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Research Article

The impact of Blockchain technique on trustworthy healthcare sector

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ABSTRACT

Following the COVID epidemic, the healthcare sector faced numerous issues as telehealth became more prevalent and the necessity for a safe and efficient healthcare record system became critical. Many issues plague the healthcare industry today, including security, trust, data availability, and drug traceability. Blockchain technology is a relatively new technology that has demonstrated its effectiveness in a variety of industries, including finance, banking, bitcoin, and healthcare. This research investigates the impact of blockchain on the trustworthiness of healthcare. The authors adopt a descriptive-analytical methodology. The trustworthiness of the healthcare sector is considered a dependent variable. However, blockchain technology is considered an independent variable. Three dimensions of dependent variables were explored: integrity, confidence, and reliability. For studying this impact, a questionnaire of 25 items was created and distributed to the stakeholders in the healthcare sector in the north of Lebanon. The collected answers were analyzed using the SPSS application and statistical tools. The results verify that the use of blockchain technology has a great impact on healthcare trustworthiness with its three dimensions (integrity, confidence, and reliability).

1. INTRODUCTION

Under the evolution of disease complexity such as (covid-19) and others, the efforts of medical research centers, scientists, hospitals, and doctors studying cases to produce suitable drugs or vaccines to cure patients of these diseases [1]. The growth of collected and saved big data in different health information systems (HIS) are centralized, defragmented, and unsecured.

The stakeholders in the healthcare sector were facing problems of sharing big medical data to study, examine, and analyze collected information from different areas and cases to benefit from the efforts of others to generalize, predict, and suggest suitable drugs. The breaches, cyber-attacks, and counterfeiting are dangerous for unsecured exfiltration, considered critical for a patient records' malicious manipulation [2].

Recent technologies, such as the Internet of Things, machine learning, image processing, big data, and blockchain, have enabled researchers to overcome previously intractable health problems. However, the vast amounts of data generated in healthcare may cause severe issues. A massive amount of data is floating about with limited access and unexploited computational procedures. As a result, performing an extensive data analysis required to obtain appropriate solutions is difficult [3]. Researchers are concentrating on primary components to overcome these fundamental difficulties in the healthcare business, including data integrity, reliability, and confidence [4].

First, data integrity is a recurring issue in today's healthcare industry. Data integrity ensures that available data is correct and appropriately modified. Incorrect data can endanger patients' health and tremendously burden clinicians [5]. It can result in numerous problems, including misconduct and poor treatment. Handling healthcare data in an unsafe environment is incredibly tough [2].

Second, reliability represents the quality and safety of healthcare systems. It shows the performance of healthcare systems during a specific period. A highly reliable system includes a descending number of risks and errors. The possibility of process failures that can induce patients' injury is very low [6].

Last, confidence is one of the main components of the relationship between patients and healthcare providers. It has many benefits, such as improving health outcomes and patient experience [7]. On the other hand, it is essential to enlighten

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that confidence differs from trust because trust merges support of internal responsibilities of the trusted person; however, confidence mixes support of outer norms and tools of the used system.

Blockchain is a revolutionary data recording mechanism that makes changing, hacking, or defrauding the system difficult or impossible. A blockchain is simply a digital log of copied and distributed transactions throughout the blockchain's complete network of computer systems [8]. Each block in the chain contains numerous transactions, and whenever a new transaction arrives on the blockchain, a block of that transaction is added to every participant's catalog. The distributed ledger technology (DLT) is utilized in a decentralized database with various participants. Blockchain is a distributed ledger technology that records transactions with an immutable cryptographic signature known as a hash [9].

Blockchain technology has recently been used to develop significant solutions in a wide range of industries [10]. Blockchain technology has lately been employed in the healthcare sector to store and distribute patient data among hospitals, diagnostic laboratories, pharmacy corporations, and clinicians. Blockchain technology has the potential to help uncover major and deadly errors in the medical industry [11]. As a result, it has the potential to increase the accuracy, security, and transparency of medical data sharing within the health care system [12-13].

This paper examines the impact of blockchain technology on the healthcare trustworthy with its dimension (Integrity, Confidence, and reliability). It is organized as followed: First, the blockchain technology and its role in the healthcare sector are described in Section 2. The research questions are illustrated in Section 3, followed by the hypotheses of this study. The methodology is described in Section 4. The results are represented and discussed in Section 5. This paper is concluded in Section 6, followed by some recommendations.

2. BACKGROUND

2.1 Blockchain

The Blockchain – also known as ledger [14] - represents a digital database distributed on nodes (see Fig. 1). These nodes are usually known as blocks. The interconnection between these nodes is performed by cryptography. Indeed, a block should contain [15]: cryptographic hash that represents the previous block, timestamp, and transaction data.

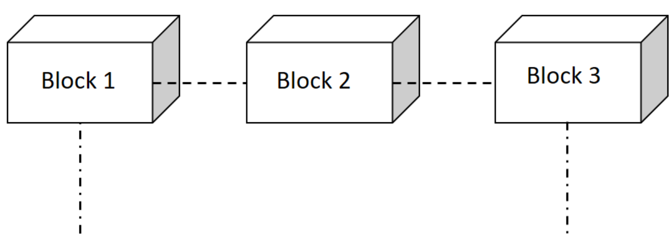

Fig. 1. Blockchain nodes

Thus, a blockchain consists of a set of separated and distributed digital blocks that contain transactions. These blocks are distributed over many computers or other smart devices. The corresponding transactions or records cannot be modified without changing all other related blocks on the same network [16].

Considering data accessibility, the authors in [17] classified Blockchain as:

- Public Blockchain: On the blockchain, any user can access, read, and publish transactions.
- Private Blockchain: Transactions can only be accessed, read, and submitted by members of a certain group of associations.
- Community/Consortium Blockchain: Transaction data can be accessed, read, and submitted by users from various organizations.
- Hybrid Blockchain: A hybrid Blockchain is a relatively new type of Blockchain. To facilitate transactions, this type merges the three other types of Blockchain: public, private, and community/consortium Blockchain. A Blockchain medium can be defined in different ways using Hybrid Blockchain.

Considering permission required to use Blockchain, the authors in [18] classified the Blockchain as:

- Permissionless Blockchain: This sort of Blockchain requires no prior permission from the user. Any user can take part in the validation process and connect to the Blockchain network via its computational media.
- Permissioned Blockchain: Prior permission is necessary to access and execute nodes in the Blockchain network to confirm transactions.
- Hybrid Blockchain: To decrease inter-Blockchain communication, a node in the chain might have both permissionless and permissioned blockchains. The Blockchain infrastructure is set up to support either a permissioned or permissionless architecture.

However, Blockchain can be categorized depending on its functionality and the use of intelligent contract support [19] into:

- Stateless Blockchain: This type of system focuses solely on the optimization of transactions that can be confirmed by computing hashes. In this case, the transaction is segregated from the smart contract logic layer. As a result, it is immune to smart contract code errors and defenselessness.
- Stateful Blockchain: Blockchain provides transaction computing capabilities as well as smart contracts in this form. Furthermore, this type supports multidimensional business logic. It optimizes and keeps logic states in place.

2.2 Blockchain in Healthcare Sector

Blockchain technology received a great interest from the researches and the industry since the invention of bitcoin cryptocurrency in 2008 [20]. Recently, many study examine the role of integration the blockchain in healthcare [21]. The key goals of this integration is illustrated in Fig. 2.

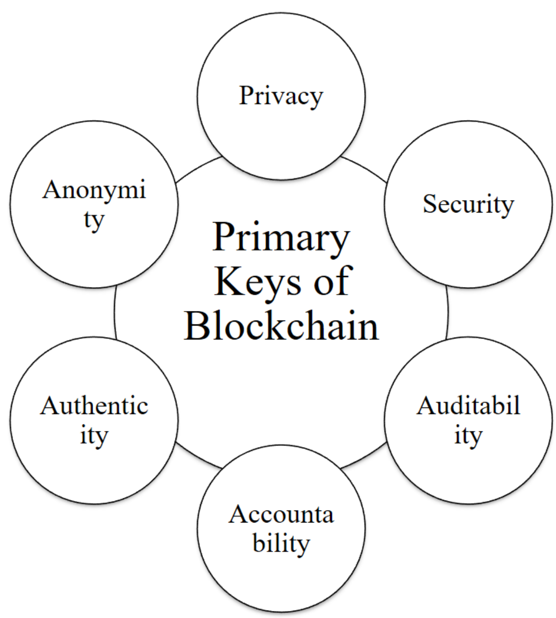

Fig. 2. Main goal of blockchain integration in healthcare sector

The primary keys of blockchain are illustrated and briefly explained as follows:

- Privacy is one of the important roles of blockchain. It consists of protecting patient data from unauthorized access.
- Security: using blockchain, data will be encrypted using asymmetric encryption techniques. This encryption will protect data from thieves.
- Auditability: The capacity to accurately trace and monitor transactions and activity within a blockchain system is referred to as auditability. This is significant because it ensures the transparency and responsibility of all system participants.
- Accountability refers to the capability to track, survey, and fix the responsibility of all employees involved in a blockchain network. It concerns a clear and evident record of all transactions and interactions between users, making it easier to identify any misconduct or unauthorized actions.

- Authenticity: It consists of verifying the identity of the person before giving permission to access the data and the network.
- Anonymity: The act of concealing one's identity is referred to as anonymity. In the context of privacy, businesses may choose to operate anonymously in order to protect the information of their users. Absolute anonymity, on the other hand, is impossible to attain; therefore, pseudo-anonymity, in which some identifying information is still present but buried or masked, is more frequent.

3. RESEARCH QUESTIONS AND HYPOTHESES

The main research question of this study can be summarizes in Fig. 3.

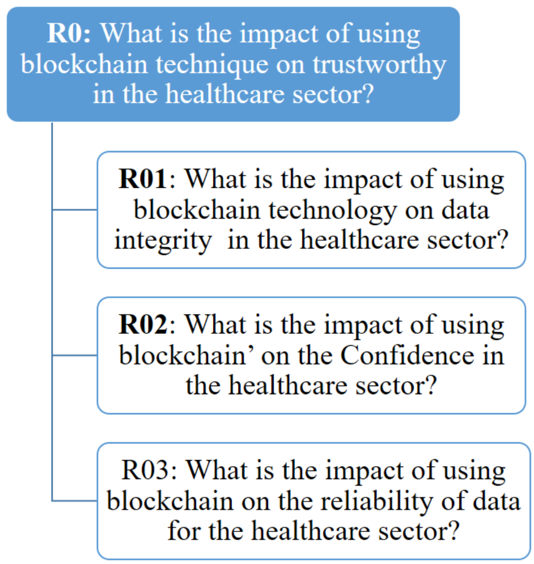

Fig. 3. Research questions of the study

Consequently, the main hypotheses of this study can be illustrated in Fig. 4.

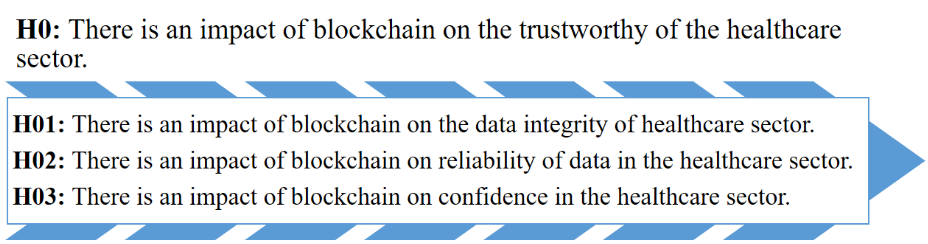

Fig. 4. Hypotheses of the study

4. METHODOLOGY

The main objective of this paper is to study the impact of Blockchain technique impact on trustworthy healthcare sector. For this reason, the following variables will be considered:

- Dependent variable: Trustworthy in the Healthcare sector.

The following dimension will be examined:

- Data integrity
- Reliability

- Confidence

Using the above hypotheses and variables, the following conceptual framework can be deduced (see Fig. 5).

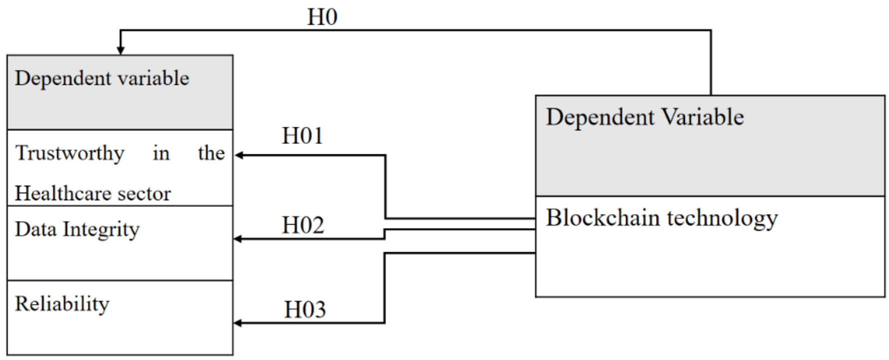

Fig. 5. Conceptual framework

In order to study the impact illustrated in Fig. 5, an analytical descriptive methodology will be adopted (see Fig. 6). First, a questionnaire is designed to cover all the variables of the study. This questionnaire is circulated among the stakeholders in the healthcare sector in the north of Lebanon to gather data. This data will be manipulated later using SPSS software and appropriate statistical tools to analyze the hypotheses of the study [22].

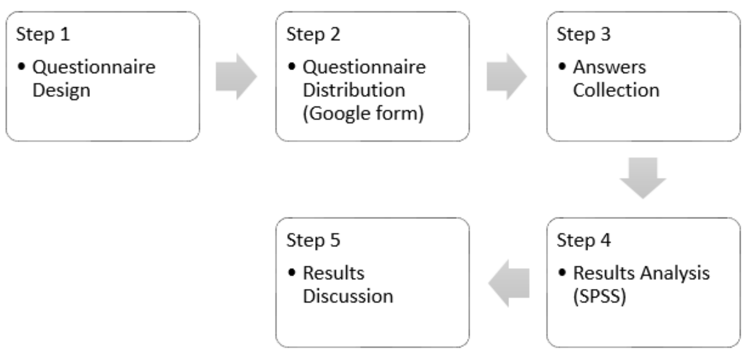

Fig. 6. Steps of analytical descriptive methodology

The questionnaire used in the paper is composite of 25 questions (see TABLE I).

TABLE I. NUMBER OF ITEMS SPECIFIED FOR THE DEPENDENT AND INDEPENDENT VARIABLES

Variable			***Number of items***
Independent	Blockchain competences		5
Dependent	Trustworthy in healthcare sector	Integrity	9
		Reliability	6
		Confidence	5

5. RESULTS AND DISCUSSION

In this section, the result of analyzing the collected answers using SPSS will be presented. During analyzing the collected answer, the five Likert scale is adopted with the associated weight illustrated in TABLE II.

TABLE II. NUMBER OF ITEMS SPECIFIED FOR THE DEPENDENT AND INDEPENDENT VARIABLES

Category	*Strongly disagree (SD)*	*Disagree (D)*	*Neutral (N)*	*Agree (A)*	*Strongly agree (SA)*
Degree	1	2	3	4	5

In this section, the sample will be presented first. After that, the statically tools adopted in this study will be described. A descriptive analysis will be illustrated later. Finally, the hypotheses of the study will be discussed and approved.

5.1 Sample

After distributing the questionnaire, 232 answers were collected. TABLE III represents a description of the sample according to sex, age and education level.

TABLE III. DESCRIPTION OF THE SAMPLE ACCORDING TO AGE, SEX AND DEGREE

Factor	Class	Number
Gender	Female	164
	Male	68
Age	Between 18 and 24	60
	Between 25 and 40	72
	Between 40 and 60	78
	Above 60	22
Degree	Technical degree	104
	Bachelor	70
	Doctor of Medicine	58

According to Table 3, the following facts can be concluded:

- The number of female stakeholders in the sample is greater than the number of male stakeholders. This is evident as the number of female nurses is greater in Lebanon.
- Only 22 people older than 60 participated in this survey. This is normal, as older people are generally disconnected from recent technologies such as blockchain.
- Only 104 stakeholders from the sample hold technical degrees. It is evident in Lebanon. Indeed, almost all the nurses that work in the healthcare sector in Lebanon come from technical institutions. Few of them continue their university studies.

5.2 Statically Tools

The following tools will be used to examine the hypotheses of the study:

- Cronbach's alpha is used to assess survey reliability by comparing the value of shared variance, or covariance, between the items that comprise a tool to the value of overall variance [23].
- The Kaiser-Meyer-Olkin (KMO) test is a statistical test that is usually used to examine if the data is appropriate for the selected factors. to define how appropriate the data is for factor analysis [24].
- Descriptive statistics (mean, standard deviation, kurtosis, and skewness)
- MANOVA test [25].

5.3 Cronbach Alpha and KMO Tests

TABLE IV shows the result of Cronbach alpha for the dependent and independent variables with their corresponding dimensions.

TABLE IV. CRONBACH ALPHA RESULTS

Variable	Class	Number
Blockchain	Blockchain	0.88
Trustworthy in healthcare sector	Data Integrity	0.89
	Confidence	0.78
	Reliability	0.79

Variable	Class	Number
Total		0.91

Cronbach's alpha value is generally between 0 and 1. The interpretation can be as follows:

- A value greater than 0.7 is considered acceptable for research purposes.
- A value less than 0.6 may suggest that the questions are not adequately connected to one another or that they do not measure the intended concept.

Therefore, according to Table IV, the data collected by the questionnaire is reliable.

The KMO test is usually used for factor analysis. It assesses the degree to which the variables in a dataset are correlated. In addition, it estimated whether the data was appropriate for factor analysis. The value of KMO is between 0 and 1. A higher value (close to 1) means that the data is more appropriate for factor analysis.

However, a KMO value between 0.6 and 0.79 represents the suitability of the data to factor, which is mediocre. Finally, the sample is considered unacceptable if the KMO values are smaller than 0.6. The KMO test value of the data in this study is 0.88. Therefore, the data is suitable for the chosen factor.

5.4 Likert Scale - Mean

TABLE V shows the mean interpretation used in this paper to interpret the Likert scale [26]:

TABLE V. THE INTERPRETATION OF THE MEAN ACCORDING TO THE LIKERT GRADIENT

Category	Strongly disagree (SD)	Disagree (D)	Neutral (N)	Agree (A)	Strongly agree (SA)
Degree	1 – 1.80	1.81 – 2.60	2,61 – 3.40	3.41 – 4.20	4.21 – 5
Mean	Very Weak	Weak	Moderate	Strong	Very Strong

TABLE VI shows the mean, standard deviation, kurtosis and skewness of the items according to TABLE V.

TABLE VI. MEAN (M), STANDARD DEVIATION (D), KURTOSIS (K), SKEWNESS (S) OF QUESTIONS OF THE SURVEY

Variable	Item	M	D	S	K
Dependent variable dimension: Integrity	Medical information is stored in a secure way.	3.957	1.0501	-.746	-.633
	Medical information is encrypted and cannot be decrypted by the hackers	3.409	1.0038	-.170	-1.324
	Medical information can be tracked according to time	4.328	.5626	-.098	-.666
	Medical information can be exchanged between stakeholders of the healthcare sector	3.634	.8921	-.391	-.559
	Patient is allowed to take access to his medical data.	3.569	1.0056	.085	-1.480
	Hospital's informatics system can validate the degree of the healthcare stakeholders.	3.414	1.0015	.064	-1.323
	The hospital's information system can track and verify the certificate of drug's origin.	3.483	1.0357	-.029	-1.401
	The hospital's information system can survey the storage and transport process of medicine to ensure its safety and validity.	4.073	1.0016	-.774	-.542
	The hospital's informatics system uses advance technology such as artificial intelligence, blockchain and others	2.983	1.1769	.194	-.787
Dependent variable Dimension: Confidence	In the event that the server fails, the informatics system can continue to operate without interruption.	3.448	.9701	-.082	-.995
	The hospital's information technology infrastructure is capable of preventing medical file piracy and theft.	3.414	1.0696	.141	-1.219
	The information system is capable of preventing the manipulation and destruction of data for a single medical file.	3.737	.9327	-.195	-.865
	The information system can prevent hackers from adding new information to a medical file.	3.621	.8891	-.072	-.736

	The informatics system includes services that allow users to access medical files (add, change, remove).	3.879	.7577	-.698	.610
	The hospital's information system allows the patient to grant permission to access the medical file or portions of it.	3.448	1.0346	-.660	-.498
Dependent variable Dimension: Reliability	API ports in the hospital's information system allow for the secure transmission of patient medical files between the hospital and guarantor businesses.	3.345	.9944	-.310	-.449
	Without the use of intermediaries, the hospital can get payment directly from guarantor businesses.	3.483	0.9063	-.055	-1.076
	The procedure of acquiring clearance from guarantor institutions for a patient is streamlined and efficient.	3.448	0.8390	-.421	-.523
	The relationship between the hospital and the guarantor firms is open and free of corruption.	3.664	0.9316	-.666	-.044
	I am certain that the information exchanged between the hospital and the guarantor companies is secure against theft and alteration.	3.720	.9732	-.038	-1.120
	I am concerned that the internet service provider may jeopardize patient privacy by sharing or selling medical files to research institutions.	3.759	0.7075	-.730	.273
Independent variable: Blockchain	The Blockchain technology employs an unbreakable data encryption method.	3.582	.7161	.315	-.402
	The Blockchain technology grants the patient the ability to master his medical file and allow or deny access to it.	3.724	.8279	.184	-.914
	The Blockchain technology protects patients' medical files completely, and information cannot be stolen or falsified.	3.750	.8045	.082	-.782
	The Blockchain system secures the exchange of information between hospitals in a safe and fast manner.	3.741	.7162	.427	-.969
	The Blockchain technology eliminates the need for a third party to act as a middleman between the patient and the guarantor institutions or other partners.	3.539	.7663	.538	-.467

According to Table VI, the mean associated with the dimension "data integrity" ranges between 2.983 and 4.073. Thus, the opinion of the stakeholders in the sample was neutral, agreeable, or totally agreeable on the integrity of the data in the current information system of the healthcare sector in Lebanon. The standard deviation values are near 1. Therefore, the gathered answers are close to the mean. The skewness value is less than zero. The collected data are concentrated on the right-hand side of the distribution. The kurtosis value is also smaller than zero. Therefore, the distribution is called platykurtic (it is flatter than a normal distribution and has fewer outliers).

According to Table VI, the mean associated with the dimension "confidence" ranges between 3.414 and 3.879. Therefore, the sample agrees on the confidence level in the healthcare sector. The standard deviation values are near 1. Therefore, the gathered answers are close to the mean. The skewness value is less than zero. The collected data are concentrated on the right-hand side of the distribution. The kurtosis value is also smaller than zero. Therefore, the distribution is called platykurtic (it is flatter than a normal distribution and has fewer outliers).

According to Table VI, the mean for the dependent variable dimension "reliability" is between 3.345 and 3.759. Therefore, the collected answers vary between neutral and agreeing that there is reliability in the current information systems used in the healthcare sector. The standard deviation values are less than 1. Therefore, the gathered answers corresponding to the reliability dimension are close to the mean, and the distribution of the answers is normal. The skewness value is less than zero. The collected data are concentrated on the right-hand side of the distribution. The kurtosis value is also smaller than zero. Therefore, the distribution is called platykurtic (it is flatter than a normal distribution and has fewer outliers).

According to Table VI, the mean of the collected answers related to the independent variable "Blockchain" is between 3.539 and 3.750. Therefore, the sample agrees that using blockchain technology in the healthcare sector will have a positive effect on data integrity, reliability, and confidence in the sector. In addition, the standard deviation values are less than 1. Therefore, the gathered data corresponding to the independent variable are normally distributed. The skewness value is greater than zero. Therefore, more answers are on the left side of the distribution. The kurtosis value is smaller than zero. Therefore, the distribution is called platykurtic (it is flatter than a normal distribution and has fewer outliers).

5.5 MANOVA Test

In this part, MANOVA test [27] is applied to approve or reject the hypothesis of the study. TABLE VII shows the results of this test.

TABLE VII. RESULTS OF MANOVA TEST

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Blockchain	Data Integrity	80.508	12	6.709	71.887	.000	.798
	Reliability	108.519	12	9.043	48.000	.000	.725
	Confidence	50.443	12	4.204	70.483	.000	.794
	Trustworthy of healthcare sector	78.998	36	8.096	65.894	.000	.774

According to TABLE VII:

- All sig. values are smaller than 0.05. Therefore, there is an impact of Blockchain on:
    - Data integrity in the healthcare sector
    - Reliability of data in the healthcare sector
    - Confidence in the healthcare sector
- The value of partial Eta Squared between Blockchain and Data Integrity is equal to 0.789. Therefore, there is a large effect of blockchain on data integrity in the healthcare sector. Thus, hypothesis H01 is approved.
- The value of partial Eta Squared between Blockchain and reliability is equal to 0.725. Therefore, there is a large effect of blockchain on the reliability of data in the healthcare sector. Thus, hypothesis H02 is approved.
- The value of partial Eta Squared between Blockchain and trustworthy of the healthcare sector is equal to 0.774. Therefore, there is a large effect of blockchain on trustworthiness in the healthcare sector. Thus, hypothesis H0 is approved.
- The value of partial Eta Squared between Blockchain and confidence is equal to 0.794. Therefore, there is a large effect of blockchain on confidence in the healthcare sector. Thus, hypothesis H03 is approved.

6. CONCLUSION AND RECOMMENDATIONS

This paper studies the impact of Blockchain technology on trustworthiness in the healthcare sector in the north of Lebanon. An analytical descriptive methodology was adopted. Blockchain was considered an independent variable. However, trustworthy on the healthcare sector was viewed as the dependent variable. In this paper, three dimensions of the trustworthy are adopted: integrity, reliability, and confidence. A survey of 25-question was designed and distributed to the stakeholder of the healthcare sector in North of Lebanon. Only 232 answers were gathered and examined using SPSS software. The results indicate that there is a large impact of Blockchain on the trustworthiness in the healthcare sector in north Lebanon.

Following the completion of the following study, the authors propose the following actions for increasing understanding and awareness of the use of blockchain technology in the healthcare sector in North Lebanon:

- Inform key healthcare stakeholders, such as physicians, administrators, policymakers, and patients, on the benefits of blockchain technology in healthcare. Seminars, workshops, webinars, and other instructional activities can help with this.
- Create blockchain use cases in healthcare that clearly highlight the benefits of the technology, such as secure data sharing, interoperability, and patient data privacy. These use cases can help healthcare stakeholders get support for blockchain deployment.
- Collaborate with blockchain technology experts to provide solutions targeted to the specific demands of the healthcare sector. This can contribute to the effectiveness, security, and scalability of blockchain solutions.
- Collaborate with other organizations or stakeholders to help raise implementation awareness. Collaboration with schools and universities, for example, to educate students about implementation, or collaboration with local businesses to implement sustainable practices, can be useful strategies to promote awareness.
- Work with government bodies to help you reach a larger audience and speak with more authority. Government authorities can also assist you in obtaining resources and funds to boost your public awareness campaigns.

- Encourage collaboration among healthcare institutions, technology businesses, and blockchain professionals to build shared blockchain standards and protocols. This can help to assure compatibility amongst blockchain systems while also lowering the cost and complexity of adoption.

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Conflicts Of Interest

The author's paper emphasizes that there are no conflicts of interest, either perceived or actual, that could impact the research integrity.

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