RAYMOND JAMES®

U.S. Research
Published by Raymond James & Associates

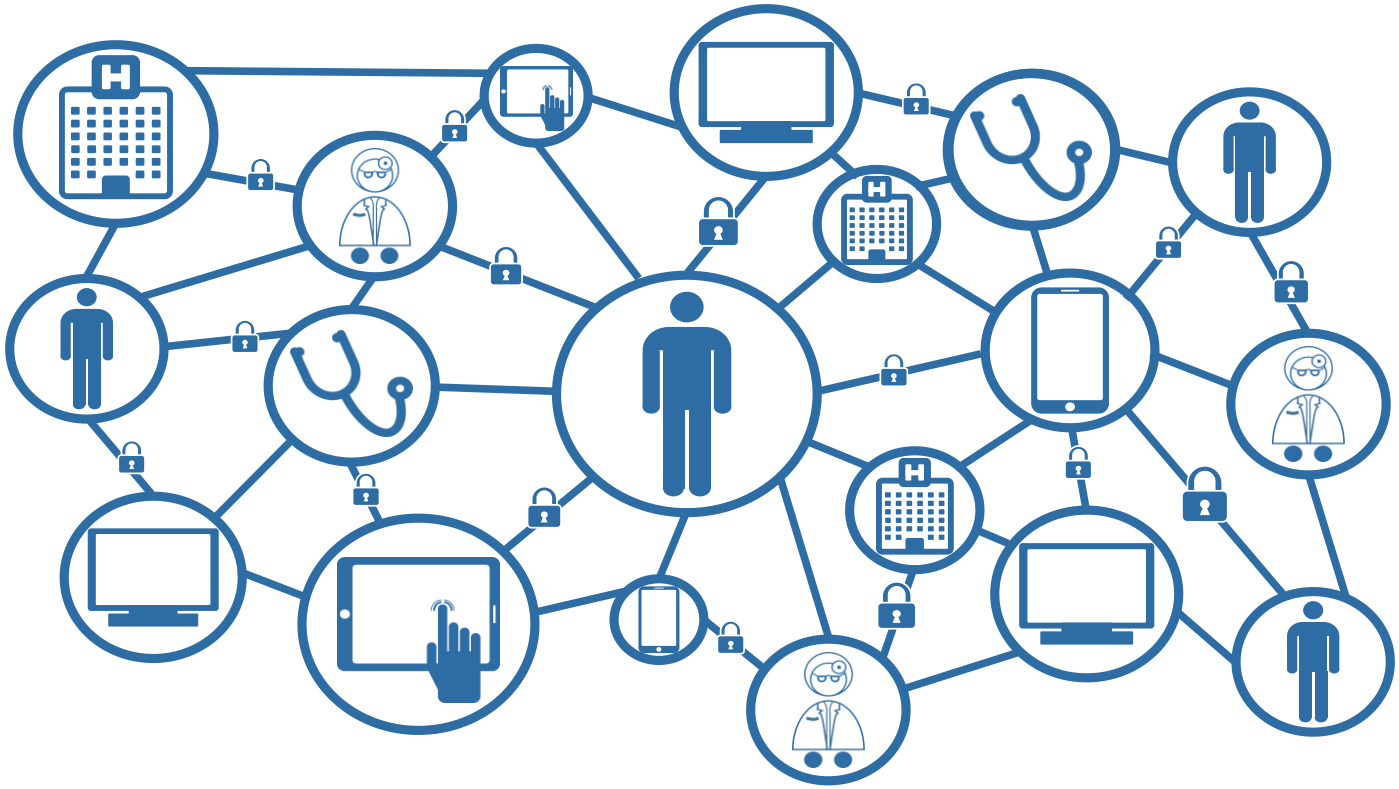
Healthcare

December 11, 2017

Industry Brief: Revised

Nicholas Jansen, (727) 567-2446, Nicholas.Jansen@RaymondJames.com
Andrew Cooper, Sr. Res. Assoc., (727) 567-2295, Andrew.Cooper@RaymondJames.com
Alex Ching, Res. Assoc., (212) 856-4362, Alex.Ching@RaymondJames.com

Healthcare IT



Can Blockchain Technology Disrupt the Healthcare Industry?

Please read domestic and foreign disclosure/risk information beginning on page 45 and Analyst Certification on page 46.

Executive Summary

In this note we discuss the applicability, potential use cases, and possible impacts of blockchain technology on the healthcare IT environment. Broad takeaways include the following:

- Blockchain technology is rapidly advancing and is now being explored across multiple industries. We believe use cases extend far beyond the financial services realm, where it is most developed at this time (bitcoin).

- Use cases in healthcare have started to emerge over the past 12-24 months, and although exact opportunities are still being determined, we view interoperability, security, credentialing, population health, claims adjudication, clinical trials, the pharmacy supply chain, and the revenue cycle as potential areas where blockchain technology could prove beneficial.

- The healthcare system in its current state suffers from significant complexity, the lack of consistent and reliable data, inefficient communication between payors, providers, and patients, and a litany of other challenges that blockchain could disrupt and/or mitigate. Removing inefficiencies from the market could yield significant savings and better patient outcomes.

- There are numerous healthcare companies – both large and small, established and new – currently investing in blockchain technology, with various pilots and programs addressing a variety of use cases for the space.

- While materially leverageable solutions do not yet exist commercially, 72% of hospital executives recently surveyed expect to utilize blockchain at scale by 2020, demonstrating clear industry interest among the C-suite even if the timeline itself proves to be a bit overly optimistic. Regardless, we see this market as accelerating in 2018 and beyond as initial concepts move past the pilot phase and into true commercial use, with trailblazers leading the way.

- The very near-term impact to our current HCIT coverage universe is limited, but we could see potential opportunities and risks throughout the healthcare IT continuum should the initial conceptual applications prove successful. The nearest-term areas of disruption likely start with claims processing and in the revenue cycle where there is a natural extension of existing financial services blockchain capabilities into the healthcare realm. Interoperability and population health management, perhaps via an improved personal health record (PHR), are the next in line to see more use cases develop.

- Many hurdles still exist before meaningful healthcare blockchain technology adoption can occur and it remains unclear if any of these possibilities can be commercially viable without broader provider and/or payor participation and investment. Only time will tell whether this technology can truly be successful in the Healthcare vertical.

Contents

For an audio synopsis of the report, follow this link.

An Overview of Possibilities and Impacts of Blockchain on Healthcare

Blockchain Is a Distributed Ledger Technology and, at Its Simplest Form, Is an Ideal System for Keeping Track of Transactions

At its core, blockchain really is just a type of computer file that most closely resembles a database. What makes blockchain unique is that data in the blockchain exists on a shared and continuously updated database that is hosted by all the computers (called "nodes") in the network simultaneously as opposed to existing on one singular platform. This is what it means to be "decentralized," which makes the ledger extremely secure, as there is no one point of weakness to be exploited by malicious parties. Each block in the blockchain is connected to and references the block before it, with the connections being secured by cryptography determined algorithms that validate data to ensure the blockchain is internally consistent. Currently, the computational power required to secure most commonly used blockchain networks and keep the chain validated comes from "miners," who use computers to solve algorithms in return for financial rewards (such as bitcoin).

One of the Largest Advantages of Blockchain Is the Removal of the Need for a Trusted Third Party to Conduct Transactions

One of the most attractive and useful aspects of blockchain is the technology's ability to eliminate the need for intermediaries when sharing information online. For example, when money is transferred between two parties, the sending party first must send the transfer request to a bank (or similar financial intermediary), which confirms things such as the sender's identity and whether the account has the required funds. Following this, the intermediary then completes the transfer to the receiving party, usually collecting a fee for the service. In addition to this process being inefficient, both the sender and receiver must have full confidence that the intermediary will not make any errors or be exposed to any type of cyberattack. With blockchain, however, peers can send money (or other data) directly to each other and be sure that everything is accurate and secure. Introducing trust where there usually is none is thus one of the most compelling characteristics of blockchain technology.

Despite Still Being in Its Early Stages, Blockchain Technology Is Currently Being Adopted by a Meaningful Number of Organizations

The first blockchain was constructed in 2008 (and began being widely used in 2009) for the purpose of exchanging bitcoins and remains the only blockchain being used by a significant number of individuals. Currently, the most developed forms of blockchain technology are still related to financial services, and the World Economic Forum predicts that 80% of all banks will have initiated projects on advanced distributed ledger technology by 2018. Additionally, IBM, one of the earliest adopters of blockchain, further predicts that by 2020, 66% of all banks will have blockchain in commercial production. The estimated market size for blockchain is projected to be $2.3B by 2021, increasing at a CAGR above 50% and could approach $10B later that decade.

Healthcare, Particularly Healthcare Information Technology, Is Extremely Well Suited to Adopt Solutions Based on Blockchain

Many of the major issues plaguing the healthcare industry as a whole right now are related to complications or inefficiencies tied to sharing patient health data. Because of the way it is constructed, blockchain is highly promising for use in healthcare, particularly as a way of sharing medical records and information in a secure fashion. If patient data was easily accessible in one location by providers, payors, and the patients themselves, an enormous amount of waste and inefficiency in healthcare would be eliminated. For example, in a situation where a health plan and a patient are dealing with an insurance contract, the blockchain can automatically verify and authorize information about that contract – there is no need for back and forth discussion between the patient and the payor about what was paid, why it was paid, and whether or not it should have been paid in the first place.

There Are Multiple Compelling Use Cases for a Healthcare Blockchain That Span Nearly the Entire Healthcare Spectrum

Of all the potential uses for blockchain in healthcare, increased interoperability is the most promising at this time. With blockchain, medical data from any EHR could be stored securely, with a new block being added to the same universally accessible chain each time a patient goes to a provider, regardless of location or specialty, linking records together in an unprecedented way. While interoperability has been the major focus of early developers, potential use cases extend meaningfully beyond it, and efforts have included cybersecurity, population health, claims adjudication, clinical trials, and pharmacy supply chain to name a few. Within this targeted list, claims adjudication would appear to be a natural extension to blockchain development activities in the financial services sector, particularly with the enormous amount of inefficiencies currently built into the healthcare billing process. As blockchain technology continues to be improved, a growing number of healthcare applications is likely to be developed, with the eventual impact potentially spanning the entire healthcare spectrum. It is too early to tell whether or not blockchain would have a significant impact within our covered HCIT universe, but one could make the case for positive and negative implications for each company.

We See Ample Opportunities, and Risks, for Players in Our Coverage Universe

Given the plethora of potential use cases for blockchain in the healthcare environment, the exact impact of the technology's development is difficult to ascertain at this early juncture. That said, we believe the EHR players – Cerner, Epic, Allscripts, athenahealth – are likely to develop tools that leverage blockchain, providing the potential for competitive differentiation and/or product expansion that could benefit the companies over time. These are most likely to be in the form of leveraging a more complete PHR, for use in management of the revenue cycle or perhaps to aid in areas like population health as data

sharing and security can be improved. Importantly, we believe the EHR will continue to play a central role around the blockchain applications and view these vendors as having opportunities to more meaningfully develop population health tools with a more advanced PHR that has broader interoperability. Behind the EHR, HealthStream also could see risks and/or opportunities as the company is a leader in the provider credentialing space for which there is clear applicability and already development of blockchain-based solutions. Payment accuracy players HMS Holdings and Cotiviti could see benefits from data standardization and traceability as it pertains to accessing data from customers and leveraging it from an analytical perspective, but we believe these same attributes of blockchain could mitigate the amount of errors as well as ease the burden for competitors and even in-house solutions for payors. We also believe Premier could leverage the technology to track product through the supply chain, for example, as well as develop more population health tools in its analytics franchise. In total, it is way too early to form investment theses just on blockchain alone, but we could see interesting ramifications within our coverage develop over time if blockchain moves beyond the concept stage in the Healthcare setting.

Despite Many Promising Use Cases, There Is a Wide Range of Challenges to Further Blockchain Adoption

Currently, an enormous amount of computational power and electric energy is needed to keep a blockchain system functioning. For bitcoin, this is done by incentivizing "miners" who essentially trade computing time and energy to verify data in exchange for fragments of bitcoins. This inherent incentive does not exist for healthcare, meaning organizations would have to commit significant resources of their own in order to successfully run the blockchain. Theoretically, a healthcare blockchain could be built that would not necessarily need to rely on miners, but could potentially use another type of technical infrastructure; currently, however, all such solutions are either prototypes or in fundamental concept testing. In addition to significant resource requirements, any type of healthcare blockchain would have the added complication of needing to comply with HIPAA rules, which govern how healthcare handles sensitive patient data and are extensive and have multiple subchapters. HIPAA rules are broad and cover areas including patient privacy, security rules, interoperability restrictions, and healthcare clearinghouse rules, and if medical data is minimized and stored on a single platform (such as on a healthcare blockchain), there are even more rules that apply to such a designated record set. Lastly, the promise of blockchain in large part depends on the network effect or getting enough parties to use the same implementation of the technology. Numerous consortiums have been formed to drive the adoption and standardization of blockchain, mainly in the financial and legal industry, but it remains unclear if any particular blockchain solution (other than the one for bitcoin itself) will ever be able to reach the required threshold. Without such universal adoption, blockchain's healthcare practicality is questionable.

Although Significant Steps Forward Are Being Made, Widespread Application of Blockchain Technology in Healthcare Is Likely Decades Away

Despite a wide variety of potential applications and interest from a diverse group of organizations, it is unlikely that blockchain technology will reach "mainstream" healthcare usage in the near future. Importantly, blockchain should not be considered "disruptive," but rather more of a "foundational" technology that has potential to create new foundations for the way transactions are conducted. While the ultimate impact is expected to be revolutionary, it is widely agreed that it will likely take decades for blockchain to seep into widespread economic and social infrastructure. The process of adoption will be gradual and steady, not sudden, as waves of technological and institutional change gain momentum. Additionally, in order for blockchain technology in healthcare to be used to its full potential, hospitals, clinics, and other organizations must be willing to bear the cost burden to help create the technical infrastructure required, which currently means prototyping and testing concepts for a relatively small user base.

What is Blockchain?

Blockchain Technology Was Originally Designed for Bitcoin

Total Bitcoins	16,715,636
Market Capitalization	**$263,822,797,147**
Bitcoin Price	$15,783
Average Transaction Value	6.70 BTC ($105,801)

Note: All numbers current as of 12/08/2017

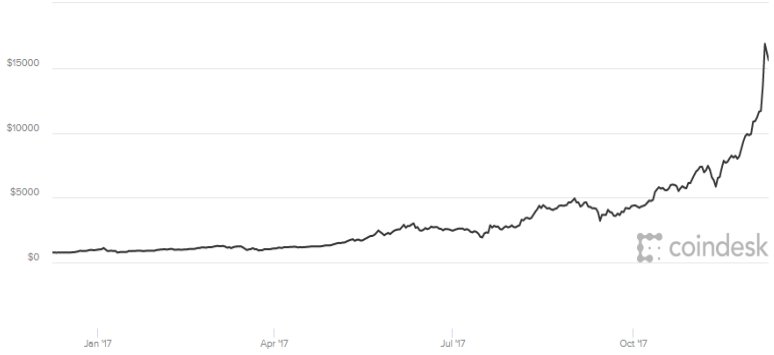


Figure 1: Bitcoin prices have increased nearly 20x in value over the past 12 months.

- Blockchain is a digital ledger technology developed in 2008 by Satoshi Nakamoto, a possibly pseudonymous person (or perhaps multiple people) who designed it as the system for the exchange of the digital cryptocurrency known as bitcoin.
- The steep rise in recent value of bitcoin demonstrates the rapid adoption of the currency, and also illustrates growth in general interest and public awareness.

Source: Raymond James research, BitInfoCharts, CoinDesk

Timeline of Events Since Foundation in 2008

2008 October	2010 May	2014 June	2014 July	2015 September	2015 September	2016 September	2017 October	2017 November	2017 December	2018+
Satoshi Nakamoto publishes the first bitcoin (and blockchain) whitepaper	The first bitcoin purchase is made: BTC 10k for a $25 pizza	LHV Pank starts research on blockchain digital security and releases the app "Cyber Wallet"	Funded by a crowd sale, the Ethereum Project (a blockchain platform with the ability to build applications) is launched	A consortium of 40 major financial institutions forms R3, committing to exploring and implementing blockchain technology	Visa, Citi, Nasdaq, and Capital One invest $30M in blockchain startup Chain.com	Since 2014, over 40 financial service institutions have invested in a blockchain or bitcoin startup	Publicly traded Bioptix changes its name to Riot Blockchain and pivots to become the first pure play blockchain company on a major U.S. exchange	Bitcoin surpasses $10,000 and major U.S. exchanges are said to be contemplating trading of the cryptocurrency	Bitcoin futures open on the Cboe Futures Exchange on December 10, 2017 and surge as much as 26% as volumes exceed dealers' expectations	The World Economic Forum estimates that 80% of all banks will have initiated projects on distributed ledger technology

Source: Raymond James research, Pioneers.io

Potential Uses of Blockchain Extend Far Beyond Financial Services

- A blockchain is a permanent **ledger** of records (just a type of computer file similar to a database, such as .CSV) of online transactions or exchanges that can be shared among a network of computers.
    - All transactions are kept secure via cryptography, and each transaction must be approved and verified in the network through a process known as “mining.”
    - Since transactions by users are directly added to the ledger, it eliminates the need for a middleman.
- Blockchain technology allows digital information to be distributed but not copied, creating the backbone of a new type of internet.
    - While originally developed for the digital currency Bitcoin and the financial services industry, the tech community is now exploring far more potential uses of the technology.
- Information held on a blockchain exists as a shared (and continuously updated) database.
    - This has obvious benefits – the blockchain database isn’t stored in any single location, and all records kept are public and thus easily verifiable by all parties.
    - No centralized version of information exists for a hacker to corrupt.
    - Hosted by millions of computers simultaneously, its data is accessible to anyone on the internet.

Blockchain is all about sharing information directly, freely, and securely

Microsoft Word vs. Google Sheets Analogy

- The traditional way of sharing documents for collaboration is to send a Microsoft Word document to another recipient, and then wait for them to make revisions and send it back.
  - **Issue: You need to wait until receiving a return copy before you can add anything else or make any change; no change can be made in "real time."**
- This is how most databases currently work: two owners can't both be editing one "ledger" at once. This is how banks maintain money balances and transfers; they briefly lock access while they make a transfer, update the other side, and then re-open access.
  - **This method is inefficient, and it also demonstrates how everything is dependent on a trusted "middle" to keep 100% secure, accurate records.**
- With Google Sheets, however, all parties have access to the same "ledger" at the same time, and a single version of the most-updated document is visible to everyone simultaneously.
  - **This is what it means to be "distributed." While you obviously don't need a blockchain to share documents, the analogy is a powerful one.**

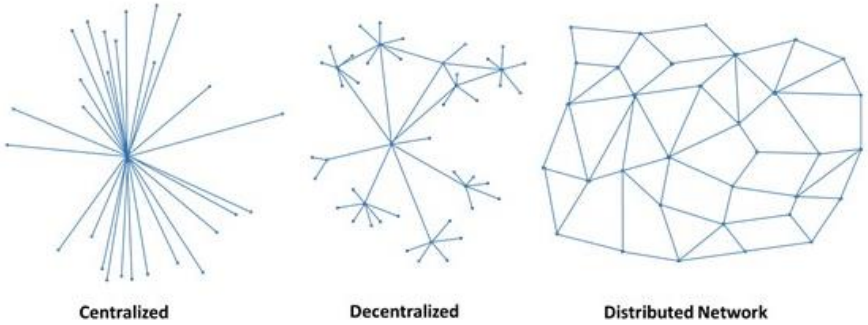


Figure 2: What makes blockchain so unique is its distributed architecture, which connects all nodes in the chain together without having any single centralized points.
Source: Raymond James research

Overview of the Key Components of a Blockchain

Durable & Robust

- By storing blocks of identical information across entire networks, the blockchain cannot be controlled by any single entity, and has no single point of failure.
- Blockchain is a mechanism for accountability, by ending missed transactions, human or machine errors, or transactions in which both parties do not explicitly consent.

Transparent & Incorruptible

- The blockchain constantly builds consensus, automatically checking in with itself every ten minutes and reconciling every transaction that happened in that interval.
- By definition, the blockchain is public, as transparent data is embedded within the network as a whole.
- In order to alter any information in the blockchain, the entire network would have to be overridden, making it virtually incorruptible.

A Decentralized Network of Nodes

- Each device connected to the blockchain becomes a node in the network; combined together, these nodes create a powerful second-level network.
- Each node is an “administrator” of the blockchain, and joins the network voluntarily.
- Through this structure of decentralization, any type of record-keeping ledger can securely be made fully public.

Trust Is Key and an Important Aspect of Blockchain

- Because there is no central management in a blockchain, anybody can use it, and there is no requirement for a trusted third party to act as an intermediary.
- Instead of a third party, blockchain uses a consensus building algorithm implemented in the technology.
- Blockchain technology provides a secure and efficient way to determine authentication and authorization.
- Blockchain has the potential to leapfrog population health by providing trust where none currently exists for continuous access to patient records by directly linking information to clinical and financial outcomes.
- By removing the need for verification by a trusted third party, any type of exchange of information becomes **less expensive, more efficient, and more secure.**

A blockchain can efficiently determine if someone is who they say they are, and whether they should be able to do what they are trying to do.

- Private key cryptography provides a powerful ownership tool that fulfills *authentication* requirements, and eliminates the need for sharing more personal information.
- *Authorization* (having enough money, sending the correct transaction type, etc.) is achieved automatically as a result of the entire distributed network applying its designated rules simultaneously.

Source: Raymond James research, Harvard Business Review, LetsTalkPayments.Com, CoinDesk

Emergence of Blockchain Technology Has Driven the Launch of a Number of Blockchain Companies on Public Indices

Company	Ticker	Price	Market Cap	Description
360 Blockchain	CSE: CODE	0.27 CAD	31.3M CAD	Provides financial services to both private and public companies, including finance advisory, merchant banking, IPO consulting, and business advisory services.
BTL Group	TSVX: BTL	$11.39	$165.4M	Offers blockchain solutions across multiple industries – from banks to energy, and even to fantasy sports. BTL has a money transfer platform using distributed-ledger-technology and smart contracts, called Interbit.
First Bitcoin Capital	OTC: BITCF	$0.48	$148.0M	One of the first vertically integrated consolidators in the bitcoin and crypto-currency arena. The company is focused on the acquisition of bitcoin startups and funding companies developing bitcoin software and hardware.
Riot Blockchain	NASDAQ: RIOT	$15.86	$132.0M	Formerly a biotech company, Riot Blockchain is the first mover on the NASDAQ as a pure play blockchain company. Riot hopes to gain exposure to the blockchain ecosystem through investments in the sector, specifically through bitcoin and ethereum.
HIVE Blockchain	CVE: HIVE	3.24 CAD	775.8M CAD	HIVE looks to “build a bridge” between the blockchain market to traditional capital markets, and is strategically partnered with Genesis Mining, a cryptocurrency mining hashrate provider.

Figure 3: While generally small and in early stages, there are several publically traded companies that focus on core blockchain platforms, demonstrating general market acceptance of the technology and an improving amount of interest from investors. Numbers are accurate as of 12/08/17.
Source: Raymond James research, Investing News, Bloomberg

Blockchain in Healthcare

Blockchain Is Well Suited for Numerous Healthcare Applications

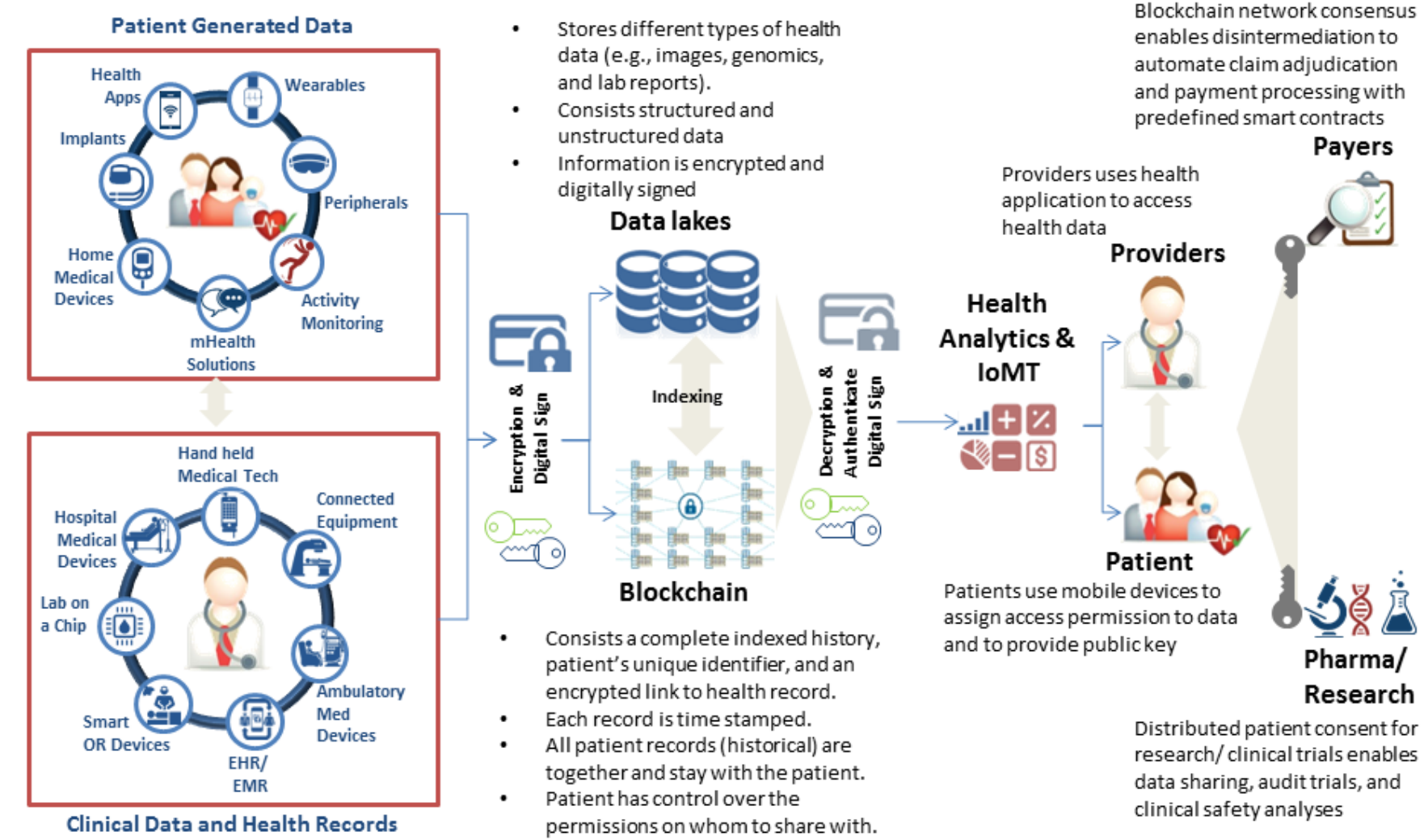


Figure 4: There are multiple potential ways blockchain could impact healthcare, spanning nearly the entire continuum. Credit: www.healthit.gov; Frost & Sullivan.
Source: Raymond James research, Forbes, HealthIT.gov

There Are a Number of Challenges Unique to Healthcare Data

- Currently, each EMR system has its own language for representing and sharing data. Critical information is often scattered across multiple sources, and isn't always accessible when needed most.
- There is currently no universal patient identifier that can compile all of a patient's data together in one place to show all care received across a lifetime.

Much of the data is in multiple places	Healthcare data resides in multiple places, from different source systems (like EMRs) or different departments (like radiology or pharmacy)
The data is either structured or unstructured	Many EMRs are designed to capture data in a way most convenient for the provider, with little regard for how the data could eventually be aggregated and analyzed
Definitions are inconsistent or variable	Different groups of clinicians may define a certain medical condition in a different way than another group. Even with consensus, new discoveries are constantly changing definitions
Regulatory requirements constantly change	Regulatory and reporting requirements continue to increase and evolve

- This results in data silos, which lead to the need for manual reconciliation, missing records, administrative complexity, and duplicated work.
- 86% of medical mistakes are triggered by data errors, 30% of medical tests are reordered because of missing records, and 6.7% of hospitalized patients have adverse drug reactions.

Source: Raymond James research, healthcatalyst.com, healthcareITnews.com, healthdatamanagement.com

EHR vs. PHR: An Important Distinction

- EHRs currently serve as a "clearinghouse" of sorts for the transportation of data; blockchain is a new form of transport, but doesn't necessarily fulfill all the services provided by EMRs.
- Even if a healthcare blockchain was formed that streamlined some "middles" in the data sharing process, allowing patients streamlined access to Personal Health Records (PHRs), it is likely EMRs would still play an important role in the aggregation and dissemination of such information.
- Given this, we find it likely that the PHR market will likely be one of the first areas of healthcare to be meaningfully impacted by a blockchain.
  - This has important implications for areas like population health, and should provide a degree of empowerment for patients given the ability to see their PHR as medical providers and payors see it.
  - Google Health discontinued a PHR service in 2011 due to issues with adoption and user uptake; however, consumer views on managing health have dramatically shifted since then, and given that a blockchain does not need an individual, central party to maintain it, blockchain offers a more compelling solution for PHR.
- Traditional EMRs will likely always have a role in healthcare regardless of any blockchain innovation.
  - The multitude of services and other tools that a complete EMR platform currently offers extends well beyond just data sharing or storage capabilities.
  - Even on the data side, at least in the mid-to-near term, it is more likely that the authorization to use certain information will be tracked in the blockchain; once verified, pointers to EMRs or other sources where the data is actually stored will pull the appropriate information.

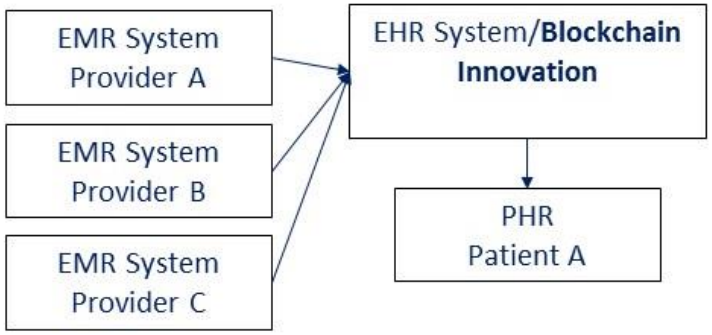


Figure 5: Currently, multiple EMRs feed data to a central EHR, which can then be used to generate a PHR accessible directly by patients.
Source: Raymond James research, HealthIT.gov

Blockchain Could Address a Number of Complexities That Exist in Today's Healthcare Landscape

	Current issues	Potential Blockchain Solution
Interoperability	Most medical records are currently proprietary to the organization that creates them. There is no easy, central way to share or access these records across different providers.	Medical data could be stored securely in a blockchain, with a new block being added to the same universally accessible chain each time a patient goes to a provider, regardless of location or specialty.
Data Security	The largest percentage of data breaches occur in the healthcare industry, and with solutions moving steadily towards the internet, preventing malicious attacks on medical data is becoming increasingly difficult.	Given that a blockchain is inherently decentralized and distributed across every computer in the system, hacking or corrupting medical data is theoretically near impossible.
Credentialing	Currently, credentialing is done largely on a system by system basis, with it often taking 30-60 days for a system to collect needed information on a given provider.	Collection onto a blockchain could create a sort of provider wallet with verified credentials from the various institutions.
Population Health	One of the most challenging aspects of population health is aggregating data for a large group of patients in a way that is easy to analyze to improve outcomes.	With blockchain, organizations can eliminate the middleman and access patient databases on a population-wide scale. Blockchain also provides trust where none currently exists for continuous access to patient records by directly linking information to clinical and financial outcomes.
Claims Adjudication	Currently, payors request data from patients and healthcare providers to determine if and how much they owe for each bill. Not only is this sensitive data, but there is often an extensive amount of back-and-forth discussion; this process is highly inefficient.	Blockchain could be used to automate significant parts of the claims adjudication process, as data moves seamlessly between payors, providers, and patients. Each party can have full confidence that the records are accurate, and that the right amount is paid by the correct party.
Clinical Trials	Data reproducibility, data sharing, personal data privacy concerns, and patient enrollment are all significant challenges for clinical research.	Blockchain-enabled, time-stamped immutable records of clinical trials, protocols and results could potentially address the issues of outcome switching, data snooping and selective reporting, thereby reducing the incidence of fraud and error in clinical trial records.
Pharmacy Supply Chain	Based on industry estimates, pharmaceutical companies incur an estimated annual loss of $200 billion due to counterfeit drugs globally.	A blockchain-based system could ensure a chain-of-custody log, tracking each step of the supply chain at the individual drug/product level.

Source: Raymond James research, Pioneers.io

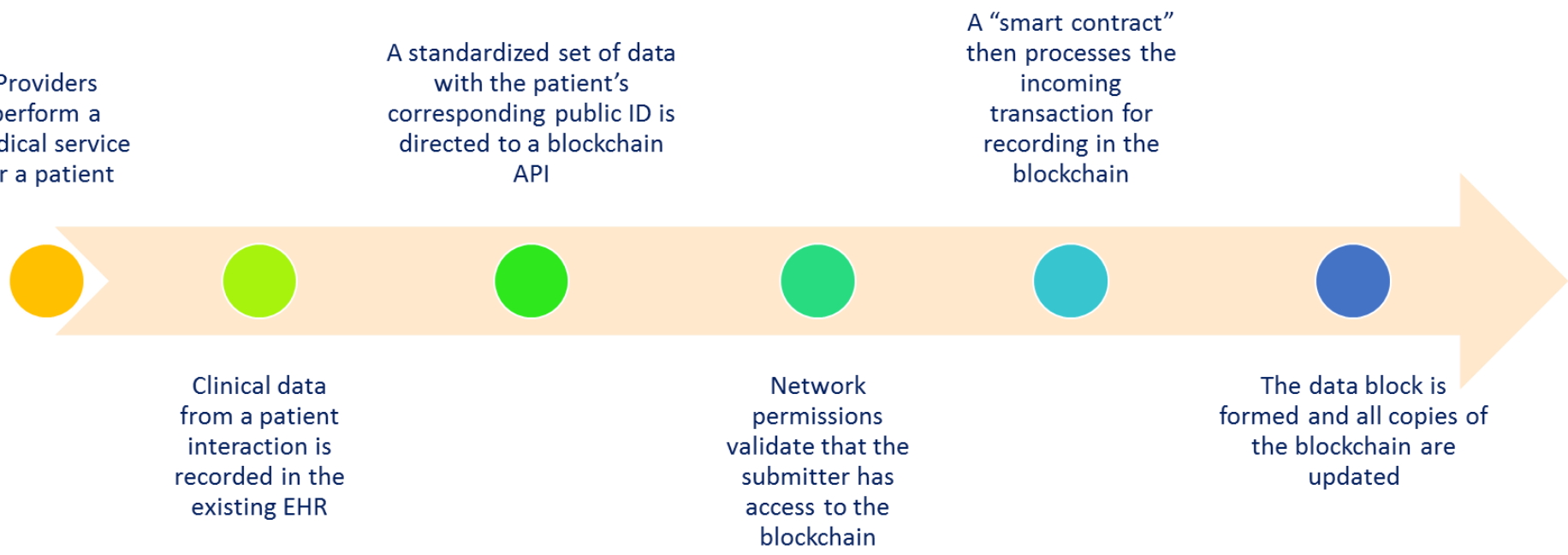
True Interoperability Can Be Achieved With Blockchain

- **Data exchange is one of the top potential use cases for blockchain in healthcare.**
- Currently, healthcare records are proprietary to the organizations that create them -- there is no national standards or shared information technology architecture for medical data.
- Sharing medical records between providers, payors, and patients is crucial for efficient and effective population health management.

Source: Forbes, Raymond James research

- By using blockchain technology, a patient's entire medical record history could be recorded in a single universal ledger, regardless of the location care was received, or what type of care was provided.
  - Every time any type of care is received, a record could be added as another block in the chain.
  - This would enable seamless access to lifetime patient data in real time, while eliminating the burden and cost of data reconciliation.
  - Patients, payors, and providers would all be able to access this data, and be sure that such data is secure and accurate.

Example of How a Medical Record Could Be Added to a Blockchain



Source: Raymond James research, Technology Review

Cybersecurity Is Inherent in a Blockchain

- With the current growth of connected health devices, it will be very challenging for existing Health IT infrastructure and architecture to support evolving internet-based ecosystems.
- By 2020, an estimated 20-30 billion healthcare internet connected devices will be used globally.
- Blockchain-enabled solutions have the potential to bridge the gaps of device data interoperability while ensuring security, privacy and reliability.

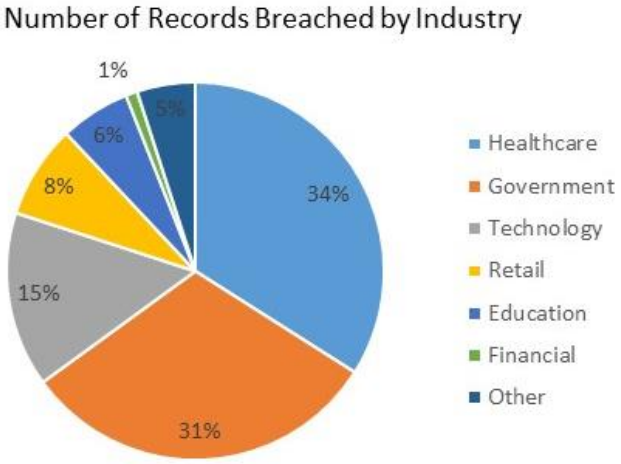


Figure 6: Healthcare organizations experience the highest rate of data breaches of any industry.
Source: Raymond James research, Forbes

ADVANTAGES:

1. With blockchain, a patient's differing interactions in the healthcare system can have improved security through multiple checkpoints rather than one single gateway.
2. Patients who are part of the blockchain would be able to approve or deny any sharing or changes to their data, ensuring a higher level of privacy and greater consumer control.
3. Patient data and other medical records are not stored at a single site or on any one platform, and by nature of the blockchain, this decentralized platform is nearly impossible to be corrupted or breached.
4. Validation sets blockchain apart from how this is currently done.
    - Currently, patients and providers must assume health information exchanges are completely accurate, even though they may not be.

The Credentialing Process Can Be Significantly Streamlined

- Currently, credentialing is done largely on a system by system basis, with it often taking 30-60 days for a system to collect needed information on a given provider.
- This information historically has been decentralized and fragmented, but includes things such as medical education and training programs, state licensures, and professional board certifications, among others.

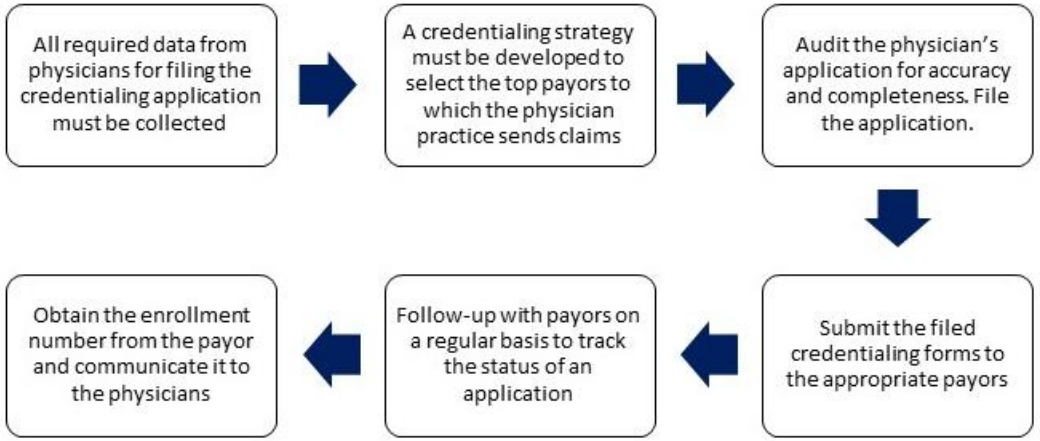


Figure 7: Current physician credentialing process flow involves numerous steps with multiple instances of back-and-forth between payors and providers.
Source: Raymond James research, Med Advantage

- Collection onto a blockchain protocol could create a sort of provider wallet with verified credentials from the various institutions. Items like medical education, for example, could be verified by the institution (i.e., medical school) once and remain on the blockchain in a secure, traceable, and trustable manner for the provider to enable health system access to.

Blockchain Is Well Suited for Population Health Initiatives

- EMRs may be very different and come from lots of different places, but the ledger itself is standardized.
  - Each healthcare event (such as an X-ray or blood work) creates a digital transaction, and bits of code group it into an encrypted block with other transactions.
  - Each transaction is validated by a physician or clinician trusted with an access key and then timestamped.
- The resulting "Smart Contracts" could be deployed as an authorization process and confirmation step that notifies the patient – or even puts them in control – when their data is shared from one address to another.

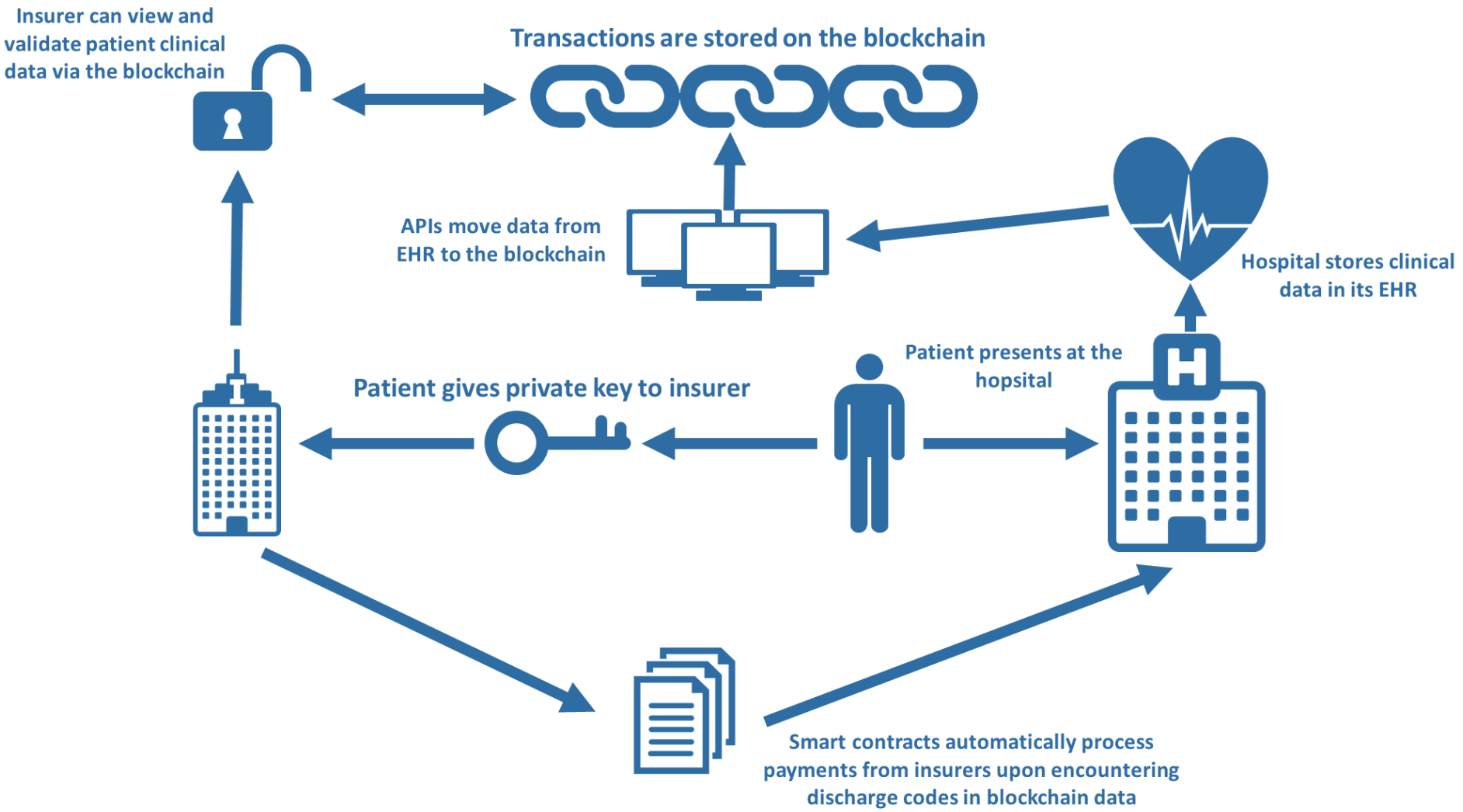
Source: Raymond James research, healthIT.gov

- Instead of relying on health information databases to aggregate data, organizations can eliminate parts of "the middle" and access patient databases on a large, population-wide scale.
- By allowing individuals to really "own" their personal health records and have easy access to all of their medical data, healthcare organizations could more easily drive consumer engagement and interaction, resulting in overall better outcomes for entire populations.
  - Right now, it is estimated that only 10% of people have access to their PHR, which greatly limits the amount of power patients have in managing their own health.

Claims Adjudication Can Potentially Be Automated

- Claims adjudication refers to the determination of the insurer's payment or financial responsibility after a patient's insurance benefits are applied to a medical claim.
- Currently, payors frequently request data from patients and healthcare providers to determine if and how much they owe for each bill. Not only is this sensitive data, but there is often an extensive amount of back-and-forth discussion between the payor, the provider, and the patient to determine who exactly owes what – this process is highly inefficient.
- Blockchain could be **used to automate adjudication**, such that the decision to deny or pay a claim is made without human intervention.
    - Blockchain technology can automate a lot of these processes by verifying the integrity of medical claims data as it moves between parties. Payors can get paid faster and have less of their data be exposed to unwanted eyes.
    - That same sort of automation could also be applied to the supply chain to monitor contracts, for example, throughout the entire lifecycle.
- An estimated 5-10% of healthcare costs are fraudulent, resulting from excessive billing or billing for non-performed services. For example, in the United States alone, Medicare fraud caused around $40 billion in losses in 2016.
- Blockchain-based systems can provide realistic solutions for **minimizing medical billing-related frauds.**
    - By automating the majority of claim adjudication and payment processing activities, blockchain systems could help to eliminate the need for intermediaries and reduce the administrative costs and time for providers and payers.
    - Blockchain could also have significant ramifications for improving some of the huge logistical information tracking hurdles.

How Blockchain Could Simplify and Accelerate the Claims Adjudication Process



Source: Raymond James research

Clinical Trials Could Be Meaningfully Improved

- Current issues: reproducibility, data sharing, personal data privacy concerns, and patient enrollment are all significant challenges for clinical research.
- Blockchain can be used to create a layer of de-identified data that researchers could tap to recruit patients and more.
- It is estimated that 50% of clinical trials go unreported, and investigators often fail to share their study results (e.g., nearly 90% of trials on ClinicalTrials.gov lack results).
  - This creates crucial safety issues for patients and knowledge gaps for healthcare stakeholders and health policymakers.

Figure 8: Blockchain solutions could potentially impact nearly all steps in the clinical trial process, from drug discovery to sales and marketing.
Source: Raymond James research, trialsjournal.com, beroeinc.com

- Blockchain-enabled, time-stamped immutable records of clinical trials, protocols, and results could potentially address the issues of outcome switching, data snooping, and selective reporting, thereby reducing the incidence of fraud and error in clinical trial records.
- Blockchain-based systems could help drive collaboration between participants and researchers around innovation in medical research in fields like precision medicine and population health management.

Potential Pharmacy Supply Chain Benefits

- Based on industry estimates, pharmaceutical companies incur an estimated annual loss of $200 billion due to counterfeit drugs globally.
- About 30% of drugs sold in developing countries are considered to be counterfeits.
- A blockchain-based system could ensure a chain-of-custody log, tracking each step of the supply chain at the individual drug/product level.
  - The blockchain allows the recording of this transaction log, and the inherent encryption in the technology contributes to the privacy of transaction data.
- Potential Uses:
  - Counterfeit Product Detection
  - Substandard Component Detection
  - Detailed Description

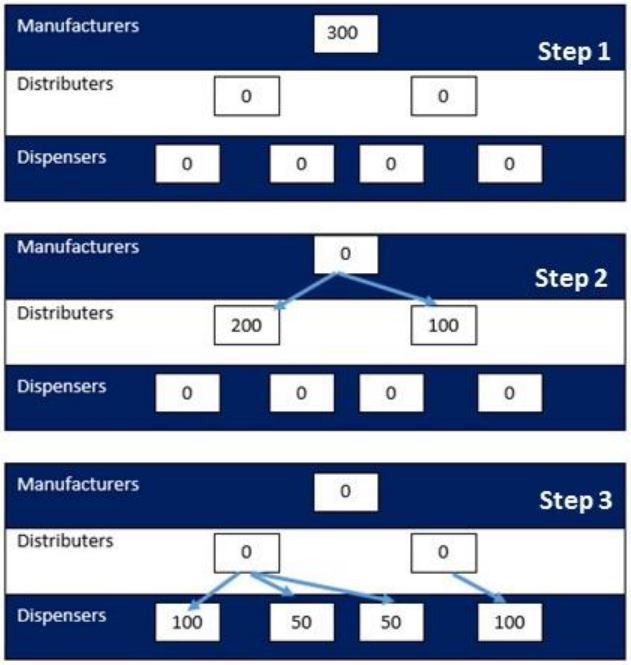


Figure 9: Above represents how blockchain can be used to keep track of change of ownership. By tracking the input and output from each member in the supply chain, the system can maintain visibility of any particular drug to recognize which parties have how much inventory at any given time. However, individual supply-chain members can only see immediate upstream and downstream transactions. Using this, regulators can track the path of any product back through the supply chain, and any issues (such as recalls) can be addressed in near-real time.
Source: Raymond James research, ONC Project, healthIT.gov

Early Blockchain Adoption in the Healthcare Vertical

IBM Has Been Leading the Way

IBM was one of the first major technology companies to meaningfully begin exploring potential applications for blockchain, starting with the Hyperledger Project in 2016. Significant milestones include:

- **December 2015:** IBM is a founding member of the Hyperledger Project, a new open ledger initiative to advance the adoption of blockchain technology.
- **June 2016:** IBM starts an effort to use blockchain technology for healthcare through IBM Watson Health.
- **October 2016:** Hyperledger launches the first blockchain working group on healthcare, starting with a deep dive into over 70 white papers published by the ONC (Office of the National Coordinator for HIT) in response to a contest called the "Blockchain Challenge."
- **January 2017:** IBM enters into a two-year research initiative with the FDA aimed at defining a secure, efficient, and scalable exchange of health data using blockchain, an important milestone.

Source: Raymond James research, IBM, Hyper Ledger, Gem Health

IBM Executive Survey Demonstrates Involvement of the C-Suite

IBM published an executive survey titled "Healthcare rallies for blockchain" in which 200 healthcare executives were surveyed about their thoughts on blockchain. Insights from this survey included:

- **16% of respondents expect to have a commercial blockchain solution at scale in 2017, and 72% expected to have such a solution by 2020.**
- One of the top frictions that could be reduced by blockchain for both payor and provider respondents is **"inaccessible data,"** with over 60% of respondents from each group citing data sharing as a challenge.
- An area of high interest was found to be aggregating wearable medical device data, which for the most part is currently stored in some type of cloud database that is rarely accessible to providers.

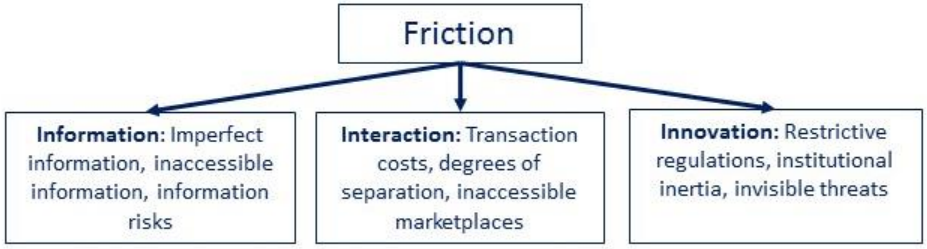


Figure 10: Blockchain is expected to greatly reduce nine sources of friction in healthcare.

Figure 11: Survey results for the highest expected area of benefits. Trailblazers are organizations that will have a blockchain solution at scale by the end of 2017.

Source: Raymond James research, IBM

Change Healthcare Has Made Significant Investments in Blockchain

- In September 2017, Change Healthcare announced that its healthcare network will adopt Hyperledger Fabric 1.0 for enterprise level blockchain application design and development.
- Blockchain capabilities will be added to Change's Intelligent Healthcare Network.
  - Such capabilities will enable customers to focus on analytics, revenue cycle, and new services without having to write code or build additional interfaces.
- By creating a distributed ledger, Change is targeting increased efficiency in claims processing and payment transactions.
- Change processes approximately 12 billion transactions worth more than $2T in claims annually, and will support the blockchain technology by the end of 2017.
- Change's blockchain-based solutions will be available on the company's administrative and financial network; cost has not yet been disclosed.

CHANGE HEALTHCARE

Company Overview

- 2,100 payor connections including nearly all government and commercial payors
- Serve 5,500 hospitals and over 800,000 physicians
- Intelligent Healthcare Network processed over 12B healthcare transactions, covering over $2T in claims in 2016
- Imaging solutions are used in over 3,3000 facilities globally

Source: Raymond James research, Change Healthcare, healthcareitnews.com

Cerner Is Running Numerous Blockchain Pilot Programs

- Cerner, one of the largest EHR players in the country, is currently running a number of experiments related to blockchain.
  - Key areas of focus are identification, financial transactions, and personal health records.
  - A number of engineers have been hired to specifically address blockchain innovation, and it is a topic of conversation at the C-suite level.
- We believe the company will have some type of blockchain product mature enough for market within a five-year time frame.
- Blockchain solutions are expected to supplement the core EHR business rather than completely replace it.
  - Innovation on the financial side is expected to precede innovation on the clinical side, simply due to a lower level of complexity.
- A trusted third party, such as Cerner, is expected to always play a role in managing health records, although blockchain could certainly minimize or streamline the "middle."
  - The total amount of healthcare information is enormous, and is likely too large to store in its entirety on one blockchain.
  - Cerner sees blockchain ultimately playing the role of an index of information with the ability to access data as needed.
- Although the impact of blockchain has not been a key area of investor focus, we believe that this could change quickly, and Cerner is well prepared to address any potential impact as the technology matures.
- We believe other EHR vendors are following a similar path at this juncture, with early development and experiments underway but no solutions near the point of commercialization yet and little material discussion in public forums on the topic.

Figure 12: Brian Ahier, a leading digital health innovator, emphasized the importance of blockchain at a Cerner-hosted event.

Source: Raymond James research, Cerner

MedRec Was the Winner of the ONC's Ideation Challenge

- MedRec is a novel, decentralized records management system designed to manage EHRs using blockchain technology.
- The MedRec whitepaper was the winner of the **ONC's Ideation Challenge in August 2016.**
- The system gives patients a comprehensive, immutable log and access to their entire medical history across providers and treatment locations.
- MedRec manages authentication, data retrieval, update tracking, data entry, and data sharing for both patients and providers.
- No centralized data repository is created; instead, a modular system design integrates with providers' existing, local data storage solutions (i.e., the providers' own EMRs).
- There is a built-in incentive system for healthcare industry stakeholders (such as government funded researchers and public health authorities) to participate as blockchain "miners," providing the computational power required to support the blockchain.
- The next step is to enhance the MedRec pilot with more data types, data contributors, and more data users.

Source: Raymond James research, MIT Media Lab, ONC

Hashed Health and the Illinois Blockchain Initiative

- Hashed Health is a consortium of healthcare companies looking to accelerate use of blockchain and distributed ledger technologies.
  - The consortium provides various services and also has formed separate partnerships looking to expand blockchain to several use cases in healthcare.
- Furthest along of these initiatives is the partnership with the Illinois Blockchain Initiative (itself a state-run consortium of Illinois state and county agencies), which is initially focused on use of blockchain for the medical credentialing process.
- The initial focus of the partnership is looking at portability and reducing complexity in the interstate licensure process. With announcement of the partnership in August 2017, we await more details on development and outcomes.
- Illinois commitment to piloting blockchain solutions make it one of the first government-sponsored entities to do so, an important milestone.

HASHED HEALTH

The Illinois BLOCKCHAIN Initiative

Source: Raymond James research, Hashed Health, The Illinois Blockchain Initiative

PokitDok Has Developed Several Promising Blockchain Applications

- PokitDok was founded to connect the fragmented data silos within healthcare, and currently offers health systems, payors, and technology companies a variety of solutions including: eligibility, claims, identity management, pharmacy, patient access, scheduling, and payment optimization.
- PokitDok has developed proprietary APIs that allow customers to quickly integrate healthcare business data into native apps or services.
- PokitDok has raised over $55M in funding, including from McKesson Ventures.
- In May 2017, PokitDok partnered with Intel to offer a blockchain solution called **DokChain**, which includes using Intel's open source Hyperledger Sawtooth as the foundational ledger.
  - **Identity management:** DokChain provides identity management to validate each party in a transaction is who they say they are.
  - **Claims adjudication**: DokChain can also perform autonomous adjudication, in which "smart contracts" can be processed instantly to resolve claims on the spot.
  - **Supply chain:** When a provider writes a prescription, the DokChain can automatically log it on the chain with transparent pricing accessible by the patient.

pokitdok

DokChain

Source: Raymond James research, PokitDok, DokChain

Other Notable Companies Working on Blockchain Initiatives Include:

- **Accenture:** Accenture formed a partnership with Microsoft and Avanade to develop an identity prototype based on blockchain technology. The prototype could potentially provide a digital identity for 1.1 billion people, particularly in developing countries, that don't have a formal government ID. Creating a formal ID for individuals such as refugees is a critical component in successfully administering and providing access to healthcare services globally.
- **Optum:** Optum, a division of healthcare giant UnitedHealth that includes many data/IT driven solutions and analytics, has invested materially in blockchain, including the hiring of a leader focused specifically on the technology. Specific focuses have not been significantly publicized, but given the breadth of solutions from Optum, we believe efforts likely span a variety of areas and topics and would expect more details to emerge over time.
- **Blockchain Health:** Blockchain Health is a software company that provides healthcare organizations with HIPAA-compliant blockchain solutions. Users can share health data with researchers through an integrated platform, which creates a secure chain of information custody.
- **Gem Health:** Gem is an enterprise blockchain company that has developed GemOS, an enterprise platform for healthcare that allows payors, providers, and patients to securely access shareable data with the right permissions. The platform complies with HIPAA, and a partnership formed in 2016 with Philips is further exploring how blockchain can support the patient-centered approach to care.
- **BurstIQ:** BurstIQ was founded in 2015, with a platform that leverages blockchain technology and machine learning to bring together disparate data sources in a unified, HIPAA-compliant data repository. The platform is fully operational with multiple business customers, and in 2016, DataIQ processed 25 billion data points. Products include HealthWallet, LifeGraph, and BurstChain.

Source: Raymond James research, respective companies listed

Potential Impacts on Certain Public Players in the Healthcare Space

	Opportunities		Risks	
EHR Players		**Severity**		**Severity**
Allscripts athenahealth Cerner cpsi QSI	First movers may gain an advantage, though broad adoption could be key for true blockchain benefit capture. Clearly interoperability through data standardization will be a benefit for those who can achieve it, as will potentially improved traceability and security. That said, initial development will likely be on the PHR front and/or on the financial (revenue cycle) side. We believe bigger players, with bigger budgets, are most likely to come out on top in a world that still sees vendor consolidation as a priority and population health as a focus. The latter area is likely to be a key market for blockchain utilization efforts, along with uses on the financial and RCM side and PHR development. We do not view blockchain as a replacement to the core EHR istelf.		Spending may not equal success, and we could see players chasing the rabbit down the hole to no material benefit if blockchain is not materially adopted overall. Players must be aware if the as of yet undetermined direction goes counter to their development efforts. Getting left behind could be a death blow for smaller players who feasted on MU money but are seeing signs of famine as they fail to innovate and keep pace with market demands.	
Payment Accuracy Players				
Cotiviti hms	Data standardization and traceability could ease the burden of the claims adjudication process and the tasks of payment accuracy players as information can be more easily connected to (faster and simpler implementations of new customers) and more easily analyzed for issues.		The easing of burdens in the field could allow more payors to bring these tools in-house vs. bringing on third party players like Cotiviti or HMS. More accurate, easy to follow and readily available records would mitigate the number of true errors and lessen the opportunity for these players overall, regardless of end customer utilization of their solutions. We view this market as perhaps the one with the most to directly lose given real success with blockchain technologies.	
Performance Services Players				
HealthStream	The Provider Solutions segment, which focuses on credentialing and privileging employees, could see the ability to maintain clearer time series data on a provider with easy permissioning to various health systems or other parties as a benefit if developed or acquired by HealthStream. We are unaware of the degree to which HealthStream has invested money or effort on this front, but simply note the potential applicability of distributed ledger technology in the space. Other areas of the HealthStream business are less likely to see impacts at least in the near-term, in our estimation.		The same opportunity in Provider Solutions could pose a threat if developed sooner or more effectively by the competition, with other players already having invested, including the likes of Hashed Health as just one example. We do not see material threats to other parts of the business at this juncture.	
PREMIER	Population health offerings and the ability to more accurately track product through the supply chain, and thus also better leverage analytical capabilities all provide avenues to benefit from blockchain solution development.		Again, the competitive nature of the population health space poses a risk for those who fail to keep pace or spend to develop solutions that don't end up with wide adoption. Access to massive datasets could wane in importance as blockchain reduces the competitive advantage by enabling more players easier access to such data.	
R1	Easier access and use of clinical data through standardization, traceability, and the immutability of the patient record make the revenue cycle one of the areas we expect could see the biggest impact in the nearest-term (though still not immediate by any means). As we discuss with EHR players, first movers could gain an advantage, but it could take adoption by other players (payors and/or providers) to make use in the revenue cycle most beneficial in the long-term.		Adoption will be needed by other players involved in the payment process, meaning efforts could be all for naught if providers, payors or EHR players ultimately do not adopt blockchain technologies. Competition from others who potentially develop uses for blockchain faster, or see faster adoption, could also prove to be a headwind.	
evolent HEALTH	With a focus on helping various healthcare players make the transition to a value-based care environment, we believe Evolent could see the potential from the ability to more easily leverage data, though the exact applicability is somewhat uncertain. Ultimately we would view blockchain more as a cost saving opportunity for the company, at least initially, as it could make the transfer and use of data faster and more efficient, but perhaps is less likely to immediately offer a leverageable solution to be sold to customers.		Some of the benefits for blockchain potentially pose a threat as we view certain aspects as possibly making the transition to fee-for-value modestly easier for health systems through the ability to more easily address current challenges in-house vs. the need to hire an outside solution provider that is specialized in the space. Clearly adoption would need to come from others for Evolent to benefit, and likely for risks to materialize as well.	
inovalon	The impact of data standardization could be the ability to more easily and efficiently collect and analyze the information, potentially benefiting Inovalon over time as it develops its algorithms and other solutions to take advantage of blockchain.		As with other specialized companies who offer third party analytical solutions, we believe that the advantages of blockchain could prove a headwind for Inovalon in the event that health systems are able to do more with in-house IT resources. Certainly Inovalon offers more advanced levels of analytics than what most can do internally now or likely will develop in the future, but around the edges we beleive there could be modest headwinds as the gap between what can be completed in-house and what Inovalon offers could narrow modestly if blockchain is fully embraced and leveraged by health systems.	

Source: Raymond James research, company data

Risks and Challenges

Blockchain Is More of a Foundational Technology Than a Disruptive One

- Eight years after Bitcoin launched, the original blockchain built by Satoshi Nakamoto is still the only one that a meaningful number of people actually use.
- Blockchain should not be considered a "disruptive" technology, which typically attack traditional business models with lower cost solutions and can take over incumbent firms quickly.
- Blockchain is more of a "foundational" technology that has potential to create new foundations for the way transactions are conducted.

"No other blockchain-based software initiative seems to be at any real risk of hockey-sticking into general recognition, much less general usage."
– Jon Evans, principal at HappyFunCorp and TechCrunch Columnist

- While the ultimate impact is expected to be revolutionary, **"It will take decades for blockchain to seep into our economic and social infrastructure. The process of adoption will be gradual and steady, not sudden, as waves of technological and institutional change gain momentum."**
  - Harvard Business Review

The Costs of Constructing a Healthcare Blockchain Are High

- Currently, an enormous amount of computational power and electric energy is needed to keep a blockchain system functioning; for bitcoin, this is done by incentivizing "miners" who essentially trade computing time and energy to verify data in exchange for fragments of bitcoins.
- A healthcare blockchain could be built that would not necessarily need to rely on miners, but could potentially use another type of technical infrastructure.
    - Right now, however, all solutions are currently prototypes or fundamental concept testing.
- Specific rules would also be needed to make it better suited for healthcare.
    - System must facilitate the exchange of information between patients, providers, and payors.
    - System must be secure from cyberattacks and comply with all privacy regulations.

The amount of energy needed to maintain bitcoin's blockchain system is extremely high:

- About 300,000 bitcoin transactions occur per day
- This averages out to **215KWh** of power needed from miners for each transaction
- The average American household consumes **901KWh** per month
- Even assuming a theoretical scenario in which all miners use the most efficient method possible, each bitcoin transaction would still require **77KWh**

Source: Raymond James research, Vice

Privacy and Other Regulatory Issues Add Complexity

- HIPAA rules, which govern how healthcare handles sensitive patient data, are extensive and have multiple subchapters.
  - Any type of healthcare blockchain would have to comply with all HIPAA rules, making it even more complex to create such a blockchain.
- HIPAA rules are broad, and cover: patient privacy, security rules, interoperability restrictions, and healthcare clearinghouse rules.
- If medical data is minimized and stored on a single platform (such as on a healthcare blockchain), there are even more rules that apply to such a designated record set.

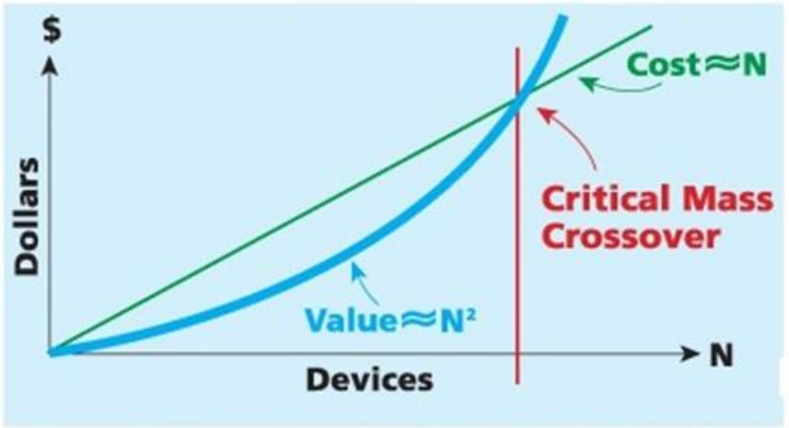
HIPAA Overview

- Protects privacy and confidentiality of patient information
- Assures security of electronic information
- Some states have laws more stringent than federal HIPAA, and take precedent
- Four key areas: privacy standards, electronic transaction standards, security standards, unique identifiers

Source: Raymond James research, HIPAA

Many Solutions Require Near Universal Adoption

- The promise of blockchain in large part depends on the network effect, or getting enough parties to use the same implementation of the technology.
- Numerous consortiums have been formed to drive the adoption and standardization of blockchain, mainly in the financial and legal industry.
- However, it's unclear if any other particular blockchain solution (other than bitcoin itself) will ever be able to reach this threshold. Without such universal adoption, blockchain's practicality is questionable.
- Some countries have already banned the use of bitcoin, and government legislation could present a significant challenge to widespread adoption.



Metcalfe's Law: the value of a communications network is proportional to the square of the number of connected devices/users of the system.

Figure 13: In order to be worth the investment, a critical mass of devices must be connected to the network

Source: Raymond James research, Forbes

Bitcoin issuers are not registered with the SEC, and the bitcoin marketplace is currently unregulated. Bitcoin and other cryptocurrencies are a very speculative investment and involves a high degree of risk. Securities that have been classified as Bitcoin-related cannot be purchased or deposited in Raymond James client accounts.

Important Investor Disclosures

Raymond James & Associates (RJA) is a FINRA member firm and is responsible for the preparation and distribution of research created in the United States. Raymond James & Associates is located at The Raymond James Financial Center, 880 Carillon Parkway, St. Petersburg, FL 33716, (727) 567-1000. Non-U.S. affiliates, which are not FINRA member firms, include the following entities that are responsible for the creation and distribution of research in their respective areas: in Canada, Raymond James Ltd. (RJL), Suite 2100, 925 West Georgia Street, Vancouver, BC V6C 3L2, (604) 659-8200; in Europe, Raymond James Euro Equities SAS (also trading as Raymond James International), 40, rue La Boetie, 75008, Paris, France, +33 1 45 64 0500, and Raymond James Financial International Ltd., Broadwalk House, 5 Appold Street, London, England EC2A 2AG, +44 203 798 5600.

This document is not directed to, or intended for distribution to or use by, any person or entity that is a citizen or resident of or located in any locality, state, country, or other jurisdiction where such distribution, publication, availability or use would be contrary to law or regulation. The securities discussed in this document may not be eligible for sale in some jurisdictions. This research is not an offer to sell or the solicitation of an offer to buy any security in any jurisdiction where such an offer or solicitation would be illegal. It does not constitute a personal recommendation or take into account the particular investment objectives, financial situations, or needs of individual clients. Past performance is not a guide to future performance, future returns are not guaranteed, and a loss of original capital may occur. **Investors should consider this report as only a single factor in making their investment decision.**

For clients in the United States: Any foreign securities discussed in this report are generally not eligible for sale in the U.S. unless they are listed on a U.S. exchange. This report is being provided to you for informational purposes only and does not represent a solicitation for the purchase or sale of a security in any state where such a solicitation would be illegal. Investing in securities of issuers organized outside of the U.S., including ADRs, may entail certain risks. The securities of non-U.S. issuers may not be registered with, nor be subject to the reporting requirements of, the U.S. Securities and Exchange Commission. There may be limited information available on such securities. Investors who have received this report may be prohibited in certain states or other jurisdictions from purchasing the securities mentioned in this report. Please ask your Financial Advisor for additional details and to determine if a particular security is eligible for purchase in your state.

The information provided is as of the date above and subject to change, and it should not be deemed a recommendation to buy or sell any security. Certain information has been obtained from third-party sources we consider reliable, but we do not guarantee that such information is accurate or complete. Persons within the Raymond James family of companies may have information that is not available to the contributors of the information contained in this publication. Raymond James, including affiliates and employees, may execute transactions in the securities listed in this publication that may not be consistent with the ratings appearing in this publication.

Raymond James ("RJ") research reports are disseminated and available to RJ's retail and institutional clients simultaneously via electronic publication to RJ's internal proprietary websites (RJ Investor Access & RJ Capital Markets). Not all research reports are directly distributed to clients or third-party aggregators. Certain research reports may only be disseminated on RJ's internal proprietary websites; however such research reports will not contain estimates or changes to earnings forecasts, target price, valuation, or investment or suitability rating. Individual Research Analysts may also opt to circulate published research to one or more clients electronically. This electronic communication distribution is discretionary and is done only after the research has been publically disseminated via RJ's internal proprietary websites. The level and types of communications provided by Research Analysts to clients may vary depending on various factors including, but not limited to, the client's individual preference as to the frequency and manner of receiving communications from Research Analysts. For research reports, models, or other data available on a particular security, please contact your RJ Sales Representative or visit RJ Investor Access or RJ Capital Markets.

Links to third-party websites are being provided for information purposes only. Raymond James is not affiliated with and does not endorse, authorize, or sponsor any of the listed websites or their respective sponsors. Raymond James is not responsible for the content of any third-party website or the collection or use of information regarding any website's users and/or members.

Additional information is available on request.

Analyst Information

Registration of Non-U.S. Analysts: The analysts listed on the front of this report who are not employees of Raymond James & Associates, Inc., are not registered/qualified as research analysts under FINRA rules, are not associated persons of Raymond James & Associates, Inc., and are not subject to FINRA Rule 2241 restrictions on communications with covered companies, public companies, and trading securities held by a research analyst account.

Analyst Holdings and Compensation: Equity analysts and their staffs at Raymond James are compensated based on a salary and bonus system. Several factors enter into the bonus determination including quality and performance of research product, the analyst's success in rating stocks versus an industry index, and support effectiveness to trading and the retail and institutional sales forces. Other factors may include but are not limited to: overall ratings from internal (other than investment banking) or external parties and the general productivity and revenue generated in covered stocks.

The views expressed in this report accurately reflect the personal views of the analyst(s) covering the subject securities. No part of said person's compensation was, is, or will be directly or indirectly related to the specific recommendations or views contained in this research report. In addition, said analyst has not received compensation from any subject company in the last 12 months.

Ratings and Definitions

Raymond James & Associates (U.S.) definitions

Strong Buy (SB1) Expected to appreciate, produce a total return of at least 15%, and outperform the S&P 500 over the next six to 12 months. For higher yielding and more conservative equities, such as REITs and certain MLPs, a total return of at least 15% is expected to be realized over the next 12 months.
Outperform (MO2) Expected to appreciate and outperform the S&P 500 over the next 12-18 months. For higher yielding and more conservative equities, such as REITs and certain MLPs, an Outperform rating is used for securities where we are comfortable with the relative safety of the dividend and expect a total return modestly exceeding the dividend yield over the next 12-18 months.
Market Perform (MP3) Expected to perform generally in line with the S&P 500 over the next 12 months.
Underperform (MU4) Expected to underperform the S&P 500 or its sector over the next six to 12 months and should be sold.
Suspended (S) The rating and price target have been suspended temporarily. This action may be due to market events that made coverage impracticable, or to comply with applicable regulations or firm policies in certain circumstances, including when Raymond James may be providing investment banking services to the company. The previous rating and price target are no longer in effect for this security and should not be relied upon.

Raymond James Ltd. (Canada) definitions

Strong Buy (SB1) The stock is expected to appreciate and produce a total return of at least 15% and outperform the S&P/TSX Composite Index over the next six months.
Outperform (MO2) The stock is expected to appreciate and outperform the S&P/TSX Composite Index over the next twelve months.
Market Perform (MP3) The stock is expected to perform generally in line with the S&P/TSX Composite Index over the next twelve months and is potentially a source of funds for more highly rated securities.
Underperform (MU4) The stock is expected to underperform the S&P/TSX Composite Index or its sector over the next six to twelve months and should be sold.

Raymond James Europe (Raymond James Euro Equities SAS & Raymond James Financial International Limited) rating definitions

Strong Buy (1) Expected to appreciate, produce a total return of at least 15%, and outperform the Stoxx 600 over the next 6 to 12 months.
Outperform (2) Expected to appreciate and outperform the Stoxx 600 over the next 12 months.
Market Perform (3) Expected to perform generally in line with the Stoxx 600 over the next 12 months.

Underperform (4) Expected to underperform the Stoxx 600 or its sector over the next 6 to 12 months.
Suspended (S) The rating and target price have been suspended temporarily. This action may be due to market events that made coverage impracticable, or to comply with applicable regulations or firm policies in certain circumstances, including when Raymond James may be providing investment banking services to the company. The previous rating and target price are no longer in effect for this security and should not be relied upon.

In transacting in any security, investors should be aware that other securities in the Raymond James research coverage universe might carry a higher or lower rating. Investors should feel free to contact their Financial Advisor to discuss the merits of other available investments.

Rating Distributions

	Coverage Universe Rating Distribution*			Investment Banking Distribution		
	RJA	RJL	RJEE/RJFI	RJA	RJL	RJEE/RJFI
Strong Buy and Outperform (Buy)	52%	68%	53%	24%	45%	0%
Market Perform (Hold)	43%	29%	34%	11%	24%	0%
Underperform (Sell)	5%	3%	14%	10%	29%	0%

* Columns may not add to 100% due to rounding.

Suitability Ratings (SR)

Medium Risk/Income (M/INC) Lower to average risk equities of companies with sound financials, consistent earnings, and dividend yields above that of the S&P 500. Many securities in this category are structured with a focus on providing a consistent dividend or return of capital.

Medium Risk/Growth (M/GRW) Lower to average risk equities of companies with sound financials, consistent earnings growth, the potential for long-term price appreciation, a potential dividend yield, and/or share repurchase program.

High Risk/Income (H/INC) Medium to higher risk equities of companies that are structured with a focus on providing a meaningful dividend but may face less predictable earnings (or losses), more leveraged balance sheets, rapidly changing market dynamics, financial and competitive issues, higher price volatility (beta), and potential risk of principal. Securities of companies in this category may have a less predictable income stream from dividends or distributions of capital.

High Risk/Growth (H/GRW) Medium to higher risk equities of companies in fast growing and competitive industries, with less predictable earnings (or losses), more leveraged balance sheets, rapidly changing market dynamics, financial or legal issues, higher price volatility (beta), and potential risk of principal.

High Risk/Speculation (H/SPEC) High risk equities of companies with a short or unprofitable operating history, limited or less predictable revenues, very high risk associated with success, significant financial or legal issues, or a substantial risk/loss of principal.

Raymond James Relationship Disclosures

Raymond James expects to receive or intends to seek compensation for investment banking services from the subject companies in the next three months.

Stock Charts, Target Prices, and Valuation Methodologies

Valuation Methodology: The Raymond James methodology for assigning ratings and target prices includes a number of qualitative and quantitative factors including an assessment of industry size, structure, business trends and overall attractiveness; management effectiveness; competition; visibility; financial condition, and expected total return, among other factors. These factors

are subject to change depending on overall economic conditions or industry- or company-specific occurrences. Only stocks rated Strong Buy (SB1) or Outperform (MO2) have target prices and thus valuation methodologies.

Risk Factors

General Risk Factors: Following are some general risk factors that pertain to the businesses of the subject companies and the projected target prices and recommendations included on Raymond James research: (1) Industry fundamentals with respect to customer demand or product / service pricing could change and adversely impact expected revenues and earnings; (2) Issues relating to major competitors or market shares or new product expectations could change investor attitudes toward the sector or this stock; (3) Unforeseen developments with respect to the management, financial condition or accounting policies or practices could alter the prospective valuation; or (4) External factors that affect the U.S. economy, interest rates, the U.S. dollar or major segments of the economy could alter investor confidence and investment prospects. International investments involve additional risks such as currency fluctuations, differing financial accounting standards, and possible political and economic instability.

Specific Investment Risks Related to the Industry or Issuer

Healthcare Information Technology Industry Risks

HITECH Act
Failure for the HITECH Act to materially drive electronic health record adoption rates higher within inpatient and ambulatory healthcare provider communities could adversely impact the anticipated growth and demand trajectories of HIT solution providers.

Credit Risk
A tightened credit environment has the potential to slow ambulatory HIT spending, as we believe that physician offices will react to broader economic changes similarly to small businesses.

Healthcare Sector General Risks
Potential risks such as reimbursement cuts, acquisition integration, and higher-than-expected operating costs (we note continued cyclical pressure on labor, supply and malpractice costs), as well as a slowing managed care pricing cycle, could negatively impact the healthcare sector.

Additional Risk and Disclosure information, as well as more information on the Raymond James rating system and suitability categories, is available at rjcapitalmarkets.com/Disclosures/index. Copies of research or Raymond James' summary policies relating to research analyst independence can be obtained by contacting any Raymond James & Associates or Raymond James Financial Services office (please see raymondjames.com for office locations) or by calling 727-567-1000, toll free 800-237-5643 or sending a written request to the Equity Research Library, Raymond James & Associates, Inc., Tower 3, 6th Floor, 880 Carillon Parkway, St. Petersburg, FL 33716.

For clients in the United Kingdom:

For clients of Raymond James Financial International Limited (RJFI): This document and any investment to which this document relates is intended for the sole use of the persons to whom it is addressed, being persons who are Eligible Counterparties or Professional Clients as described in the FCA rules or persons described in Articles 19(5) (Investment professionals) or 49(2) (High net worth companies, unincorporated associations etc) of the Financial Services and Markets Act 2000 (Financial Promotion) Order 2005 (as amended) or any other person to whom this promotion may lawfully be directed. It is not intended to be distributed or passed on, directly or indirectly, to any other class of persons and may not be relied upon by such persons and is therefore not intended for private individuals or those who would be classified as Retail Clients.

For clients of Raymond James Investment Services, Ltd.: This report is for the use of professional investment advisers and managers and is not intended for use by clients.

For purposes of the Financial Conduct Authority requirements, this research report is classified as independent with respect to conflict of interest management. RJFI, and Raymond James Investment Services, Ltd. are authorised and regulated by the Financial Conduct Authority in the United Kingdom.

For clients in France:

This document and any investment to which this document relates is intended for the sole use of the persons to whom it is addressed, being persons who are Eligible Counterparties or Professional Clients as described in "Code Monétaire et Financier" and Règlement Général de l'Autorité des Marchés Financiers. It is not intended to be distributed or passed on, directly or indirectly, to any other class of persons and may not be relied upon by such persons and is therefore not intended for private individuals or those who would be classified as Retail Clients.

For clients of Raymond James Euro Equities: Raymond James Euro Equities is authorised and regulated by the Autorité de Contrôle Prudentiel et de Résolution and the Autorité des Marchés Financiers.

For institutional clients in the European Economic Area (EEA) outside of the United Kingdom:

This document (and any attachments or exhibits hereto) is intended only for EEA institutional clients or others to whom it may lawfully be submitted.

For Canadian clients:

This report is not prepared subject to Canadian disclosure requirements, unless a Canadian analyst has contributed to the content of the report. In the case where there is Canadian analyst contribution, the report meets all applicable IIROC disclosure requirements.

Proprietary Rights Notice: By accepting a copy of this report, you acknowledge and agree as follows:

This report is provided to clients of Raymond James only for your personal, noncommercial use. Except as expressly authorized by Raymond James, you may not copy, reproduce, transmit, sell, display, distribute, publish, broadcast, circulate, modify, disseminate or commercially exploit the information contained in this report, in printed, electronic or any other form, in any manner, without the prior express written consent of Raymond James. You also agree not to use the information provided in this report for any unlawful purpose.

This report and its contents are the property of Raymond James and are protected by applicable copyright, trade secret or other intellectual property laws (of the United States and other countries). United States law, 17 U.S.C. Sec.501 et seq, provides for civil and criminal penalties for copyright infringement. No copyright claimed in incorporated U.S. government works.