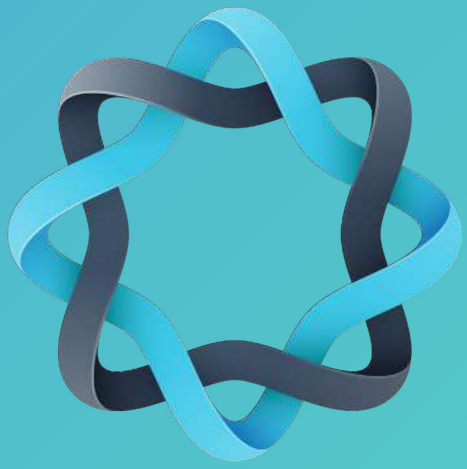

MEDICALCHAIN

Whitepaper 2.0

Contents

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1.0 Abstract

Thank you for taking the time to read the Medicalchain Whitepaper. This paper is the result of collaboration between doctors, allied health professionals, blockchain specialists, academics and business advisors.

Medicalchain uses blockchain technology to create a user-focused electronic health record and maintain a single true version of the user's data.

Medicalchain enables users to give healthcare professionals access to their health data and records interactions with this data in an auditable, transparent and secure way on Medicalchain's distributed ledger.

Moreover, Medicalchain is a platform for others to build applications on top of to complement and improve the user experience. Users will be able to leverage their medical data to power a plethora of applications and services.

Medicalchain White Paper 2.0 will outline the vision of Medicalchain, the current issues in healthcare, as well as give a brief summary of the blockchain technology used and how Medicalchain is utilising it to address specific issues to make healthcare better for users.

2.0 Letter from the CEO

Dear Reader,

Thank you for taking the time to research Medicalchain and read our Whitepaper. This has been a culmination of hard work and dedication from all of the team here at Medicalchain and we would like to proudly share our vision with you all.

As a medical doctor I have worked long hours while managing expectations and multitasking to satisfy tight deadlines. Despite such experiences nothing had prepared me for the challenge of growing Medicalchain from the ground up. I could not have done this without the support of my Co-Founder and COO, Mo Tayeb. Working side by side, we have selected the finest individuals to join our team to become, what we now know as Medicalchain.

Our team is a unique one: a perfect blend of clinicians, engineers, developers and visionaries from the world over. We have nine different nationalities representing us, each bringing with them their own personal views and experiences of healthcare in their respective countries.

The Medicalchain team have the drive and commitment to improve healthcare for those who need it most: the patients.

> **Our mission is to improve care for people by placing the patient at the center of the digital transformation of healthcare.**

We enact this mission by empowering patients with the tools to engage in a more comprehensive healthcare experience, such as accessing their own records on their mobile device, or conducting a consultation via webcam with a doctor anywhere in the world, we can improve people's lives.

It has been an amazing journey so far and we are fortunate to have such strong support from the community who has helped to drive us onwards in developing this platform. We are only at the beginning and I truly believe the most exciting times lie ahead. Please continue to follow and support us here at Medicalchain so that we can truly make a difference in the healthcare industry.

Best wishes,

Dr. Abdullah Albeyatti
Medicalchain CEO and Co-Founder

3.0 Executive summary

Medicalchain is a decentralized platform that enables secure, fast and transparent exchange and usage of medical data. We use blockchain technology to create a user-focused electronic health record and maintain a single true version of the user's data.

Medicalchain will enable users to give conditional access to different healthcare agents such as doctors, hospitals, laboratories, pharmacists and insurers to interact as they see fit.

Each interaction with their medical data is auditable, transparent and secure, and will be recorded as a transaction on Medicalchain's distributed ledger. We protect patients' privacy in the process and at all times. Medicalchain is built on the permission-based Hyperledger Fabric architecture which allows varying access levels; users control who can view their records, how much they see and for what length of time.

By empowering users we can build the future of healthcare together. Medicalchain will be a platform for other digital health applications to develop on; users will be able to sign for these applications and services which are powered by their health data and secured by smart contracts. Medicalchain is currently developing two applications to work alongside the platform: a doctor-to-patient telemedicine application and a health data marketplace.

The telemedicine application will enable users to consult a real doctor remotely (for example, on their phone) for a small fee payable directly to the doctor.

With the marketplace, Medicalchain will enable users entirely at their will, to negotiate commercial terms with third parties for alternative uses or applications of their health data as for instance would be the case with sharing this with researchers. It is intended that Medicalchain and others will contribute many more applications to the platform - helping bring value to all stakeholders.

Medicalchain's platform will be powered by **"MedTokens"**. We are issuing 500 million tokens, which will be distributed at a rate up to 1 token to $0.25 USD in ETH and/or BTC. These will be offered in a crowd selling process commonly known as an "ICO" or "Initial Coin Offering."

The contribution period will follow our presale and begin on **February 1st 2018**. More details on our ICO can be found below on page 31.

4.0 Introduction to the Healthcare of Today

4.1 Expectations of Healthcare Users

In today's world, users expect an instantaneous and seamless flow of data. Many industries have adopted, or are beginning to adopt necessary technologies to guarantee their users' expectation for instant information. Unfortunately, the healthcare industry has lagged behind. Legacy systems are burdensome, slow, oftentimes vulnerable and have little role for the patient.

4.2 Fragmented Health Services

Health data contained in legacy systems is siloed and difficult to share with others because of varying formats and standards. In short, the current healthcare data landscape is fragmented and ill-suited to the instantaneous needs of modern users. As a result of this, stakeholders are incentivized to keep their own records, and no singular version of the truth exists.

4.3 Lack of patient centricity (passive user)

The relationship between healthcare professionals and patients has long been a paternalistic one. In recent times however, there has been a significant shift of authority.

> **Medicine is being democratised and patients are more empowered.**

It is now considered reasonable to seek a second opinion and patients are expected to contribute to decisions made about their treatment choices.

Even in single-payer system like the UK's National Health Service (NHS), patients have the right to choose where and when they receive their care. Thus, with patient mobility comes the need for information mobility. In order to provide the best care patients not only can, but must have control over their own data.

4.4 Ill-informed Clinical Decision Making (data driven decision making risk of fatalities)

Clinicians rely upon investigations and tests to make informed decisions about a patient's diagnosis and possible treatment plan. Traditionally, an investigation or test should only be requested and arranged if this is going to lead to a different possible diagnosis or alternative treatment plan. Unfortunately, even when the results of an investigation or test have returned, these are rarely shared widely with all of the health professionals involved in the patient's care and are normally isolated, or siloed, at the institution which requested them originally.

The patient's quality of care suffers as a result of this. Other institutions are not aware of a patient's complete history and in turn this could lead to incorrect decision making, delays, and unnecessary costs for the patient or health institution. In the worst case, these medical errors can be fatal. Research at the American John Hopkins Hospital by Makary et al, 2016 concluded that medical errors are the third leading cause of death in the United States and that "most errors represent systemic problems, including poorly coordinated care."

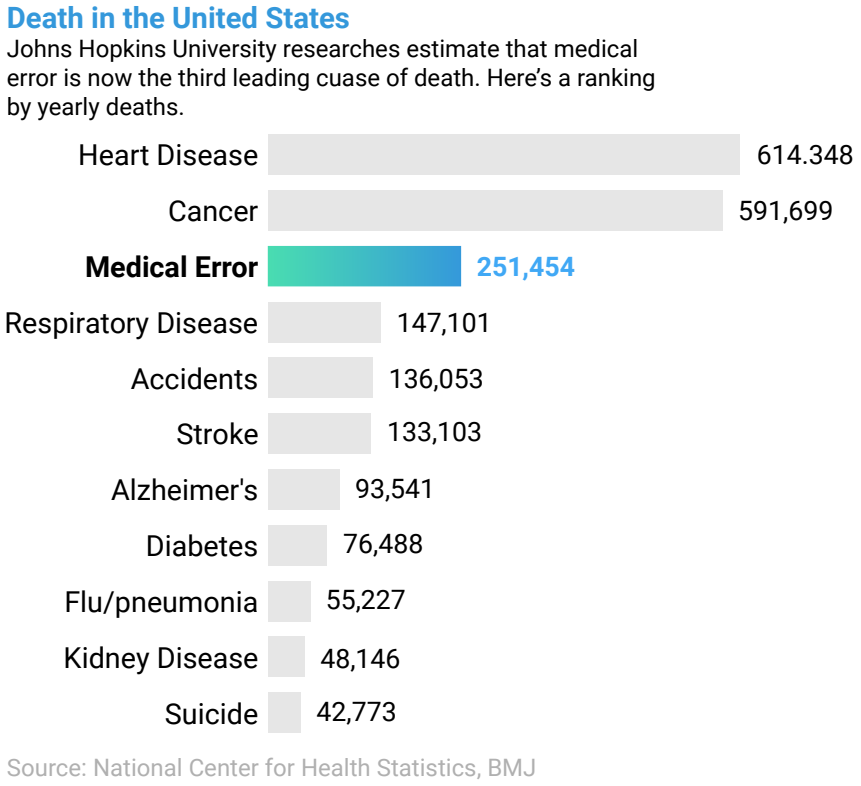


Figure 1: Table showing yearly death rate as per John Hopkins University research in 2016

4.5 Security Risks to Patient Data

At present, electronic health records (EHR) are stored on centralized databases in which medical data remains largely non-portable. Centralization increases the security risk footprint, and requires trust in a single authority. Moreover, centralized databases cannot ensure security and data integrity, regardless of de-identification and controlled access requirements. Centralized health databases are legally a requirement and necessity in most countries worldwide and therefore require an added layer of technology to improve their portability and security.

As cybercrime around the world is on the rise, healthcare systems also become targets and are no exception as shown by recent ransomware hacking. The technology that powers these systems is under attack on an unprecedented scale. In fact, the healthcare industry has more data breaches than any other sector and medical records are being stolen and sold on darknet markets where they are 10 times more valuable than credit card data.

"Your medical information is worth 10 times more than your credit card number on the black market."

Figure 2: Technology News, Reuters, September 24th 2014

In spring of 2017, over a dozen NHS Hospitals and GP surgeries in the United Kingdom and over 300,000 machines in 150 countries were the target of the WannaCry attack. This attack led to days of uncertainty for millions of patients, cancelled appointments and caused the NHS to come to a grinding halt. WannaCry was ransomware with shadowy origins which highlighted the vulnerability of our healthcare systems to potential threats and a sober warning about the inadequacies of the current infrastructure. WannaCry is just the latest in a long list of countless accounts of cybercrime.

Privacy is often compromised from within organizations. The medical records of 26 million patients were exposed because the systems being used by thousands of GPs were not secure. Hundreds of thousands of strangers could access the records held at 2,700 practices and patients would have no knowledge of their privacy being breached.

Many have tried to overcome this issue, and it is high on the agenda of many governments and a source of frustration for both doctors and patients. A significant component of the challenge centers on data security. Security is paramount because medical data is incredibly sensitive.

4.6 Lack of Transparency

4.61 Increasing Costs

For patients and professionals, the present system is incredibly slow, inflexible and woefully opaque. These problems are equally visible throughout the claims process. When a patient needs services (from a provider such as a general practice, a pharmacy or nursing home), health plans are used to determine how much of the cost they will pay. In order to determine this cost, the health plan must validate services received from the provider against the agreement the patient and health plan have, and then share their findings with the provider. This only occurs if the provider is "in-network" with a health plan. For a provider to be considered in-network, a complex agreement needs to be negotiated which adds a significant expense to the provider's administration costs. One part of these costs are Billing and Insurance Related (BIR) costs which include activities such as maintaining benefits databases and keeping records of services delivered. BIR costs are projected to reach $315 billion dollars by 2018 and take up to 3.8 hours for the average physician to navigate.

On average, this whole process takes between one to two weeks if done electronically and takes three to five weeks by paper. Moreover, this process is rife with places for miscommunication and misunderstanding to occur. For care to actually take place, multiple people need to check multiple archaic agreements against multiple records. The result is an inefficient and opaque process that leaves stakeholders and ultimately patients feeling confused and skeptical.

4.62 Insurance Fraud

Whether you have employer-sponsored health insurance or you purchase your own insurance policy, health care fraud inevitably translates into higher premiums and out-of-pocket expenses for consumers, as well as reduced benefits and coverage. For employers this increases the cost of providing insurance benefits to employees, which then increases the overall cost of doing business. Moreover, the reality for many patients is that the increased expense as a result of fraud, could mean the difference between affording health insurance or not.

Fraud by design dictates that false information be represented as fact. A common healthcare fraud involves perpetrators who take advantage of patients, by entering into their EHR false diagnoses of conditions they do not have, or of exaggerating conditions they actually do have. This is done so that fraudulent insurance claims can be submitted for payment.

"The total cost of insurance fraud is estimated to be more than $40 billion per year."

FBI.gov

Unless this discovery is made early on, these false or exaggerated diagnoses become part of the patient's documented medical history within the health insurer's records if not in other databases as well.

4.63 Record Tampering

Medical records are to be considered not only as medical documents, but also as legal documents. To pass off a rewritten record as contemporaneous is a criminal offence and any retrospective changes have to be clearly marked, dated and signed, and the reason for such changes clearly documented.

Altering existing medical records, removing records, or adding false records puts a healthcare professional at risk of medicolegal repercussions. Disclosure of authentic and original clinical notes is essential when a claim is brought up, and failure to do so can make a claim indefensible.

4.7 Telemedicine Market

Healthcare costs are on the rise around the globe as societies struggle to deal with aging populations and rising chronic disease burden. Current models of care delivery, particularly in places like the US and UK, are unsustainable. One trend combating increased costs has been the rise in digital health services. The value of the global digital health market was valued at $80 billion U.S dollars in 2015 and is expected to increase to over $200 billion by 2020 with a CAGR of 21%.

Digital health solutions such as Telemedicine will be critical for driving efficiency and reducing costs. The scope of Telemedicine covers referrals, second opinions, education, follow-up care, monitoring, diagnostics and treatments across numerous specialities.

Examples include Telecardiology, Teleradiology, Telepathology, Telepsychiatry, Teledermatology and others. Clearly there is a large market, and benefits include:

- Improved quality of care
- More time for doctor-patient interactions
- Improved access to consultation
- Reduced costs

The market is currently dominated by North America and Europe though highest growth is expected in India, China, and Japan in the next few years.

In 2017, the global telemedicine market was estimated to be worth $23.8 Billion and is projected to exceed $55 Billion by 2021.

There are several challenges to full implementation:

Unfortunately, most modern Telehealth systems are not integrated with the core financial and clinical systems used by healthcare organizations. Data remains within the Telehealth application and requires manual entry later into health records.

Digitisation promises much potential, but adding an additional silo without incorporating the information does not add value. In order to succeed, systems, devices, and data need to be seamlessly integrated. Privacy and security law issues must consider the management of data in non-traditional formats (for example, audio and/or video) and the sharing of data responsibilities encountered.

To minimize the privacy/security risk of Telehealth encounters, providers require reliable methods for verifying and authenticating the identities of the patient and practitioners. Blockchain solutions are a great tool to overcome these issues.

5.0 Medicalchain Solutions: The Healthcare of Tomorrow

5.1 Medicalchain Dual Blockchain

Medicalchain is built using a dual blockchain structure. The first blockchain controls access to health records and is built using Hyperledger Fabric. The second blockchain is powered by an ERC20 token on Ethereum and underlies all the applications and services for our platform.

5.2 Hyperledger Fabric

The Hyperledger blockchain network is permission based and requires users to sign up to use it. Permissioning on the network is controlled using Hyperledger modeling and access control languages. Hyperledger Fabric is a platform for distributed ledger solutions underpinned by a modular architecture delivering high degrees of confidentiality, resilience, flexibility and scalability.

Medical information is often highly sensitive, in both a social and legal sense, so a closed blockchain such as Hyperledger Fabric helps to retain the necessary privacy required for such an application.

Hyperledger Fabric is a better solution for managing access to health records, as it accommodates for multiple layers of permission, meaning the owner of a set of data can control which parts of their data is accessed.

5.3 Ethereum and Smart Contracts

Ethereum is a digital platform where thousands of powerful computers around the world work in harmony to host the Ethereum network. Ethereum's blockchain represents all accounts and transactions made by its users. Every time you send an Ether, the currency of Ethereum, to another user, those computers act as accountants by verifying the validity of the transaction. Once the verification is approved by those "accountants" the money is then transferred to the other user, making transfers secure, transparent and conflict-free.

Smart Contracts are code held and executed on the Ethereum blockchain. Anything that can be programmed normally can be programmed within the Ethereum network.

Processes that normally require a professional or notary can be automated and validated by smart contracts in a wholly transparent and secure way. For example, the average physician spends 3.8 hours weekly on billing and insurance related activity. Imagine the cost savings if these processes were conducted on smart contracts and validated by the Ethereum network.

5.4 Medicalchain as a Healthcare Platform

Using blockchain technology, smart contracts, and our cryptocurrency, Medicalchain provides the infrastructure for digital health applications and services to be built. These applications and services will be seamlessly powered by user's health data. Anyone will be able to develop on Medicalchain's platform and we hope to foster a thriving ecosystem to provide value, reduce costs, and ultimately improve people's lives.

5.5 Identity management using Civic

Identity fraud is a massive problem in the world.

Hackers steal identities and impersonate users to incur huge costs on both users and businesses. To combat this, Medicalchain has partnered with Civic and will use Civic's Secure Identity Platform to easily and securely manage the identities of users in a decentralized way. Civic's decentralized architecture with the blockchain and biometrics on the mobile device provides multi-factor authentication without a username, password, third-party authenticator, or physical hardware token, ensuring user's privacy in a simple and safe way.

6.0 Technical Explanation

6.1 Participants Definitions and Permissions

With a plethora of different actors, identity management and access to data is key to Medicalchain's solution. A dynamic system has been developed that identifies actors and gives them the appropriate scope over a health record, contingent on the patient's permission. Below are some examples of read/write permission:

6.2 Table: Read / Write Permission

Participant	Permission
Practitioner	• Read/Write on permissioned EHRs. • Request permission for other Practitioner/Institutions to gain Read/Write access.
Patient	• Read their EHR. • Permission a Practitioner/Institution to Read/Write EHR or a portion of their EHR. • Revoke permission from Practitioners/Institutions. • Permission next of kin / emergency contact to Read/Grant permission • Write certain attributes to EHR ◊ Amount of tobacco consumed daily ◊ Alcohol consumed weekly ◊ Weekly exercise • Ability to integrate IoT data into EHR
Research institution	• Read permissioned EHRs

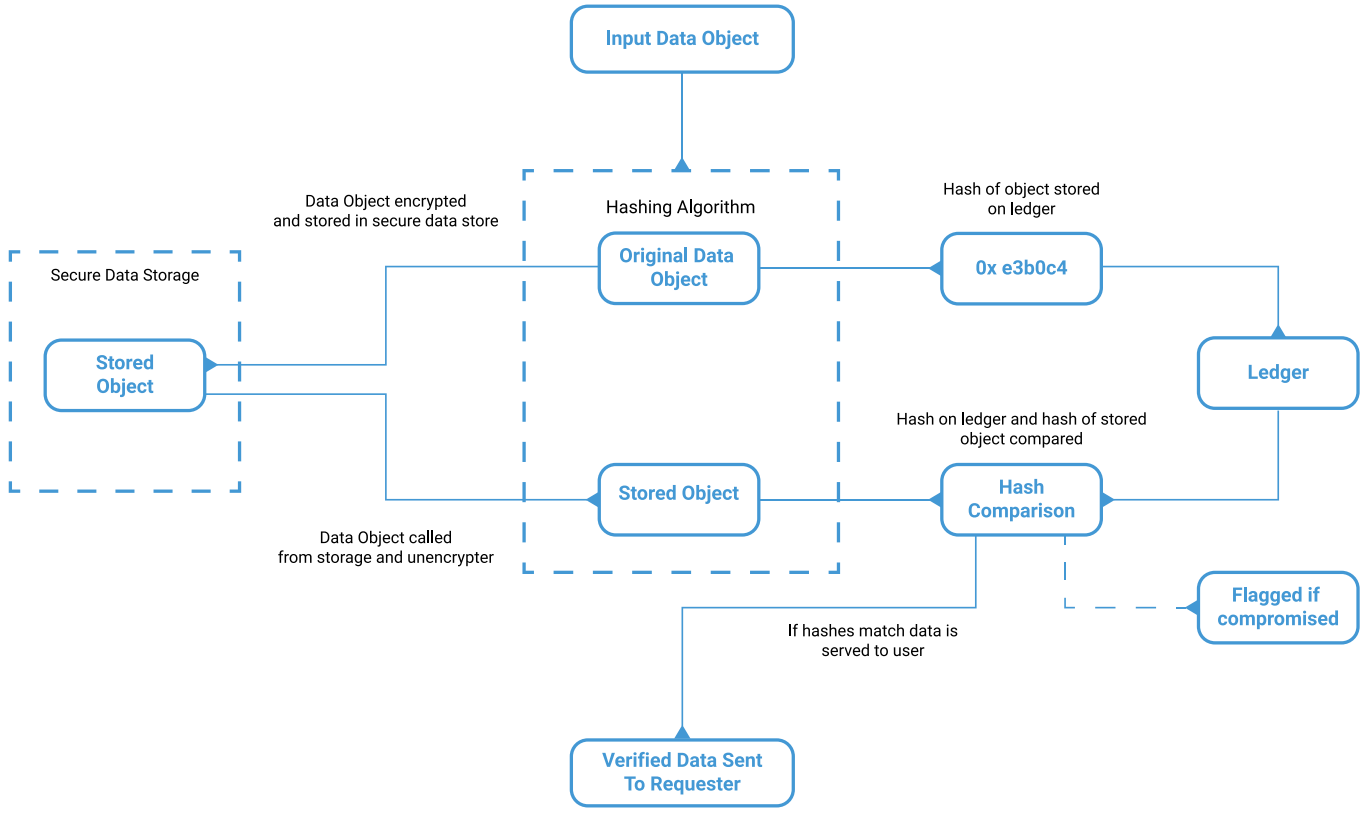
6.3 Encryption Cryptography

To ensure privacy, health records are encrypted using symmetric key cryptography. The record will be encrypted and stored on a data store within the appropriate regulatory jurisdiction. The symmetric key will be encrypted with the public key of a 2048-bit RSA key pair. **Each time an entity is given permission to access the patient's record:**

1. The record is decrypted with the owner's private key
2. The symmetric key is encrypted with the public key of the authorized user

In the case that a participant's access is removed from a health record:

1. The symmetric key is decrypted with the private key of the owner of the EHR
2. The EHR is decrypted using the symmetric key
3. The record is re-encrypted with a new symmetric key
4. The symmetric key is encrypted with all the remaining authorized users public keys



If a user is authorized to access a health record and requests access then the following process takes place:

1. The private key of the requesting user is used to decrypt the symmetric key for the EHR
2. The decrypted symmetric key is used to decrypt the patient's EHR

6.4 Transactions

Any interactions with health records are recorded as transactions on the network. Transactions are viewable only to the participants associated with the transaction.

Here are examples of how transactions take place on Medicalchain.

Patient Granting Access

- Patient A grants access to EHR to Practitioner A
- Practitioner A's ID is added to Patient A's authorized asset on the ledger
- Patient A's ID is added to Practitioner A's authorized asset on the ledger
- The Symmetric key for the EHR is decrypted with Patient A's private key
- Symmetric key is then encrypted with Practitioner A's public key

Patient Revoking Access

- Patient A revokes access from Practitioner A
- Practitioner A's ID is removed from Patient A's authorized asset
- Patient A's ID is removed from Practitioner A's authorized asset
- Patient A's private key is used to decrypt Symmetric key for EHR which is used to decrypt the EHR
- The EHR is encrypted with a new Symmetric key
- The new Symmetric key is encrypted with Patient A's public key and the public keys of all the remaining ID's that have permission

Practitioner Referring Patient

- Practitioner A updates the permissions to allow Practitioner B to access the Patient's EHR.
- Chaincode will check that the Practitioner A has permission on the EHR.
- Practitioner A uses its private key to decrypt the EHR's symmetric key
- Practitioner B's public key is used to encrypt the Symmetric key
- Practitioner B's ID is added to Patient A's authorized asset
- Patient A's ID is added to Practitioner B's authorized asset

6.5 Data Structure

Hyperledger's modeling language will be used to define the domain model for the network. Below are some examples from the .CTO file of how models will be defined and stored on the chain. These are subject to change depending upon different regulations and requirements in order to make the Medicalchain platform HIPPA and GDPR compliant.

Participants

Patient

Variable Type	Variable	Description
String	ID	A unique string (128-bit UUID)
Asset	PersonalDetails	Structure defined in asset
String (Array)	authorized	Array of all participants ID's that have been authorized to read EHR
Asset	MedicalRecord	Structure defined in asset

Practitioner

Variable Type	Variable	Description
String	ID	A unique string (128-bit UUID)
Asset	PublicProfile	Structure defined in asset
String (Array)	Patient	Array of all participants ID's that have been authorized to read EHR
Asset	MedicalRecord	Structure defined in asset

Assets

Personal Details
Relationship: Patient (Participant)

Variable Type	Variable	Description
String	ID	Unique ID for asset
String	FirstName	User's given name
String	LastName	User's last name
String	EmailAddress	User's email used to sign up
Int	Dob	Unix timestamp of DOB
concept	Address	Defined in Concepts section
Super-Type	Owner	Extends Patient (Participant) asset

Practitioners public profile
Relationship: Practitioner (Participant)

Variable Type	Variable	Description
String	ID	Unique ID for asset
String	FirstName	User's given name
String	LastName	User's last name
String	EmailAddress	User's email used to sign up
Int	Dob	Unix timestamp of DOB
concept	Address	Defined in Concepts section
String	Identification ID	The assigned number the practitioner was given when registered with practice
Array	Qualification	Qualifications practitioner holds
String	Image Url	Pointer to practitioners image
Super-Type	Owner	Extends Practictioner (Participant) asset

Medical Record

Variable Type	Variable	Description
String	ID	A unique string (128-bit UUID)
Super-Type	Owner	Extends Patient (Participant) asset
Super-Type	Author	Extends practitioner (Participant) asset
Array	Permissions	Array of participant IDS
String	File Hash	SHA-256 hash of the latest version of the file
Float	Version	Int increments every time a file is updated
String	Pointer	This points to where the file is in storage out-side of the blockchain

Concepts

Address

Variable Type	Variable	Description
String	Numer	Numer/name of building
String	Street	A unique string (128-it UUID)
String	City	Extends Patient (Participant) asset
String	Country	Extends practitioner (Participant) asset
String	Postal/zip code	Area code

6.6 Permission Definitions

Hyperledger fabric includes an access control language (ACL), which defines access over the elements of the CTO domain model above. By defining ACL rules we are able to control which resources participants have access to on the network's domain model. Some examples of these access rules are shown below:

```
rule PatientAccessPractitionerPublicProfile {
    description: "Patients can access practitioners public profiles"
    participant: "org.acme.medicalchain.Patient"
    operation: READ
    resource: "org.acme.medicalchain.PractitionerPublicProfile"
    action: ALLOW
}
```

```
rule PractitionerCanReadPatientIfAuthorized {
    description: "Allow Practitioner read access to all granted patients"
    participant(p): "org.acme.medicalchaindev.Practitioner"
    operation: READ
    resource(r): "org.acme.medicalchaindev.Patient"
    condition: (r.authorized && r.authorized.indexOf(p.getIdentifier()) >
-1)
    action: ALLOW
}
```

```
rule PractitionerCanUpdatePatientViaTx {
  description: "Allow Practitioner update access to all granted patients"
  participant(p): "org.acme.medicalchaindev.Practitioner"
  operation: CREATE, UPDATE
  resource(r): "org.acme.medicalchaindev.Patient"
  transaction(tx): "org.acme.medicalchaindev.UpdateRecord"
  condition: (r.authorized && r.authorized.indexOf(p.getIdentifier()) > -1)
  action: ALLOW
}
```

6.7 Medicalchain API Platform

Medicalchain will offer an API that will permit third parties to obtain and interact with EHRs with the user's permission. All endpoints available in the UI will be available to developers. We hope to cultivate a robust ecosystem of applications and services.

7.0 A Better System for Care

7.1 User Control

In the current healthcare system, patients have their health information spread over multiple systems, hospitals, networks and potentially countries.

There are multiple fragmented records from the same patient, held at different institutions all with their own snapshot of the patient's health at the point of their interaction with them, such as blood tests, imaging and clinic letters. Medicalchain will chronologically arrange all of these records and filter them into the specific categories above to aid data handling. Such a categorization would make the records more accessible and understandable for patients and it will also facilitate researchers in searching for the information relevant to them.

Medicalchain provides the user full access and control over their data.

The user will have the capability to provide differing levels of access to various users, by assigning a set of access permissions and designating who can query and write data to their blockchain.

The patient, being the owner of their own medical records, will be able to fully control who accesses their data and which information they access. The patient would have the ability to grant access to their EHR to other users and revoke access by setting up a time limited gateway, thereby improving data security.

Approved clinicians on the Medicalchain platform will have the ability to 'read and write' to the patient's records. Moreover, the Medicalchain platform will provide the users with a full log of who has access to their medical data, the time of access and the particular types of data that can be accessed.

7.2 Data Security

The Medicalchain system uses a double encryption mechanism on a closed, permissioned based blockchain. The security of health records is secured beyond any centralised data system currently in use. Patient data is not accessible directly on the blockchain.

The blockchain acts as a pointer to where patient data is held in an encrypted format, meaning that anyone attempting to intercept patient data will be unable to with the ease that is required to access data existing in any central location.

7.3 User Centric Model

In the current healthcare system, patients have their health information spread over multiple systems, hospitals, networks and potentially countries. There are multiple fragmented records of the same patient, held at different institutions with their own snapshot of the patient's health during their interaction with them such as blood tests, imaging, and clinic letters. Medicalchain will order and filter all of these records into a chronological order and the specific categories above to aid data handling. Such a categorization would make the records more accessible and understandable for patients, and it will also facilitate researchers in seeking out the information important to them.

7.4 Health Data Revolution

Bold companies like 23 and Me, Fitbit, Apple, Nest, and Qardio are rapidly innovating to expand the frontier of the data that is collectable. We already have remarkable access to anatomic, biological, environmental, genomic, phenomic and physiological data. New ideas and technologies will only move this frontier further. If we can connect these disparate data sources, then caregivers and researchers will have unprecedented insight into patient's lives. Ultimately this will lead to lowered costs, better patient outcomes and better research.

Medicalchain wants to be at the forefront of this revolution and will seek to integrate as many sources of health data to its platform as possible.

Medicalchain will start with integrating Apple HealthKit and common wearables, before moving to add support for diagnostic tests, IoT, and other digital health. Patients and their doctors will have the ability to view this data along with their electronic health record.

7.0 A Better System for Care

7.5 Patient Safety

Medicalchain has also developed a backup access system for emergency situations, ensuring patient safety at all times.

A patient can generally grant or decline healthcare professionals access to their records. However, in the event of an emergency and with the patient incapacitated, there must be an ability to view certain information in order to provide the best possible care.

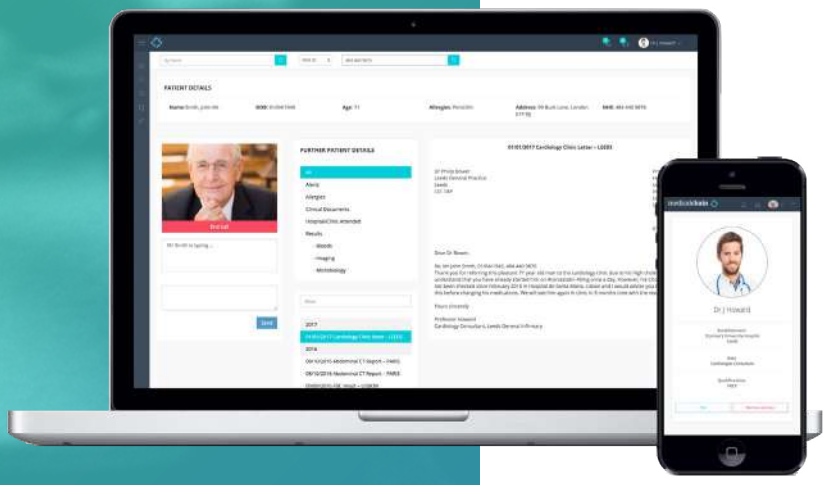
The most vital information needed in an emergency would be the patient's name, their next of kin, medications, allergies and any advanced decisions they may have made. Patients using the Medicalchain platform will have the ability to select in advance which areas of their records can be viewed in an emergency situation. Clinicians would not need to know any more than this in an emergency situation.

In the case that the patient is incapacitated or unconscious and unable to grant access to their records, the emergency bracelet the patient is wearing would be scanned to unlock this information. Two clinicians would have to agree that given the situation, access to this information without the patient's explicit consent was clinically in the patient's best interest. To be clear, a patient's entire record would not be unlocked, but only information that would be vital in an emergency situation and the patient had prior agreed to sharing in such a situation.

To unlock this information, two doctors would need to scan the emergency bracelet the patient is wearing, or their wearable device which would unlock access to these key parts of their medical records.

This would enable clinicians to provide the best care possible to a patient in an emergency situation and would avoid mistakes such as giving the patient medications they are allergic to or treatments which are contraindicated based on their known medical history.

7.61 Clinical Communication



Along with increased access to emergency information, Medicalchain allows clinicians to communicate with each other with ease. As an authorised healthcare professional updates a patient health record, the system will update that record on Medicalchain. Any clinician with authorised access to that users records will see the updates within seconds.

As health records are updated via Medicalchain for all access authorized parties, there is no need for patient data to be manually transferred from system to system.

Medicalchain will be usable in any browser on any computer. As a result, any doctor with a browser and an internet connection will be able to access the documents that were shared with them. Issues currently associated with interoperability are resolved this way and costs are associated with the transportation of notes currently undertaken by junior clinicians or administrative staff are cut down on.

7.62 Borderless Health and Social Care

With the utilisation of data compliant storage nodes alongside borderless blockchain technology the user will be able to transport their records with them as they travel. Healthcare services become borderless as telemedicine services allow users to interact with clinicians in other countries. This will be particularly beneficial for travelling business men and women, alongside those moving abroad that do not wish to have the inconvenience of getting their records sent over to their new healthcare provider.

7.7 Transparency

7.71 Patients / Users

In present day healthcare, there is a lack of transparency between all actors involved. Patients have no immediate access to health records written by medical professionals. Medical professionals are only able to share data quickly within their own organisation or with other health professionals using the same EHR system. Insurance companies are kept in the dark, unless they request patient data which is required for a claim. Researchers who could benefit society are forced to seek anonymised data from multiple intermediaries, which is both costly and timely. The lack of transparency on how patient data is handled also leaves the user unaware of how their data is currently being used.

7.72 Health Insurance

Patients are unknowingly and in some instances, knowingly not disclosing their health conditions to insurance companies. As a result of this incorrect information, patients can pay incorrect premiums for years, only to discover that their claims are declined in the instance they need to make one.

7.73 Transparency Cost Benefits

The verifiability and immutability of health records on Medicalchain's platform allows insurance companies to make a more accurate assessment of an individual's health and health premiums should reflect this.

By allowing health insurers access to their health records, patients could be rewarded for their transparency in the form of lower premiums.

Moreover, patients could pledge to a set of health goals with their insurer and be rewarded as they reach milestones associated with those goals.

In the same way 'black box' GPS devices are installed in cars by insurance companies to monitor driving habits, with those driving sensibly being rewarded with lower insurance costs.

The same can be applied with health insurance with regular engagement, measurement uploads, proof of therapy compliance and attendance at a gym might incentivise rewards from health insurers.

8.0 Token Utilites

8.1 MedToken

Once the patient has access to their own EHR this will enable the following key features to be used in conjunction with the Medicalchain platform.

8.2 Telemedicine Consultations

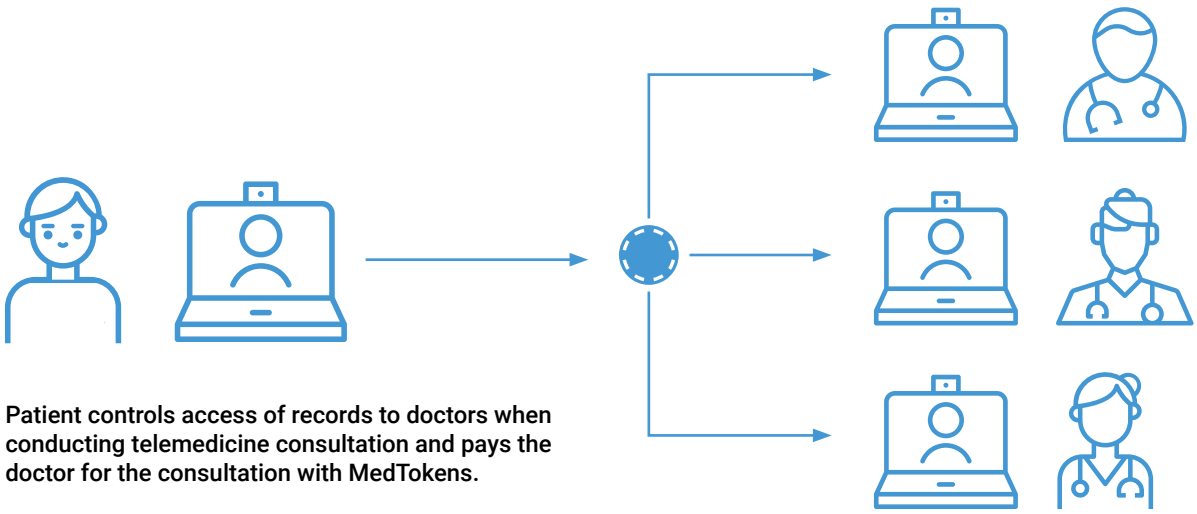
Telemedicine, an online consultation with a doctor and patient using a webcam interface, is set to be the future of consultations. Medicalchain not only provides this established and successful format of consultation, but will accommodate the doctor by enabling them to interact live with the patient's records during the consultation. Patients would grant access to their records during the telemedicine consultations, allowing for a more in-depth, informative, and valuable experience for both the patient and doctor.

8.21 Patient Benefits

From the patient's perspective, the time for seeking a consultation is massively reduced by removing the need to physically attend the doctor's practice. There are many simple ailments that are currently managed over the telephone, but by providing a telemedicine component we can improve the patient's experience by facilitating a visual consultation which would be more in-depth and beneficial to both the doctor and the patient.

8.22 Clinician Benefits

To attend a doctor's appointment requires a patient to cancel their work in advance or a take their child out of school for the appointment. There is then the waiting time at the clinic in order to see the doctor, often times for a simple request. Telemedicine provides the patient with the opportunity to select a specific time to conduct the consultation at their convenience , encouraging patient choice and freedom. Further, patients are able to choose which doctor they would like to conduct their consultation with offering greater choice and building a relationship between that



Patient controls access of records to doctors when conducting telemedicine consultation and pays the doctor for the consultation with MedTokens.

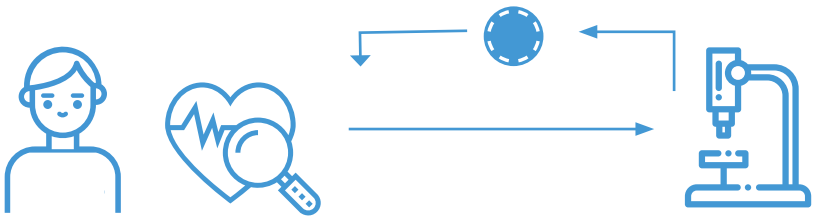
There are also further benefits from the telemedicine experience which Medicalchain delivers. Telemedicine platforms available today offer online visual consultations but do not have access to longitudinal health records. Medicalchain offers this unique value and provides patients with privacy controls. Patients will be able to choose the level of detail visible and allocate viewing rights to their chosen doctor for as long as they feel necessary.

8.3 Health Data Marketplace Control

As with the founding principal of Medicalchain, patients should have control over their health records, and they should also benefit from the potential value that they possess.

Medicalchain will connect research institutions with users who are willing to have their health data used in studies in a health data marketplace. Users will be given clear information as to how their data is being used and what data will be required. In many cases anonymised data will be permissible, ensuring the privacy of everyone involved. In return, participants will be compensated in MedTokens. Patients will be given the ability to unlock the monetary value that their health data holds, they will be more engaged with their health conditions and the next generation of cutting edge medicine will be powered.

Pharmaceutical and research companies will also benefit from the changes brought in by Medicalchain. They will be able to seek out patients who have opted in to being contacted by researches so that these institutions can interact directly with the patient. By doing so, companies will no longer need to approach a hospital or clinic and can go straight to the people whose information will be used. Not only will this increase efficiency, but it is a more transparent process that strikes a relationship which is symbiotic and sustainable.



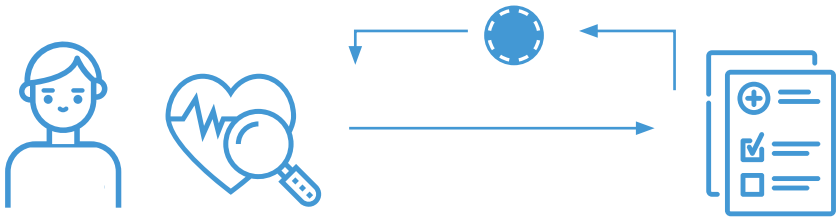
Patient grants access of personal health data to researchers in return for incentivisation with MedTokens

There would be a few broad categories of data leasing agreements though more are likely to evolve over time. Here are a few we envision:

- One time leasing. Institutions will use APIs provided by Medicalchain to pull relevant data from participants from our servers.
- Longitudinal studies. Institutions that need to see data over a period of time will be able to ask users to stream their data. Ex: how many steps users have walked per day or what their heart rate looked like today.
- Collated data. Medicalchain would combine normally disparate data sources and provide easy access to these data sources with user consent.
- Ongoing anonymized data offerings. Users could opt in to have their data anonymized and labelled as accessible to research institutions interested in it. Institutions would have the ability to filter by broad categories (e.g 40-50 year old, 25+ BMI, male) and users would be paid every time their data is accessed.

8.4 Potential Insurance Integration

Users could allow health insurers access to their health records. In turn, insurers could rest assured that the information they are making decisions upon is trusted, verifiable and patients could be rewarded for their transparency in the form of lower premiums. Moreover, patients could pledge to a set of health goals with their



Patient grants access of personal health data to insurance companies in return for incentivisation with MedTokens

insurer and be rewarded as they hit milestones associated with those goals. Regular weight and blood pressure measurement uploads, proof of therapy compliance and attendance at a gym might incentivise rewards from health insurers with lower premiums or rewarding users with MedTokens.

8.5 Powering Medicalchain's Platform

Users will be able to pay for a variety of other applications and services that have been developed on Medicalchain's platform. Integrations with a plethora of different healthcare sectors are possible and the above is only the beginning of the revolution that is coming.

9.0 Cost Impact Analysis

9.1 Users

Whereas typically for a patient to gain access to their medical records, they would need to apply to their service provider and pay all associated administrative fees to have these released to them, with Medicalchain, the user would provide consent to have their data retrieved on their behalf, and stored free of charge on Medicalchain's nodes. Once this has been carried out, the patient would then use the Medicalchain application to have a standardized, single point of access to those records at their discretion, eliminating the need for additional administration fees should they lose this data, or need to send original, physical copies at any time, instead they would grant access to this data to any requesting parties.

Having permanent access to their own data, should patients attend a consultation or need to seek medical assistance away from their usual healthcare provider, they become the means of transferring those records, mitigating the risk of lack of patient data during the consultation.

Utilising Medicalchain's tele-consultation platform, users would have dramatically decreased wait times, which would save money considering the reduced need for time off work. Further, without the need to physically attend an appointment or consultation, a patient would remove entirely the need for travel expenses to and from any physical location, with all associated parking charges included.

9.2 Clinicians

For Clinicians on-boarded onto the Medicalchain platform, they would have immediate access to conduct tele-consultations with any users also on the platform. This will provide them with an additional revenue stream, meaning they could practice without any overheads other than a computer with internet connection.

This availability would decrease the chance of cancellations due to patients being unable to physically attend a consultation. Cutting this variable out saves on facility expenses, administration costs and the need for additional staff to be present.

9.3 Healthcare Providers

There are a plethora of benefits to healthcare providers. First of all, these will benefit from having a more complete picture of a patient's health condition. Medicalchain's single true record will be the sole place providers would need to look for patient data, providing peace of mind and reducing time spent on gathering records. Moreover, providers would benefit from not having to constantly invest to upgrade or upkeep their health record systems.

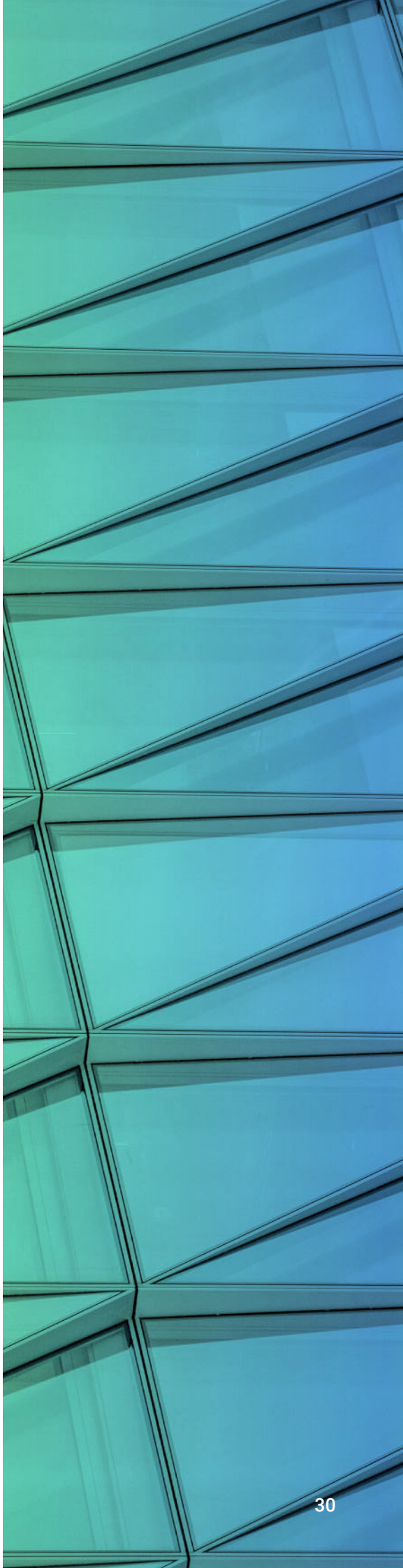
9.4 Researchers

Researchers would have the ability to reach a global audience of patients through Medicalchain's health data marketplace. This would increase the potential sample size used in research and improve the accuracy of the results. Costs would be reduced by simply pulling the relevant information from a participant's health record, with their consent, instead of the burdensome process of forming research groups and going through health providers for access to health data.

9.5 Insurers

Verifiable, immutable data, means that insurance companies will need to spend less man hours checking data, that they can trust the data presented to them, both from the patient granting them access and likewise from the medical professional's notation.

Similarly, if an insurance company wanted the patient to be completely transparent with them, in order to offer them an accurate premium based on their medical records. They would offer the patient MedTokens and/or offer a cheaper premium as an incentive for their transparency.



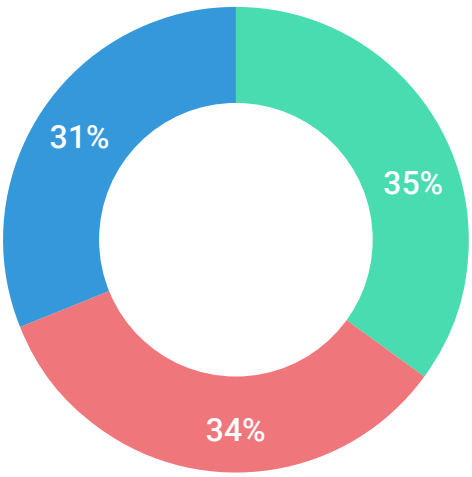
10.0 Token Sale

Medicalchain's ICO will be a capped sale raising **$24 million (24,000,000) equivalent of ETH and/or BTC with whitelisted contribution caps.** Medicalchain will be issuing **500 million (500,000,000) ERC20 tokens**, called MedTokens, to create a new blockchain based healthcare ecosystem.

These tokens will be offered in a crowdsale to allow participants to purchase MedTokens early as well as contribute and support the further development of Medicalchain. Starting on February 1st 2018, participants will have the ability to contribute and receive MedTokens in exchange for their ETH by sending Ether to a designated address.

During the ICO MedTokens will be distributed at an exchange rate of 1 token = $0.25 equivalent in ETH and/or BTC and offered before this date at a discount in a pre-sale.

500 million tokens issued



community development
crowdsale
retained by the company

Of these **500 million tokens...**

- **35%** will be offered in the pre-sale and crowdsale
- **34%** will be retained by the company, team, advisors, founders and future employees. Within this 34%...
  - **10%** will have already vested.
  - **12%** vests over 2 years.
  - **12%** over 4 years.
  - Founders: **15%**
  - Company development: **8%**
  - Team, advisors, early backers: **11%**
- **31%** will be retained for community development. Medicalchain will use these tokens to help grow an ecosystem on it's blockchain by educating others, supporting node holders, bringing partners onto its platform, conducting pilots, and sponsoring industry leading events. This will vest over 4 years.

11.0 Timelines

11.1 The Story so far

Work on Medicalchain started in early 2016 when founder Dr. Albeyatti identified an issue with writing clinical notes on patients being discharged out of the hospital and having their care transferred back to their family doctor (general practitioner). These notes, known as "Discharge Summaries" contain a substantial volume of mandatory information that is often written in freeform text by the doctors. The notes are subject to errors. For example, doctors may forget to include vital medical information, such as the correct dosage or course of drug prescription. These errors put the patients' wellbeing at risk, incur raised costs, and represent a liability for the hospital. To address this, Dr. Albeyatti co-founded Discharge Summary with Bara Mustafa.

First employed in Leeds Teaching Hospital Trust, UK, the tool was designed to generate accurate and timely notes when patients are sent home. Discharge summary received a positive welcome and was adopted by junior doctors as well as consultants and other healthcare practitioners.

Discharge Summary, by improving communication and standardizing data, demonstrated to Dr. Albeyatti the power of digital health to lower costs and improve outcomes. He sought to apply this insight to a broader problem: disparate health systems. In short, documents are transferred, often on paper, to other organisations where the exchange of data results in no single version of the truth. Moreover, oftentimes IT systems are not interoperable; they cannot talk to each other let alone use each other's vital data. Dr. Albeyatti expanded the team by bringing Mo Tayeb, Jay Povey, Robert Miller as well as a combination of medical doctors, allied health professionals, and experts from the blockchain community.

Together, the team has developed Medicalchain–complementing Discharge Summary and helping to build Dr. Albeyatti's vision.

Over the past few months a flurry of work has been completed and Medicalchain has been featured at world renowned forums such as the Financial Times Digital Health Summit, Blockchain Labo, and the Technology Innovation. The work to date has resulted in a public Beta, which will be released in February, as well as several key partnerships. One thing is for sure: Medicalchain is leading the way in blockchain applications in healthcare and digital health's role in our daily lives.

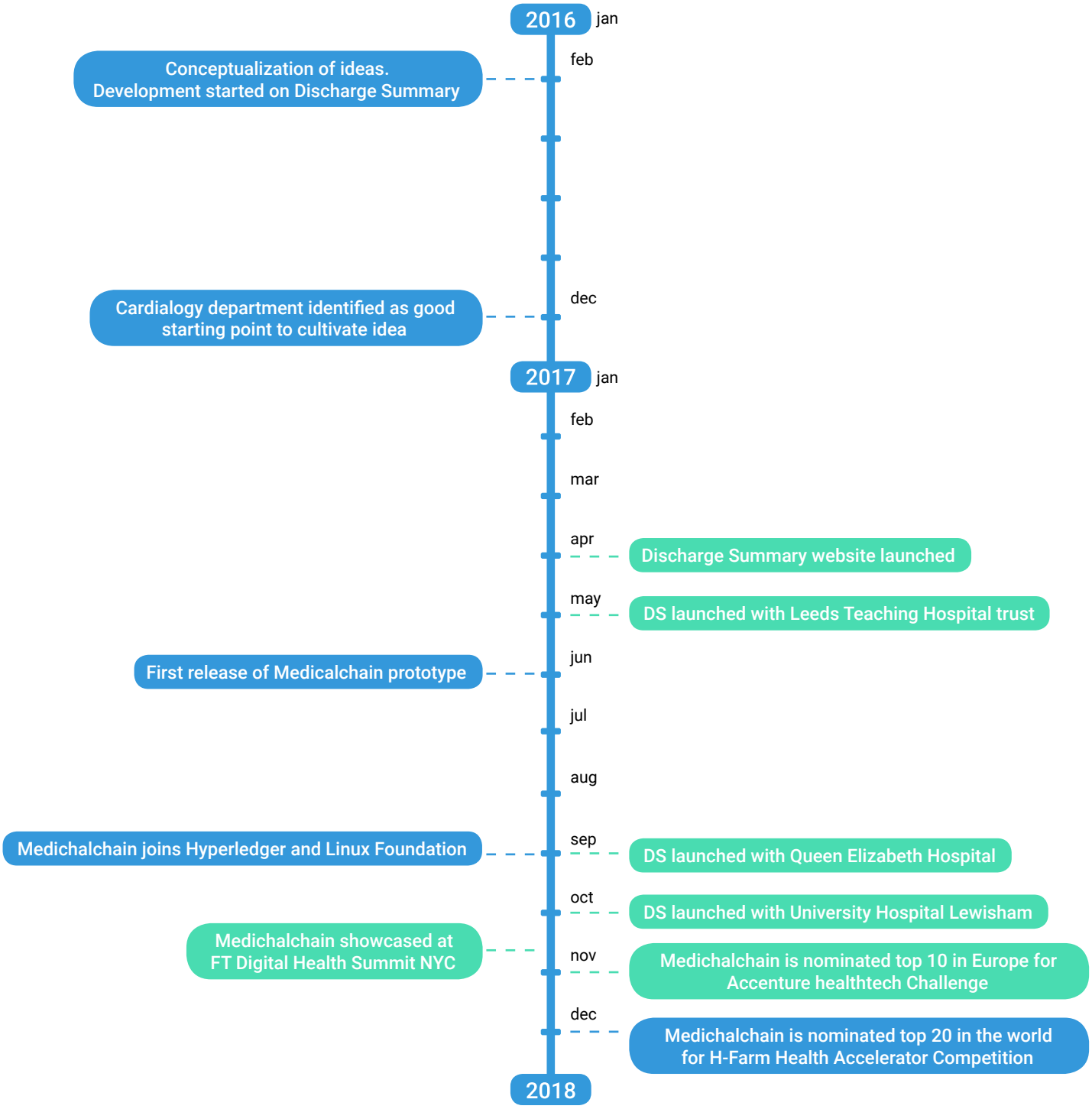
11.2 Current Developments

The proof of concept is in its final phase and the development is now focused on design and UX/UI experience. The core of the application, Medicalchain's secure API and blockchain, is ready for the release of the Beta. The nodes setup and operated during the Beta are run by Medicalchain, but over time Medicalchain will include other nodes onto it's network. Several of these conversations are underway already with hospitals, universities and non-profit organisations.

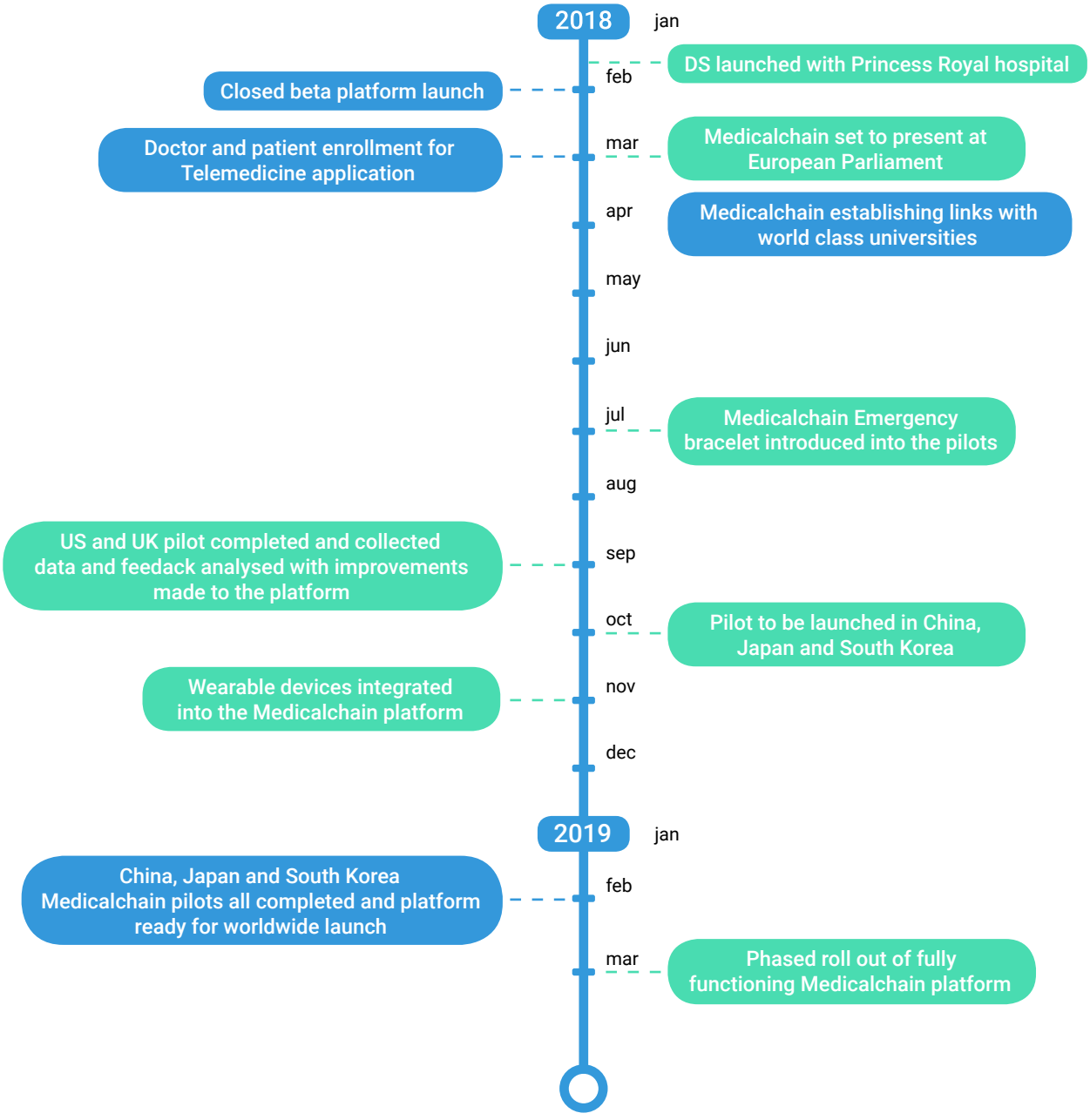
11.3 Collaborative Design

To enhance the user experience of Medicalchain a range of global advisors have been selected to work on specific use cases. Expert patients, doctors, health professionals, health providers, insurance and pharmaceutical companies will take part in system design consultation with blockchain developers. The Beta release with enable testing of each use case, with the trialing community providing feedback via the platform.

11.4 Roadmap



11.4 Roadmap



11.5 Route to market

The identified actors that will require initial onboarding include:

- Patients / Service Users
- Clinicians
- Non Profit Node Services
- Research Institutes / Pharma

Expert patients have expressed great interest in the benefits to owning and managing their own health records. We are working with several disease specific organisations to onboard experienced healthcare users to test the collation of data processes, alongside the user interface.

Medicalchain has several community campaigns running, on a variety of platforms to raise awareness of the project and the benefits of blockchain for healthcare users.

Communication platforms include:

- Global Events
- International Press Releases
- Sponsored Meetups
- Telegram
- Email Campaigns
- Linkedin
- Reddit
- Twitter
- Bitcoin Chat
- LINE
- WeChat
- Kakao Talk

Communication to users is focused on safety and security of patient data. Education on blockchain technology is seen as a priority, to raise awareness, gain trust and influence adoption of Medicalchain. Innovators and early adopters will be the primary target market for system trials. Influential users that witness the benefits of Medicalchain will be the main catalysts for further patient onboarding.

As we continue with awareness and onboarding campaigns, Medicalchain will offer a service where it will request healthcare records for consenting users. Our legal team are working with system developers to build API integration compliant with various international regulations. We acknowledge that some countries may have barriers to the decentralization of data and we are working with others to negotiate these barriers.

The data migration process would require a user to complete a short form of consent, highlighting the providers they wish to obtain records from who they had previously visited.

Physical documents will be scanned and mined for information which will then be encrypted and uploaded to data lakes. Electronic records will be standardized, encrypted and uploaded.

Medicalchain is approaching clinicians individually and at an organisational level. This multilevel approach will allow for forward thinking health providers to test the Medicalchain platform throughout their service but does not exclude innovative autonomous healthcare professionals. We will work alongside clinicians to test the pilot with consenting patients and assist providers with patient targeted marketing material to improve user adoption.

11.5 Route to market

The key incentives for clinical onboarding include:

Cost savings: Decreased need for repeat diagnostics, decreased administrative costs for record retrieval/ transportation, decreased risk of errors associated with inaccurate or unobtainable medical records.

Increased revenue: Access to global patients when completing chargeable telemedicine consultations complete with simultaneous up-to-date healthcare records.

Non profit organisations with the required compliance documents and experience in handling sensitive, will have the opportunity to partner with Medicalchain. Organisations will be incentives to act a secure nodes for holding encrypted health data.

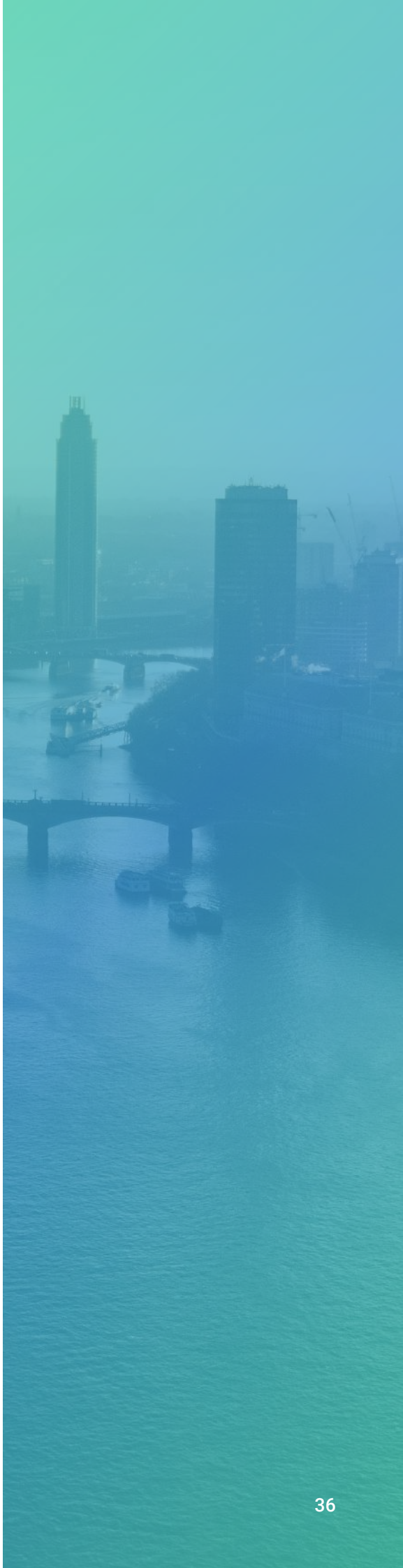
The key incentives for node onboarding include:

Financial incentivisation: MedTokens will be used to support the maintenance of the node as well as incentivise the hospital, university and/or non-profit organisation to continue acting as a node.

Public relations opportunity: To be a node for Medicalchain and part of an international community of healthcare providers. An opportunity to be a leader in the future of healthcare and become involved in blockchain technology.

Research Institutes / Pharma

Medicalchain is currently in discussion with several large pharmaceutical and health research organisations, who have expressed interest in . The organisations will have the ability to request data from any Medicalchain user.



11.6 Looking forward

Medicalchain has ambitious goals for the future.

We want to improve people's lives by building the digital infrastructure for the healthcare of the future.

We're looking for driven people or organizations to help us realize that vision. If you're interested in working with Medicalchain, please send an e-mail to contact@medicalchain.com.

MEDICALCHAIN