The Effect of Blockchain using Big data and the Internet of Things in Healthcare

Bassant Nabil Mohamed*, Hatem Abdelkader
Information Systems Department
Faculty of Computers and Information
Menufia University, Egypt

***Abstract*—Modern organizations of all sizes emphasize safeguarding sensitive consumer information. Regardless of the limits given by the degrees they choose to pursue, people are nevertheless required to possess data management skills. In addition, determine if the data should be centralized or decentralized to meet the objective of enhancing accessibility. In addition, you will need to be able to monitor who has access to your data and regulate who has access to your data.**

***Keywords*—Big data; blockchain; internet of things; data security; healthcare; data processing cost; IOMCT; climate change and global warming**

I. Introduction

This article focuses on the Internet of Things (IoT) and massive datasets to investigate the use of blockchain technology, specifically to enhance the overall quality of the healthcare system. The fast growth of the internet of things is inextricably related to the rapid growth of the information technology sector (IT). A Model (Internet Of Medical Thing) IOMCT was created to address these issues since it was difficult to get the necessary insurance approvals and there was a difficulty with the dispersion of information. This concept was created to solve the challenges associated with getting the requisite insurance approvals. In addition, there is a reduced likelihood that sensitive information and data may be stolen by unauthorized individuals as a direct result of being exposed.

The findings of this research indicate that the technique we have developed will contribute to the safeguarding of patients' personal information. In addition, it will improve people's awareness of the connection between paper use and global warming. Therefore, it is fair to assume that individuals would choose the paperless technique, which will contribute to the conservation of natural resources.

It should not come as a surprise that healthcare is a top priority in countries with low per capita income since it has direct effects on the health and longevity of the people. It has the potential to considerably benefit society as a whole by reducing the occurrence of a broad range of illnesses and ailments that are harmful to one's health as shown in Fig. 1. This study should be continued since its potential benefits to society as a whole are substantial. In light of this, it is glaringly evident that recent advances in technological capabilities and ongoing research and development have been crucial to the advancement of the medical sector [1].

In the not-too-distant future [19], it is anticipated that the Internet of Things will become a formidable mechanism for the production of counterfeit wristbands, smart cards, and watches. Using a blockchain ledger in this capacity, data such as a patient's heart rate, blood pressure, and blood sugar levels may be recorded automatically and exactly.

Advanced Technologies including the IoT, Blockchain, and Big Data, can assist doctors and medical sectors in the early diagnosis of various diseases.

As a direct consequence of technological improvements, our lives have grown simpler, more accurate, and more reliable. By the time you conclude this essay, you will understand how to simplify the patient care procedure at any medical institution. The Internet of Things employs a broad range of technologies, including sensors, the cloud, wireless technology, and security, to name a few [10]. Paper organization. Section II explains the essential problems and illustrates the objectives of the paper. Section III explains the literature reviews of the previous researchers. Section IV explains the research methodology. Section V explains the Healthcare proposed model (IOMCT). Section VI explains the proposed Blockchain Algorithms. Section VII illustrates the results of the research. And finally, Section VIII clarifies the conclusions and recommendations of this paper.

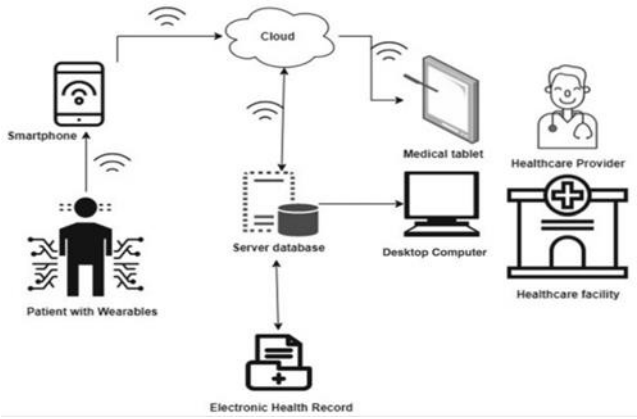

Fig. 1. Conceptual model of IoT in healthcare [1].

II. Problem Definition and Objective

In the HealthCare era, the patient always feels that he wastes a lot of time to form registration or even if wants just a simple consultation. So, he must move through the whole

*Corresponding Author.

hospital procedure, and waste time in waiting. On the other side, for people who face problems with heart pulse rates, sugar rate or blood pressure continuous monitoring and observation are. They don't have a solution except to go to the doctor and wait till they take only consultation, or they can only send an email or message to the doctor and then wait till he answers. In another situation, people don't need their data to be exposed to all hospitals. As he can see the patient history from before. So, according to that patient cannot own and control or secure his data from exposure. In addition, people who work in sensitive positions, and face some health problems, don't have the luxury to save their information. So, in this paper, we will go through all these problems and propose effective solutions.

III. Literature Review

Jalel Ktari and his coworkers came up with the concept of developing a heterogeneous embedded platform to facilitate the construction of electronic health records (EHRs) with multiple inputs. This platform can collect data from a variety of sensors that are interconnected via the internet of things. Utilizing Ethereum's permissioned network, this method encrypts data not once, but twice, thereby enhancing the security of the data [17]. To complete this task, the PoW consensus technique will be utilized. We decided on this course of action to protect the privacy of our patients. This information must be protected from both unauthorized access and prying eyes [3].

Tian-Fu Lee, et al. proposed a mechanism for preserving medical information that considers the entire process of data from data generation through transmission by wearable devices to mobile devices and then to a medical Center server [4]. In a presentation, Gautam Srivastava et al. discussed both the advantages and practical challenges associated with using blockchain-based security solutions for the Internet of Things-based remote patient monitoring. In addition, it assesses the relative benefits and drawbacks of a variety of cryptographic algorithms that might be useful for Internet of Things deployment. In this study, we provide a paradigm for securely transporting data over networks and storing data in the cloud using low-overhead cryptographic techniques, such as the ARX encryption scheme [5].

Partha Pratim Ray and colleagues [6] suggested the use of an IoBHealth data-flow architecture for storing, retrieving, and managing electronic medical information. IoBHealth combines blockchain technology with the Internet of Things. The purpose of this presentation by K. Azbeg and colleagues is to classify the Internet of Things and blockchain technology applications in the medical industry. Six distinct medical service applications were examined, along with a study of the problems that may occur when trying to use Blockchain technology in IoT-based healthcare systems [7]. In a newly published research, Manal Al-rawashdeh and her colleagues categorized the characteristics that influence IoT adoption as follows: personal considerations, technical considerations, security issues, health concerns, and environmental aspects [8].

The authors undertake a literature study on the issue of healthcare IoT application adoption between 2015 and 2021. The purpose of this study was to compile prior studies on the acceptability and deployment of Internet of Things (IoT) technologies in smart healthcare. The research painstakingly explored, obtained, evaluated, and synthesized the relevant material for the study [9].

A. Decentralization

We need a decentralized system in order to avoid many-to-one traffic flows, as well as ensuring that the system is both resilient and scalable. It's possible that using a decentralized approach would reduce the amount of time that passes between blocks of information in Blockchain [13]. An overlay scattered network is used in our approach to the problem.

B. Healthcare Providers and Patients

Patients or insurance companies might hire healthcare professionals to carry out diagnostic procedures or to provide therapy initiatives. When they get a network alert, medical practitioners are able to begin treating patients immediately after receiving the notification [13]. Patients have complete authority over the individuals who are granted access to their medical information and are free to revoke consent at any time [5]. This covers the companies that supply their insurance and healthcare services.

C. Smart Contracts

Any agreement that is made via an Internet of Things device has the potential to be converted into a "smart contract" and put into effect when certain criteria are satisfied [18]. Take into consideration the fact that we determined the highest and lowest values of blood pressure for each of our patients. If the smart contract receives a blood pressure measurement from a wearable device that is outside of the normal range, it will send an alarm to the appropriate individual or healthcare professional and save the abnormal data in the cloud. This will allow the provider to see the data in real time. The contemporary world has given rise to a wider variety of potential uses for RFID technology. This technology has seen widespread use for the automation of industrial processes as a direct result of the complicated manufacture of consumer goods such as motor cars, home appliances, and other products (refrigerators and washing machines) [11]. The Vatican Library, which possesses more than two million books, uses a technology called radio frequency identification (RFID) to speed up inventory and book searches, automate book distribution, and assist in the prevention of theft. Over seven hundred of the major libraries in the world have either already accepted this technology or are in the process of adopting it [2, 3].

RFID chips are being embedded into all newly issued passports by a growing number of countries throughout the globe. These travel papers are referred to as biometric e-passports, and they include a chip that has the same information as the printed pages of the passport. The healthcare industry is "establishing a foothold" for this technology [14]. A woman and her baby might be connected at the hospital via the use of an RFID bracelet. In traditional hospitals, they are often used to keep track of patients who need continuing medical attention by following their movements throughout the facility. The unique usage of the idea of a wireless sensor network [4] that is used to monitor and change physical things is shown by connecting the tracker to the heart rate monitor. The connection

between these devices and GPS trackers, mobile phones, social networking platforms, cloud servers, and big data analytics tools is now essential to the functioning of the Internet of Things (IoT) [12].

IV. Proposed Methodology

This research and its methodology, suggest new research methods, newly apply, and interpret the existing methods, also it complements scientific theories, concepts, and models with new data and newly interprets this data, presents new empirical data obtained through the application of the existing and new research methods, and independently collected, processed, and analyzed by the researcher [20].

Methodology of this research contains:

1) Data collection.
2) Data preparation.
3) Data analysis.
4) Data processing Costs.
5) Data Acquisition.

A. Data Collection

Data should be collected from multiple resources, like public and private sectors hospitals and clinics, most of the data could be collected from the ministry of health.

B. Data Preparation

Data should be classified according to each major and specialty in the health industry, like, Cardiology, Dermatology, Chest, ENT, gastroenterology, Nephrology, Orthopedics, and Ophthalmology. In the end, each patient should have like a folder that contains all his history in every specialty.

C. Data Analysis

It was taken from various perspectives through various technologies: The blockchain is a decentralized, auditable, and reliable ledger for storing and transferring data. It is a database that tracks the activity of the various users it serves in its most fundamental form. Utilizing this decentralized database should not put you in danger. Users are supplied with the option to independently check the chain's validity via distributed data storage and verification. [3] Blockchain technology will help in saving all information for one patient in a block taking its hash function as a reference to another block, to build up a chain of blocks that configure a blockchain. Internet of Thing (IoT), which help in collecting data from cloud sources or databases that have the patient information got from sensors applied in bracelets, watches, and electronic cards. Big Data it’s a concept of how to save structured and unstructured data combined from all sources that contain all information needed, through its techniques.

D. Data Processing Costs

Another key challenge that modern healthcare organizations have to overcome is the high cost of gathering and distributing patient data. The vast majority of time is used by sharing the patient's medical history to other facilities. It is both time-consuming and expensive to compile a patient's complete medical history from the several, non-computerized hospital record systems that are available [15]. It is possible that the administrative expenses generated by present healthcare systems for third parties will be reduced if blockchain technology is used. In addition to this, it enables flexible data access to the patient's medical record. The patient's medical record is compiled and kept up to date using information from a range of sources, such as personal wearables, mobile devices, and patient records. It is possible that blockchain technology may reduce the operational costs of healthcare providers since it would consolidate patient data in a single location.

The process of getting useful data from extensive databases is referred to as information extraction [4]. The strategy is dependent on the manner in which the information is gathered [5]. "Having access to the data is fantastic, but it serves no use if we are unable to turn it into something of value." Because of this, it is the most important component of big data, since it is the area in which the majority of businesses invest their money and resources in order to gain knowledge and make money [16].

E. Data Acquisition

The majority of data-collecting systems take analogue wave patterns and convert them into digital values so that they can be processed more easily. A data collection system is comprised of a variety of components all working together to form the whole. Sensors are devices that collect data from the real world and convert it into a format that computers and other electronic devices can interpret. Signal conditioning circuitry that transforms analogue sensor data into a format that can be successfully digitized. Following conditioning, sensor signals are transmitted to an analogue-to-digital converter, which receives the digitized data. Through data acquisition, we can close the circle of integrating the internet of things with blockchain and big data. The majority of the time, software applications used for data collection are managed by programs written in one of several general-purpose programming languages. [2].

V. Healthcare Proposed Model IOMCT

Proposed Model Phase 1

A. Internet of Medical Card Thing (IOMCT) Phase 1

The IOMCT model represents the cycle of patient data collection.

Phase one as shown in Fig. 2 talks about two paths for data collection:

When the IoT that is represented in the patient bracelet detect the patient’s heart pulse, Sugar Rate, and pressure Rate. Then add this information to the patient Block through the cloud storage. So that it will update the patient history, which will be automatically added to the patient card when uploading the updated information through the cloud storage. Data collection is formed in the hospital when the patient presents the card to the reception desk. It only needs just one tap to check the patient’s data.

B. Internet of Medical Card Thing (IOMCT) Phase 2

Phase two as shown in Fig. 3 talks about the rest of entire procedure that represented in validating the patient data in couple of steps.

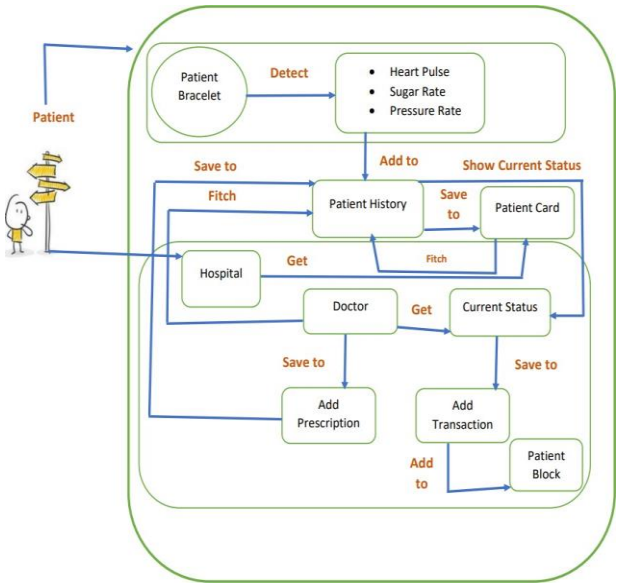

Fig. 2. IOMCT model Phase 1.

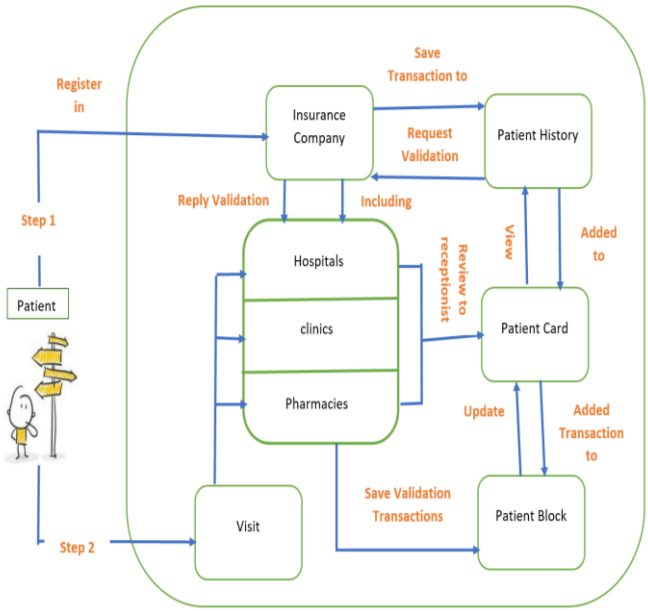

Fig. 3. IOMCT model Phase 2.

First step, with the insurance company whether for hospitals, clinics, or pharmacies and save validations results to the patient history that will be added directly to the patient Block through cloud storage to update the patient Card information.

Second step, when patient visit any of the hospitals, clinics or pharmacies, this visit will be updated in the patient block and added to the patient card so that data will be automatically maintained and updated whenever any new visit happen.

VI. HealthCare Proposed Blockchain Algorithms

The Tables I and II show the IOMCT model algorithm phase 1 and phase 2 that present the Blockchain creation and the hash creation.

TABLE I. IOMCT Algorithm Phase 1

Algorithm 1: Blockchain Creation

Input: hashlib, json, Time
Output: new blockchain
Procedure:

-Step1: Create essentially chain object. x = essential block. chain
Y = Current transaction z = nodes.
X []
x.y = []
x.z = set []

-Step2: Create new Block for the created chain in step1.
x. new block (p.hash= 1, proof=100) where p.hash = previous block hash = SHA1

-Step3: Generate hash for blocks.
Define hash (block):
Block_string = json.dumps (block. Sort_key=true). encode ()
Where json used for sorting &exchanging data &
Generate SHA256 value.
Return.hashlib. sha256 (block_string).hexdigest().
Where hashlib is a module for hashing messages.

-Step4: Create new block in the created blockchain
Define new_block (x, proof, p.hash = Name):
Where
Block = {'index' = len(x.chain)+1,
'timestamp'= time(),
'transactions': x.y,
'proof' = proof,
'p.hash': p.hash or x.hash (x [-1]),
}
x.y = [] x.append (block)
return block
where x.y [] for resting the current list of transaction

-Step5: Create last block
Define last_block (x):
Where last_block (x) return the last block in the chain(x)
return x [-1]

End procedure

TABLE II. IOMCT ALGORITHM PHASE 2

Algorithm 2: Blockchain Creation
Input: hashlib, json, Time, x [essential block.chain], y [current transaction]
Output: add new transactions to blocks & validate their data
Procedure:
-Step1: Define new transactions statement Define N_T (x, sender,recipient, amount):
x.y.append ({"sender": sender,
"recipient": recipient, "data": amount,})
Return int (x.last_block['index']) +1 Where N_T = new_transaction
-Step2: Define proof of work statement.
Define proof_of_work (x, last_proof): Proof = 0
While x. validate_proof (last_proof, proof) is false:
Proof + = 1 Return proof
Where pr is containing 4 zeroes & pr is the previous pr
-Step3: validate proof
Define validate_proof (last_proof, proof): Guess= pr {last_proof} {proof}
.encode()
Guess_hash =hashlib.sha256 (Guess).hexdigest()
Return Guess_hash [:4]=="0000"
Where validate_proof shows if
hash (last_proof, proof) contains 4 zeroes or not?
End procedure

VII. RESULTS

Results in this paper were taken from two stages:

1) Development Stage: that presents code written using the python tool.

2) Interface designed application stage, with the aid of a designed card handles all information about a certain patient that will hold the card: this design is connected with the code forming the results shown below.

- First Stage: Development Stage: The code below will initiate the new blockchain node and create a new globally unique identifier as shown in Fig. 4.

```
app = Flask(__name__)

node_identifier = str(uuid4()).replace('-', '')

blockchain = BlockChain()
```

Fig. 4. Unique identifier.

The blockchain class object definition by initiating:

- New chain array.
- Current transactions array.
- New Node creation.
- New block creation and setting the hash method and proof (success) as shown in Fig. 5.

```
class BlockChain(object):
    """ Main BlockChain class """
    def __init__(self):
        self.chain = []
        self.current_transactions = []
        self.nodes = set()

        self.new_block(previous_hash=1, proof=100)
```

Fig. 5. New block creation.

The code below shown in Fig. 6 describes the new block by setting the index, timestamp, current transaction, proof, and previous hash. According to the code above shown in Fig. 5, the previous hash is passed with the value one. However, if it is passed by none the value will be set according to hashing value done in the previous chain block value.

```
def new_block(self, proof, previous_hash=None):

    block = {
        'index': len(self.chain)+1,
        'timestamp': time(),
        'transactions': self.current_transactions,
        'proof': proof,
        'previous_hash': previous_hash or self.hash(self.chain[-1]),
    }
```

Fig. 6. Hashing value.

```
@staticmethod
def hash(block):


    block_string = json.dumps(block, sort_keys=True).encode()
    return hashlib.sha256(block_string).hexdigest()
```

Fig. 7. Code value.

The code shown above in Fig. 7 was developed to hash the block using the SHA256 protocol .After setting the block, we will empty the current transaction array. Then, adding the new block to the current node as shown in Fig. 8.

```
self.current_transactions = []
self.chain.append(block)
return block
```

Fig. 8. Chain protocol.

The code shown in Fig. 9 and Fig. 10 is for new transaction creation in the blockchain and setting the transaction values. However, before submitting the transaction received, we will check if the required values are passed or not (sender, recipient, and amount).

```
def new_transaction(self, sender, recipient, amount):

    self.current_transactions.append({
        "sender":sender,
        "recient":recipient,
        "data":amount,
    })
    return int(self.last_block['index'])+1
```

Fig. 9. New transaction creation with setting values.

```
@app.route('/transaction/new', methods=['GET'])
def new_transaction():

    values = request.get_json()
    required = ['sender', 'recipient', 'amont']

    if not all(k in values for k in required):
        return 'Missing values.', 400

    index = blockchain.new_transaction(
        sender = values['sender'],
        recipient = values['recipient'],
        amount = values['amount']
    )

    response = {
        'message': f'Transaction will be added to the Block {index}',
    }
    return jsonify(response, 200)
```

Fig. 10. Registration nodes.

Registering new nodes by getting the JSON object and then searching for node values as shown in Fig. 11. The code checks if there are no nodes. So, it will give an error. Otherwise, iterating on nodes and adding them to the current block.

```
@app.route('/nodes/register', methods=['POST'])
def register_nodes():
    values = request.get_json()

    print('values',values)
    nodes = values.get('nodes')
    if nodes is None:
        return "Error: Please supply a valid list of nodes", 400

    for node in nodes: blockchain.register_node(node)

    response = {
        'message': "New nodes have been added",
        'all_nodes': list(blockchain.nodes),
    }

    return jsonify(response), 201
```

Fig. 11. New nodes.

The new node addition will be done by calling the below code shown in Fig. 12.

```
def register_node(self, address):

    parsed_url = urlparse(address)
    self.nodes.add(parsed_url.netloc)
```

Fig. 12. Additional new nodes.

Fig. 13 shows how to find the whole chain in the current blockchain by passing the chain value along with the length of the chain.

```
@app.route('/chain', methods=['GET'])
def full_chain():
    response = {
        'chain': blockchain.chain,
        'length': len(blockchain.chain),
    }
    return jsonify(response), 200
```

Fig. 13. Whole chain value.

Now in Fig. 14 shown below, it finds the latest block in the chain.

```
@property
def last_block(self):

    return self.chain[-1]
```

Fig. 14. Latest block.

The below code as shown in Fig. 15 validates if the proof is like the previous proof containing the same structure with leading four zeros in both.

```
def proof_of_work(self, last_proof):

    proof = 0
    while self.validate_proof(last_proof, proof) is False:
        proof += 1
    return proof
```

Fig. 15. Mining block.

Before mining the block, some inputs need to be validated like the below code shown in Fig. 16 to validate the proof by encoding the last proof values using SHA256 protocol and then validating if the proof does contain four leading zeroes or not.

```
@staticmethod
def validate_proof(last_proof, proof):

    guess = f'{last_proof}{proof}'.encode()
    guess_hash = hashlib.sha256(guess).hexdigest()
    return guess_hash[:4] == "0000"
```

Fig. 16. Input validation.

After submitting the transaction, the next step is mining as shown in Fig. 17. So, the code below will be used to mine the newly submitted block through the following:

1) Running the proof of work.
2) Submitting new transaction.
3) Rewarding the mining server for finding the proof by one coin.
4) Hashing the block.
5) Adding the new block.

- Second Stage: Interface designed application stage

As mentioned in this paper, the data of health records will be distributed and secured through the blockchain, however, we need to show the data using different channels like mobile, tablets or other devices that will be used by medical authorities or doctors. We believe that this data should be managed dynamically and completely by the patient to show only the piece of information required. This will be achieved through a health record card that will be owned by the patient and s/he can control this data through a health record administration app.

The health record will be shown to the doctors, and authorities by tapping the card on an NFC reader that could be mobile, tablet or handheld that has NFC embedded to show the health record as shown in Fig. 18.

The health record will be shown on the device according to a piece of information selected through the medical record administration app as shown in Fig. 19.

```
@app.route('/mine', methods=['GET'])
def mine():

    last_block = blockchain.last_block
    last_proof = last_block['proof']
    proof = blockchain.proof_of_work(last_proof)

    blockchain.new_transaction(
        sender=0,
        recipient=node_identifier,
        amount=1,
    )

    previous_hash = blockchain.hash(last_block)
    block = blockchain.new_block(proof, previous_hash)

    response = {
        'message': "Forged new block.",
        'index': block['index'],
        'transactions': block['transactions'],
        'proof': block['proof'],
        'previous_hash': block['previous_hash'],
    }
    return jsonify(response, 200)
```

Fig. 17. Mining step.

Fig. 18. Patients' health card.

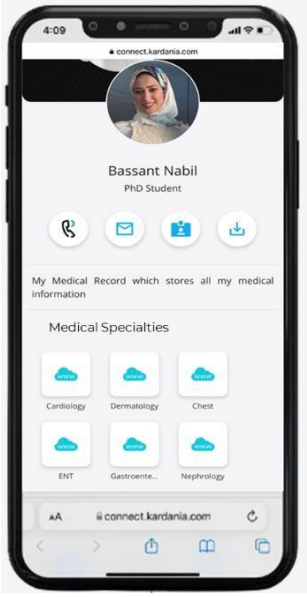

Fig. 19. Patient record.

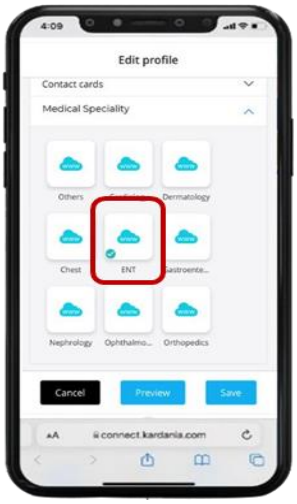

Fig. 20. Segmentation.

The patient can edit his medical profile to select which information is to be shown once the card tapped on the device (ex: ENT) as shown in Fig. 20.

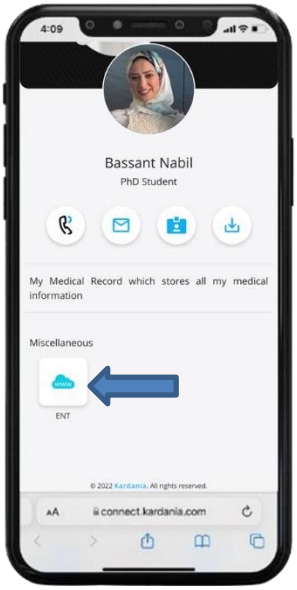

Fig. 21. Profile.

Now, the information that will be shown on the card is what is selected through the administration app. So, the ENT medical record information will be shown, and authorities/doctors can click on it to show the data as shown in Fig. 21.

The document shown in the Fig. 22 mentioned above is the last medication taken by the patient and now the doctor can take a decision accordingly. All this information and documents are synced through the patient block in the ministry of health block chain with all security measures taken benefiting from encryption and distributing data across all servers.

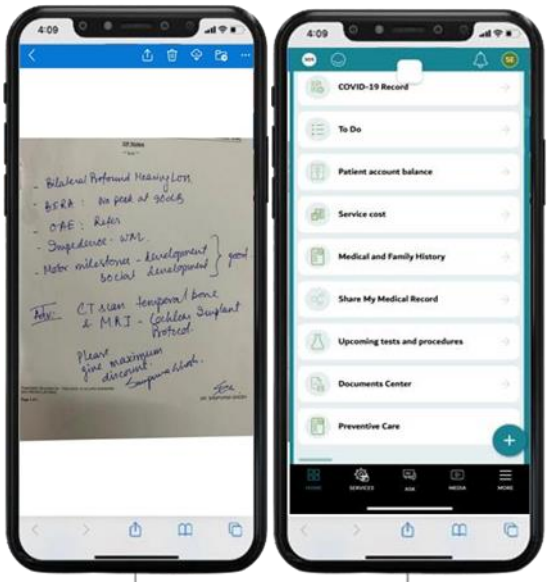

Fig. 22. Documentation.

VIII. Conclusions and Recommendations

Even though blockchain is still thought of as a concept that is in its infancy, a significant amount of study has been carried out on the topic. There are still research holes that need to be filled, even though there has been some development in our understanding of how these things might be used in Hyperledger. The course of this investigation led to the discovery of a potential loophole in the data security that is in place between the participants. The vast majority of the work done in the field thus far has been devoted to investigating a wide variety of subjects, including the transmission of sensitive data, the veracity of distributed systems, various ideas and types of blockchains, blockchain capabilities, and distributed ledger technology.

In addition to above loophole, the policies that should be implemented should be integrated pragmatically to support data compliance with code of ethics in using the online data. A unified health policy based on multidisciplinary partnership is critical to safeguard online data and promote public trust.

During this long journey, there's a lot of other pillars that will need to be studied like the migration and integration between medical authorities in addition to the cost of ownership and return of investment.

Relying on this paper, a real case is under study now in Abu Dhabi for facilitating to the UAE citizens who are getting some treatments abroad and how they can manage their health record to show the piece of information required from the authorities abroad to avoid sharing the medical history over emails with doctors or through physical documents.

The approach proposed through this paper is serious trail that approaching to connect all stakeholders in one platform taking into consideration the data security and integrity.

Adding to this, there are some benefits will be achieved

- Better healthcare service quality.
- Better patient experience.
- Holistic connected care
- Unified patient medical record.
- Increasing the efficiency of services provided.

ACKNOWLEDGMENT

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