

# Big Data Analytics Quality in Enhancing Healthcare Organizational Performance: A Conceptual Model Development

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**Abstract**—The advancement of Big Data Analytics (BDA) has aided numerous organizations in effectively and efficiently adopting BDA as a holistic solution. However, BDA quality assessment has not yet been fully addressed, therefore it is necessary to identify essential BDA quality factors to assure the enhancement of organizational performance, particularly in the healthcare sector. Hence, the goals of this study are to recognize and analyse the determining factors of BDA quality as well as to suggest a conceptual model for enhancing the performance of healthcare organizations via BDA quality assessment. The proposed conceptual model is based on a related theoretical model and previous research on BDA quality. The essential BDA quality factors being selected as determinants consist of reliability, completeness, accuracy, timeliness, format, accessibility, usability, maintainability, and portability. The findings of this ongoing study are used to develop a conceptual model that is proposed in line with the ten-research hypothesis and may offer a better assessment quality model to improve the performance of healthcare organizations.

**Keywords**—Big data analytics; BDA quality factors; BDA quality assessment; organizational performance; healthcare

## I. INTRODUCTION

Big Data Analytics (BDA) has been used as an end-to-end solution in most organizations, especially healthcare organizations. The use of BDA contributes a significant impact on the enhancement of organizational performance. There are various potential outcomes of BDA for healthcare organizations such as Information & Communication Technology (ICT) infrastructure, operational, managerial, strategic, and organizational benefits [1]. BDA implementation in healthcare organizations affects the efficiency of ICT infrastructure, thus reducing system redundancy and quickly transferring data among healthcare ICT systems and applications [2]. BDA potentially produces some operational outcomes such as enhancing the precision and quality of clinical judgments, processing a substantial amount of health information quickly, and having access to medical data right away for analytics [3]. Likewise, the recent pandemic of Covid-19 has proven BDA as a significant solution in healthcare organizations not just for the analytics part but also for data acquisition for better planning, pandemic, and patient monitoring [4].

The BDA implementation in the healthcare industry may face certain obstacles that have been faced when developing

solutions specifically to deal with the Covid-19 pandemic [5]. Information accuracy, security, and privacy are some of the related BDA issues that may affect the performance of healthcare organizations [5][6]. Moreover, healthcare organizations must assess BDA quality to make sure that the related system and application produced by BDA implementation is portable, near real-time information, and easy to maintain to entice consumers to use it in the long run [7]. The effectiveness and efficiency of healthcare organizations can be increased with the right and essential BDA quality factors being fulfilled [8] and this is in line with the finding by Fosso Wamba [9]. The negative implications of poor BDA quality, such as incorrect decision-making, have caused considerable harm to organizations [10][11] especially in healthcare due to life or death decisions depending on having accurate information [12].

In the context of Malaysia's healthcare, Malaysia ranked 47th out of 60 countries left far behind Singapore ranked 9th for access to Universal Healthcare Coverage (UHC) in the recent The Cost of Healthcare Index report [13]. Access to the UHC is a score that represents how much of a country's population has easy access to essential health services and it covers the entire range of high-quality healthcare services, including palliative care, treatment, rehabilitation, and health promotion [14][13]. Achieving UHC is one of the targets the nation of the world set when adopting the Sustainable Development Goals (SDGs) in 2015 [14]. It is showing the urgency for the assessment of BDA quality to overcome BDA quality such as accessibility, usability, and reliability.

Various studies have been conducted on BDA quality; however, the focus is more on "data" quality and does not cater to BDA quality holistically [10][7], and the BDA quality assessment in healthcare is still an understudied research topic. Consequently, the objectives of this paper are to 1) determine the contributing factors to BDA quality; and 2) develop a BDA Quality (BDAQ) conceptual model for enhancing healthcare organizational performance.

The subsequent section will examine the theoretical context, and the third section will glance at the research methodology. The discussion and conclusions of the BDA quality factors are covered in the fourth section, which also suggests a conceptual model for the BDAQ. The study is concluded in the last section by highlighting the contribution of the research and making suggestions for future studies.

## II. THEORETICAL BACKGROUND

Several studies have focused on constructing BDAQ models by adopting the Information System Success Model (ISSM) of DeLone and McLean [15] and Wang and Strong [16] while other studies are also incorporating resource-based view theory (RBV) [17]. From the RBV perspective, an organization's competency is dependent on quality to efficiently manage its vital resources and gain a competitive advantage, which can be reflected in enhanced organizational performance [9]. RBV focuses on generating exceptional organizational performance by establishing valuable, rare, unique, and irreplaceable (RIN) resources of superior quality [18]. RBV is in line with the Information System Success Model (ISSM) of DeLone and McLean [15] as both highlight the competencies of in-house information systems to influence organizational performance [9]. To improve healthcare organizational performance, ISSM has been adapted to emphasize data, information, and system quality factors related to outcomes and benefits for the healthcare organization [19].

System and information quality have both been recognized in ISSM as crucial elements of organizational effectiveness [20]. Most previous studies have used ISSM as the main theoretical framework. Wamba [21] in their findings suggests that information quality represents four essential BDA quality factors; completeness, currency, format, and accuracy have a significant positive impact on organizational performance. Chiu [22] had been used ISSM with three groups of quality factors; system quality, service quality, and information quality with a mediating effect on user satisfaction and user continuance intention revealed that the three groups of quality factors positively influenced user satisfaction, and user continuance intention.

Wang and Strong [16] as a theoretical model in another way presented quality factors into four primary categories,

namely intrinsic, contextual, representational, and accessibility. The intrinsic category implies datasets having inherent quality, whereas the contextual category emphasizes the requirement of the task that quality be evaluated in context [7], [16]. The representational category highlights quality in terms of its presentation, while the accessibility category reinforces the significance of computer systems that give access to data [7], [16][23]. There are some characteristics for each category that are employed as particular indicators of quality. For instance, the intrinsic category's factors are objectivity and accuracy, while the contextual category's factors are timeliness and relevance. The representational category's factors are interpretability and understandability, while the accessibility category's factors are accessible security and simplicity of use [7]. Ghasemaghahi and Calic [24] used BDA quality factors produced by Wang and Strong [16] to examine the effect of BDA on quality factors and confirmed the critical role of BDA quality in enhancing organizational decision-making.

Current BDA quality models primarily rely on the Information System (IS) theoretical model and are largely based on data and information quality rather than a suitable and comprehensive component of BDA quality factors [7], [25]. Differing from traditional Business Intelligence (BI), BDA, as mentioned earlier, covers end-to-end solutions, a full life cycle, and is inclusive of related BDA systems and applications. Thus, it is very important to leverage broader and holistic theoretical models. To fill this theoretical gap, this study integrates the most common theoretical model in Information System (IS) research with the related Software Engineering (SE) theoretical model which are McCall[26], Boehm[27], Evan & Marciniak, Deutsch & Willis, DROMY's, FURPS+'s, SEI, and ISO/IEC25010 [28]. Table I present the occurrence of quality factor from the ten theoretical models that have been summarized for this study.

TABLE I. QUALITY FACTORS DERIVED FROM THEORETICAL MODELS

Theoretical Models	McCall [26]	Boehm [27]	Dromey [31]	Evans & Marciniak [32]	Deutsch & Willis [33]	FURPS+'s [34]	SEI [35]	ISO/IEC 25010:2011 [36]	Wang & Strong [16]	DeLone & McLean ISSM [15]	Frequency
Reliability	x	x	x	x	x	x	x	x		x	9
Completeness	x	x		x	x			x	x	x	7
Maintainability	x	x	x	x	x		x	x			6
Accuracy	x	x		x	x				x	x	6
Portability	x	x	x	x	x			x			6
Usability	x			x	x	x		x		x	6
Efficiency	x	x	x	x	x						5
Integrity	x	x		x	x		x				5
Flexibility	x			x	x					x	4
Consistency	x	x		x							3
Understandability		x							x	x	3
Testability	x	x						x			3
Relevancy									x	x	2
Compatibility								x			1
Believability									x		1

### III. METHODOLOGY

As shown in Fig. 1, several steps were taken in the creation of the conceptual model for assessing the BDA quality factors. Prior to identifying the pertinent theories, the review process continued with content analysis and was founded on the Systematic Literature Review (SLR) approach [29][30]. 23 publications on the BDA quality in various domains were investigated as part of the review activity, which divided them into two categories: empirical and case study research analysis. A research question like "What are the essential BDA quality factors to consider in constructing BDA Quality (BDAQ) model?" is formulated as the first step in the initial investigation. After further research was conducted using electronic journal databases like Scopus, Science Direct, Emerald, IEEE, Google Scholar, and the snowballing method, 23 pertinent publications were selected. After that, a matrix table was used to examine the pertinent articles (Table II).

This study selected nine factors from theoretical models and previous research to be considered in the development of the BDAQ model, with the results detailed in the subsequent section (Section IV). In conclusion, the conceptual model and related factors are discussed. Finally, in the conclusion, the BDAQ conceptual model is presented along with the essential BDA quality factors.

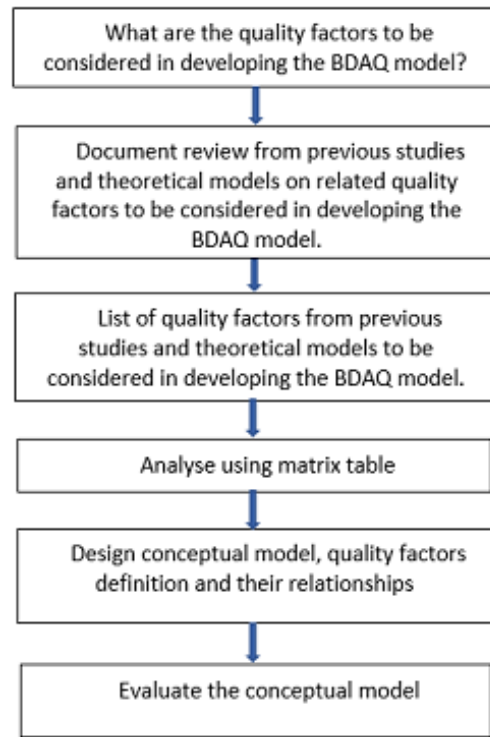


Fig. 1. The Workflow of BDAQ Conceptual Model Development.

TABLE II. BDA QUALITY FACTORS FROM PREVIOUS STUDIES

Authors Quality Factors	Wook et al. (2021) [7]	Ji-fan Ren et al. (2017) [20]	Fosso Wamba et al., (2019) [9]	Côrte-Real et al. (2020) [10]	Aljumah et al. (2021) [37]	Trinchera, et al. (2019) [21]	Kwon et al. (2014) [38]	Ghasemaghaei (2019) [24]	Akter et al. (2017) [39]	Shariat Panahy et al. (2013) [40]	Ayyash, (2017) [41]	Ameen et al. (2020) [42]	Zheng et al. (2013) [43]	Popović et al. (2012) [44]	Masri et al. (2020) [45]	Gürkut & Nat, (2018) [46]	Gorla et al. (2010) [47]	Alaoui & Gahi, (2019) [48]	Bahrami & Shokouhyar (2021) [49]	Haryadi et al. (2016) [50]	Verma (2017) [51]	Chiu et al. (2021) [22]	Keikhosrokiani et al. (2020) [52]	Frequency	
Timeliness	×	×	×	×	×	×		×	×	×	×		×		×	×		×	×	×	×		×	18	
Completeness	×	×	×	×		×	×	×	×	×	×				×	×		×		×	×	×			16
Accuracy	×	×	×	×		×		×	×	×	×				×	×		×		×	×		×		15
Reliability		×	×		×				×			×	×	×	×	×	×		×	×		×	×		14
Format		×	×	×		×		×	×				×		×		×								9
Accessibility	×	×			×			×					×	×					×	×					8
Responsiveness		×	×									×					×						×		5
Privacy		×			×				×																3
Usability																						×	×		2
Interactivity													×									×			2

#### IV. FINDINGS AND DISCUSSION

The relevant BDA quality factors from the SLR are presented in Table II and include the following; reliability, completeness, accuracy, timeliness, accessibility, and format that affects enhancing organizational performance. Table III presents the integration of quality factors from a related theoretical model and from the previous studies with nine quality factors that have been chosen based on their frequency and suitability in the healthcare context. The frequency of each quality factor was shown in Fig. 2 as a summary frequency of quality factors integrated from related theoretical models and previous studies.

Reliability and completeness were shown to be the two most frequent quality factors highlighted in both theoretical models and previous studies on BDA quality. This is followed by accuracy, timeliness, format, accessibility, usability, and maintainability. Maintainability and portability have been found not been discussed in BDA quality previous studies. However, these two quality factors are the most prominent quality factors found in the related theoretical model as can be seen in Table I. Based on the finding from the theoretical model matrix, this study decided to consider and choose maintainability and portability as part of the nine essential BDA quality factors for the BDAQ conceptual model. Drawing on the ten theoretical models and twenty-three previous studies from the SLR, the BDAQ model is conceptualized and determined by nine quality factors: reliability, completeness, accuracy, timeliness, format, accessibility, usability, maintainability, and portability.

##### A. Reliability

The definition of reliability by McCall et al. [26] is "the extent to which a program is expected to perform its intended function with the needed precision". The reliability of BDA reinforces the confidence that a BDA platform is interference and disruption-free [37]. Reliable data helps BDA to provide precise decision support and increase the effectiveness of services offered [10], [38]. An overwhelming amount of research studies discovered a relationship between improving organizational performance and reliability as a BDA quality factor [9], [20], [39]–[41]. Hence, it is encouraging to examine reliability as one of the essential BDA quality factors and its relationship with healthcare organizational performance.

##### B. Completeness

Completeness is one of the most frequent quality factors from theoretical models and previous studies as shown in Table III. Completeness in this study context refers to that all necessary data and information of BDA are provided and complete either in the stage of data acquisition, data processing, visualization, analytics, related BDA's system and application in the healthcare organization. Failure to assess the completeness of the BDA in healthcare will heavily affect not just decision-making but the confidence of the end-users for the healthcare services [53]. Numerous research demonstrated the significant impact completeness has on improving organizational performance as a primary determinant of BDA quality factors [9], [20], [42], [54]. Therefore, completeness has been selected as one of the essential BDA quality factors of the proposed BDAQ conceptual model.

##### C. Accuracy

According to Wixom and Todd [55], accuracy includes perceived exactness of information, conformance to truth or value in the real world, correctness, validity, and precision [16], [56]. It also checks to see if the data were entered correctly and if the values are accurate [57]. As part of the BDA quality factors, accuracy is important in healthcare because it can affect how decisions are made [58], [59] and have a strong impact on organizational performance based on the experimental case study by Alaoui & Gahi [48]. Inaccurate data may lead to clinical mistrust, the inability to properly interpret data, as well as a higher likelihood of mistakes [60].

##### D. Timeliness

Making decisions based on old data might result in erroneous insights, hence timeliness has been regarded as an important factor of BDA quality [61]. Timeliness or currency is defined as "the amount to which the age of data is appropriate for the task at hand" and represents the user's perception of the degree to which the information is up to date [55]. In BDA's healthcare applications such as clinical decision support, hospitals, caregivers, etc., the timeliness of data is one of the greatest issues [62]. Since doctors make decisions based on larger amounts of clean, up-to-date data, the process should be less cumbersome, faster, and more precise [62]. Most past empirical studies found timeliness was a significant BDA quality factor and had a significant positive effect in enhancing organizational performance [9], [20], [49], [63]. However, a study by Wook et al. [7] found that timeliness had no significant effect on BDA applications conducted from individual perspectives. Timeliness is one of the essential BDA factors that had been selected for the proposed BDAQ model, thus the significance of timeliness will be analyzed in the actual study and the relationship in enhancing healthcare organizational performance will be examined.

##### E. Format

The format "represents the user's perspective of how well the information is presented" and the BDA system's presentation of the information [9], [55]. In the area of healthcare, the healthcare information offered by BDA is well-formatted, well-organized, and presented clearly on the screen [55]. Data is obtained and acquired from numerous sources in

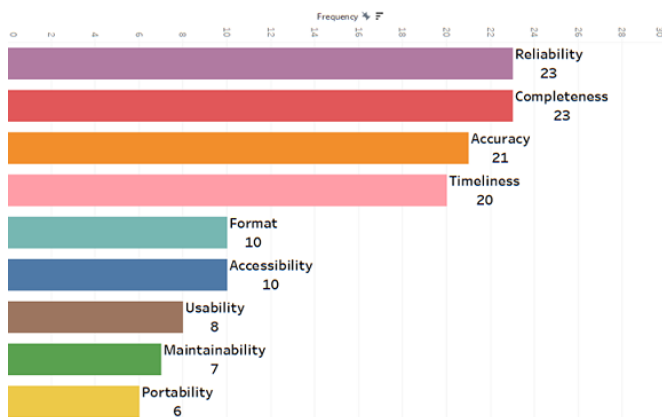


Fig. 2. Summary of BDA Quality Factors.

both electronic and non-electronic formats, and then it is transformed into the desired format during this essential phase [60], [64]. But data sources come in a wide range of functions, structures, and forms [65] including text, photo, audio, video, web content, GPS data, sensor data, and others, and are geographically scattered [66]. BDA in healthcare is challenging because it must deal with numerous types of unstructured data, in contrast to traditional data analysis where data types are often structured [6][67]. However, BDA is anticipated to work with a combination of unstructured and structured data [6]. Numerous studies have looked at and suggested that format was a significant determinant of BDA quality factors and significantly improved organizational performance [9], [21], [47], [63], [68].

#### F. Accessibility

Accessibility is the degree to which data is available, easily accessed, and quickly retrieved [16]. The system's accessibility influences the extent to which managers may access a scalable and efficient analytics platform [37]. Wang and Strong [16] emphasize that a system must be accessible without tolerance for privacy and security. Accessibility in the context of BDA in healthcare is not just about data accessibility but BDA's system and application accessibility. Wook et al. [7] selected accessibility as a BDA quality factor because the computer system must ease data access and storage in BDA applications. The efficacy of BDA implementation in healthcare is significantly determined by accessibility [69]. BDA solutions as end-to-end healthcare solutions must be able to generate unconstrained applications of diffused and accessible machine learning algorithms that support healthcare data analytics on Hadoop systems [70]. BDA applications in healthcare either web-based or mobile have now given a big impact on the public in accessing healthcare information. A finding by Wook et al. [7] demonstrated that data accessibility plays a significant role in bridging the digital divide and providing users with effective access to BDA applications. The studies revealed that accessibility has a substantial impact on BDA applications [7].

#### G. Usability

Usability describes the amount of work needed to understand, use, prepare input, and interpret a program's output [26]. Although modern medical BDA has numerous drawbacks, it is nonetheless a very promising resource for insurers and other academics. Not only for doctors and patients but also for everyone interested in secondary usage, improving BDA quality should be a top focus. There are a variety of steps that could be taken to improve the usability of data and the system of BDA in healthcare, and some of them are through quality assessment [71]. Ensuring high levels of usability to access pertinent data is a frequently mentioned challenge for BDA's system and application in healthcare [72]. Medical practitioners and researchers have used extensive BDA to improve patient care through data science, but their usability in the presence of BDA cannot be guaranteed to justify clinical use enough [72]. Two studies from twenty-three previous studies have usability as a quality factor as shown in Table II. User satisfaction and the success of human interaction with healthcare applications will be achieved when usability is fulfilled [52]. The testing is

typically associated with usability testing to reduce system defects and evaluate user experience [52]. Thus, this study considers usability as one of the essential BDA quality factors to be examined further.

#### H. Maintainability

Maintainability refers to the efforts required by users and maintenance staff to determine the cause of system failure, and the components or system that need to be fixed or restored [26]. Based on Table III, maintainability is found in seven of ten of the theoretical models. However, maintainability has been not found in any of the twenty-three previous studies on BDA quality. Maintainability has been selected as one of the determinants of BDA quality factors. Assessing maintainability will allow users to customize the setting on BDA's system and application without causing any errors or affecting the system's quality [73]. BDA's system and application in healthcare should be easy to maintain as it will very important to restore the operable condition within a specified time in case of any failure. The enormous amount of data in the healthcare system is expanding exponentially at a breakneck speed [62]. Collective decision-making will be impacted as a result of the genuine obstacles in maintaining BDA storage and processing in healthcare organizations since incomplete healthcare data will be more challenging to incorporate into an analytical platform [62].

#### I. Portability

The degree to which a system may be deployed or transferred from one hardware, software, or other operational or usage environment to another is referred to as portability [27], [74]. Similar to maintainability, portability has been selected to fill the theoretical gap for this study. The challenges of BDA portability include the simultaneous combination of information derived from many platforms, particularly in the healthcare context, to accommodate all healthcare information [75]. In today's digital era, everyone appears preoccupied with tracking their fitness and health data using the built-in pedometers of their portable and wearable gadgets such as smartphones, smartwatches, fitness dashboards, and tablets [76]. BDA's system and application in healthcare should be effectively adapted for a different software, in evolving hardware, and work independently with other systems [77]. Therefore, portability is selected as one of the essential BDA quality factors that could affect enhancing healthcare organizational performance.

TABLE III. SUMMARY OF BDA QUALITY FACTORS

Quality Factors	Theoretical Models	Previous Studies	Frequency
1. Reliability	9	14	23
2. Completeness	7	16	23
3. Accuracy	6	15	21
4. Timeliness	2	18	20
5. Format	1	9	10
6. Accessibility	2	8	10
7. Usability	6	2	8
8. Maintainability	7	0	7
9. Portability	6	0	6

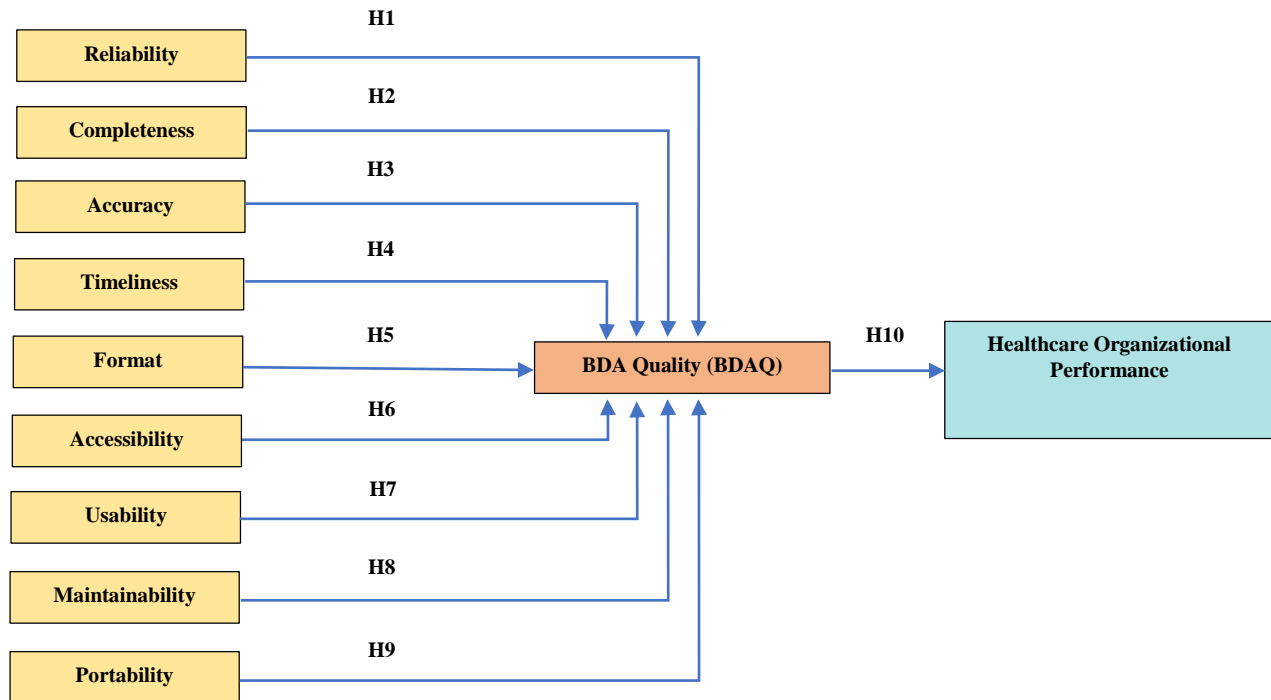


Fig. 3. BDAQ Conceptual Model in Enhancing Healthcare Organizational Performance.

Fig. 3 illustrated the proposed BDAQ conceptual model with ten hypotheses. BDAQ will be specified as a higher-order or second-order construct that contains nine first-order formative constructs. The study will apply the repeated indicator approach to estimate the scores for the first-order BDAQ constructs [78].

H1: Reliability is significant BDAQ factor in enhancing healthcare organizational performance.

H2: Accuracy is significant BDAQ factor in enhancing healthcare organizational performance.

H3: Completeness is a significant BDAQ factor in enhancing healthcare organizational performance.

H4: Timeliness is a significant BDAQ factor in enhancing healthcare organizational performance.

H5: Format is a significant BDAQ factor in enhancing healthcare organizational performance.

H6: Accessibility is a significant BDAQ factor in enhancing healthcare organizational performance.

H7: Usability is a significant BDAQ factor in enhancing healthcare organizational performance.

H8: Maintainability is a significant BDAQ factor in enhancing healthcare organizational performance.

H9: Portability is a significant BDAQ factor in enhancing healthcare organizational performance.

H10: BDAQ has a significant positive effect on healthcare organizational performance.

## V. CONCLUSION

A conceptual model was discovered to be useful in assessing BDA quality. The model may measure and analyze the relationship between reliability, completeness, accuracy, timeliness, format, accessibility, usability, maintainability, and portability as essential BDA quality factors that affect enhancing healthcare organizational performance. The subsequent research activity will involve the creation of a questionnaire-based survey instrument. The proposed conceptual model and surveys will subsequently be validated by an expert from academia, healthcare, and industry. In this regard, a pilot study will be done, which will be followed by the actual study. The model will then be tested using statistical tools, and the resulting insights will enable healthcare organizations to assess the essential BDA quality factors for ensuring that quality compliance is committed and fulfilled when implementing BDA as end-to-end solutions in healthcare organizations. Thus, will improve the efficiency and effectiveness of ICT infrastructure, operational, managerial, and strategic decision-making of healthcare organizations that affect enhance healthcare organizational performance.

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