How Blockchain Technology Could Disrupt Healthcare

From managing patient data to tracking drugs through the supply chain, blockchain could solve some of the healthcare industry's biggest problems.

The healthcare industry is plagued by inefficiencies, errors, bureaucracy, and high administrative costs.

Could blockchain technology help solve some of these challenges?

For all the hype, there's no question that blockchain's distributed ledger technology can offer real value for the healthcare industry.

Blockchain could help solve some of the industry's most pressing compliance, interoperability, and data security issues, as well as enable new patient-centric business models.

But unlocking blockchain's potential for healthcare will be a slow process, and change is unlikely to come fast.

In this report, we analyze where blockchain is likely to be integrated into healthcare in the short, medium, and long term, based on known stakeholders, scalability requirements, and necessary safeguards.

Some of the most exciting projects involve the wholesale reimagining of how healthcare data is accessed and owned — though realistically, this is a far-off possibility.
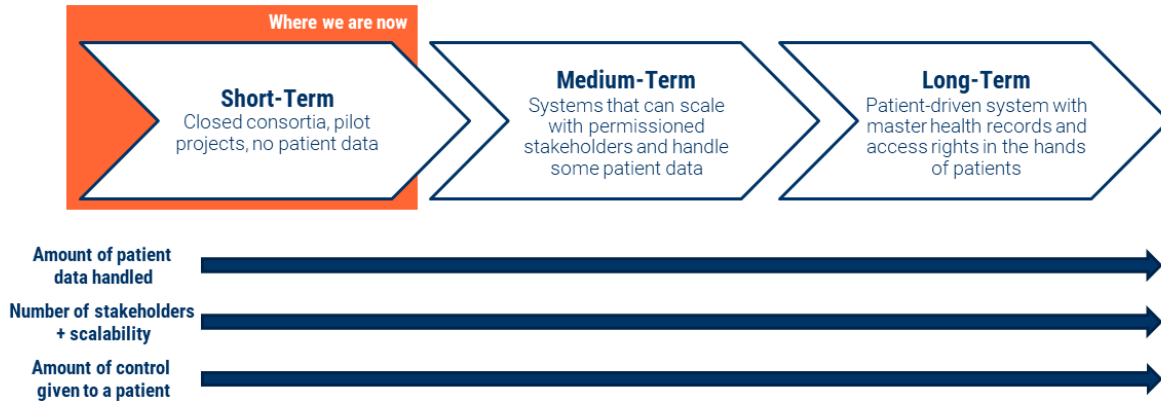
More immediately, we could see simplification of back-office operations and improved traceability in the supply chain.

Below, we'll explore the projects already underway, and what future applications might look like.
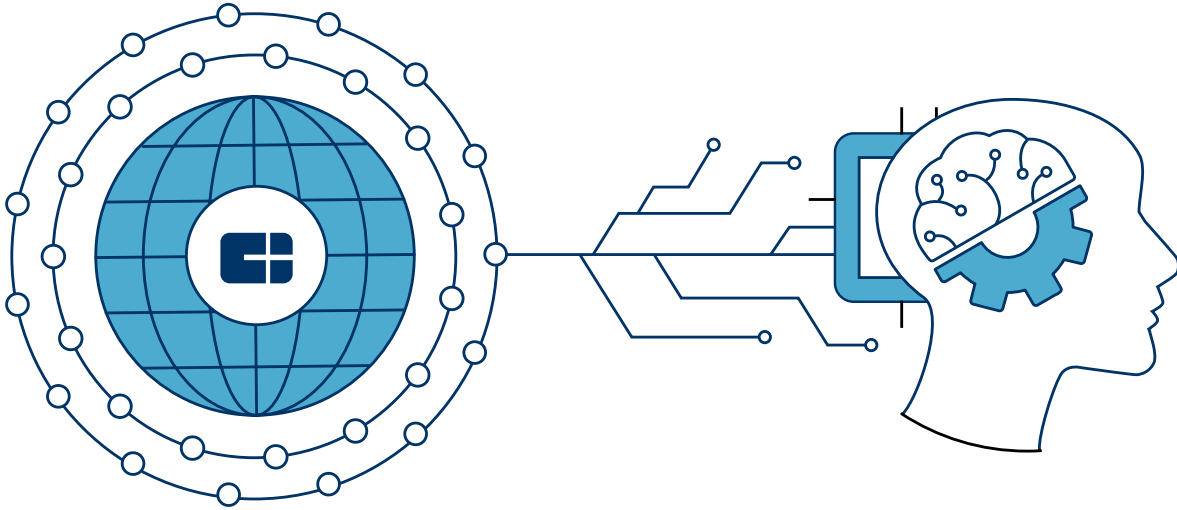
Blockchain + Healthcare: A Potential Roadmap

Use cases for blockchain will start in small projects that reduce duplicative work but can eventually shift to a system where patient's control access rights to their data

Where we are now

Short-Term
Closed consortia, pilot projects, no patient data

Medium-Term
Systems that can scale with permissioned stakeholders and handle some patient data

Long-Term
Patient-driven system with master health records and access rights in the hands of patients

Amount of patient data handled →

Number of stakeholders + scalability →

Amount of control given to a patient →

CBINSIGHTS

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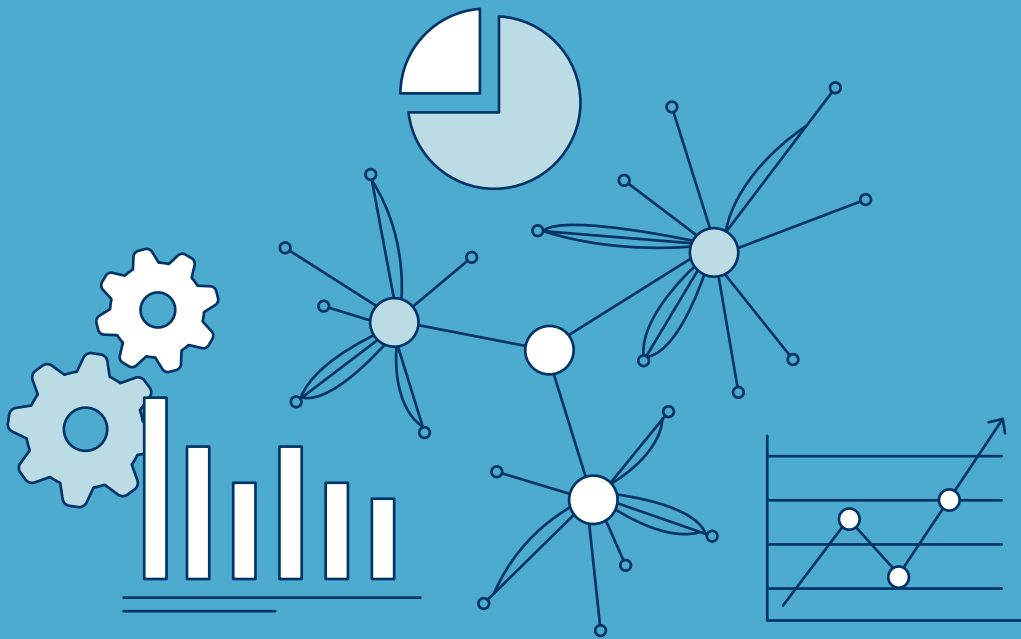
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Beti Cung,

CORPORATE STRATEGY, MICROSOFT

Microsoft

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1 Why blockchain for healthcare?

Blockchain technology allows for transparent, peer-managed, secure data tracking across computing devices, and creates a public, chronological database.

Why is this so useful for healthcare?

Blockchain has potential to offer new solutions in healthcare because it is:

Consistent: With blockchain, data can't differ across databases because there is one single record. This reduces issues with duplicate or tampered data and makes the data itself much more accessible, rather than trapping it in different organizations' record-keeping systems.

Append–only: Users can only add transactions to a database, making everything traceable and auditable.

Ownable: An entity can "own" data and choose who gets to access it. Instead of a company selling someone's data to a third party, that person can control where their data goes.

Clear rules: One version of the database is used, and the rules about it are known. (The lack of data standards and master records in healthcare has created fragmentation and frustration across the industry.)

Decentralized: Copies of the database are kept in multiple places and no third-party needs to exist as an administrator. This reduces overhead and the need for middlemen (which healthcare has in spades). This also prevents centralized systems from becoming completely locked down and inaccessible.

These qualities are great for institutions or patients handling health data. Blockchain makes data harder to tamper with and easier to share between parties is easier. There are also many cybersecurity benefits, including traceability and the ability to verify who has accessed certain data.

For a full primer on how blockchain, smart contracts, and the core technology work, read our **What Is Blockchain?** report.

WHY NOW?

Money began pouring into the blockchain space in 2017, largely due to Initial Coin Offerings (ICOs), where companies would sell tokens attributed to their company. This included several healthcare companies.

Cryptocurrency prices and ICO hype have since slowed dramatically. However, equity funding to blockchain companies is **rising fast**.

Initial Coin Offerings (ICOs) went from hot to declining, including some healthcare projects

Disclosed funding of completed ICOs. January 2017 – May 2018
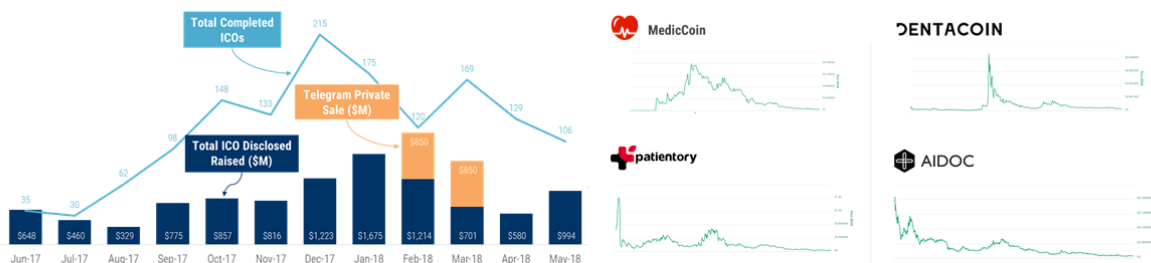
On earnings calls, "blockchain" **has skyrocketed** in mentions, though rarely in the context of healthcare. Most healthcare companies that mention blockchain do so in a exploratory or pilot project capacity.

Patents that mention "blockchain" or "distributed ledger" for healthcare applications have also begun to tick upward, as highlighted in **this CBI platform patent search**. IBM, Walmart, Bank of America, and several others are looking at different applications of blockchain across emergency response, compliance, and data-sharing agreements.

Companies are talking about blockchain applications, though more slowly in healthcare

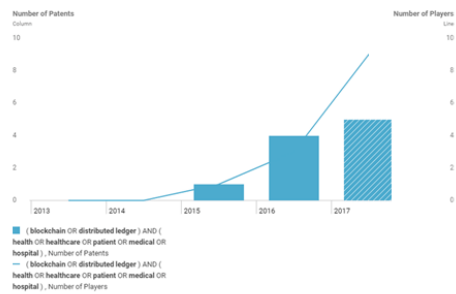**Mentions of 'blockchain' on earnings calls skyrocket, talk in healthcare is still nascent**

Q3'13 – Q2'18

Number of mentions

- blockchain SOURCE: ALL
- blockchain AND (healthcare OR patient OR medical OR doctor) SOURCE: ALL
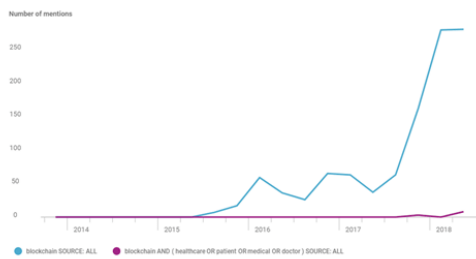
Number of blockchain + healthcare patents filed

2013 – 2017

Number of Patents
Column

Number of Players
Line

- (blockchain OR distributed ledger) AND (health OR healthcare OR patient OR medical OR hospital) , Number of Patents
- (blockchain OR distributed ledger) AND (health OR healthcare OR patient OR medical OR hospital) , Number of Players

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Despite more companies and money entering the space, it's still very early days for blockchain and healthcare applications.

Below, we'll go through areas where we think there might be initial inroads, from the short-term through to imagining a future system with decentralized health records at the core.

2

Short-term applications

Most of the initial healthcare applications for blockchain and distributed ledger technology are focused around closed consortia and back-office operations that don't involve patient data.

HEALTHCARE CONSORTIA & MANAGING PROVIDER INFORMATION

Corporations are taking their first steps into blockchain-based projects by joining small, closed consortia that use distributed ledger systems or permissioned blockchains to keep data among the companies involved.

Initial projects aim to prevent duplicated work by sharing data via distributed ledger systems. However, none of these projects focuses on patient data, because it is so sensitive.

One project has involved UnitedHealthcare, Optum, Quest Diagnostics, Humana, and Multiplan joining together to make sure their provider directories are up to date. (The Centers for Medicare and Medicaid Services (CMS) fines insurers if their provider information is not current.)

By sharing this provider information with each other, these companies can reduce work, since data is stored and updated in a shared, accessible database.

Hashed Health is working on several projects with smaller consortia. For example, the company is developing a credential verification system for physicians to prove they're licensed to operate in certain areas.

Currently, physicians have to go through a separate credentialing process for each institution and state they plan to work in, a process which can take 30 — 90 days for each institution.

This process could be faster, simpler, and cheaper if there was a shared record of a physician's credentials accessible by all parties authorized by the physician. A blockchain-based system could enable that, giving physicians the private key to grant access to whichever institution is asking for credentials.

Healthcare consortia are tackling small problems incrementally

HASHED HEALTH

Select Partners:

GHX.   **accenture**

martin ventures   **CHANGE HEALTHCARE**

Goals: Develop proof of concepts where blockchain protocols can improve healthcare.

Notes: Consortia has slowly added more members over time, has released project on verifying if a healthcare provider is licensed for the services they're providing and their geography.

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UnitedHealthcare®

OPTUM™   **Quest Diagnostics™**

Humana.   **MultiPlan®**

Goals: Create a central provider directory with up to date information; a shared directory would prevent duplicative work.

Notes: It's a win for all parties involved: insurers have up to date directories for less work, providers have a singular place to update their information, and consumers have a clear source for correct information. Additional buy-in from health giants will make it increasingly valuable.

DRUG SUPPLY CHAIN

Another area where Hashed Health and several other companies are working on developing blockchain solutions is in the pharmaceutical supply chain. Counterfeit drugs and recalls of medicines (especially outside of the US) make traceability a high priority for the supply chain.

Thanks to the Drug Supply Chain Security Act (DSCSA), in the next few years pharmaceutical supply chain players will have to join interoperable electronic systems that will allow them to track each drug throughout the entire supply chain.

Blockchain solutions are one possible way to tackle this.

Chronicled is launching a pilot called MediLedger with several large drug companies and drug supply chain giants. The project uses a closed blockchain system (open for vetted participants to join) to track who touched what drug at what time.

By ensuring that only manufacturers can commission serial numbers and attach unique identifiers to products (which are noted by the ledger) the system makes it much more difficult for a counterfeit product to enter the chain at a random point. The blockchain system uses zero-knowledge proofs to allow companies to ensure compliance without actually sharing data with each other.

Zero-knowledge proof is a data-sharing method that allows two parties to verify if something occurred without actually revealing specific underlying data to each other.

Blockchain-based supply chain systems can also connect to RFID tags and temperature logging mechanisms to ensure that environmental requirements were met across the supply chain. If the rules are laid out clearly, this system can execute in a mostly automated fashion using smart contracts.

3 Medium-term applications

Medium-term projects will move beyond pilots and involve more stakeholders. These projects will also start looking at ways to house and share patient data.

It may take longer to implement these projects, because they require cooperation between more parties and the risks associated with accidental patient data leakage are high.

CLAIMS MANAGEMENT, PAYMENT, & PRIOR AUTHORIZATION

The back-end of healthcare is slow, complex, and expensive.

Billing- and insurance-related costs are an estimated 18% of total national health expenditure. The AMA found that more than a quarter of practices had to wait 3+ business days for a prior authorization (approval from a patient's insurer to cover a drug).

Blockchain, aligned with data standards, has the potential to speed up some of these processes and reduce costs.

One area where this might be possible is in claims management, where several middlemen are focused on standardizing data, following complex and variable procedures.

How medical billing and claims processing works today

1. The patient schedules an appointment. The provider verifies insurance and confirms coverage.

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2. The provider offers health services and uses the appropriate ICD and CPT codes to create a medical bill. It enters changes into its billing software. Patients could be charged a copay.

3. The provider sends paper and electronic claims to a clearinghouse to be cleaned, audited, and formatted before being sent to a payer. These claims can also be sent directly to high-volume payers.

4. The payer adjudicates the claim and makes sure there are no errors, then decides how much of the bill it will cover, based on its contract with the provider and the patient's plan. The patient's costs are calculated based on their copay and deductible.

5. The provider is reimbursed by the payer. The patient is sent a bill. The payer and/or provider collects and processes the amount owed by the patient.

A lot of this work requires accessing complex data from different entities.

Payers have to know what services a patient received, and the patient's specific plan. Doctors need to know how much to charge a patient. And everyone wants to know where in its lifecycle a claim currently is.

Change Healthcare has built a system that follows the life cycle of a claim, tracking every transaction listed above (data submitted for review, the review itself, approval or denial, etc.). The company has also improved the speed and scalability of processing transactions, which has been a bottleneck in many public blockchain projects.

Change Healthcare says it facilitates nearly 14B transactions a year between 2,100 payers, 5,500 hospitals, and 33,000 pharmacies, among others.

According to Emily Vaughn, Director of Blockchain Product Development at Change Healthcare:

*"The ability to see a claim's status isn't what's innovative here — there are a number of solutions on the market already that can do that. The exciting part is proving that **blockchain technology is actually capable of meeting the volume demands in healthcare.** In healthcare, a standard requirement for a network solution at scale would be around 30M transactions per day... On its biggest trading day to date, Ethereum topped out at around 1.4M transactions. **The solution we designed is capable of processing 50M transactions per day.** So our announcement isn't just about a new offering — it's about improvements on the scalability of blockchain technology in general."*

Pre-vetting new participants before they join the permissioned blockchain could help the system scale.

One way to do this is by setting up rules-based smart contracts that run automatically if pre-set criteria are met. (This is what **PokitDok** is trying to do with its DokChain product to speed up claims approval.)

In this system, a network could authenticate and pay providers based on the rules in a smart contract that auto-adjudicates payment when pre-set criteria are met.

1. identities of the parties involved in each transaction. DokChain's Identity by Consensus allows us to generate and manage an identity while maintaining privacy and anonymity, and providing a very high level of identity validation confidence.

2. The time at which a transaction takes place. Identity by Consensus also provides auditable transparency of all interactions.

3. The exact payment conditions at the time of the service. The conditions for payment are defined in the terms of the smart contract. Since the actual smart contract is "registered" on the blockchain, the knowledge of these conditions can be looked up at any time.

4. That the conditions were satisfied by all parties.

This could also theoretically be done with prior authorizations for drugs.

Currently, prior authorizations are conducted by insurance companies to make sure all other options have been explored before expensive drugs are approved.

This costly process is largely rule- and checklist-based, and currently takes 1 — 15 days.

Smart contracts could potentially speed up parts of this process by codifying a payer's rules around a drug, verifying whether every alternative was explored, and verifying whether previous drugs/tests caused adverse reactions. However, this would require easy access to a patient's medical record, which could present a significant obstacle.

In an ideal world, the back-end of healthcare would be able to track a patient through the continuum of care and access needed information when necessary. This would require a unique patient identifier that tracks a patient through the system and logs the transactions the patient engages in.

A blockchain system that succeeds in tracking where a patient is, and what procedures/tests they've had, could avoid a lot of duplicative processes and keep everyone informed.

Already, companies like **PatientPing** have built entire businesses on giving real-time notifications of admission and discharge to all of a patient's caregivers/providers. A blockchain system where known entities are permissioned to track a patient's whereabouts and treatments (without necessarily storing information about test results, etc.) could hugely reduce administrative needs.

A system with patient data at the center could simplify the claims and prior authorization process

Current Prior Authorization/Claims System

Blockchain Prior Authorization/Claims System
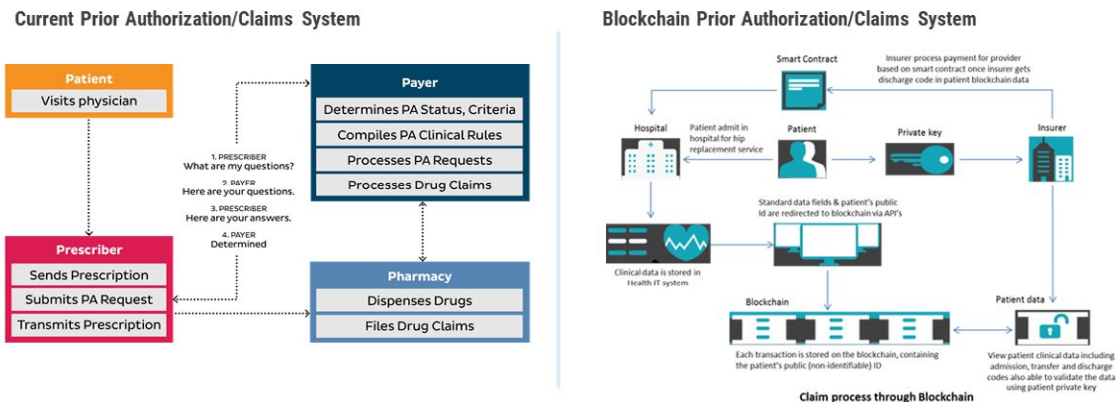
However, to do this would require a level of cooperation and patient data access that is challenging to implement any time soon.

HEALTH INFORMATION EXCHANGES & RESEARCH DATA

Data is getting more and more valuable — whether to train algorithms, find better therapeutics, or understand where clinical trials should be set up. This means existing health players have an opportunity to monetize their datasets.

Right now, de-identification of data is a process that requires third parties. But as these become more accepted, we can envision a blockchain-based system that could facilitate data exchange. In addition, new regulations around how third parties use consumer data (GDPR, Consumer Privacy Acts, etc.) will force companies to develop audit and consent trails for where the data goes.

HealthVerity is one of the players in this space, combining a health data exchange with a blockchain product to manage permissions and access rights.

Healthcare data exchanges can both provide compliance and remove middlemen with blockchain + data standardization

HealthVerity Marketplace

Discover, link and license the HIPAA-compliant data that is right for you.

Leverage our data discovery and cohort-building tools to license exactly the healthcare and consumer data that you need from exactly the data providers that you want.

Learn More

California Legislature Passes Amendments to the California Consumer Privacy Act

September 21st, 2018

HealthVerity Consent

Leverage blockchain technology to aggregate and manage customer data use permissions.

Seamlessly consolidate all consumer or Healthcare Provider consents and permissions across every enterprise touchpoint to support evolving data privacy requirements.

Learn More

Some projects are trying to bypass exchanges altogether and get patients to donate their data to research.

This is probably more likely to happen in the cancer, uncurable, and rare disease populations and areas where people are more active participants in their healthcare.

To researchers and pharma companies, patient data is invaluable. Helping these members to better log their data and making it easier to give researchers access to it would make the data more widely usable and potentially enable better collaboration between research institutions.

One area we might see this first is in genomics — where rare variants are valuable and people are particularly concerned with third parties getting access to their data or profiting off it (law enforcement, life insurance, etc.).

By putting data access rights in the hands of patients, it's possible to set up incentive systems that can be monetized based on demand for data.

This monetization model could be in dollars, though some companies are exploring alternatives. **Luna DNA** is experimenting with offering shares of the company. Doc.ai is considering giving tokens to participants in exchange for their data. The tokens can be used to pay for services on the network (e.g. instantaneous advice).

Blockchain can give data access control to patients and better align them with researchers
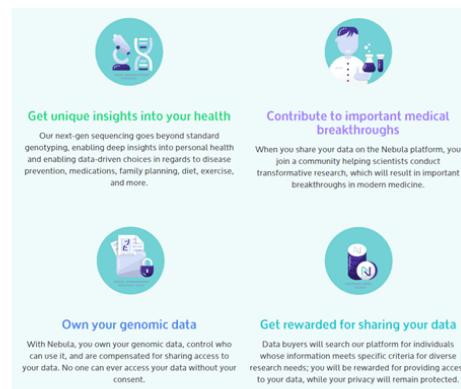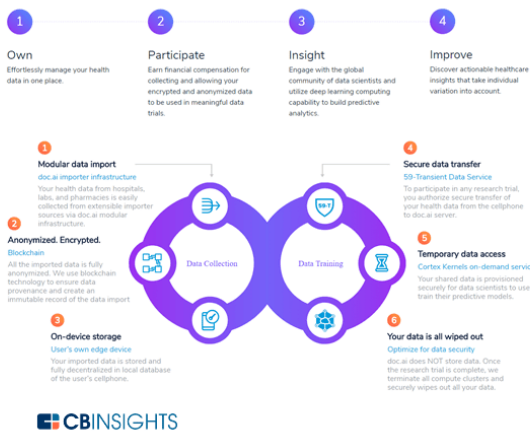
In the future it's possible that this kind of data marketplace might not need a third-party intermediary at all.

In a different model, a patient could put their data up for sale and an entity could request to pay for access to it.

A group of other network participants could verify and process the transaction, adding that block of transactions to the end of the chain and receiving tokens for completing that verification

task. Through this process, a third party is no longer needed to manage the exchange of data and currency.

RESEARCH & TRIAL DESIGN

Beyond better data sharing, blockchain offers an opportunity to improve healthcare before the treatment phase: in research and clinical trials.

Effective research and clinical trials require the coordination of multiple sites and stakeholders, as well as careful management of massive amounts of sensitive data coming from different sources.

Proposed Study Design Using Smart Contracts

Trial protocol and setup with inclusion/exclusion criteria, study design, consent form, etc. would be programmed into a smart contract.

Enrollment, data capture, analysis, etc. are conducted. Data is frozen once criteria from first smart contract is hit.

Study is published if all contracts are fulfilled, with the underlying data and analysis tools available for sharing

BMC

A blockchain can improve informed consent and structuring protocols (documents that make clear the objective, trial design, and how efficacy will be assessed). By determining early on how a study will be conducted and analyzed, third parties can quickly see whether the original design was adhered to.

Timestamps and smart contracts could ensure researchers stick to study design and don't change the criteria or analysis mid-trial. This helps remove some of the biases that can occur when conducting research or clinical trials, and better ensures reproducibility and publishing of negative results (which frequently doesn't happen).

Another important function blockchain can fulfill is connecting disparate data within a study, which frequently takes place across different research facilities and is administered by different researchers. This would prevent the need to reconcile separate databases together to create a traceable record of what a participant did.

Patient consent forms could give access rights to each vetted entity as they use and attach new data, which becomes available to every participant on the ledger (rather than needing to reconcile separate data collections together). This would ensure no data is lost or tampered with.

Once a study is finished, there would be an easily accessible audit trial that can be submitted to regulatory parties, auditors, or other researchers (a job usually handled by electronic trial master files).

As more granular data is captured via sensors like wearables, supply chain tracking, etc. it'll be easier to see possible failure points in the study as well.

A permissioned blockchain could give all the members of a clinical trial or study a timestamped, real-time view into what data and transactions were happening to a study participant at a given time since they each have a copy of the shared database. This removes the data reconciliation process and makes it easy to walk through how a study was conducted end-to-end (which is good for auditors and people who want to reproduce the study).

While these solutions could make studies easier to conduct, they don't solve one of the biggest pain points: recruiting patients that meet the correct criteria. More easily accessible patient records could make this easier to address.

Long-term applications

In the long run, the true benefit of a blockchain-based ledger are decentralized patient records as a platform.

Giving patients the ability to easily access their health records, as well as grant providers comprehensive access, would change the shape of healthcare.

There are lots of obstacles to overcome before this goal can be reached. Clearer regulations, more ways to create and capture data outside of the existing EHR system, and figuring out more secure ways to store massive amounts of data are just some of the issues that will need to be addressed.

UNIVERSAL IDENTITIES, PATIENT HEALTH RECORDS, DAPP SERVICES

The lack of interoperability in the healthcare system is a massive issue, causing duplicative work and a bad patient experience at best and medical errors at worst.

A survey from the Ponemon Institute found 86% of medical errors were due to patient misidentification.

Meanwhile a Black Book survey estimated costs of repeated care due to duplicate records at an average ~$1950 per inpatient and $800 for emergency departments.

Rife with errors
Estimates for percentage of mistakes in matching patient identities

ONC estimate of the best error rate

7%

Typical identity error rates within an organization

20%

Typical identity error rates when organizations exchange records

60%

Source: ONC, CHIME

Cybersecurity is also a massive issue, considering how expensive healthcare data breaches are.

Most health record breaches happen because someone delivers information to the wrong place, or people access records they are not supposed to have privileges to access, according to a Verizon Enterprise report.

A blockchain ledger would create audit trails of who accessed a health record, creating more accountability.

In addition, developers haven't been able to build the kind of user-friendly, third-party platforms for healthcare that have been advanced in so many other sectors. But as patients generate more data — via consumer diagnostics, wearables, genomics, and more — it could be structured and captured into a patient-owned personal health record.

A decentralized patient health record system could better capture data and give better data access controls to patients. Patients could give keys to their data to whoever they want authorized.

This would threaten any business model that is dependent on hoarding data as a moat. It would also mean that companies would have to better demonstrate the kind of value they would give patients directly in exchange for their data (as opposed to buying it from third parties that collect and de-identify the data).

Pharma companies, for example, rely on this kind of data to better inform marketing campaigns and areas they should be targeting for clinical trials.

Projects underway

We've seen the announcements of several projects related to patient data, though we have yet to see the actual deployment of such applications.

In January 2017, Du announced a partnership with NMC Healthcare to implement electronic health records using blockchain. Estonian blockchain technology startup GuardTime will also be involved. The project was slated to launch in Q1'18, but the application has not been released yet.

In general, a decentralized personal health record is likely more doable in countries which have existing unique patient identifiers which the US still lacks.

Estonia and India have recently established these identifiers, though there are concerns that this could negatively impact citizens' privacy and potentially expose sensitive information in the event of a breach.

Once decentralized patient records are common, a decentralized application (dApp) layer for different services will be much more feasible, since data access will be much easier. These ecosystems would need groups of miners and token incentives to verify each transaction in the network, including the exchange of services for currency or data. (This is similar to what we described in the health data exchange section above.)

Decentralized app (dApp) ecosystems can be built on top of blockchain PHRs. Apps exist today but infrastructure is not yet in place.
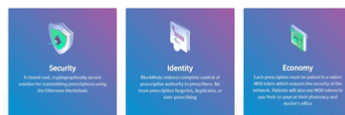

Care Coordination

simply**vital** health

- Platform allows coordination and communication with other providers
- Algorithms forecasts costs in near-real time
- Blockchain technology creates a secure audit trail for care
- Machine learning improves accuracy over time

E-Prescribing

BLOCKMEDX

The BlockMedx System

| Security | Identity | Economy |

Telemedicine/Second Opinions

well

Spend WELL   Earn WELL

Patients	Clinicians
Charities	Lenders
Borrowers	Validators
Employers	Translators
Payors	Patients
Pharma	Pharmacies

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5 Challenges to implementing blockchain for healthcare

Blockchain integration in healthcare will be a slow process.

Regulations around patient privacy make it difficult to get stakeholders onboard or provide third parties access to relevant but not identifiable information. GDPR in the EU is also potentially at odds with blockchain projects (though it could also be a catalyst for improved compliance solutions).

Lack of data standards means blockchain projects are being worked on in siloes.

Existing healthcare stakeholders are disincentivized to solve many of the problems blockchain aims to tackle. It took a $30B+ incentive system via the HITECH Act and many years to switch hospitals to electronic medical records.

Scalability is still an issue with most blockchain projects and storing data on a blockchain is expensive.

However, solutions to these problems are being explored.

On the data standards front, the establishment and adoption of Faster Healthcare Interoperability Resources (FHIR) is setting the groundwork for a third-party development ecosystem to flourish. Shared data standards are also necessary for many aspects of blockchain tech, like smart contracts, to work.
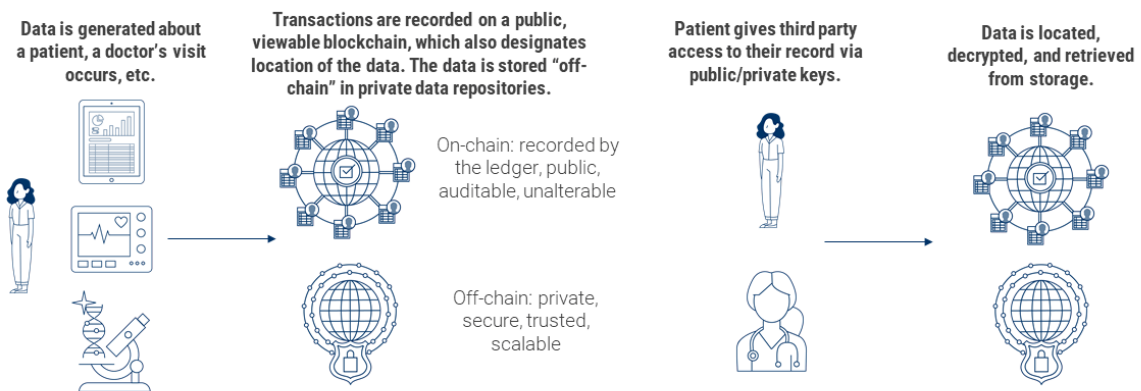
New cryptography techniques — like zero-knowledge proofs, **homomorphic encryption**, and secure multi-party computation — allow computation to be performed on data that's encrypted. This means that sensitive information can still be used without actually being exposed.

Better data access models can incentivize patients, hospitals, etc. to monetize their digital assets (e.g. patient data).

And finally, to solve for scalability and sensitivity, blockchain projects are exploring ways to combine on-chain solutions (recorded on a distributed ledger itself) with off-chain ones (actions that occur off of the ledger).

Transactions, emergency data, and more could be stored on a blockchain system, while larger data storage needs could be met by private repositories.

On Chain + Off Chain solutions being built to solve for both scalability and data sensitivity

Data is generated about a patient, a doctor's visit occurs, etc.

Transactions are recorded on a public, viewable blockchain, which also designates location of the data. The data is stored "off-chain" in private data repositories.

On-chain: recorded by the ledger, public, auditable, unalterable

Off-chain: private, secure, trusted, scalable

Patient gives third party access to their record via public/private keys.

Data is located, decrypted, and retrieved from storage.

6 The road ahead

Blockchain technology and distributed ledgers have real potential for healthcare.

Blockchain could bring patients to the center of the healthcare ecosystem by giving them the power over one of their most valuable resources — data.

However, understanding where and when it can be useful is key. When looking at solutions, there are several important questions to ask:

1 Can a project be done without a blockchain? Would it work equally as well if it used cash, or another existing technology?

2 Is blockchain a big improvement from the existing process?

3 What stakeholders need to be involved for a blockchain project to work, and are they properly incentivized to do so in this system?

4 Is there good reason to think this solution would succeed in the market today?

As the ecosystem is built out, there will be increasingly more opportunity to deploy blockchain applications. However, there are also merits to centralization as well, including speed, privacy, and more. Knowing when to opt for centralization vs. decentralization will be key.

The healthcare industry can expect more blockchain entrants aiming to figure out the balance between the two. Those that can have the potential to completely change processes, business models, and information flows in healthcare.