

CDC Health Information Innovation Consortium February Forum

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Chief Public Health Informatics Officer
Office of Public Health Scientific Services

Tuesday, February 20, 2018
10:00-11:00am ET
Century Center 2500, Room 1200 + ReadyTalk



February Presenter



Dr. Savel is the Director of the Informatics Innovation Unit in the Division of Public Health Information Dissemination. In this role, he collaborates with CDC staff and the broader public health community to develop, test, and evaluate innovative tools and technologies with the potential to improve public health practice.

Dr. Savel received his medical degree from the Icahn School of Medicine at Mount Sinai, and his undergraduate degree in psychology from Wesleyan University. He received residency training in General Surgery and Family Medicine, and is a graduate of CDC's Public Health Informatics Fellowship Program.

Dr. Savel is an adjunct professor in the Applied Public Health Office at the Rollins School of Public Health at Emory University, and, on his own time, maintains his clinical skills in addiction medicine, treating patients with opioid addiction. He is on the editorial board of the open access, peer reviewed journal, *Blockchain in Healthcare Today (BHTY)*. He is a member of the American Medical Informatics Association (AMIA) and the American Society of Addiction Medicine (ASAM).



Blockchain 101 for Public Health

Tom Savel, MD

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CDC Health Information Innovation Consortium Forum

February 2018

What is a blockchain?

- A distributed immutable ledger of transactions
- The underlying technology behind the cryptocurrency known as Bitcoin
- What TCP/IP (internet protocol) has been for the exchange of information, blockchain can be for the exchange of value



What is a blockchain?

- A set of tools for cryptographic assurance of data integrity, standardized auditing, and formalized contracts for data access
- A technology which empowers participating members to exchange items of value through a distributed ledger - that each member owns - and who's content is always in sync



No really, what's is a blockchain: 5 Principles*

- Distributed Database
- Peer-to-Peer Transmission
- Irreversibility of Records
- Computational Logic (automated)
- Transparency with a degree of anonymity (pseudonymity)



* Harvard Business Review – Halamka et al., 2017

Blockchain: Is it of value to me?

“It is most useful when multiple loosely coupled distinct organizations or entities want to confidently share and audit information and automate mutually beneficial processes”



What is a blockchain? One more time...it is...

■ Distributed

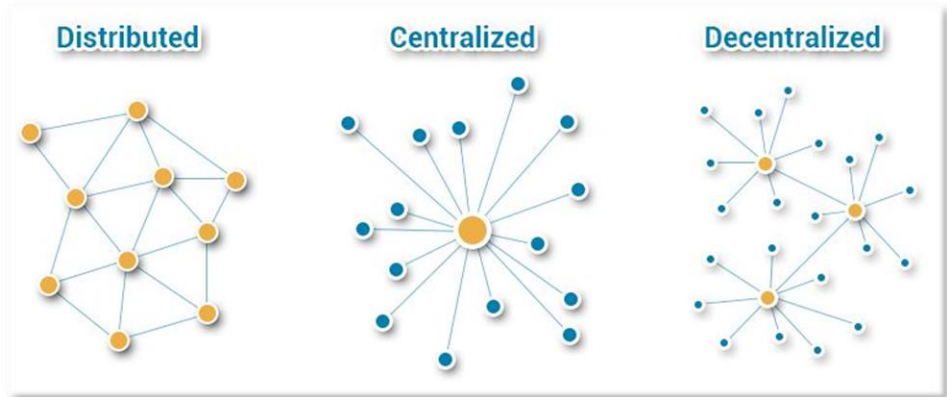
- Decentralized, shared, etc.
- Affording high availability

■ Immutable

- Write only
- Extremely “hacker resistant”
- Affording high Integrity

■ Ledger

- Transaction record (e.g., of financial data, contractual data, physical assets)
- Uses a validation process (consensus protocol)

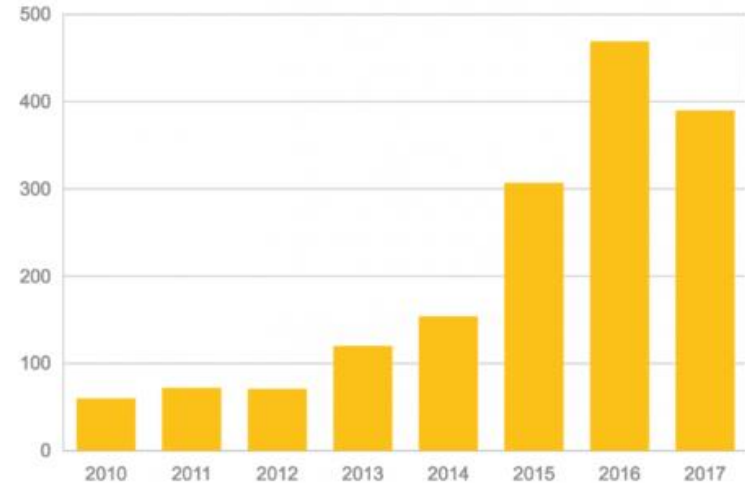


LEDGER	
Transactions	Value
Mary → John	10.000
John → Lisa	0.345
Sandra → David	18.4332
Lisa → Sandra	7.156
David → Mary	12.3402
Brian → Lisa	3.029381
...	...

Is Blockchain new?

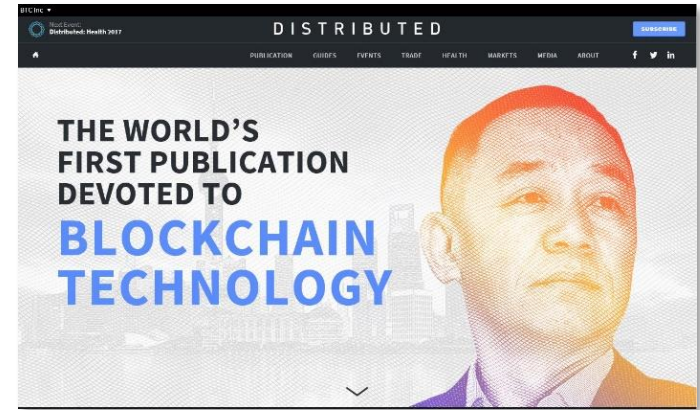
- No...but it is now gaining rapid popularity
- Over \$4.5 Billion in private funding for Blockchain-related projects in 2017 (Forbes)
- Dramatic increase in number of Blockchain patents filed (coindesk.com)
- Still in its early stages of development and implementation – similar to the internet itself in the late 1990s

Number of Patent Applications



Blockchain development activity

- Significant activity in the Corporate, Academic and Federal spaces:
 - IBM, Microsoft, MIT, GA Tech, GSA, FDA, DHS, DOD, ONC, OMB, NIST, OPM, Postal Service, State Dept., Treasury Dept., Federal Reserve, and hundreds of blockchain startups.
 - <https://emerging.digital.gov/blockchain-programs>
- New Magazines / Journals:
 - Traditional (e.g., Wired): DISTRIBUTED (2017)
 - Peer-reviewed: Blockchain in Healthcare Today (2018)



Digging a bit deeper into Blockchain: All hype? No.

- Leverages and expands existing capability of the internet
- Based on mathematics and cryptography (not magic):
 - (Tech speak: merkle trees, cryptographic hashes, public and private keys, etc.)
- Can be used for many different purposes
- When used in finance – it finally solves the very challenging “double spend” problem

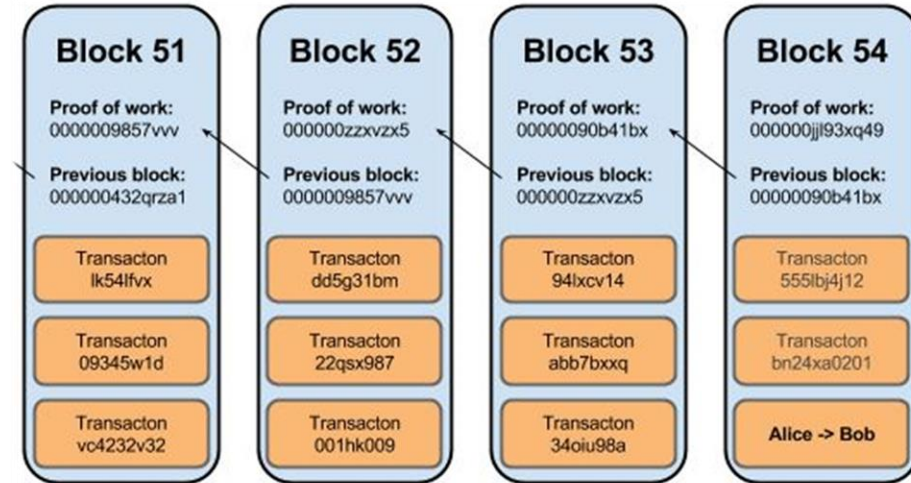


Why is it called Blockchain?

- The power of the technology to be a “trusted source of truth” - is based on its ability to permanently connect groups of validated transactions...

[connection = called a chain]

[group = called a block]



Remember: the blockchain data continues to grow and is automatically replicated to every connected node... to potentially thousands of nodes. Sound inefficient? It's the cost of being a “trusted source of truth”

Why does an internet-based “trusted source of truth” matter?

- You don't need a trusted 3rd party with a blockchain infrastructure
- Critical ledgers / databases are ubiquitous in our society – and most always require a trusted 3rd party
- Examples:
 - For financial transactions: Bank
 - For drivers license, auto tags, etc.: DMV



Why does an internet-based “trusted source of truth” matter?

Blockchain technology can enhance the internet - from an internet of knowledge and information sharing - to an internet of value and value exchange – where trust and security are “baked in”



Blockchain: There isn't just one

- There are 3 general categories of blockchains:
- Similar to the idea of internet vs. intranet web sites
- Public (full access by anyone)
- Permissioned (consortium)
- Private (i.e., within an organization)



Blockchain: There isn't just one

- There are many different types / configurations of blockchains – with more being created every day
- Similar to the idea of using different operating systems (iOS, Android, Windows, Linux, etc.)
- Examples:
 - Bitcoin Blockchain
 - Ethereum Blockchain
 - Hyperledger Fabric
 - IOTA “Tangle”

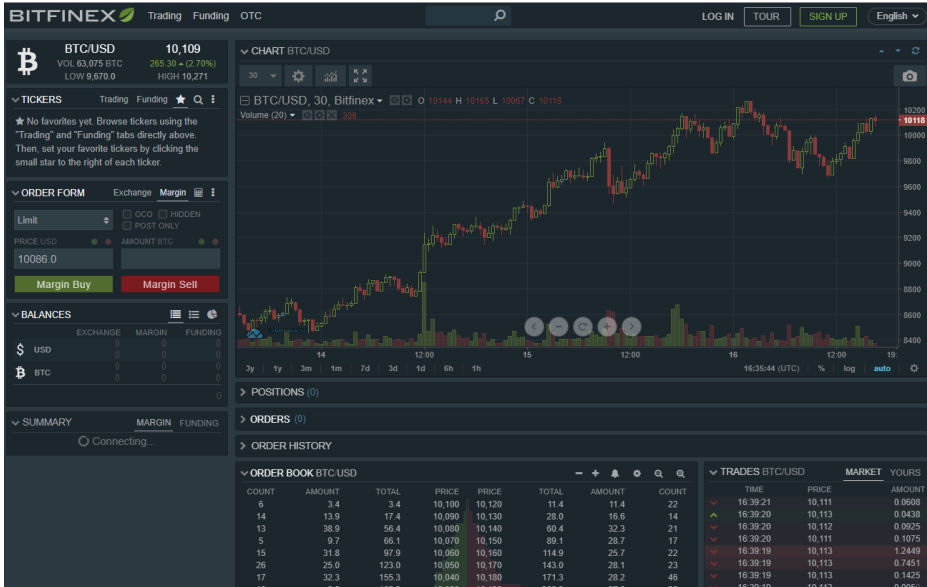


Blockchain: A foundation for new ecosystems

- Blockchain technology can support a wide variety of unique use cases
 - Decentralized file sharing, Digital asset exchange, Real estate transactions, Proof of authorship, Laboratory / pharmaceutical asset tracking, etc.
- Examples:
 - Bitcoin - single purpose - exchange and store value
 - Ethereum - distributed application platform
 - i.e., an app store for blockchain-based apps (dApps)
 - Offers custom tokens, smart contracts, etc.



Blockchain: A foundation for new ecosystems



#	Name	Market Cap	Price	Volume (24h)	Circulating Supply
1	Bitcoin	\$170,881,820,826	\$10,130.30	\$8,246,650,000	16,868,387 BTC
2	Ethereum	\$91,748,367,603	\$939.53	\$2,655,990,000	97,653,577 ETH
3	Ripple	\$44,311,348,455	\$1.14	\$720,047,000	39,009,215,838 XRP *
4	Bitcoin Cash	\$25,685,740,372	\$1,513.51	\$887,929,000	16,970,975 BCH
5	Litecoin	\$12,903,974,027	\$233.58	\$1,456,610,000	55,244,108 LTC
6	Cardano	\$10,514,178,988	\$0.405529	\$206,724,000	25,927,070,538 ADA *
7	Stellar	\$8,320,551,289	\$0.451283	\$67,302,500	18,437,546,483 XLM *
8	NEO	\$8,268,325,000	\$127.21	\$193,756,000	65,000,000 NEO *
9	EOS	\$6,749,271,805	\$10.02	\$283,330,000	673,418,723 EOS *
10	IOTA	\$5,836,040,759	\$2.10	\$51,454,100	2,779,530,283 MIOTA *

The Blockchain Token: Unit of value exchange



- Public blockchains (almost always) leverage a token
 - (not required with private/permissioned blockchains)
- A token (i.e., digital asset) can be many things...and have different purposes:
 - Digital Currency
 - To support the creation of a “marketplace”
 - A unit of value – to be exchanged within distributed app ecosystem
 - Initial Coin Offering (ICOs) – to be exchanged for fiat currency (e.g., USD)
 - Proxy for physical asset
 - Exchangeable for other digital assets / fiat currencies
 - Coinbase, Kraken, Bitfinex, Bittrex, Binance, etc.

Using the Blockchain: making a transaction

- What is involved in a transaction event recorded on blockchain?
 - Unique Sender
 - Wallet (can be explicit or hidden from the user)
 - Contains Public Key – to receive & Private Key – send
 - Transaction Data (i.e., the data packet / metadata)
 - Financial asset, activating a change in rights to view or access a digital or real world asset
 - Receiver
 - Unique (most often) or multiple (i.e., automated by a “smart contract”)
 - Wallet (can explicit or hidden....same as sender)



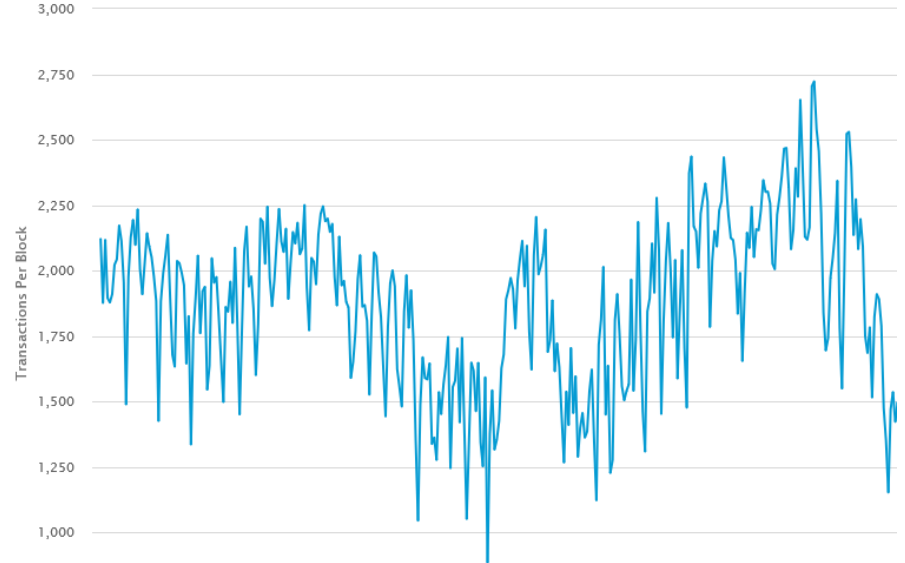
Using the Blockchain: the transaction – a deeper look

- Inherent to a standard blockchain- every transaction is stored...every one...forever.
- With, for example, the public (Bitcoin) blockchain – transactions are grouped and processed in blocks (thousands of transactions)
- Blocks are then tied together with 1-way digital fingerprints (cryptographic hashes)

Average Number Of Transactions Per Block

The average number of transactions per block.

Source: blockchain.info



Using the Blockchain: the transaction – a deeper look

- Transactions take time (which varies based on the blockchain type/platform)
 - Huge area of development / activity to improve transaction efficiency
 - There are significant challenges which need to be rapidly overcome (e.g., projects: plasma, lightning network)
- Transactions can have fees (for public blockchains)
 - to prevent spam, misuse of resources
 - e.g., Ethereum requires “Gas”
- All transactions require validation (consensus protocol)
 - Many types
 - Also, a very rapidly evolving area



Blockchain: Validation (have you heard of mining?)

- Blockchain technology elegantly leverages computer science, mathematics, cryptography, & game theory
- For a public blockchain – the goal is to incentivize unknown, untrusting participants to work with the system and not try to break it



Blockchain: Validation (have you heard of mining?)

- There are many types of consensus protocols
 - Proof of Work – classic but incredibly costly (electricity, etc.)
 - Mining – Competing to solve a computationally intensive problem to validate transaction
 - GPU, ASIC (Application Specific Integrated Circuit), etc.
 - With the winner of the competition receiving a financial reward
 - Proof of Stake – Ownership
 - Proof of Authority
 - Proof of Space-Time
 - Proof of Capacity
 - Proof of Elapsed Time (e.g., Intel)
 - With more being studied and tested every day



Blockchain: Quick recap and breather....



- Blockchain doesn't solve every problem
- Most useful ***“when loosely coupled distinct organizations / entities want to confidently share and audit information and automate mutually beneficial processes”***
- Removes the need for intermediaries – and thus gives control back to the users / original data / asset owners
- Provides a source of truth / trust between untrusting participants

Blockchain: Where is it ideal?

- It excels in 3 general types of activities in a non-centralized / distributed environment:
 - Tracking and Tracing of Assets / Value
 - i.e., chain of custody (provenance)
 - Data Exchange
 - Automation of operational processes



Blockchain: Once last piece – “the data”

- Important issue:
 - Can / should I put all my data on the blockchain?
 - No, no and no...
 - You will hear the terms “on chain” and “off chain”
 - Remember- what you put on the chain is replicated to all the nodes
 - It’s important to keep the blockchain light...



Blockchain: Once last piece – “the data”

- There are other “on chain/off chain” issues to consider:
 - Privacy / Transparency
 - PII, etc.
 - Storage Capacity Issues (IPFS, Minio, etc.)
 - Large files: e.g., chest x-rays, etc.
- This issue must be carefully evaluated for each unique blockchain implementation

Important Note: It is possible to link off-chain data (encrypted PII, large files, etc.) to the blockchain – and ensure data integrity (via digital fingerprint / cryptographic hashing)



Blockchain: Its impact on the digital global economy

- Accounting
- Digital Identity
- Smart Contracts
- Data Provenance
- eGov
- Supply Chain Management
- Internet of Things (IoT)
- Trade Finance
- Clearing And Settlement



Blockchain Startup Landscape

Blockchain Consulting/ App Dev 	Payments 	Identity & Reputation 	Governance & Transparency
Mining 	Exchange, Trading & Investing 		Media
Legal, Audit & Tax 	Content Management 	Data Analytics, Compliance & Security 	Social Network
Wallet 	Data Provenance & Notary <p>@vijaymichalik @Frost_Sullivan @lawrencelundy @OVioHQ</p>		Supply Chain & Logistics
Prediction Markets 	Public Chain Infrastructure 		Commerce & Advertising
Financial Services Infrastructure 		Enterprise Infrastructure 	

Blockchain: Its impact to Healthcare

- Identity Management – Patients, Providers
- Medical Record Management
- Medicaid Management Information Systems
- Benefits Administration
- Data Security
- Reimbursement
- Clinical Trial Management
- Pharmaceutical Supply



Healthcare Data Infrastructure (e.g., Blockchain-as-a-Service)



Electronic and Patient Health Records



Healthcare Analytics



Med Device & IoT Security



Identity



CHRONICLED



accenture

Supply Chain (e.g., Pharma)



CHRONICLED

Digital Medicine & Care Delivery



Advisory, Dev Shop & More



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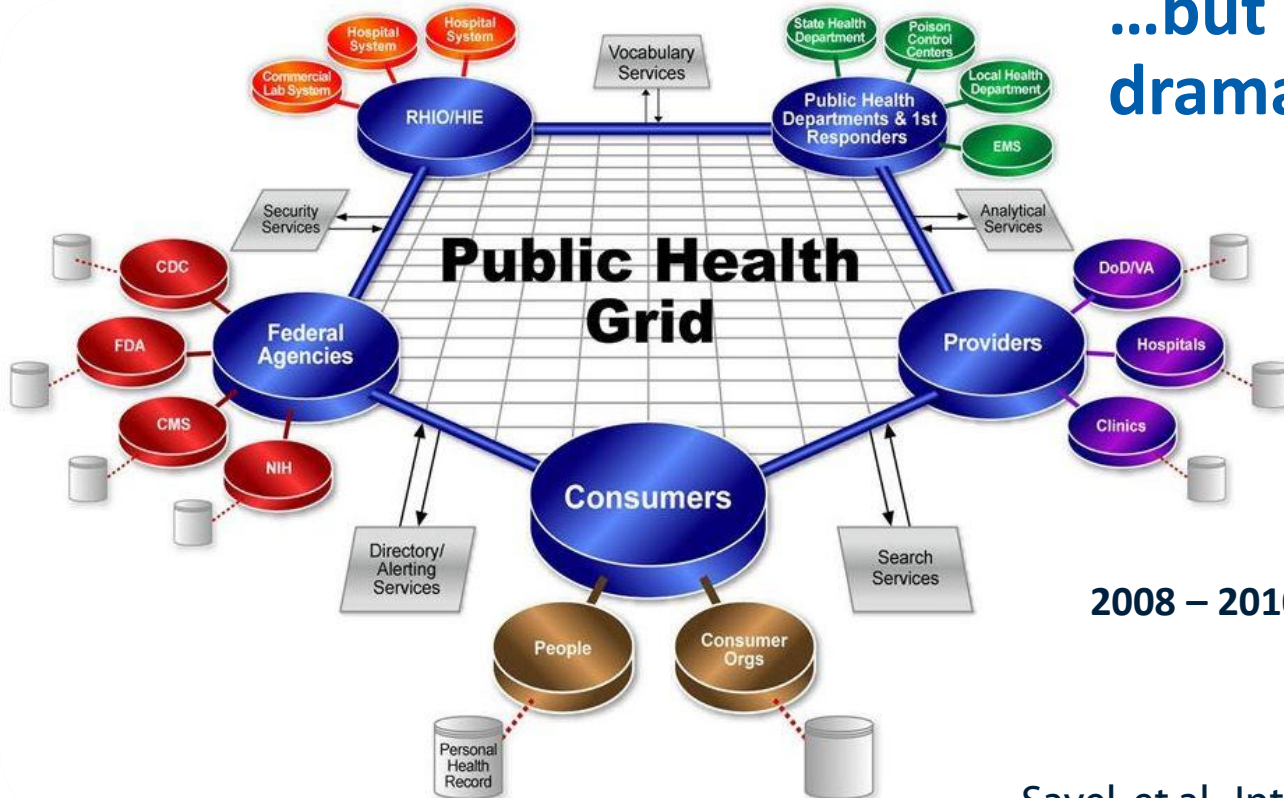
Blockchain: What about public health?

- Blockchain technology can impact public health at many levels:
 - CDC
 - Within & between programs
 - Examples: laboratory, countermeasure tracking, surveillance and other data...
 - Prototypes...
 - Between programs and partners
 - The entire Public Health Community (as a consortium)
 - Federal, State, Local, etc.



Blockchain & Public health: The vision hasn't changed...

...but the technology has dramatically matured



2008 – 2010: PHGrid



Blockchain: What about public health?

- Blockchain technology can impact public health at even more levels (in time):
 - Public Health / Clinical Healthcare Exchange
 - Health research data
 - Connections to other health and non-health related blockchains:
 - Financial, pharmaceutical, food supply blockchains



Blockchain: What about public health?

- Many use cases to consider (with varying levels of effort & numbers of stakeholders)
 - Surveillance / Monitoring
 - Event detection, situational awareness, notifiable condition reporting, surveillance / vital statistics, specimen tracking / results reporting, outbreak management
 - Interventions
 - Response management, inventory allocation and distro., resource utilization (hosp. beds, etc.)



Blockchain: What about public health?

- Many use cases to consider (with varying levels of effort & numbers of stakeholders)
 - Prevention
 - Vaccination campaigns, wellness programs, health awareness campaigns
 - Communication / Alerting
 - Health alerting, decision support, public communications, health training and communications



Blockchain: Challenges

- The challenge is that the shift to blockchain is a fundamental change on many levels
 - Historically:
 - Centralized system
 - Single point of failure
 - Manual Processes
 - Sending / Receiving data “messages”



Blockchain: Challenges

- The challenge: the shift to blockchain is a fundamental change

Decentralized / Distributed data / value exchange ecosystem

Control is given back to the data owner / stakeholder

Increased transparency

Increased Security

Post/Link data to blockchain – not to specific stakeholders

Automated Processes

Improved Efficiency

Works well with microservices

Enhanced Metrics

Permanent longitudinal record / log



Blockchain: Next steps

- All of us need to become familiar with the technology
 - What does it does well? What are its limitations?
 - Understand which blockchain tools and resources best fit with public health use cases
 - How does blockchain tech. fit into the larger picture of an ecosystem of services
- Continue to explore new and existing use cases and implement small pilot projects
- Gradually implement and expand successful blockchain solutions



Blockchain: Next steps

- Overall Goals:
 - Reduce costs & Improve efficiencies
 - Improve transparency and security
 - Make blockchain-based solutions invisible to the users-----
 - IT JUST WORKS (just like our phones)
 - “If users see cryptographic hashes- we have failed”

Thank you!

Questions?

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For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Q&A



Items of interest

- **New Publication – “Modernizing Centers for Disease Control and Prevention Informatics Using Surveillance Data Platform Shared Services” [\[link\]](#)**
- **CDC GitHub organization - <https://github.com/CDCgov/>**
- **Code For Atlanta Civic Hack Night– 2/27 – [\[link\]](#)**
- **HHS Entrepreneur in Residence Program [\[link\]](#)**
- **Next Forum – May 21, 1-2pm ET- Electronic Case Reporting, STD Case Reporting**