Blockchain in Healthcare

GROUP #8

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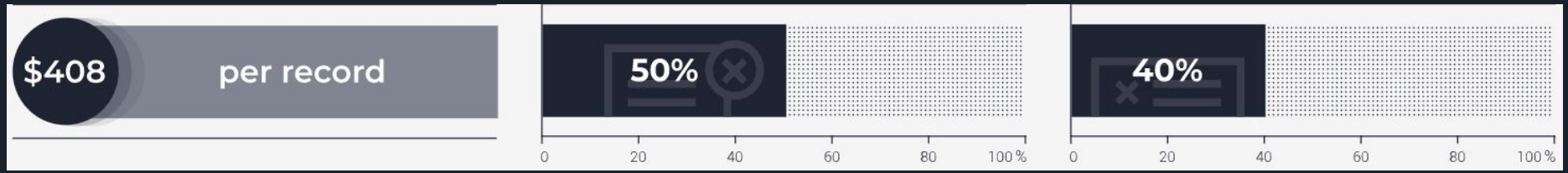
Why? (Cont'd)

Some Drawbacks of the Current Systems



- The cost of data breaches per record
- 50% of clinical trials in the US are unreported.
- 40% of healthcare data records contain errors or misleading information.

Why?

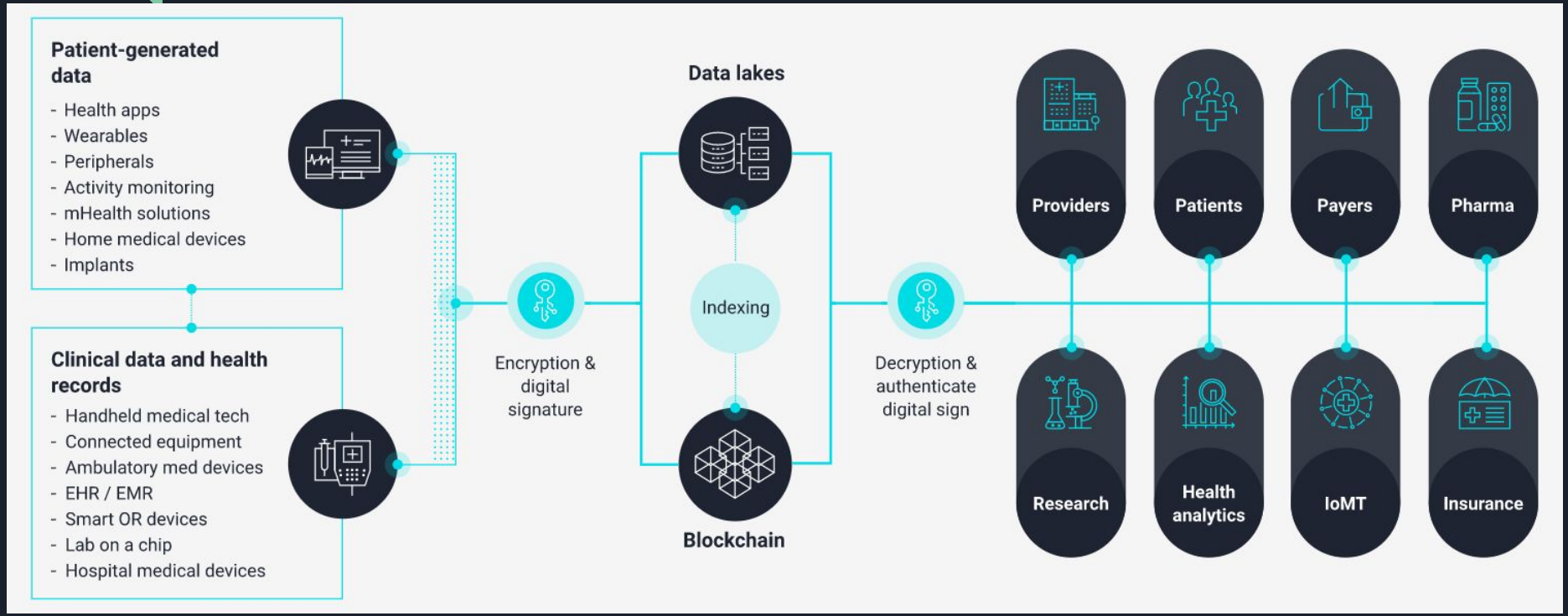
Why Blockchain Can Be Useful for Healthcare?

- The healthcare industry has trailed other sectors in adopting new technologies and applications.

- However, the current system has some drawbacks.

How?

How the System Works?



How the System Works? (Cont'd)

1- Clinical Trials

- Blockchain technology fosters transparency and trust between stakeholders, reduces audit costs, and improves pharmaceutical supply chain management.

- It includes participants (manufacturers, packagers, distributors, dispensers, and regulators) and details like manufacturing locations, shipping dates, batch numbers, expiry dates, storage temperature, and unique identification numbers.

How the System Works? (Cont'd)

2- Data Sharing

Blockchain technology preserves :

- the integrity of data exchanges between healthcare providers,
- Patients and third parties like insurers,
- Delivering real-time data sharing, global standards,
- Regulatory compliance.

It also empowers individuals to be accountable for their healthcare, reduces costs and makes the healthcare industry more efficient.

How the System Works? (Cont'd)

3- Electronic Health & Medical Records (EHRs & EMRs)

Blockchain allows patients:

- to control their own healthcare data,
- to manage the accesses by doctors, hospitals, healthcare providers and laboratories

to past and present ailments, treatments, and family history of medical problems.

A single, securely-stored version cannot be accessed or changedwithout authorization.

How the System Works? (Cont'd)

4- Medical Device Tracking

Blockchain allows healthcare device tracking across device lifecycle from manufacture to decommission.

At every stage:

- current location of the device,
- a full location history and all the manufacturer,
- reseller,
- serial number,
- repair history and other data associated with the device.

How the System Works? (Cont'd)

5- Micropayments

Blockchain used to facilitate micropayments without a third party, offering a direct, trackable flow of transactions.

There are additional applications in rewards program development for patients who attend appointments on schedule, contribute their data to clinical trials and research and follow medical care plans.

How the System Works? (Cont'd)

6- Accelerating R&D (Ar-Ge)

Blockchain technology streamlines and accelerates R&D in healthcare,

- boosting innovation,
- lowering costs at pharma and medtech companies,
- quickly processing R&D data gathered from research labs from around the world.

Leverage transparency, auditability and accountability to ***benefit from the skills and knowledge of medical practitioners and researchers around the world.***

How the System Works? (Cont'd)

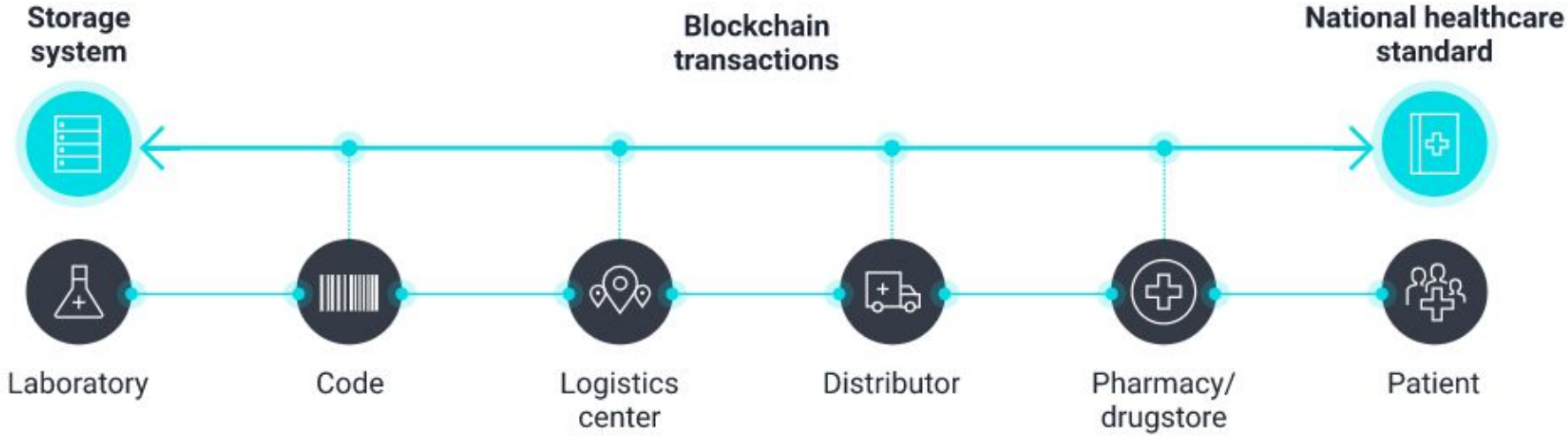
7- Drug Traceability

Blockchain application helps overcome the increasing risk of counterfeit or unapproved drugs.

1. Transactions are timestamped,
2. Drugs are registered by smart contract,
3. Pill containers are identified,
4. and a complete path of origin, with integrated GPS and chain-of-custody logging,

ensures reliable drug delivery.

Drug Tracing Visualized



How BC Advances the Quality of Healthcare?

- **Healthcare Excellence**
  - Blockchain technology in the healthcare industry enables a patient-centric approach to data management and retention and deliver higher service standards.
- **Improved Information Security**
  - Blockchain technology guarantees data provenance in healthcare and allows enhanced trust without the need for third parties.
- Interoperability
  - Blockchain technology prevents unauthorized information access and improves patient healthcare data management.
- Data Integrity
  - Editing or falsifying medical data becomes impossible, and health information, medical test dates and results, billing and payments are immutably and automatically recorded, preventing fraudulent activity and saving money currently spent on manual data tracking.

Which improvements can Blockchain put forward?

- Stopping counterfeit drugs
- Patient - doctor interactions
- Tracking clinical trials and pharmaceuticals
- Improving medical record keeping - accessing
- Reducing Costs

Improvement #1:
Stopping Counterfeit Drugs

Improvement #1:

How Blockchain Could Eliminate Counterfeit Medicine

Blockchain technology can be used to ensure transparency from start to finish in the Medicine Supply Chain.

Firstly, let’s begin with facts and pharmaceutical industry and then we will talk about how can blockchain can solve this problem.

Stopping Counterfeit Medicine
Problem

Counterfeit medicines are killing an estimated 1 million people a year. The World Health Organization (WHO) estimate that around 10% of medicines across the world are counterfeit and that this rate is as high as 30% in some areas of Asia, Latin America and Africa.

As a result, the OECD has deduced that the counterfeit pharmaceutical industry is worth somewhere in the region of $200bn annually – for comparison, the illegal drug trade is worth around $246bn.

Blockchain technology can help us by securing data in a way that is impossible to manipulate has potential to tackle this counterfeit drug industry by tracking the movement of drugs.

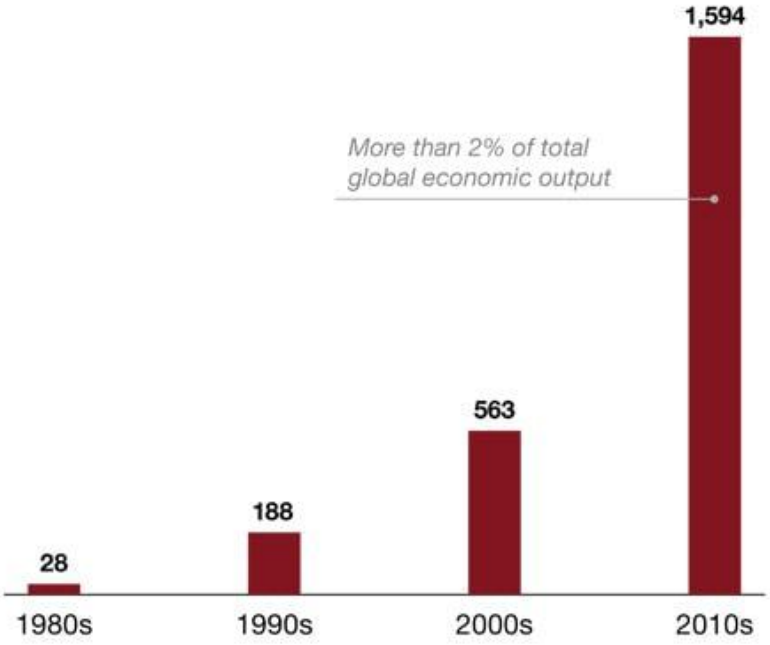
Counterfeiters can produce look-alike drugs which are costless.

Criminals duplicate packaging, shape, taste and feel so much that it is nearly same as original medicine. Patients and doctors can’t tell the difference.

Exhibit 1

Damage from counterfeit goods, by industry

Surging cost of counterfeiting (€ billions, based on average annual estimate of global counterfeiting revenues)



Global counterfeiting market by sector (€ billions)
2013 estimates, not all sectors included

Prescription drugs	188
Electronics	158
Foods	46
Auto parts	42
Toys	32
Clothing and shoes	23
Sporting goods	6
Tobacco	4
Cosmetics	3
Aircraft parts	2
Weapons	2
Alcohol	0.9
Watches	0.9
Diplomas and degrees	0.9
Pesticides	0.7
Money, IDs, and passports	0.3

Source: NetNames, "The risks of the online counterfeit economy," 2016; NetNames, "Counting the Cost of Counterfeiting," 2015; Strategy& analysis

Stopping Counterfeit Medicine
Solution

Decentralization - Immutability:

We can use decentralization, encryption methods and immutable record-keeping from Blockchain Technology. This means it can be used to track and secure goods at each stage in the supply chain process.

Supply Chain

The same methodology can be applied to **pharma supply chains** to prevent the distribution of counterfeit medicine. Blockchain can be used to **ensure there is verifiable proof of what has been delivered to who and by whom, with complete transparency** and without doubt. **As the drug moves through the supply chain, each transaction would therefore be noted and time-stamped** using the ledger system of blockchain to ensure security and safety of the product.

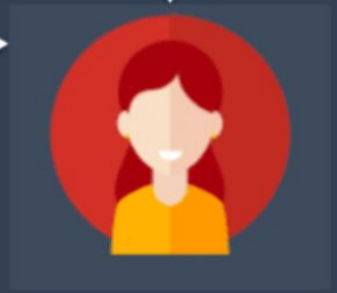
Tracking the supply chain of a drug

- An application called ***lifecrypter*** was developed to solve the problems we have discussed.
- This application ensures that the drug is verified at every checkpoint from production to sale.
- With using Contract unique ID, user security and originality are protected.

The manufacturer sends the drugs to the wholesaler

The wholesaler sends the drugs to the pharmacist

The pharmacist delivers the drug to the patient



The manufacturer produces the drug and marks it with an unique code

A hash is produced

The information is stored on the blockchain

The wholesaler verifies the origin of the product

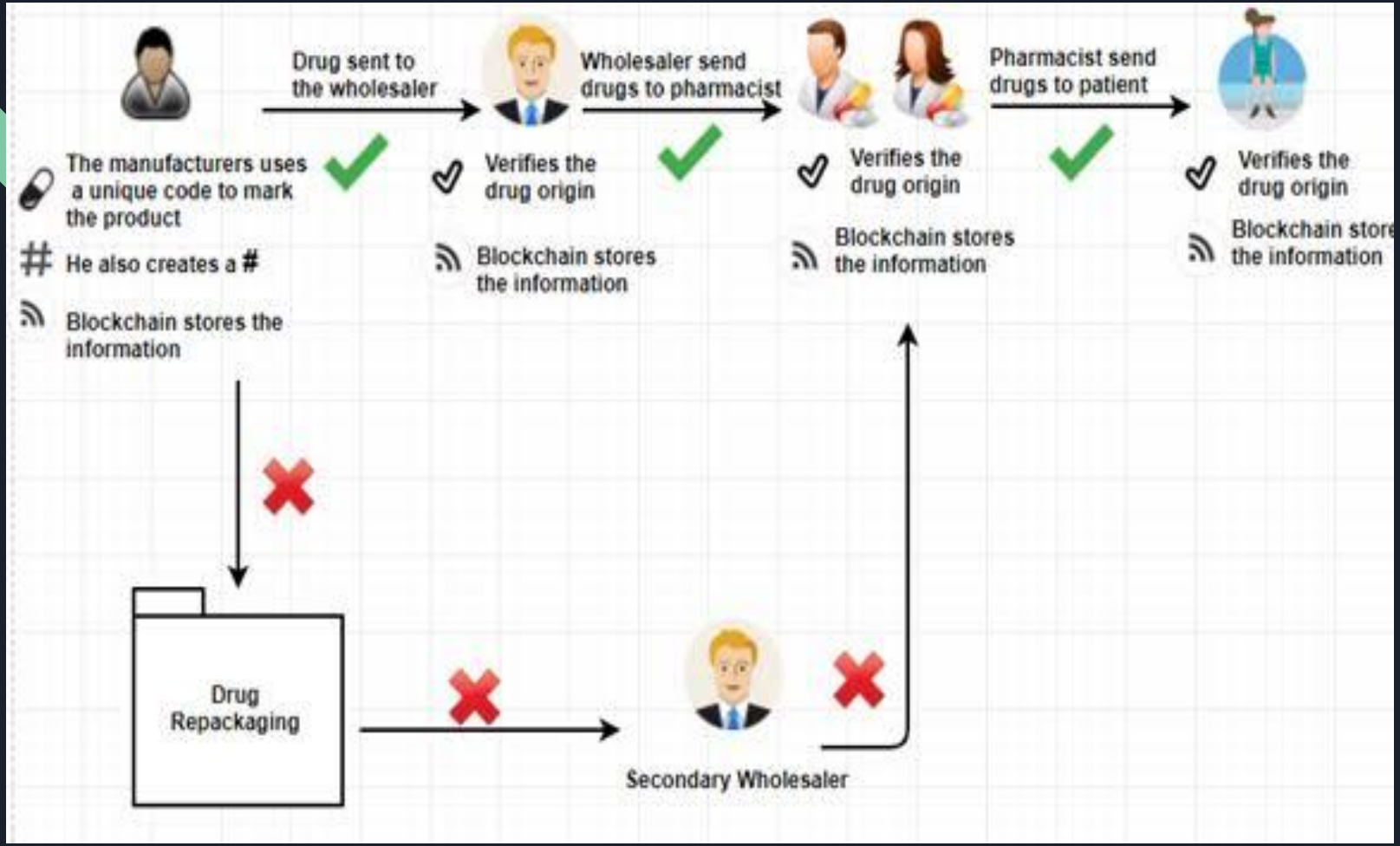
The transaction between the manufacturer and the wholesaler is added to the blockchain

The pharmacist verifies the origin of the product

The transaction between the wholesaler and the pharmacist is added to the blockchain

The patient verifies the origin of the product

The transaction between the pharmacist and the patient is added to the blockchain


Drug sent to the wholesaler
Wholesaler send drugs to pharmacist
Pharmacist send drugs to patient
The manufacturers uses a unique code to mark the product
He also creates a #
Blockchain stores the information
Verifies the drug origin
Blockchain stores the information
Verifies the drug origin
Blockchain stores the information
Verifies the drug origin
Blockchain stores the information
Drug Repackaging
Secondary Wholesaler

Improvement #2:
Patient-Doctor Interactions

Patient - Doctor Interactions
Problem

One of the important problems in healthcare today is:

Organizations hold multiple and fragmented records about patients.

- This can lead to involuntary use of informations & records about patients.
- In this context, the requirement for creating a smart healthcare ecosystem was born.
- This ecosystem is expected to limit actions of “hospitals”, “doctors”, “insurers” on records.
- Additionally, the good behaviours are rewarded, bad behaviours are punished (or not rewarded.) (Will be explained).

Known Approach: Medical Chain Solution

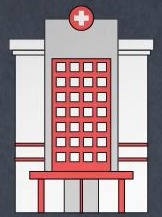
Medical Chain creates such smart ecosystem by putting medical record transactions on the blockchain.

With Medical Chain, a smart contract is launched to give time-limited access to a patient's electronic health records.

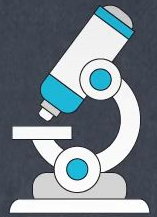
In This Smart Contract Patients

- Reward doctors, provide advices / second opinions to other patients
- Give access to health companies, scientists to monitor the progress,
- Are rewarded.

DOCTOR



HOSPITAL



LAB

PHARMACY

INSURER

MEDICALCHAIN

- Doctor adds notes

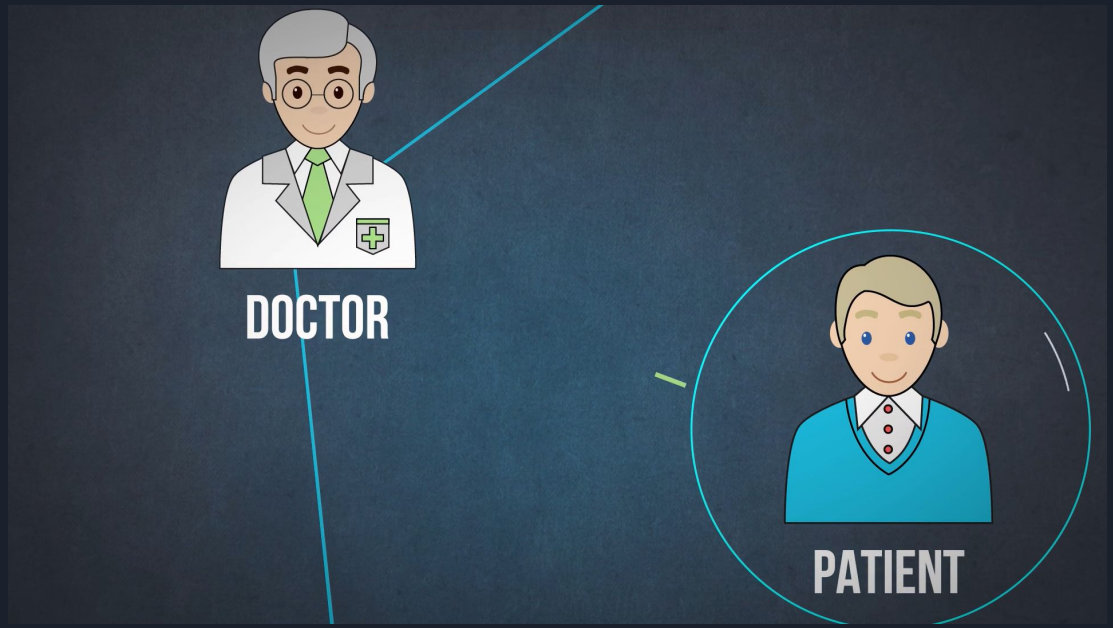
- Hospital adds scan results, registration information.

- Insurer has limited access to verify these steps.

- Lab adds lab results.

- Pharmacy adds dispenses medication info.

Patient-Doctor Interaction

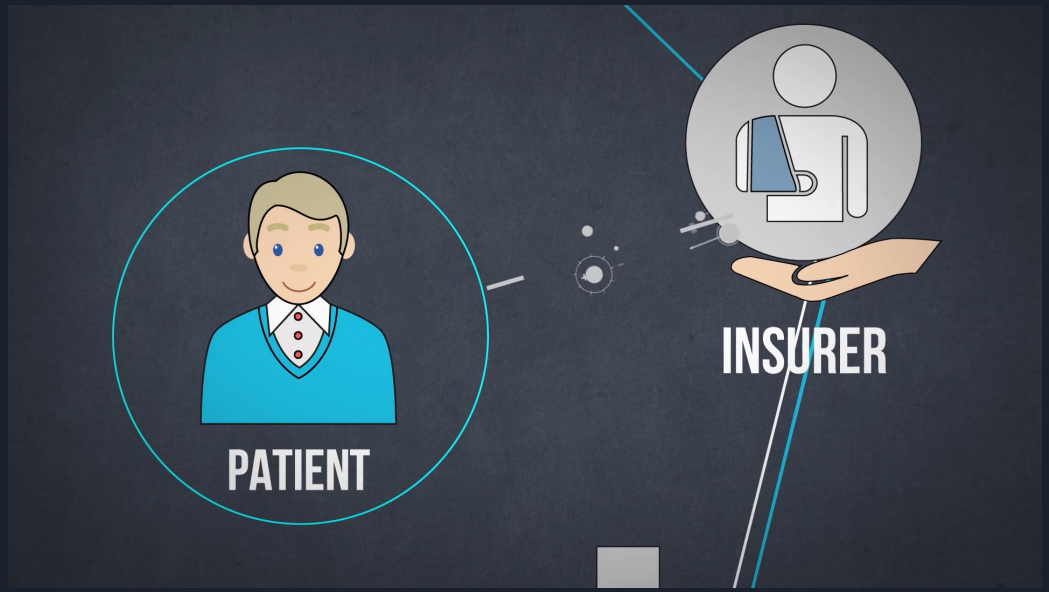


Patients reward doctors remotely.

- They review the medical operations.

- Provide advices / second opinions to other patients, on whether they are happy with that doctor or not.

Patient-Insurer Interaction

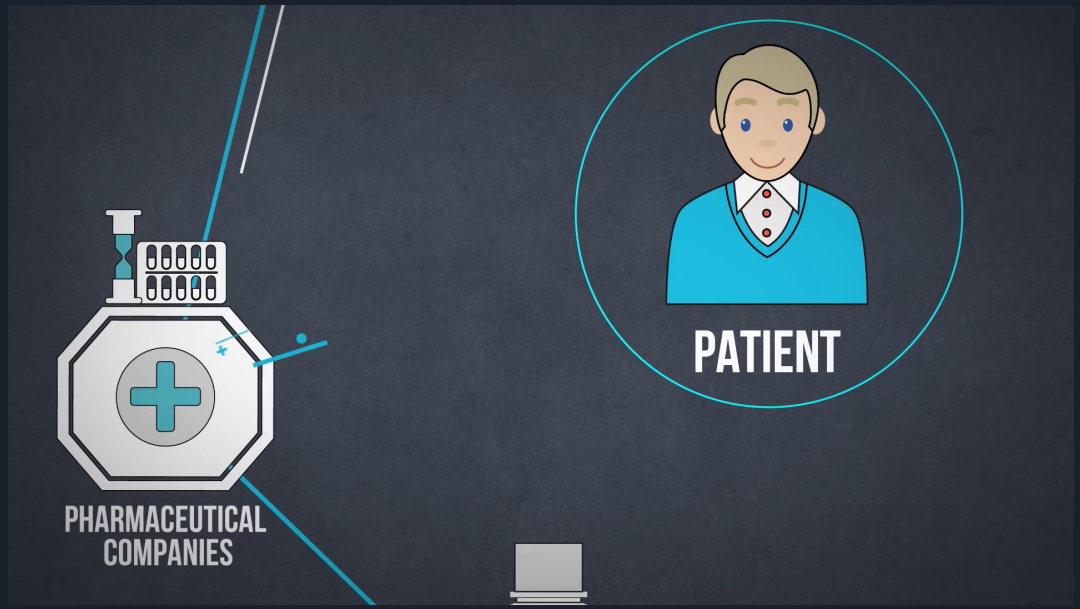


Patients give health insurers access to their records to monitor the progress.

- If insurers did their job well, they are rewarded with tokens .

- If they act badly, they get their rank (point) reduced.

Patient-Company Interaction



- Patients are rewarded for giving time-limited access for research institutions to their health records for medical experiment purposes.

Incentives

Why would people join this ecosystem?

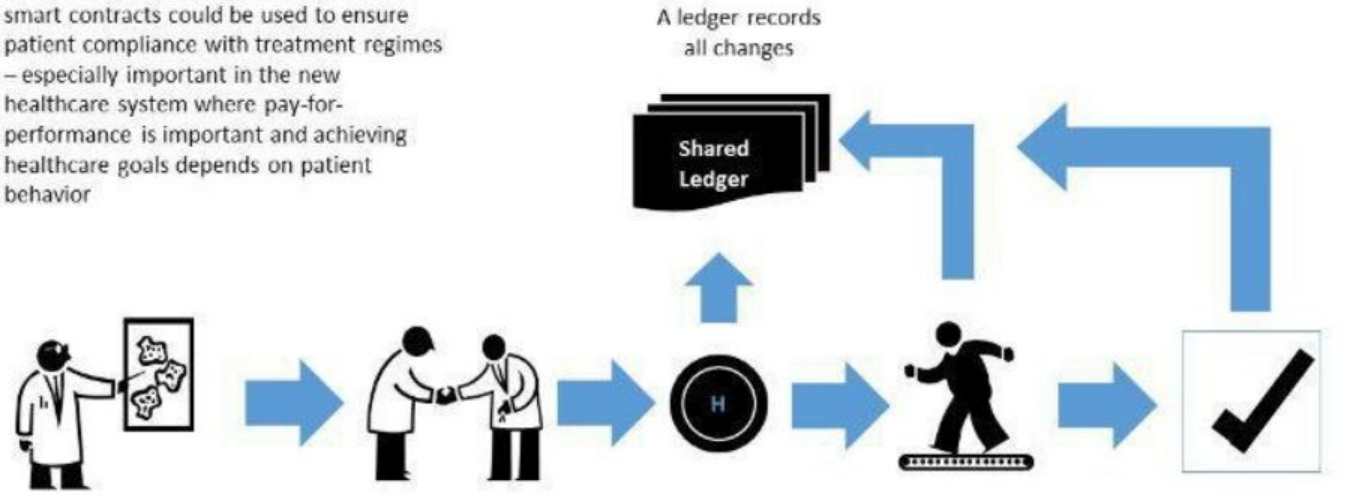
People are not tend to change their habits, from out of nowhere.

So, there must be some incentives for them.

What are these?

- Patients will earn MedTokens(1MTN = 0.02 TL) when they share their clinical records.
- Doctors, Hospitals, Insurers will reach larger audiences, if they act well.
- Science and Healthcare capabilities will grow faster, since the amount of data and number of qualified participants increase, so the investments from companies will be larger.

A "HealthCoin" provides a way in which smart contracts could be used to ensure patient compliance with treatment regimes – especially important in the new healthcare system where pay-for-performance is important and achieving healthcare goals depends on patient behavior

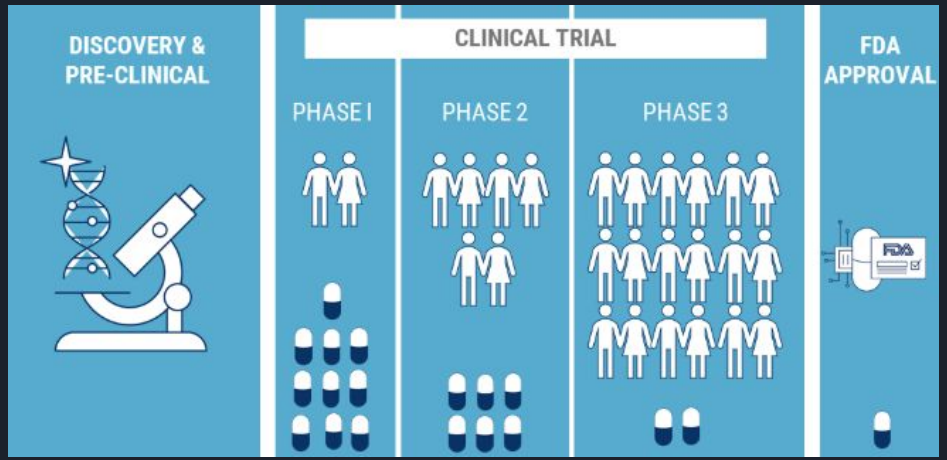


Improvement #3:
Tracking Pharmaceuticals and Clinical Trials

Pharmaceuticals
Problem

The pharmaceutical value chain starts with the drug development process. This process on average takes about fifteen years from drug discovery to regulatory approval.

The drug development process



Clinical trials start with initial human testing on healthy volunteers followed by testing in a larger group of patients to establish safety and efficacy.

The trials consist of three consecutive phases:

- phase I
- phase II
- phase III

in which safety, effectiveness, and efficiencies are tested

Pharmaceuticals
Solution

If clinical trials are completed successfully, companies go to marketing. The decision on the marketing of the drug decides to go to relevant government agencies in many countries, including Turkey not the drug company.

Blockchain usage summarizes the process of the drug from clinical trials to the market.

Quality issues and consumer safety are the most important issues for this process and after. Let's see how we can handle these problems using blockchain.

Pharmaceuticals
Solution

In order to ensure the safety of the supply chain and the traceability of the medical product, there are laws adopted by each country.

Despite the law, we face a lot of problems such as:

- Parallel trading emerges from differences in the price of pharmaceuticals across countries .
  - for example, any drug is 8 TL in Turkey, while in Germany the 5 euro. so the drug can be sold on the black market.
- Counterfeit drug problem.
  - The World Health Organization (WHO) estimates worldwide sales of counterfeit medicines to $75 billion in 2010, a 90% rise in five years. According to the WHO, in more than 50% of cases, medicines purchased over the illegal sites concealing their physical address are counterfeit drugs.

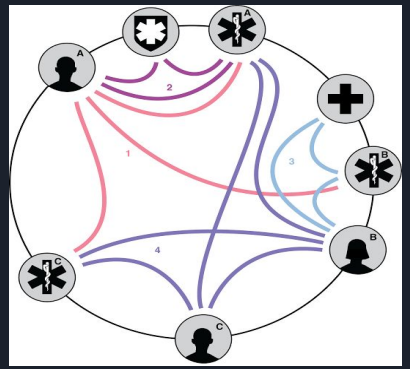
Improvement #4:
Medical Record Keeping - Accessing

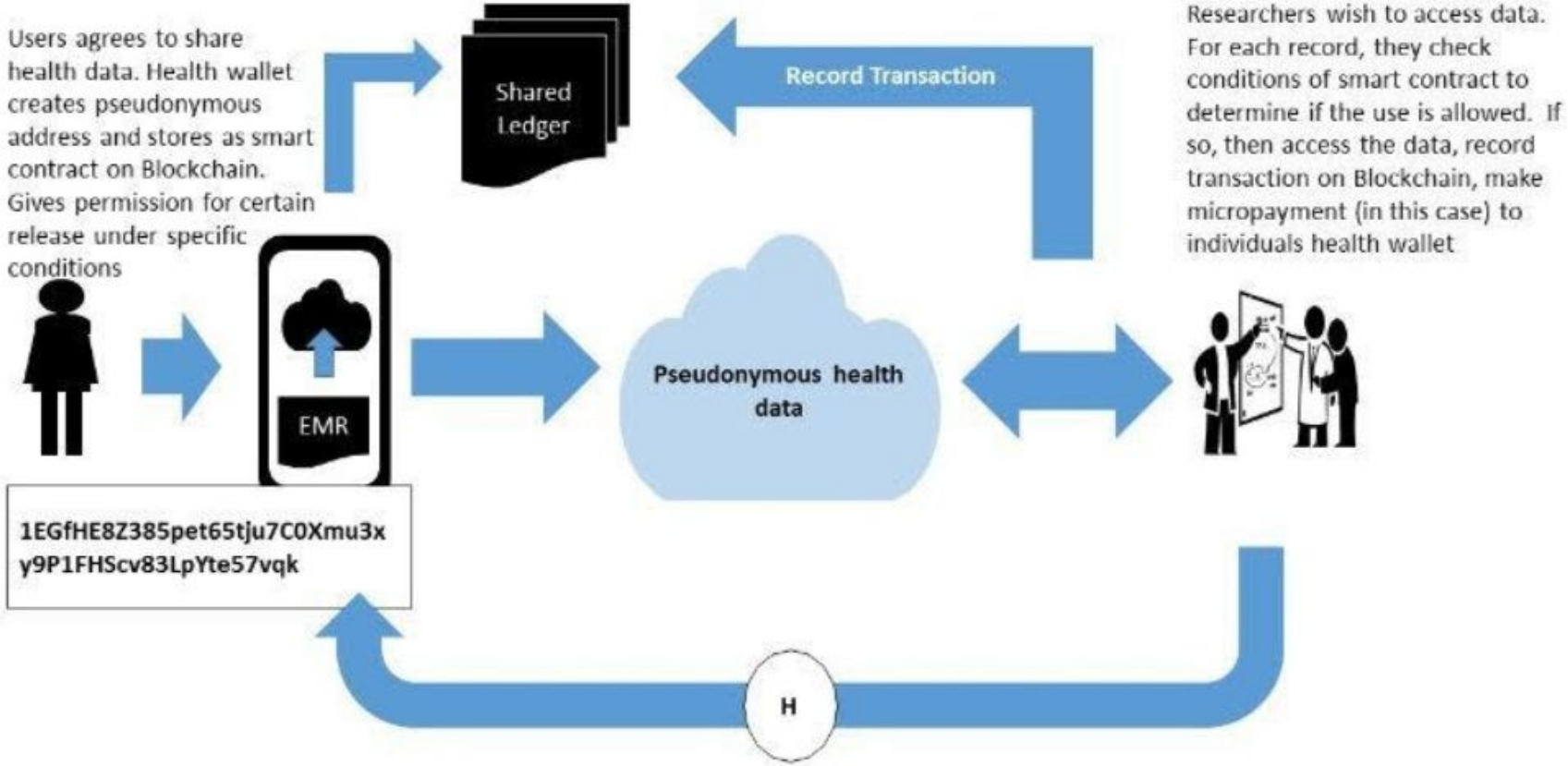
Improvement #4:
Medical Record Keeping with Blockchain

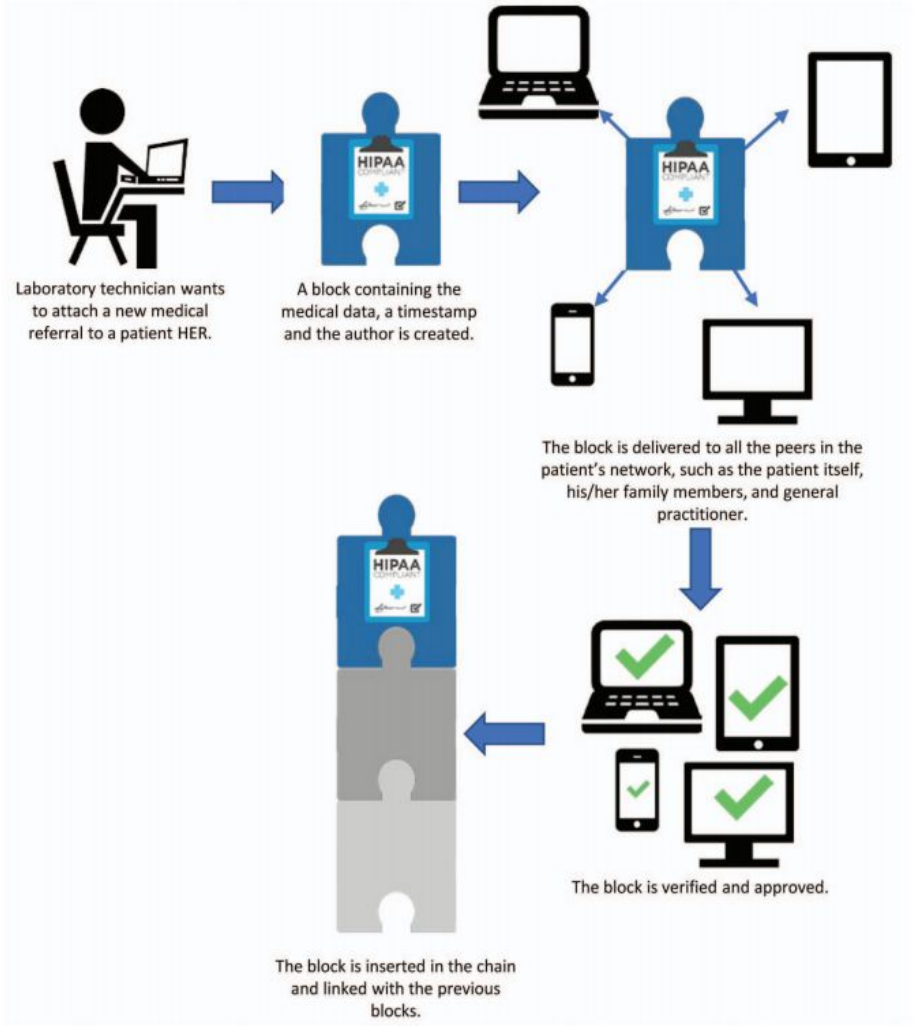
The aim is to put the patient in control of their medical data, giving them the power to share the single, most comprehensive version of their record, with every organisation in their medical network.

Fragmented, isolated patient records create inefficiencies and inaccuracies across the breadth of the healthcare system.

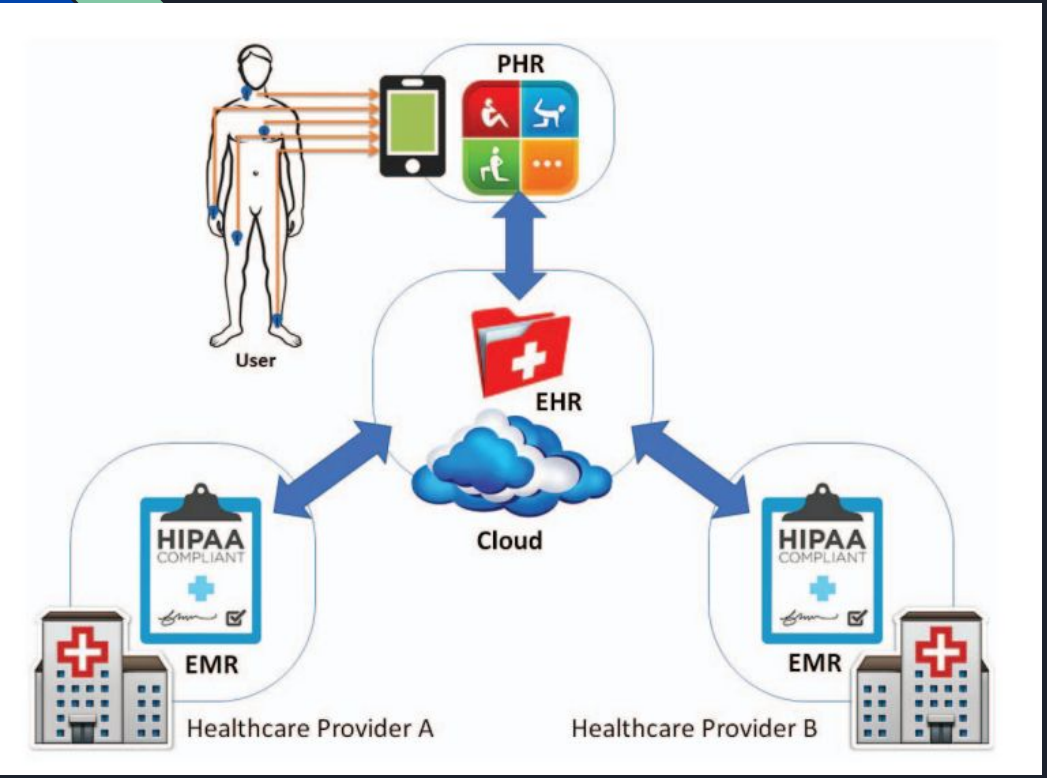
Known Approach: MedRec.




Users agrees to share health data. Health wallet creates pseudonymous address and stores as smart contract on Blockchain. Gives permission for certain release under specific conditions
Shared Ledger
Record Transaction
Researchers wish to access data. For each record, they check conditions of smart contract to determine if the use is allowed. If so, then access the data, record transaction on Blockchain, make micropayment (in this case) to individuals health wallet
EMR
Pseudonymous health data
1EGfHE8Z385pet65tju7C0Xmu3x
y9P1FHScv83LpYte57vqk
H
Health coin payment is made – can be converted to money, used in HSA, or to purchase medical services. Could be Bitcoin



Blockchain could reinvent the way patients' electronic health records are shared and stored by providing safer mechanisms for health information exchange of medical data in the healthcare industry, by securing it over a decentralized peer-to-peer network.



Blockchain technology has the potential to transform health care by placing the patient at the center of the health system and increasing the security, privacy, and interoperability of health data.

This technology could provide a new model for health information exchange by making electronic health records more efficient and secure.

Improvement #5:
Cutting Costs

Costs
Problem

Access to quality, affordable healthcare in the United States is a slow-moving national crisis. Overall spending on healthcare rose nearly 4% in 2017.

As a share of GDP, healthcare spending is nearly 18%, roughly double the average amount spent by other advanced nations.

According to a recent McKinsey report, healthcare costs have risen more than 800% since 1960, while wages have increased by only 16% on average over the same time.

According to the Premier Healthcare Alliance, a lack of interoperability costs 150,000 lives and $18.6 billion per year.

Costs
Problem (Cont'd)

A universally centralized platform would cost a prodigious amount of money to upkeep.

Hospitals, insurance providers, pharmaceutical companies, and many other parties spend billions of dollars annually to keep their systems up and running efficiently and securely.

Running many of these processes on a Blockchain would either be free or require a de minimis per transaction fee.

Eventually, these savings would be cycled back to the patient receiving care.

Blockchain makes costs transparent and reduces the amount of outgoing money.

August 05, 2019 - Healthcare blockchain could save the industry up to $100 billion per year in costs related to IT, operations, support functions, personnel, and health data breaches by 2025, estimated a report by BIS Research.

Pharmaceutical companies will benefit from using blockchain to track drugs, thus reducing the around $200 billion these companies lose from counterfeit drugs each year, the report noted.

Proposed Model
“Life on Chain”

Healthcare is the touchstone of research areas, hence it is the main Investment point, as expected.

There are already many Blockchain-based establishments, companies set up for this purpose.

However, they are generally independent foundations from each other.

Our idea is to combine the “Improvements” into a single model, which results in a more complete ecosystem.

“Life on Chain” is not just a union of the previous ideas/methods.

“Life on Chain”
(Cont’d)

With “Life on Chain”:

- Record Keeping
  - Medical records,
  - Patient, Doctor, Pharmaceutical, Insurer, Company, Hospital informations.
- Tracking - Supply Chain
  - Drug , Equipments,
  - Clinical Trials
- Patient - Doctor - Insurer… relationships
  - Ranking, voting,
  - Rewarding good behavior, Punishing bad behavior
- A universal currency that is produced and used in this system

“Life on Chain”
(Cont’d)

“Life on Coin”, united all the improvements mentioned earlier into one piece.

However, this proposal model should include new ideas / solutions.

This new idea is:

A Blockchain which contains a “Pool of Unresolved Treatments, Cures”.

“Life on Chain”

Comes up with a new idea

The main idea behind this innovation is to ***speed-up*** the progress in ***finding new treatments*** to ***new health problems.***

In this context, a pool of unresolved treatments in medical industry will take place.

Also, the verified treatments will be publicly available so that people will transparently see what kind of treatments should/will be applied on them. This can solve the problem of “Malpractice”.

“Life on Chain”

Pool of Resolved / Unresolved Treatments

A pool contains such treatments, publicly.

- If a new health problem comes up, first checking if that problem is cured.
- If not cured, it is added to “unresolved treatments” pool.

The process is:

1. A Doctor, scientist thinks that he/she came up with a new treatment,
2. Announces that idea to the chain,
3. If 50% + 1 of the system of doctors-scientists agree with this treatment, that idea is presented officially with authorized systems.
    a. That doctor/scientist gets his overall point (rank) increased.
    b. The majority voters’ ranks are also increased.
    c. The minority voters’ ranks are decreased.

“Life on Chain”

“Ranking System”

In this context, a ranking system is to be used.

Advantages

With this system:

- Participants can convert their ranks(points) into “LifeOnCoin” (LOC).

  < Imaginary for now :,) >

- Also, the ranks of the participants(doctors, scientists) indicate the reliability and quality of them, so that the doctors with higher ranks will have more reputation and more job opportunities.

This implies the participants to act good.

“Life on Chain”

Advantages & Disadvantages

Advantages

Speed and Simplicity: Healthcare operations are merged under one roof.

Useful-Correct: On chain, only correct and useful informations, records will take place.

Far from Bad Behaviors: Verified records are immutable. Good behaviors are rewarded with currency and ranking system. Bad behaviors are punished - not taken into account.

Disadvantages

Disadvantages of general Blockchain systems. (Computing power, transaction speed, storage..)

General Conclusion
Advantages & Disadvantages

General Conclusion

Advantages of Blockchain on Healthcare

- Patients have control over their data.
- Medical history of a data (trial, operation, drug) is complete, consistent, timely, accurate, and easily distributed.
- Agreement can be reached without the involvement of a trusted mediator; thus, avoiding a performance bottleneck and a single point of failure.
- Changes to the blockchain are visible to all members of the patient network, and all data insertions are immutable. Also, any unauthorized modifications can be trivially detected.

General Conclusion

Disadvantages of Blockchain on Healthcare

- Besides a cost-benefit analysis, healthcare providers must be aware of regulations concerning medical records and patients' rights.

- One of the principles of the Organization for Economic Cooperation and Development privacy guideline, on which many data protection laws are based, provides the right-to-erasure to individuals.

- Given the sensitivity of healthcare data, anyone planning to use blockchain to store them cannot ignore this legal obligation to erase personal data if warranted.

One other problem is:

While financial transactions are small bits of data, medical records can be quite lengthy. Storing an entire record in the blockchain will be costly.

In order to deal with this problem, off-chain storage of data is suggested.

Where data is kept outside of blockchain, but the hashes of the data are stored in the blockchain. This is said to be the best of both worlds, as healthcare data is stored off-chain and may be secured, corrected, and erased as desired.

Questions?

References

- http://explore-ip.com/2017_Blockchain-Technology-in-the-Pharmaceutical-Industry.pdf
- https://www.ibm.com/blogs/blockchain/2018/12/what-are-the-use-cases-for-blockchain-tech-in-healthcare/
- https://blockgeeks.com/guides/blockchain-in-healthcare/
- https://www.ibm.com/blogs/blockchain/2019/12/protect-pharmaceutical-product-integrity-with-the-pharmaceutical-utility-network/
- https://openledger.info/insights/blockchain-healthcare-use-cases/
- https://journals.sagepub.com/doi/full/10.1177/1460458219866350
- https://medicalchain.com/en/
- https://www.computer.org/publications/tech-news/research/blockchain-health-medical-records-cloud-security
- https://medrec.media.mit.edu

Thanks for Listening.