The Nexus of Blockchain and Healthcare

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Investing in Entrepreneurs that Improve Healthcare

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I. Introduction

In healthcare, the "triple aim," put forth by the Institute for Healthcare Improvement is posited to be a primary objective for many clinicians, policy-makers, entrepreneurs, and investors alike. This aim includes three tenets that are essential for bettering healthcare: 1) improving the patient experience of care (inclusive of care quality and patient satisfaction), 2) improving the health of populations, and 3) reducing the per capita cost of healthcare.[1] To achieve the triple aim requires improvements in quality, access, and efficiency from all facets of the healthcare industry – not an easy feat.

One such emerging technology that has received significant recent attention, but not yet adoption, for its ability to address problems in healthcare and work towards the triple aim, is blockchain. Media, computer scientists, and industry experts alike have likened the blockchain to the healthcare industry's panacea, referring to it as "revolutionary to every aspect of healthcare"[2] and "the solution for healthcare inoperability and fragmentation."[3] Though it may still be too early to evaluate the validity of these claims and to fully understand whether blockchain can "dramatically increase IT and organizational efficiencies"[4] and "transform patient safety,"[5] it is clear that the impact of blockchain is imminent and here to stay.

To better understand what role blockchain will play in healthcare and develop a thesis within the space, it is first useful to examine how the technology works and what it is being used for in other industries. In addition, we must consider how the technology is traditionally funded, what the current and future use cases are within healthcare, and the status of today's blockchain health companies.

II. Brief Overview: What is Blockchain and Why is it Important?

The history of blockchain begins in 2008 with the advent of Bitcoin, a digital currency that operates on an underlying blockchain platform. It was in 2008 that Satoshi Nakamoto first published a white-paper titled "Bitcoin: A Peer to Peer Electronic Cash System" which described Bitcoin as the first digital platform to not require a third-party intermediary (i.e. a financial institution) for the transfer of currency between individuals.[6] Bitcoin's invention was revolutionary to money transfer, mainly because of the underlying blockchain technology. Blockchain provides for the decentralization of Bitcoin data, allowing for digital security in the transfer of 'coins' (currency) and eliminating the need for a middle-man to validate the transaction.[7] Satoshi Nakamoto (a pseudonym), whose identity or identities are still in question, is thought to be both the inventor of Bitcoin and of the first version of blockchain technology.[10] Since then, Bitcoin's popularity has grown and different blockchains have been developed as the basis for other applications – within and beyond the scope of money transfer.

Bitcoin is enabled by the enhanced security provided by blockchain, which is fundamentally due to the technology's functionality as a decentralized database for Bitcoin's financial transaction data.[8] The database is differentiated from other technologies due to a few key qualities: it is "time-stamped, transparent (anyone can see the ledger of transactions), and decentralized (the ledger exists on multiple computers)."[10]

Blockchain functions as a distributed leger, or essentially, what can be thought of as a shared record book.[9] Copies of this record book exist on the computers (called nodes) that partake in the network. For example, every individual who owns Bitcoins and has a 'Bitcoin wallet' has a copy of the entire shared record book of Bitcoin transactions on their device. These copies are synchronized

via the internet and each person with a copy of the blockchain-enabled 'record book' has access to all of its contents, enabling transparency.[12] Blockchain networks, much like the internet, can be private or public,[12] and are not owned or managed by a single individual, but rather, by the collective.[13] This is unlike the case of a traditional bank, where the data is centralized, owned, and managed by one entity.

As they occur, digital transactions are grouped together with other transactions taking place during a certain time frame (i.e. 10 minutes) in a "cryptographically protected block."[12] These time-stamped blocks are then transmitted to all devices across the network. Then, the blocks are validated by 'miners'. In the case of cryptocurrency, miners are "members of the network with high computing power" and may receive rewards in the form of coins or tokens for validating transactions.[12] In healthcare, physicians or pharmacists – trusted with an access key that enables them to validate transactions – may function as the miners.[10] Finally, after transactions are validated, they are timestamped and added chronologically to the shared record books.[14] The blockchain record book shows a history of all transactions (packaged as blocks) and is available to everyone within the chosen network. The content of the distributed leger may be financial transactions, as in the case of Bitcoin, or it may be a history of what happens or is recorded during a doctor's visit or procedure, as would occur in the case of a blockchain-enabled electronic health record.[14]

The main value-add of blockchain technology is its decentralized functionality, which enhances security, making the platform more durable and reliable. Many traditional databases are susceptible to hacking or cyberattacks that can result in stolen identities, undermined data integrity, or even entire networks being shut down, given that they have "centralized repositories and single points of failure."[15] In addition, other benefits of blockchain include empowering users through

enhanced control and visibility of data, providing for higher quality data and faster transactions, ensuring process integrity, creating simpler, transparent and immutable databases, and reducing the costs associated with transactions by eliminating overhead expenses and third party intermediaries.[11]

However, there are also many limitations of the technology that must be considered alongside the benefits. Regulatory challenges are a primary concern that may inhibit widespread adoption; modern currencies and other potential use cases (i.e. electronic health records, clinical trial data, etc.) are traditionally heavily regulated by governmental entities, which have yet to establish regulatory guidelines related to the use of blockchain.[15] There are also integration and adoption concerns, given that blockchain use would require not only a fundamental change in how companies traditionally store data, but also a paradigm shift in how users and operators are accustomed to interacting with it.[15] Finally, associated high energy needs and high initial capital costs of the technology, as well as complex database architecture or algorithms, could prove inhibitive for usage and adoption.[15]

III. Applications of Blockchain

Blockchain, which has existed for less than a decade, is most well-known for its uses in money transfer, given its first application and role in the founding of Bitcoin. Since then, there have been nearly 1300 cryptocurrencies invented and available over the internet.[12] After Bitcoin, with a market cap of nearly $130 billion USD, the next most widely known cryptocurrency is Ethereum (market cap just under $32 billion USD) as of the time of this writing.[12]

Ethereum, born in 2015, is fundamentally a public blockchain network and much like Bitcoin, enables trade of a cryptocurrency called "Ether".[13] While Bitcoin and other cryptocurrency blockchains serve primarily as peer-to-peer digital currency exchanges, Ethereum allows for "smart contracting" and enables a wide range of capabilities, allowing its reach to extend far beyond money

transfer.[17] The public blockchain networks give developers the tools they need to create and deploy decentralized, blockchain-enabled technologies, providing for the "development of potentially thousands of applications all on one platform."[17] (There are also private or semi-private blockchains that may see adoption within healthcare much sooner than public chains. IBM blockchain is but one example here). So far, these applications have targeted a wide range of topics, including crowdfunding, event forecasting, and identity protection.[17] The Ethereum platform relies on Ether, the cryptocurrency that serves as payment from the platform's clients who request operations to the machines or developers executing the operations. The Ethereum website refers to Ether as its "fuel," in that it ensures that the network remains healthy and that developers create quality applications. Ether, unlike bitcoin, is not intended to be used as a currency but rather to be used as a "crypto-fuel" to pay for computation. However, in practice, many individuals have purchased Ether to take advantage of skyrocketing growth trends.

Indeed, Ether and Bitcoin cryptocurrencies have both experienced rapid acceleration and growth since their launch, setting a precedent for the success blockchain technologies can achieve and indicating the potential for these companies to expeditiously accelerate growth. Despite the frenzy over cryptocurrencies and media attention to how blockchain technology may revolutionize financial transactions, leading to blockchain being dubbed "the revolution of the modern economy,"[11] money transfer is far from its only promising application. In fact, applications of blockchain exist within a wide range of industries including insurance, automotive, security, and healthcare, among many others.

One way blockchain may revolutionize society is through enabling a new form of cloud-storage; since traditional cloud-based services are managed by one entity (such as Box or Dropbox),

there is potential for new technologies to allow information to be stored in a decentralized manner on a blockchain-powered network.[14] Applications like Storj and Factom are currently testing the waters of this use-case. Another application of blockchain is within digital identity or security, which can be applied within many industries. For banking, healthcare, national security, or even online shopping, a blockchain-based identity authentication system would likely reduce both fraud and administrative burden.[18] One such application, ShoCard, is developing a digital identity that works akin to a driver's license and is "so secure that a bank can rely on it."[18] Blockchain could also be applied within voting, notarization, real estate, and music, as well as several other use-cases.[15] The potential of blockchain today has been compared to the Internet in the 1990s for good reason; its growth is rapid, uncertain, and may impact the world we live in in ways that we cannot yet fathom.

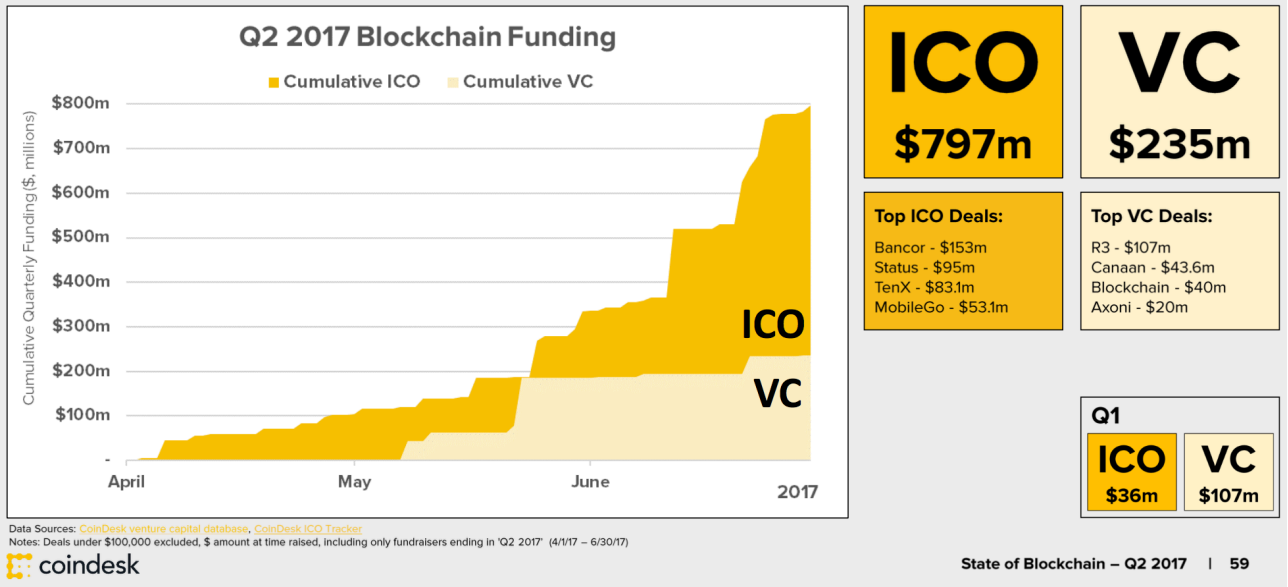
IV. Funding Sources of Blockchain Companies

This technologic eruption has also elicited a new form of fundraising for blockchain-enabled companies. Blockchain companies can fundraise not only by raising traditional venture capital, but also by using a new form of capital-raising specific to blockchain companies, called an Initial Coin Offering, or ICO.

ICOs are similar to IPOs, but are uniquely distinct, functioning primarily as an unregulated medium by which companies can crowdsource funding. Through an ICO, a company trades future cryptocoins (akin to 'stocks' of the company) in exchange for cryptocurrencies that already possess "immediate, liquid value," such as BTC or Ether.[16] Initially, ICOs were used as a funding mechanism to develop new cryptocurrencies, but more recently, ICOs have been used to serve a wider range of purposes, including raising funding for venture capital funds.

ICOs have been described as "bubbly," and many experts have warned that growth is likely to wane.[20] However, the success of these coin offerings is likely due to "early Ethereum adopters making serious returns" and has provided for several "great innovations."[17] Take the recent August 2017 ICO for Filecoin, a storage network that "turns cloud storage into an algorithmic market", wherein miners earn native Filecoin tokens by providing storage to clients.[18] This company raised a record-breaking $200 million USD in the span of sixty minutes.[19] In addition, the quick, high-capital raising power of ICOs have also proven viable within venture capital. Blockchain Capital, a venture capital firm investing in blockchain technology companies, raised their target fund size of $10 million USD in the span of six hours.[20] Other firms, like Homebrew, a San Francisco based seed-fund focused on fintech, have hinted at the possibility of following-suit and raising their next fund through an ICO.[21]

Figure 1. Q2 2017 Blockchain Funding[22]



Though ICOs offer another medium to raise capital, many blockchain companies have still pursued fundraising through traditional venture capital. High profile, venture-backed blockchain companies include Coinbase, which has raised over $217 million USD to-date.[23]

At the time of this writing, blockchain companies have cumulatively raised over $3.5 billion USD through ICOs and nearly $1.9 billion USD through venture capital funding,[24] as shown in Figures 2 and 3 below.[25] For the first time in history, Q2 2017 saw blockchain ICO funding surpass blockchain equity funding.[26] This trend continued through Q3 2017 as well, and is illustrated in Figure 4 below.[27]

Figure 2. Capital Raised by Blockchain Companies via ICOs[24]

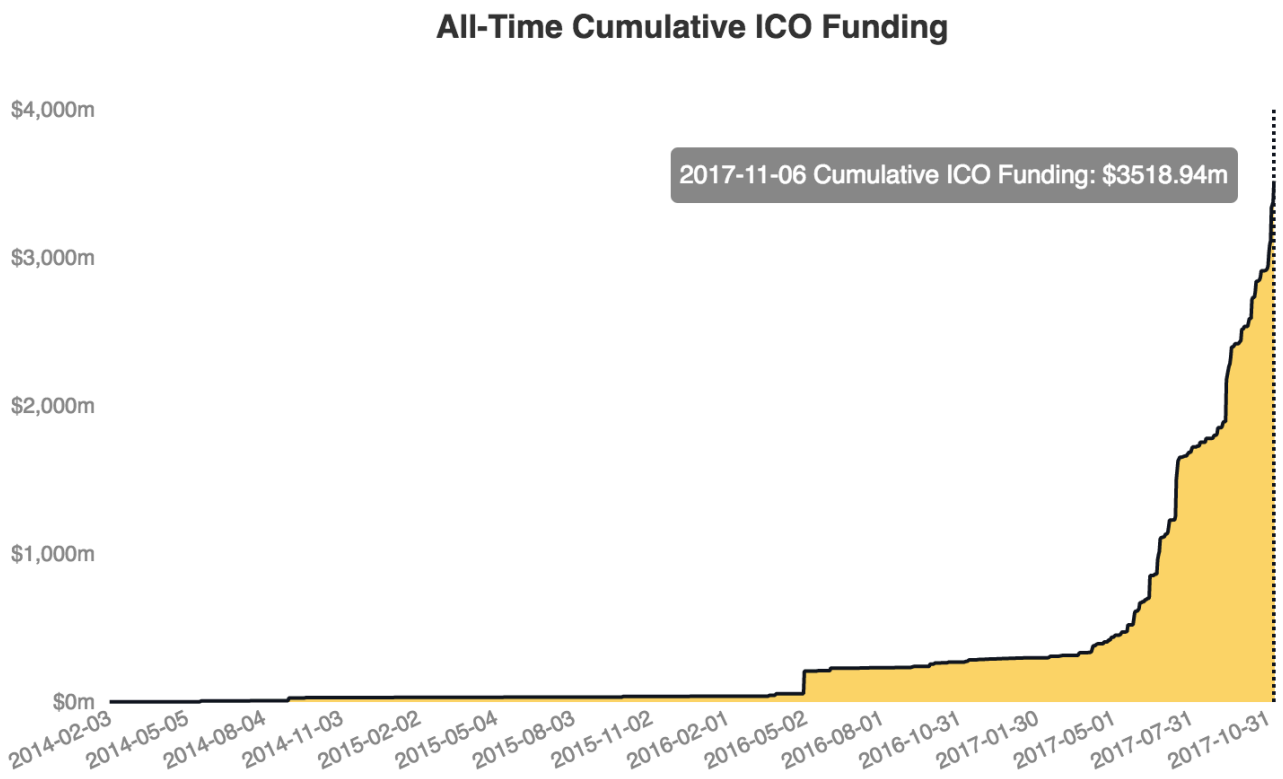


Figure 3. Monthly Capital Raised by Blockchain Companies via ICOs[24]

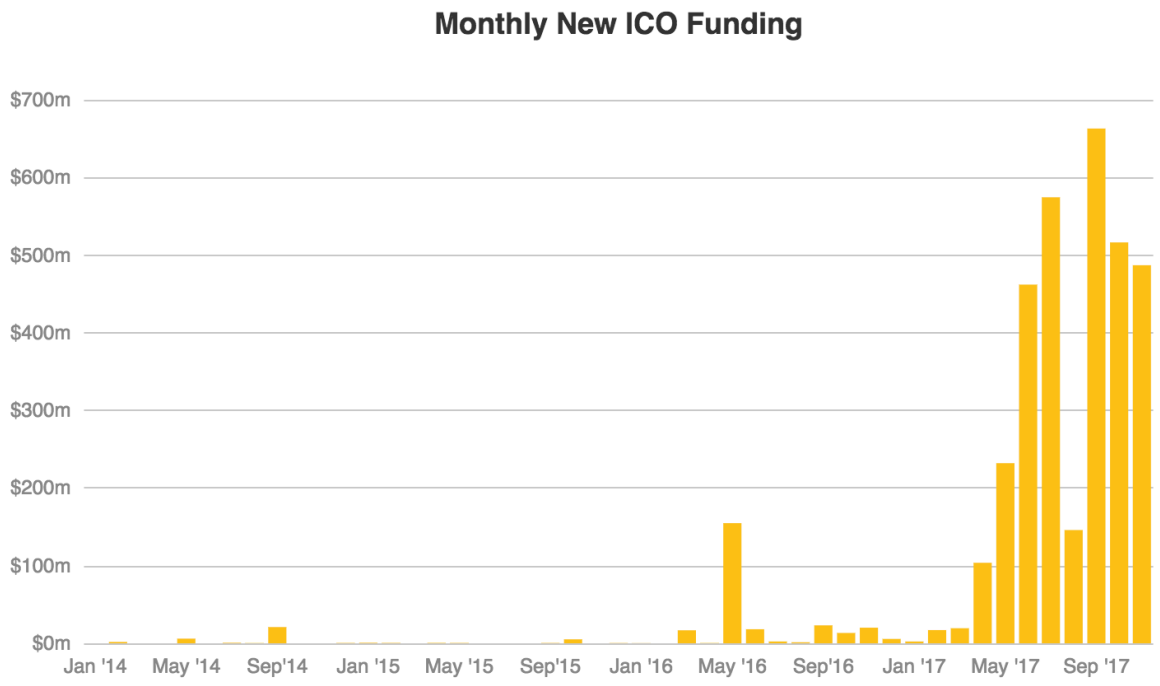
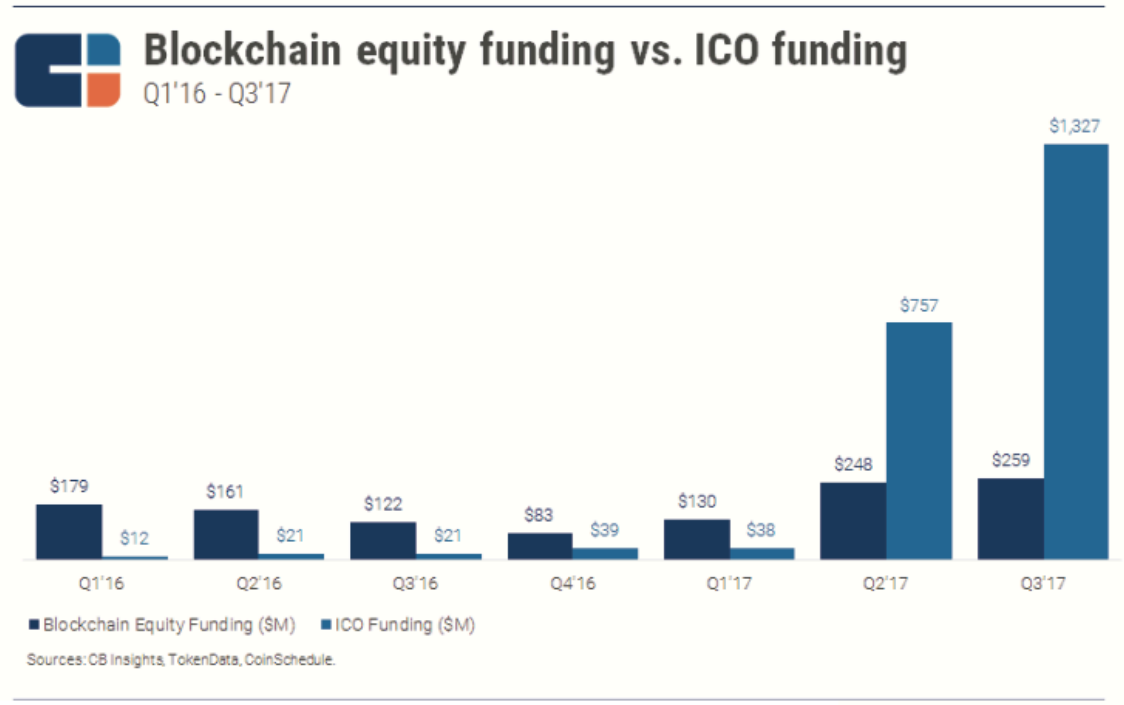


Figure 4. Blockchain Equity Funding vs. ICO Funding[27]



Still, VC-backed deals see much activity in terms of blockchain equity investments. For 2017, active VCs with a minimum of one blockchain investment is on track to reach a total of 120 by the end of Q4, representing a 33% increase from 2016 figures.[29] VC investment strategy has shifted over time as well, focusing initially on bitcoin-centric companies, expanding to private blockchain providers disrupting other industries through Ethereum, and now delegating interest to the token economy (yielding much ICO interest). With the emergence of new blockchain technologies, VC firms are now utilizing investment vehicles such as the following: cryptocurrency hedge funds like Polychain Capital to diversify investments and allocate them to a varied portfolio; direct venture investments via Simple Agreement for Future Tokens (SAFT) into exchanges or mining companies that track trading volume; and private blockchain investments that are run by centralized administrators.[28]

V. State of the Industry

The demonstrated opportunity of blockchain continues to garner attention by professionals in the healthcare industry. In an IBM survey of over 200 healthcare executives in 16 countries, 16% of participants expected to have fully implemented, scalable blockchain platforms relating to their business by the end of 2017.[29] Meanwhile, all regulations that keep healthcare institutions normalized are anticipated to apply seamlessly to these same blockchain technologies, given the transparent and trustworthy footprint that blockchain provides across all sectors. Furthermore, 90% of healthcare institutions are targeting blockchain pilots and are "planning to invest by 2018 across several business areas."[30] However, there are many regulatory risks involved, accentuated by the slow-moving pace of the healthcare industry that typically does not integrate change quickly. At FCA Venture Partners,

we understand that strategies governing traditional venture capital investing do not necessarily translate to those strategies governing blockchain investing.

However, it is still paramount that companies do not get lost in the hype of blockchain and neglect fundamental business strategies, losing sight of the problem their product seeks to address. This is especially true for healthcare blockchain startups, since this industry's complications are much more entrenched than those of other industries. In healthcare especially, there might be solutions outside blockchain that cloud companies' value proposition. The team, product offering, distribution methods, and implementation strategies must drive business strategy. Blockchain startups should emphasize that their new technologic capabilities are a means to an end, not a final solution. The underlying technology and its functionality certainly contribute to the success of the product, but cannot be the sole offering in and of itself. Typically, within healthcare, blockchain startups will find that the same issue they've identified is already being solved by another healthcare company, but just using a different technology. These proposals could be viewed as more digestible and thus easier to integrate than any intimidating blockchain application.

Accordingly, blockchain startups must ask themselves the following: is blockchain really necessary in order to deliver this product or service to our target market? Oftentimes, the answer is no. While blockchain can supplement established systems and processes, its adoption will be difficult to enforce if the value-add of a company is only a marginal increase from traditional methods. For startups, this makes the funding aspect particularly difficult. However, if blockchain companies find themselves in the minority of the population and can develop a product with quintessential blockchain integration, then there is a great opportunity to garner funding and disrupt the healthcare industry. To determine which designation a company falls under, they must assess whether or not their product

could be built with another technology stack, or if blockchain is absolutely essential for delivering the proposed solution. See Figure 5 below for examples of such successful healthcare use cases.

VI. Healthcare Blockchain Use Cases

Figure 5. New Healthcare Blockchain Functionalities

USE CASE	PRODUCT BUILT ON TRADITIONAL FRAMEWORK	PRODUCT BUILT ON THE BLOCKCHAIN
Medication Adherence	Rely on instructions from doctor, potentially combined with new technologies (ie smart pill box).	Individual adherence profiles across all drug datasets; token incentivizing programs to subsidize drug costs.
Clinical Trial and Drug R&D Process	Lack of communication across agencies through exploration, clinical development, regulation review, quality control, and other stages.	Provide transparency to the drug R&D process, reliably tracking drug supply/distribution. Ledger is easily shared across several Pharma organizations via a "keyed" entry.
Patient Centered EHR	One centralized system, difficult to operate, not freely accessible by patients, and is subject to hacking.	Comprehensive, immutable log to easily access medical information across all providers and treatment sites. Patient simply grants access.
Revenue Cycle Management	Records are maintained by a central entity, wherein concrete login information is required for access.	Peer-to-peer network for storing and sharing data. Smart contracts and digital identities control access, enforcing anonymity.

Medication Adherence

Failure to properly adhere to medical prescriptions incurs a yearly nationwide cost of $300 billion USD and a mortality rate of 125,000 deaths per year.[31] Blockchain companies such as ScriptDrop have been founded to ameliorate this issue. ScriptDrop delivers a patient's prescriptions directly to their home address, negating the need to physically trek to the pharmacy. Their platform also reinforces adherence itself by providing a virtual assistant, which can remind patients of dosage schedules and track their compliance. They integrate the blockchain by coalescing all that data into

one single data set, subsequently stored as a user profile. Furthermore, ScriptDrop plans to capitalize on blockchain tokens, using them as an incentive mechanism through which patients earn 'points' or rebates based on their continual adherence, ultimately subsidizing a portion of the co-pay for their next prescription.[32]

Clinical Trial Records

Drug R&D is both extraordinarily time consuming and costly – taking over ten years and $2 billion USD to successfully complete.[33] Consequently, providing an accurate measure of how to track drugs as they are propelled through this process is difficult, oftentimes leading to the production of fraudulent drugs. In 2015, the CDC found that 30% of drugs sold in developing countries were knock-offs.[34] Another study found that in "a recent project to monitor clinical trials, just nine in 67 trials it studied (13 percent) had reported results correctly."[29] Now, the FDA's recent Drug Quality and Security Act requires that each sole unit of a drug is branded with an electronic serial number, which has the propensity to be placed and tracked on the blockchain.[35] Along the timeline of the drug's R&D process, various agents at facilities where the next stage occurs (such as a Phase II Clinical Trial) can cite the specific drug's serial number, acknowledge that it arrived at their stage of the process, and post that information to the blockchain. At each registered 'check-in' a digital footprint is published to the blockchain, allowing regulatory agencies such as the FDA to track a drug's development and analyze whether the time a drug spent at a certain stage is cause for concern.

Some companies are already attempting to tackle this niche. A company in the U.K., Blockverify, is developing a pilot which allows consumers and medical industry professionals to scan pills and verify their validity, tracking their past movements through the R&D process.[29] Another example is lending provider MayoClinic, which leverages the data analytic capabilities of IBM's

Watson to scour clinical trials for data needed to "match patients with appropriate clinical trials."[36] If blockchain use becomes more widespread, companies such as MayoClinic will have increasingly unobstructed access to the data necessary for personalizing healthcare approaches.

Medical and Health Records

Of course, one of the major burdens of today's healthcare system is the incredible lack of communication across providers. Distinctive healthcare agencies all manage their records differently, and each agency's compartmentalization only exacerbates the process' static nature.[37] In quantifiable terms, Premier Healthcare states there is roughly $93 billion USD in potential savings that would manifest over 5 years as a result of data sharing.[38] Outside of mere functionality, healthcare's centralized nature is susceptible to data breaches. In 2015 alone, hacking efforts and/or IT incidents led to 112,000,000 data breaches across 350 international companies.[39] In practice, blockchain technology remodels the battered healthcare framework by facilitating an ownership shift from that of the provider to that of the patient. In fact, Estonian startup Guardtime recently finalized a deal with the government to secure 1,000,000 health records, utilizing its blockchain technology to provide an unalterable trail of progress that can be tracked, accessed, and verified in real time.[40]

Revenue Cycle Management

The interaction between payers and providers is facilitated by complex, arduous claims processes. This leads to delays, backlogs, and for the patient, stress over an unresolved healthcare bill. Furthermore, providers and payers purposefully do not share data with one another.[37] Their rationale? By keeping cost information private, hospitals maintain a competitive advantage over the insurance agencies. If hospitals distributed this information for public use, different patients could receive different insurance rates, leading to hospitals paying more for certain visits than others.[37]

Agencies should consider implementing an automated claims processor, wherein price and product are directly linked. By then publishing the processor to the blockchain, the claim is resolved in real time.[41] Payers and providers alike would be able to watch it progress, seeing exactly why one agency paid X dollars, since Y conditions were met. An added benefit of such a platform is ease of use for providers. In their role, the submitted claim mirrors the established manner of electronic form submissions, after which the blockchain is solely responsible. In September 2017, Change Healthcare announced their entrance to this space with the adoption of the "Linux Foundation's Hyperledger Fabric 1.0 for blockchain application design and development."[42] This collaborative network includes banking, supply chain, IT, and healthcare platforms, improving the efficiency of payment transactions.

VII. Conclusion

While it is still very early days to fully comprehend blockchain's role in healthcare, we at FCA Venture Partners believe that this technology has the potential to address some of the top concerns in data sharing and security within the U.S. healthcare system. We are actively seeking investment opportunities into companies using blockchain to solve unique problems that widely adopted technology solutions fail to address. Initial Coin Offerings have changed the role venture capital firms play in funding blockchain startups; however, because of the unique complexity and difficultly of building a healthcare startup (in relation to other industries), having a value-added capital partner ally who understands the intricacies of healthcare can create an unfair advantage over competitors without these types of investors.

And, lastly, we view this document as a living and breathing work in progress, as we understand that this market is rapidly changing by the minute!

VIII. Appendix

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