76 – 7.55, p < 0.00007, I² = 97%) as shown in Fig. 4. One study favored the technology factors as a highly influencing factor while two studies showed that environment had more influence on CCA than technology factors.

4.5 Business vs. Human factors

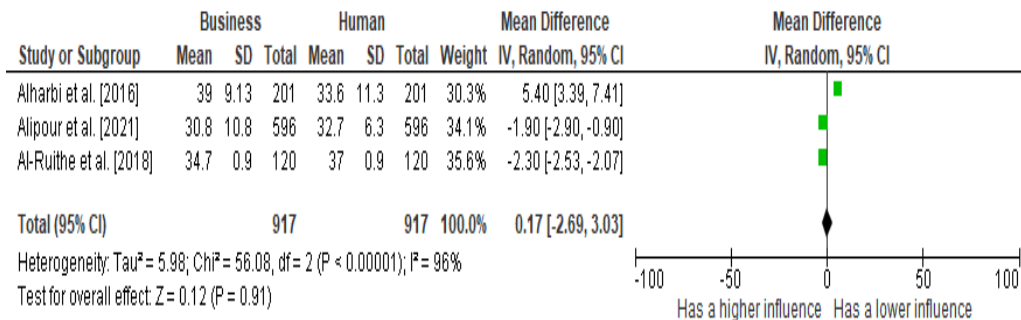


Fig. 5. Business and human factors influencing CCA in healthcare organizations

In a comparison between business and human factors on CCA, two studies showed that the business impacts were higher and more influencing than human factors (MD 0.17, 95% CI -2.69 – 3.03, p < 0.00001, I² = 96%). Only a study showed that human factors had more influences than business factors.

5. Discussion

Mean differences from random-effects models were used to calculate the continuous outcome of meta-analysis. Therefore, this method aims to measure the mean difference in (technology vs. organizational), (technology vs. environment), and (business vs. human) groups. When outcome measures are based on a meaningful scale and all included studies are reported using the same scale, the MD between two groups can be used to measure the treatment effects [38]. Hence, an MD estimate has been achieved from each study in this meta-analysis.

This meta-analysis showed that organizational and environmental factors were more influencing on the CCA than technology factors. On the other hand, this study’s findings

showed that business factors had more influencing impacts on CCA compared to human factors. The one reason behind the lower influence from technological factors might be the updated cloud services that meet the maximum requirements of healthcare organizations. This is because services providers upgrade and add new features in their existing services on cloud infrastructure [42]. Since in routine and emergency working health information is continuously updated by the hospital personnel and emergency system supported by cloud services ensures the availability of information to the corresponding people [43]. Organizational factors were found among dominating factors of CCA in the healthcare sector. "Top management support" and "attitude towards the change" were among the top sub-influencing factors [29]. Since averages of mean and SD values were reported together in this meta-analysis. Therefore, we measured the combined effects of sub-influencing factors. Several studies have ranked the influencing factors, and the ranking of factors varies in these studies. For instance, study [10] ranked privacy issue as the topmost concern to adopt CC in healthcare organizations; another study ranked "soft financial analysis" as the most concerning factor from the business category of main factors. This creates confusion among researchers to interpret the results of similar factors in the literature.

A study [10] mentioned 15 concerning factors about CCA in KSA healthcare organizations. Based on the 5-point Likert scale data and its analysis, loss of control and data governance, and trust, privacy, and security issues were highly picked by the survey participants. The mean value of these concerns was reported as ≥ 4.00 than the other factors. Interesting results were reported in a study [26] where a decision maker's context gained a higher mean value of 3.90 compared to TOE factors. These results were in the context of the KSA health industry, which is highly affected by the decisive factors of decision-makers. Since CCA adoption in major cities of KSA is more under the decisive control of decision-makers. In addition to TOE factors and their sub-influencing factors, as mentioned in recent research [27], human factors were also identified among the most influential factors. The mean value of human factors was reported as 3.27 ± 0.63 which is smaller than the mean value of environmental factors. However, it was higher than technological and organizational factors. The human dimensions were introduced by Lian et al. [35] with mean score of 4.02 ± 0.54 and Yaghoubi et al. [44] ranked them at second position among top influencing factors. This indicates that like TOE, human factors are important that affect the CCA adoption in healthcare organizations. However, the variance in mean values from these studies might be due to knowledge and cultural changes in targeted participants from different countries. For instance, the cloud community with the know-how about cloud computing indicated that availability, integrity and privacy as the most influencing factors for organizations [45].

Liao et al. [32] stated that cost-effectiveness was a challenging issue of CCA in healthcare organizations. It was ranked at the top of the list of cloud management issues followed by software scalability from cloud software used in healthcare organizations. The analysis of these two factors indicated that the cost is the primary influencing factor during CCA that determines the successful implementation of cloud in the health industry. Similarly, 19 barriers to CCA were identified, which were distributed in four categories including, financial, customer, internal process, and learning and growth [46]. Financial issue constraints were ranked at the top of factors in the list followed by security concerns of users. The findings of these studies showed that cost or financial issues were important factors and could influence the success of CCA in the healthcare industry.

Many studies identified challenges and influencing factors of CCA in the healthcare industry. However, none of them has presented a meta-analysis of contributing factors by their comparison in healthcare organizations [14].

The main limitation of this study is the inherent characteristics in the 5 studies included in this meta-analysis. We identified 17 studies that met the inclusion criteria, however, 5 studies met the eligibility criteria to perform meta-analyses using the mean, SD values, and several survey participants. The remaining studies used different outcome measures, which did not allow us to make a perfect grouping. Lack of uniformity in the number of survey participants in clouded studies was another limitation. Also, some studies did not show piloting the survey questionnaire to bring clarity to the questionnaire.

6. Future Challenges

Security of users' data in healthcare sector is a big challenge to researchers. Information exchange between host organizations and users need to be properly monitored to avoid its tampering or leakage. The second challenge is the integration and transition of data. It has become difficult to integrate Netflix with the secure and reliable infrastructure. Related challenges to data transition are latency and encryption issues [17]. These challenges are specially focused in developing countries, which require budget and capabilities to become of coping with these challenges.

Another challenge for healthcare professionals and CC technologists is to manage the multiple users and applications while presenting a solution [18]. In addition, health repositories where data reside requires security restrictions and meeting non-functional requirements (NFRs) is real challenge that may be focused in future works. Interoperability is amongst real challenges when information related to health records is shared between various parties [47]. This challenge still needs to be addressed by developing standardized principles and using them at several technology layers.

7. Conclusion

This meta-analysis showed the comparison of TOE, business and human factors that influenced the CCA in healthcare organizations. Based on the existing literature and their mean and SD outcome measures, organizational and environmental factors had a great influence over the CCA compared with technology factors. Moreover, business factors were measured with more influence than human factors. When only randomized survey studies were pooled by excluding the study with greater participant impacts, influencing impacts of technological factors were diminished. This definition requires further investigation, and someone needs to conduct studies where consistent outcome measures are investigated.

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