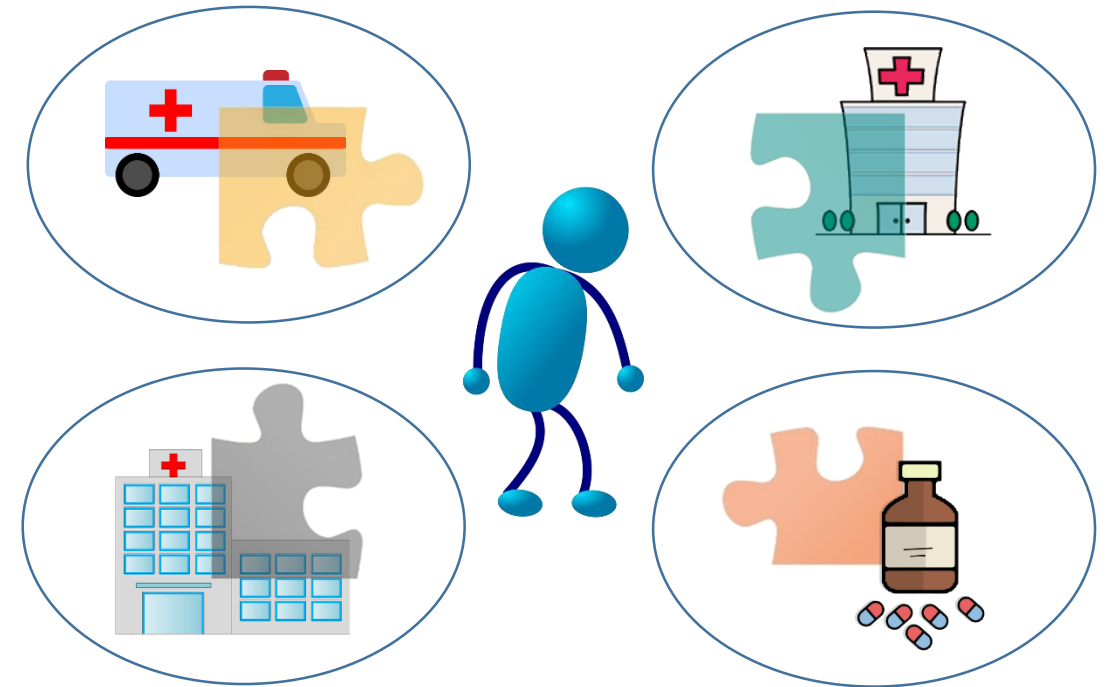
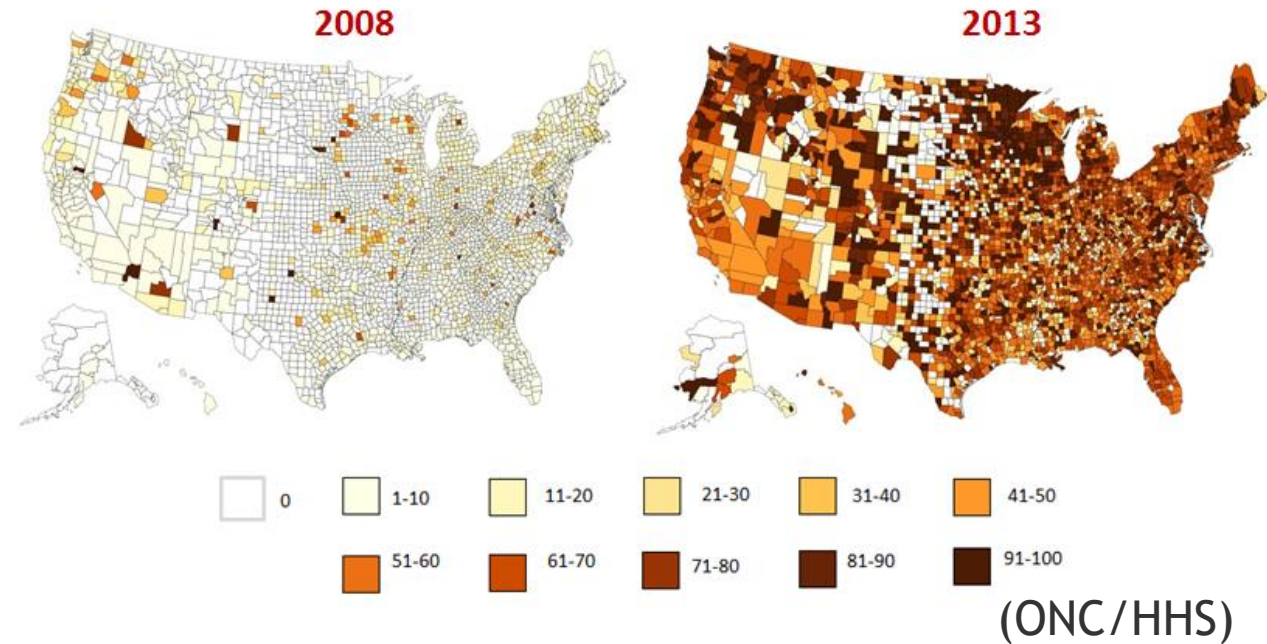


Blockchain for Health

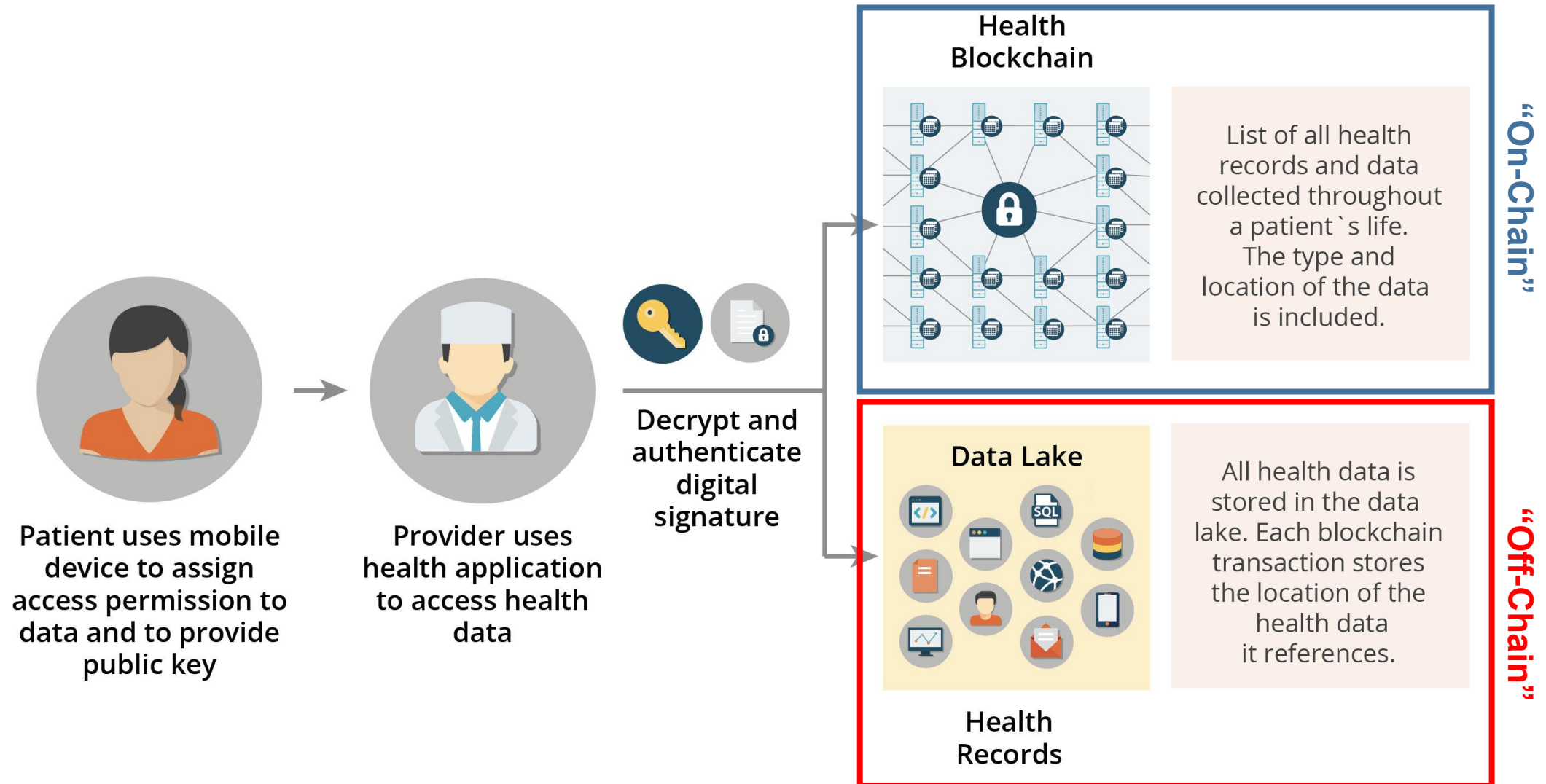
Anjum Khurshid, MD PhD
Chief, Data Integration
Assistant Professor, Population Health
Dell Medical School

Electronic medical records adoption has surged in US but data are not patient-centric



As of 2015, 96% of medical records in the US are stored electronically, but the data are not shared resulting in fragmented system of “data silos”.—Gordon *et al*, 2018

Blockchain technology can link patient's isolated EHRs



Pharmaceutical and Drugs

JMIR Res Protoc. 2018 Sep 13;7(9):e10163. doi: 10.2196/10163.

Blockchain Technology for Detecting Falsified and Substandard Drugs in Distribution: Pharmaceutical Supply Chain Intervention.

Sylim P^{#1}, Liu F^{#1}, Marcelo A^{#2}, Fontelo P^{#1}.

Pathog Glob Health. 2018 Jun;112(4):161. doi: 10.1080/20477724.2018.1503268.

Application of on-dose identification and blockchain to prevent drug counterfeiting.

Vruddhula S¹.

Expert Opin Drug Saf. 2017 May;16(5):587-602. doi: 10.1080/14740338.2017.1313227. Epub 2017 Apr 7.

A review of existing and emerging digital technologies to combat the global trade in fake medicines.

Mackey TK^{1,2,3}, Nayyar G².

Int J Environ Res Public Health. 2018 May 23;15(6). pii: E1055. doi: 10.3390/ijerph15061055.

Governance on the Drug Supply Chain via Gcoin Blockchain.

Tseng JH¹, Liao YC², Chong B³, Liao SW⁴.

⊕ Author information

Abstract

As a trust machine, blockchain was recently introduced to the public to provide an immutable, consensus based and transparent system in the Fintech field. However, there are ongoing efforts to apply blockchain to other fields where trust and value are essential. In this paper, we suggest Gcoin blockchain as the base of the data flow of drugs to create transparent drug transaction data. Additionally, the regulation model of the drug supply chain could be altered from the inspection and examination only model to the surveillance net model, and every unit that is involved in the drug supply chain would be able to participate simultaneously to prevent counterfeit drugs and to protect public health, including patients.



Electronic Medical Records

J Med Syst. 2018 Aug 10;42(9):172. doi: 10.1007/s10916-018-1025-3.

Blockchain for Healthcare: The Next Generation of Medical Records?

Pirtle C¹, Ehrenfeld J².

J Med Syst. 2018 Jul 5;42(8):152. doi: 10.1007/s10916-018-0994-6.

Secure Cloud-Based EHR System Using Attribute-Based Cryptosystem and Blockchain.

Wang H¹, Song Y².

AMIA Annu Symp Proc. 2018 Apr 16;2017:650-659. eCollection 2017.

Secure and Trustable Electronic Medical Records Sharing using Blockchain.

Dubovitskaya A^{1,2}, Xu Z³, Ryu S³, Schumacher M¹, Wang F⁴.

Stud Health Technol Inform. 2017;245:45-48.

Enabling Patient Control of Personal Electronic Health Records Through Distributed Ledger Technology.

Cunningham J¹, Ainsworth J¹.

Stud Health Technol Inform. 2018;251:7-10.

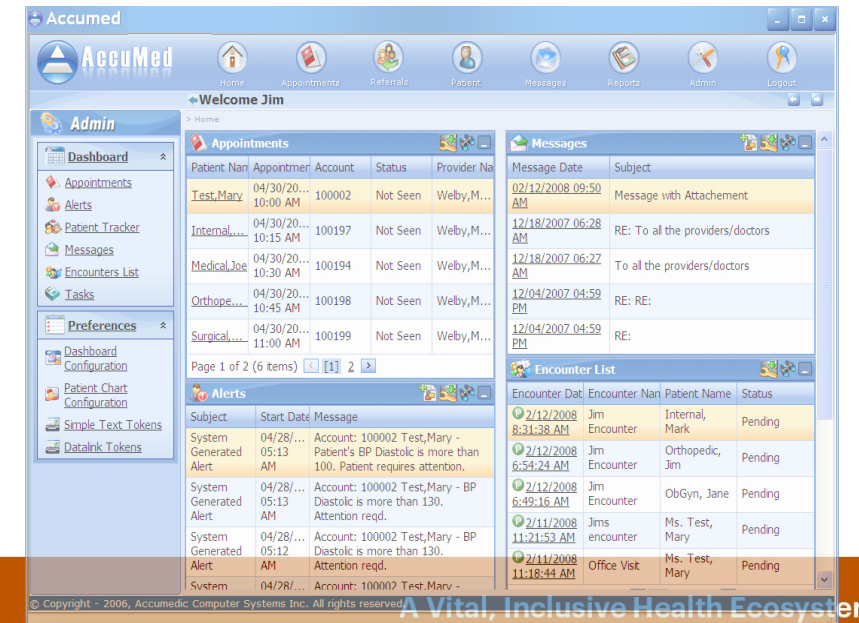
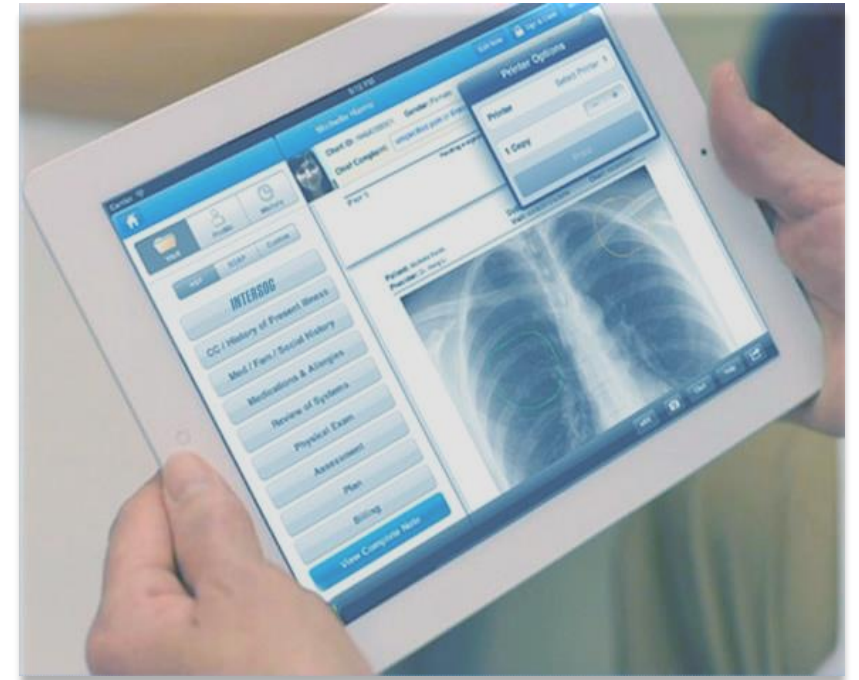
Concept for Sharing Distributed Personal Health Records with Blockchains.

Mense A¹, Athanasiadis L¹.

Author information

Abstract

The characteristics of the "blockchain" technology and especially its decentralized nature lead to the notion of neutrality, censorship resistance, and absolute truths, which makes the concept interesting for many different domains, such as finance, supply chain management, or the energy sector - of course also for the healthcare area (eHealth). Blockchains also offer the possibility for well-known access points for a distributed system with easy to use and simple to integrate programming interfaces, which makes it interesting as a central point for electronic healthcare data exchange in a distributed environment. This paper presents a concept for integrating and sharing distributed personal healthcare records based on smart contracts implemented on an Ethereum blockchain.



Interoperability

Stud Health Technol Inform. 2018;248:239-246.

Towards Designing a Secure Exchange Platform for Diabetes Monitoring and Therapy.

Weiß JP¹, Welzel T², Hartmann BJ², Hübner U¹, Teuteberg F³.

Stud Health Technol Inform. 2018;249:181-184.

FHIR Healthcare Directories: Adopting Shared Interfaces to Achieve Interoperable Medical Device Data Integration.

Tyndall T¹, Tyndall A¹

J Diabetes Sci Technol. 2018 Jul 26;1932296818790281. doi: 10.1177/1932296818790281. [Epub ahead of print]

How to Use Blockchain for Diabetes Health Care Data and Access Management: An Operational Concept.

Cichosz SL¹, Stausholm MN¹, Kronborg T¹, Vestergaard P^{2,3,4}, Hejlesen O¹.

Stud Health Technol Inform. 2018;251:27-30.

Blockchains in IHE-Based Networks.

Mangesius P¹, Bachmann J¹, Healy T², Saboor S³, Schabetsberger T¹.

J Med Syst. 2018 Jun 28;42(8):140. doi: 10.1007/s10916-018-0995-5.

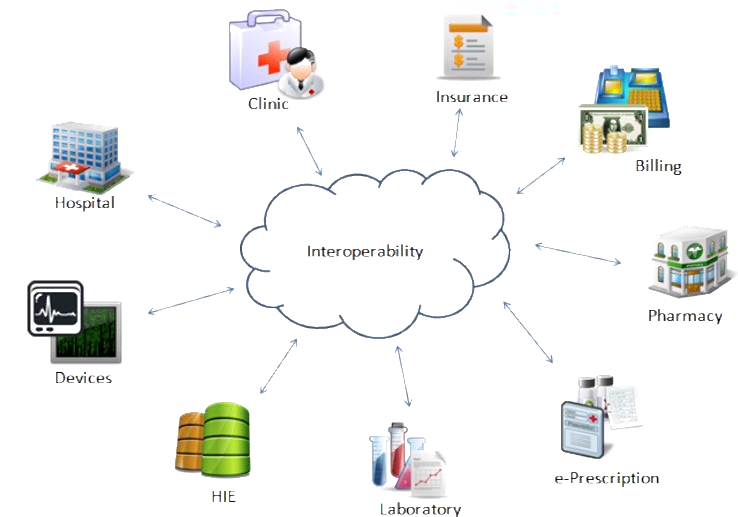
Towards Secure and Privacy-Preserving Data Sharing in e-Health Systems via Consortium Blockchain.

Zhang A¹, Lin X².

➕ Author information

Abstract

Electronic health record sharing can help to improve the accuracy of diagnosis, where security and privacy preservation are critical issues in the systems. In recent years, blockchain has been proposed to be a promising solution to achieve personal health information (PHI) sharing with security and privacy preservation due to its advantages of immutability. This work proposes a blockchain-based secure and privacy-preserving PHI sharing (BSPP) scheme for diagnosis improvements in e-Health systems. Firstly, two kinds of blockchains, private blockchain and consortium blockchain, are constructed by devising their data structures, and consensus mechanisms. The private blockchain is responsible for storing the PHI while the consortium blockchain keeps records of the secure indexes of the PHI. In order to achieve data security, access control, privacy preservation and secure search, all the data including the PHI, keywords and the patients' identity are public key encrypted with keyword search. Furthermore, the block generators are required to provide proof of conformance for adding new blocks to the blockchains, which guarantees the system availability. Security analysis demonstrates that the proposed protocol can meet with the security goals. Furthermore, we implement the proposed scheme on JUICE to evaluate the performance.



Health Data

J Med Syst. 2018 Jun 28;42(8):141. doi: 10.1007/s10916-018-0997-3.

Blockchain-Based Data Preservation System for Medical Data.

Li H¹, Zhu L¹, Shen M², Gao F¹, Tao X³, Liu S⁴.

Author information

J Med Syst. 2018 Jul 10;42(8):156. doi: 10.1007/s10916-018-1007-5.

A Proposed Solution and Future Direction for Blockchain-Based Heterogeneous Medicare Data in Cloud Environment.

Kaur H¹, Alam MA¹, Jameel R¹, Mourya AK², Chang V³.

Author information

Int J Health Geogr. 2018 Jul 5;17(1):25. doi: 10.1186/s12942-018-0144-x.

Geospatial blockchain: promises, challenges, and scenarios in health and healthcare.

Kamel Boulos MN¹, Wilson JT², Clauson KA².

Genome Res. 2018 Sep;28(9):1255-1263. doi: 10.1101/gr.207464.116. Epub 2018 Aug 3.

Realizing the potential of blockchain technologies in genomics.

Ozercan HI¹, Ileri AM², Ayday E¹, Alkan C¹.

Author information

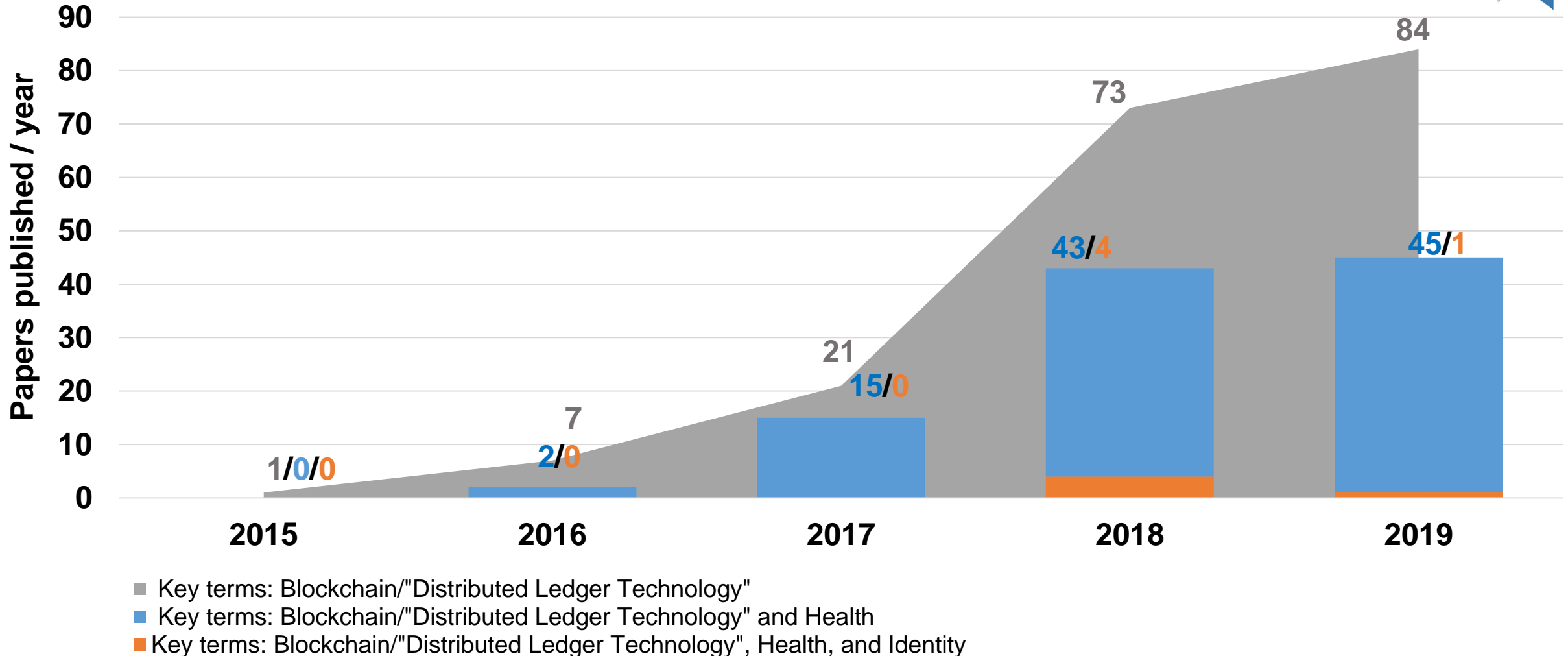
Abstract

Genomics data introduce a substantial computational burden as well as data privacy and ownership issues. Data sets generated by high-throughput sequencing platforms require immense amounts of computational resources to align to reference genomes and to call and annotate genomic variants. This problem is even more pronounced if reanalysis is needed for new versions of reference genomes, which may impose high loads to existing computational infrastructures. Additionally, after the compute-intensive analyses are completed, the results are either kept in centralized repositories with access control, or distributed among stakeholders using standard file transfer protocols. This imposes two main problems: (1) Centralized servers become gatekeepers of the data, essentially acting as an unnecessary mediator between the actual data owners and data users; and (2) servers may create single points of failure both in terms of service availability and data privacy. Therefore, there is a need for secure and decentralized platforms for data distribution with user-level data governance. A new technology, blockchain, may help ameliorate some of these problems. In broad terms, the blockchain technology enables decentralized, immutable, incorruptible public ledgers. In this Perspective, we aim to introduce current developments toward using blockchain to address several problems in omics, and to provide an outlook of possible future implications of the blockchain technology to life sciences.



Encounter	Date	Status	Patient No	Patient Name	Provider Name	Insurance	Total
1001	12/7/2007	Posted 04/17/13	1000	SMITH, JOHN B	RUBBLE, BARNEY	BC/BS	60.00
1003	12/7/2007	Ready to Post	1002	SOPRANO, TONY	HANKS, THOMAS		25.00
1012	4/1/2008	Posted 04/17/13	1009	GOETZ, MADDOE	HANKS, THOMAS	MEDICARE OF ANY STATE	95.00
1037	4/8/2008	Failed Rules	09	HOLMES, JENNIFER	HANKS, THOMAS	BLUE CROSS BLUE SHIELD	95.00
1116	5/7/2008	Failed Rules	1015	RIPKEN, CAL	HANKS, THOMAS	BLUE CROSS BLUE SHIELD SOU	55.00
1131	5/9/2008	Posted 10/09/13	1002	SOPRANO, TONY	FLINTSTON, FREDRICK	BC/BS	60.00
1140	5/19/2008	Failed Rules	1012	GEPPI, NICOLE	CINQUEGRANA, JACKIE	BLUE CROSS BLUE SHIELD SOU	0.00
1167	6/4/2008	Failed Rules	1012	GEPPI, NICOLE	CINQUEGRANA, JACKIE	AETNA MEDICAL	60.00
1178	6/9/2008	Failed Rules	1012	GEPPI, NICOLE	CINQUEGRANA, JACKIE	AETNA MEDICAL	60.00
1291	4/22/2008	Failed Rules	1009	GOETZ, MADDOE	HANKS, THOMAS	MEDICARE OF ANY STATE	0.00
1326	6/6/2008	Failed Rules	1020	,, dhris	FLINTSTON, FREDRICK	MEDICAID	0.00
1411	7/24/2008	Failed Rules	1012	GEPPI, NICOLE	CINQUEGRANA, JACKIE	AETNA MEDICAL	55.00
1443	8/18/2008	Failed Rules	007	BOND, JAMES	FLINTSTON, FREDRICK	BLUE CROSS BLUE SHIELD SOU	0.00
1452	8/20/2008	Failed Rules	007	BOND, JAMES	FLINTSTON, FREDRICK	BLUE CROSS BLUE SHIELD SOU	60.00
1485	9/2/2008	Failed Rules	1013	ELGORT, BETH	HANKS, THOMAS		50.00
1520	9/19/2008	Ready to Post	1009	GOETZ, MADDOE	HANKS, THOMAS		60.00
1544	6/11/2008	Failed Rules	007	BOND, JAMES	FLINTSTON, FREDRICK	BLUE CROSS BLUE SHIELD SOU	0.00
1555	10/8/2008	Failed Rules	1008	Ross, Sherri L	HANKS, THOMAS	AETNA MEDICAL	150.00
1632	11/12/2008	User Review	1008	Ross, Sherri L	HANKS, THOMAS	AETNA MEDICAL	115.00
1731	12/19/2008	User Review	1022	SMITH, SOPHIA	GREEN, SARA		0.00
1748	1/7/2009	Ready to Post	09	HOLMES, JENNIFER	BARKIN, ELLEN	BLUE CROSS BLUE SHIELD	135.00
							\$56,584.00

Blockchain in Healthcare research is growing but identity management remains unexplored



Austin Blockchain Pilot for homeless population

THE WALL STREET JOURNAL.

U.S. Edition | October 21, 2018 | Today's Paper | Video

Home World U.S. Politics Economy **Business** Tech Markets Opinion Life & Arts Real Estate

BUSINESS | JOURNAL REPORTS: TECHNOLOGY

Homeless People May Get Help From Blockchain

Lack of ID often prevents them from getting support services they need. A pilot project aims to remedy that.



New Dell Medical School study hopes to make health records more accessible, portable

by Fred Cantú | Thursday, March 1st 2018



May 16, 2018

AUSTIN, TEXAS TO DEVELOP BLOCKCHAIN-BASED ID FOR HOMELESS WITH BLOOMBERG GRANT

gt MAGAZINE NEWSLETTERS EVENTS PAPERS TOPICS GOVTECH BIZ
government technology

EMERGING TECH

Austin Looks to Blockchain-Powered ID Management

For homeless individuals, a secure place to store identification is not always an option, so the city has turned to developing a secure, digital record.

BY DANIEL FISHER, DATA-SMART CITY SOLUTIONS / SEPTEMBER 13, 2018



Persons Experiencing Homelessness in Austin

Persons experiencing homelessness often have many inter-related health, social and economic challenges that make it difficult to end homelessness on their own.



67%

Are unemployed/do not have earned income



62%

Report having no planned activities that bring them happiness or fulfillment



61%

Report going to the hospital or do not go for care at all when they are not feeling well



56%

Report experiencing an emotional, physical, psychological, sexual, or other type of abuse or trauma in their life



44%

Report currently experiencing a mental health problem



42%

Of the homeless population are African American, despite the fact that African Americans only make up 8% of Travis County's population



36%

Report having legal stuff going on that may result in them being locked up or having to pay fines



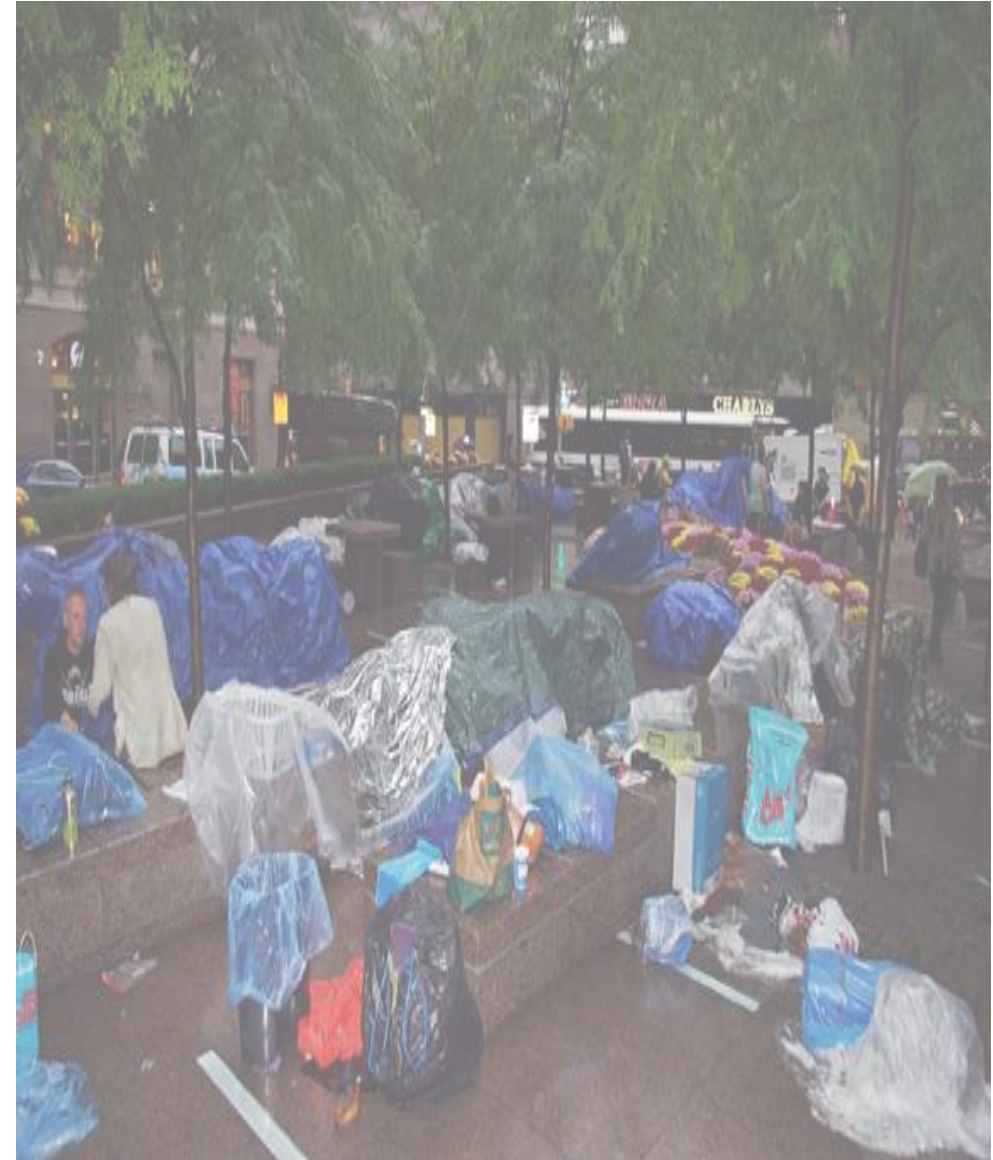
29%

Report having experienced domestic violence in their lifetime

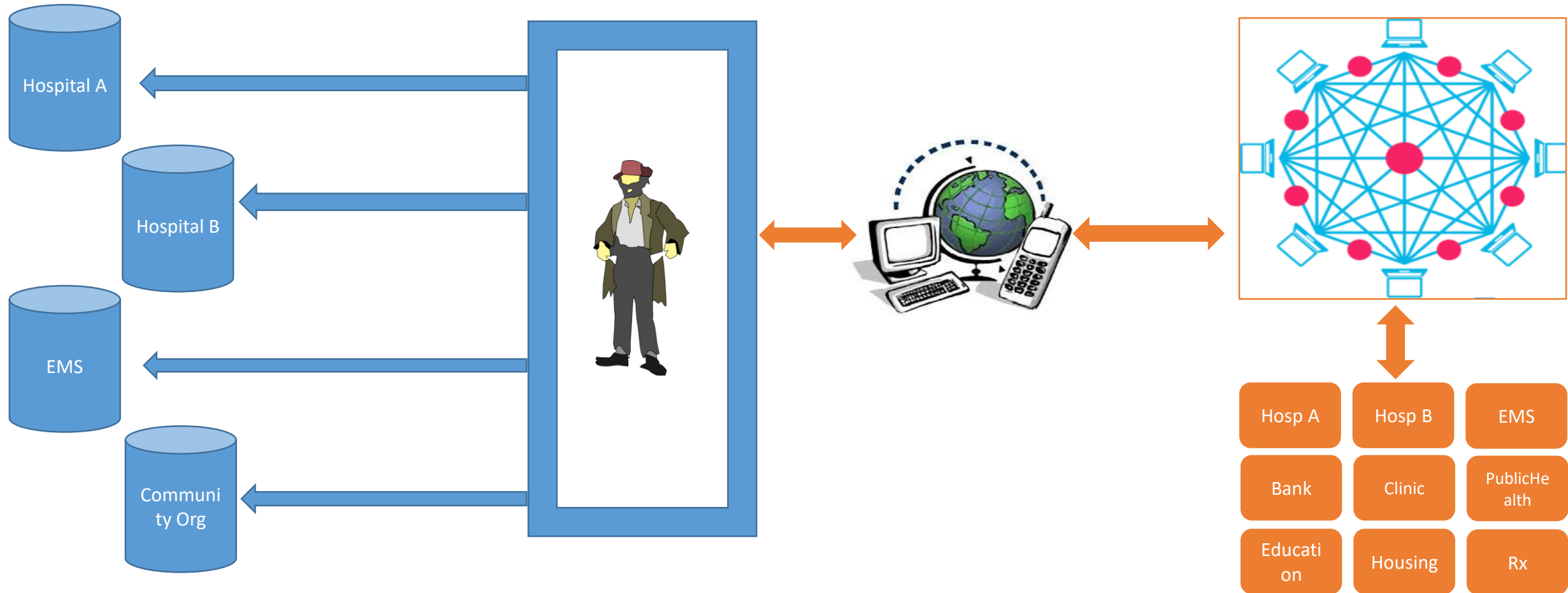


17%

Report consuming drugs and/or alcohol almost everyday or everyday for the past month



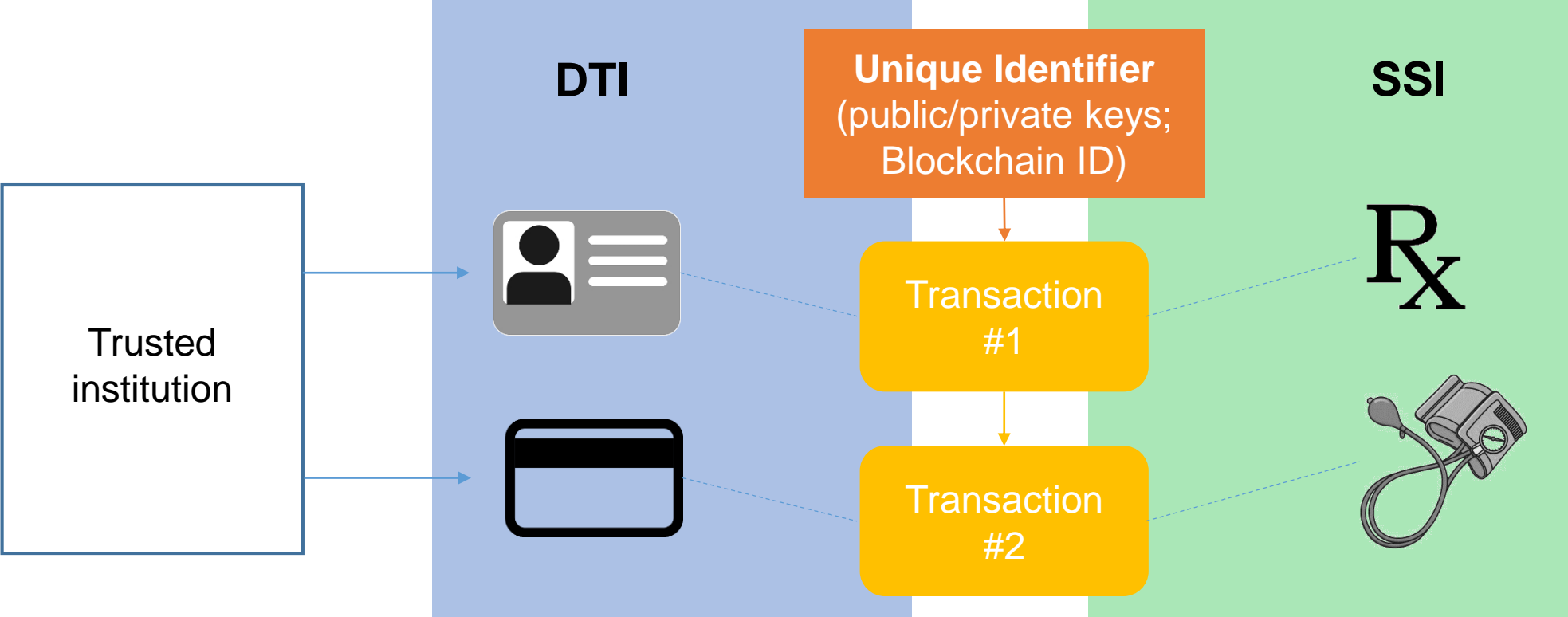
Lack of identity management is a key system failure



Khurshid, Gadnis. JMIRP 2019

Two Approaches toward Blockchain ID management

- 1. **Decentralized Trusted Identity (DTI)** – securely stores information from external, third-party credentials, including government-issued identity cards
- 2. **Self-Sovereign Identity (SSI)** – a user-controlled ledger of transactional identity attributes without reliance on external administrative authority



UT-DMS working with McCombs, ECE, iSchool to simulate identity management process

Project goal:

To make the data sharing patient-centric by:

- 1) managing electronic identity through distributed trust
- 2) giving data-sharing control across various sites to patients.



The University of Texas at Austin
Blockchain Initiative
McCombs School of Business

Call for Research Proposals

Blockchain Initiative at Texas McCombs

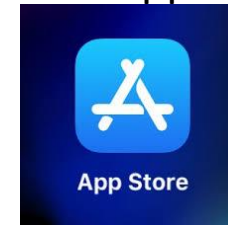
December 2018

Application Layer

Web App



Phone App



- Health-ID System can be accessed by a WebApp or Phone App.
- WebApp developed in React
- Phone apps (iPhone and Android) developed in React Native
- WebApp is a public website on S3

API



- Hyperledger ARIES controls the agents.
- Hyperledger ARIES is the interfaces between agents (Accounts) including messaging.
- Middleware for API access (how the App talks to Indy)

Identity Blockchain

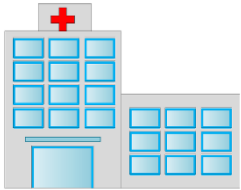


W3C, Verifiable Credentials, Decentralized identifiers

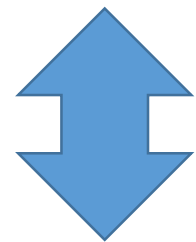
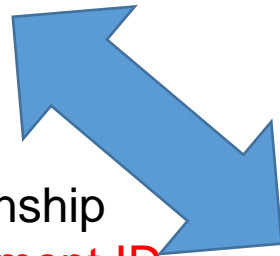
- Hyperledger INDY controls the identity management on the wallet.
- Developed in JSON
- Open ID Connect/Oauth from Amazon service

Healthcare identity management research at UT-DMS

Clinic #1

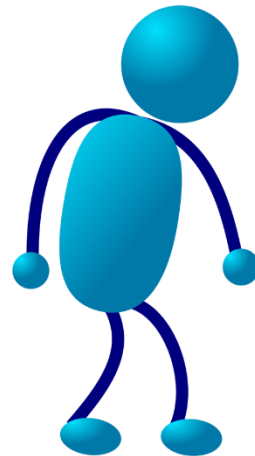


Clinic #2



First pairwise relationship
Verified **with Government ID**

Second pairwise relationship
Verified **with trust**



Blockchain Wallet:

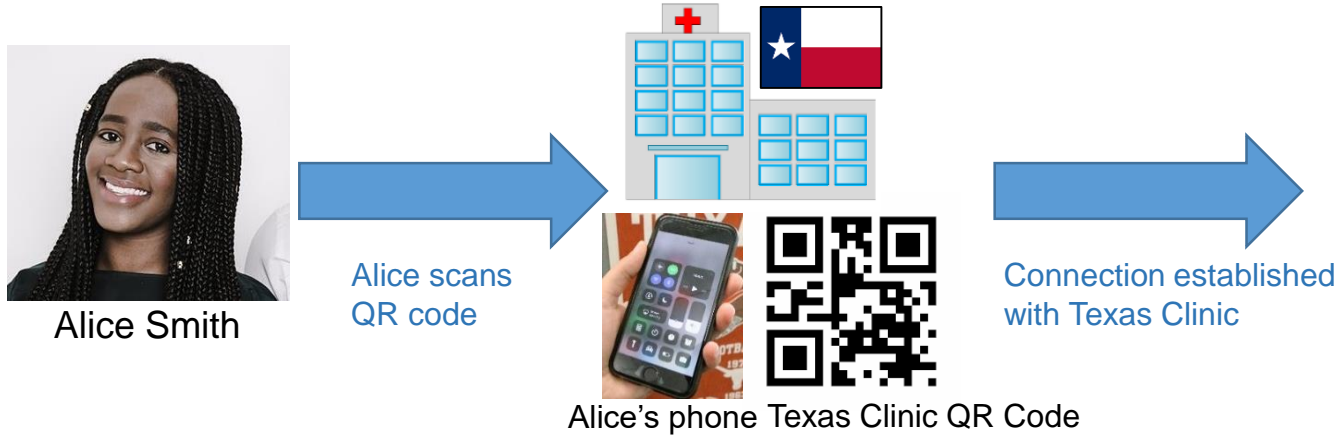
Name
Address
SSN
Email
Phone #
Insurance cards

Clinic #1 credential

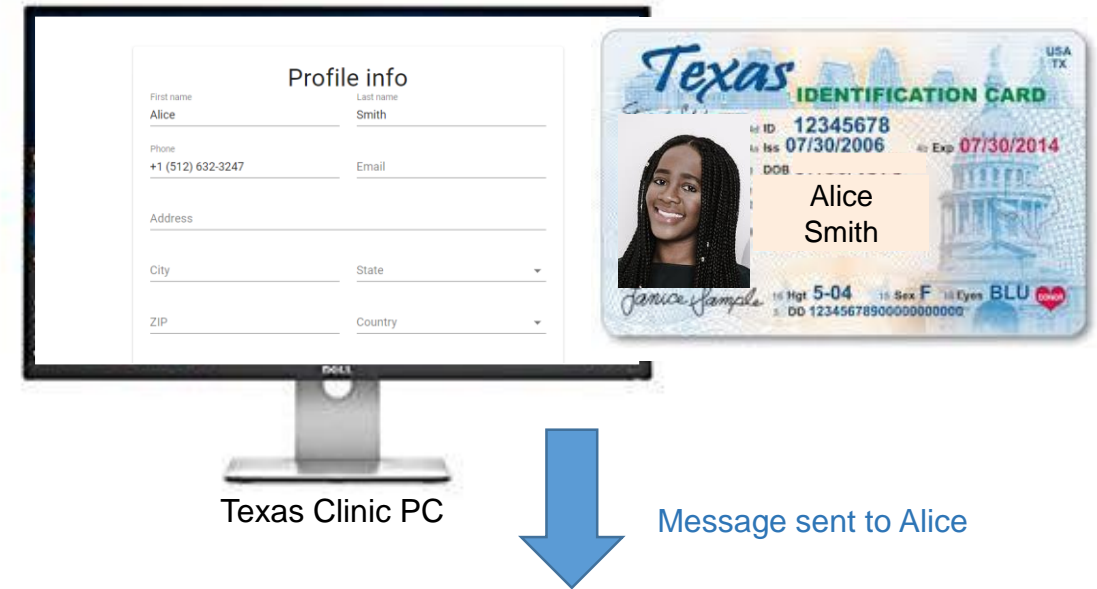
Clinic #2 credential

UT's patient-centric Health ID system using Blockchain

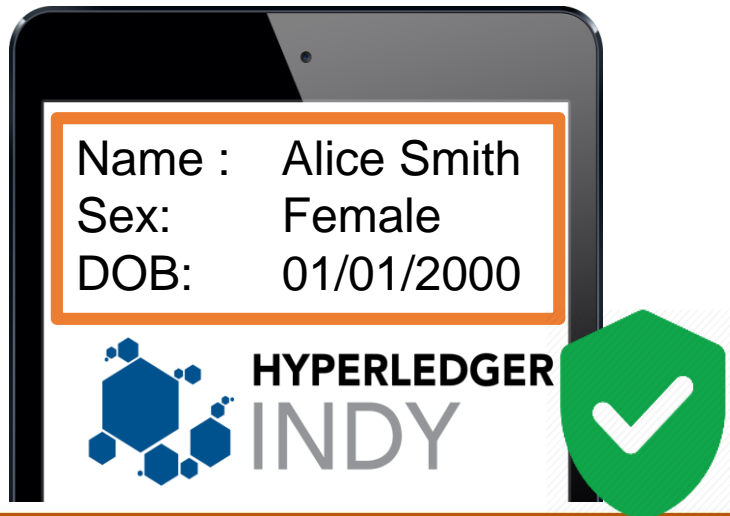
1. Alice enters Texas Clinic



2. Texas Clinic creates Profile based on government-issued ID in Web app



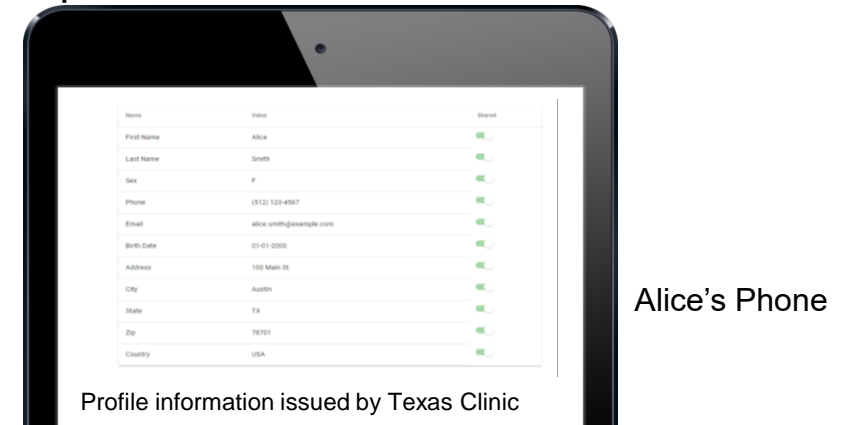
4. Alice's wallet contains sharable profile



Blockchain credential validated

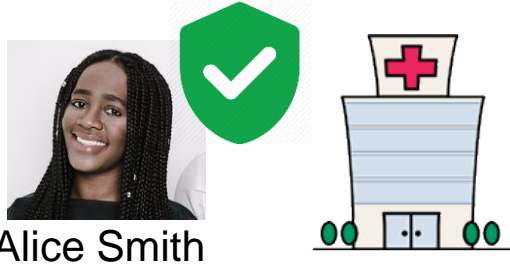
A blue arrow points from the right towards the wallet, with the text 'Blockchain credential validated' below it.

3. Alice accepts Profile from Texas Clinic



Alice shares validated Health ID to enroll at 2nd Clinic

1. Alice enters 2nd Clinic



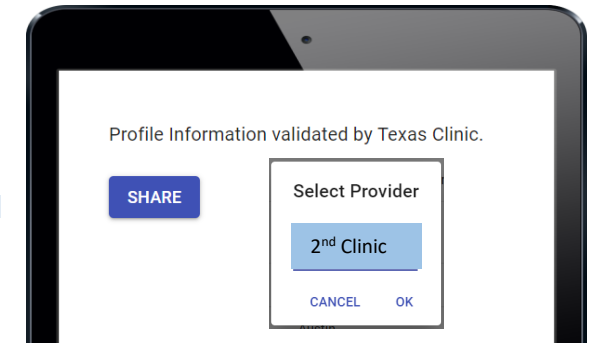
2. Alice scans QR at 2nd Clinic

Alice goes to receptionist desk



3. Alice shares validated profile

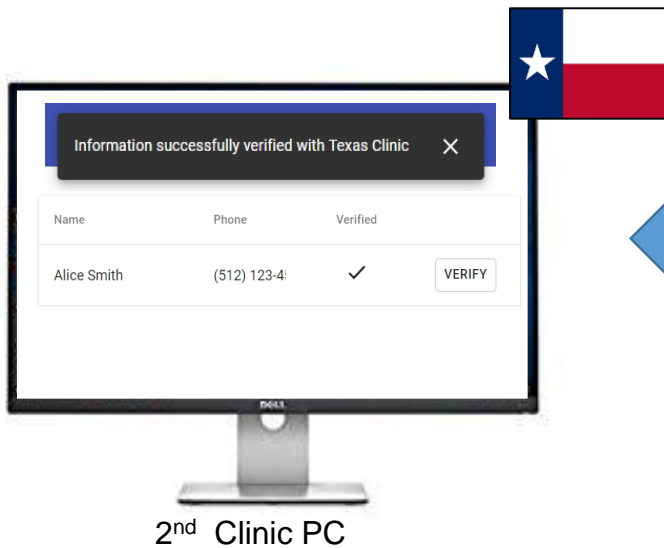
Connection established with 2nd Clinic



Alice's phone

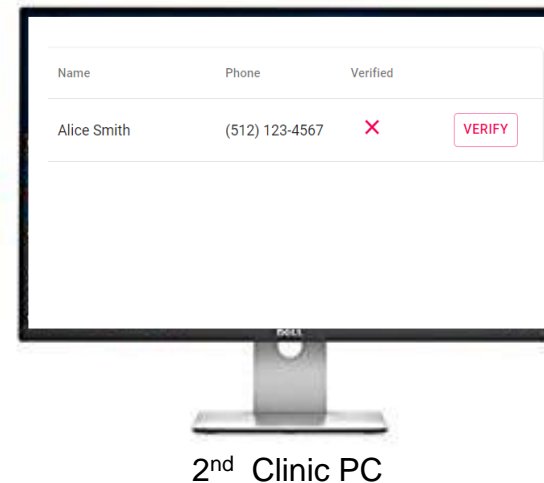
Message sent to Alice

6. Alice's profile verified by Texas Clinic



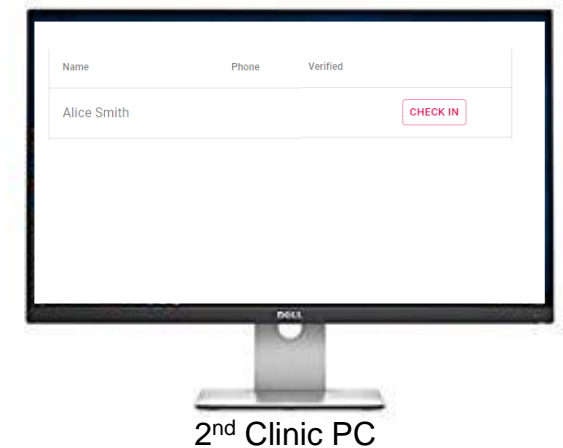
Message sent to Texas Clinic

5. 2nd Clinic cryptographically verifies Health ID



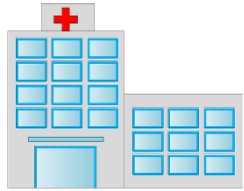
Alice check-ins to clinic

4. Alice's information sent to 2nd Clinic system



Healthcare consent management research at UT-DMS

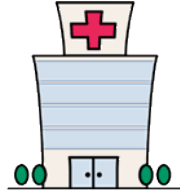
Clinic #1



Data shared



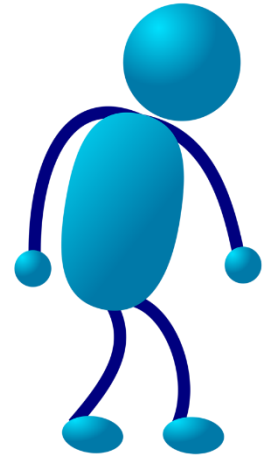
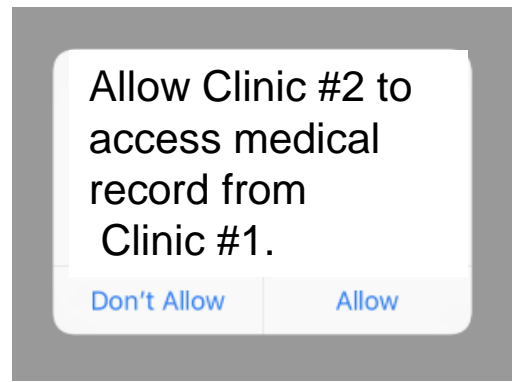
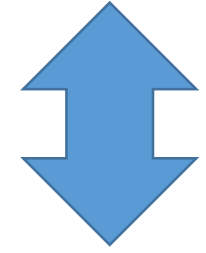
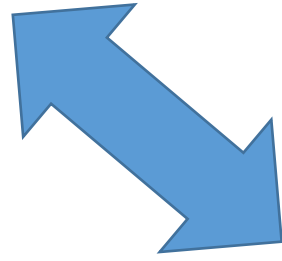
Clinic #2



Data shared



Research Group



Blockchain Wallet:

- Name
- Address
- SSN
- Email
- Phone #
- Insurance cards

Clinic #1 credential

Clinic #2 credential

Research participation

Summary

- Many challenges need to be addressed in making healthcare data available for clinical care, research, and patient engagement
- Blockchain technology provides potential solutions
- Research on blockchain technology applications in healthcare is limited
- Applications of blockchain for identity management, consent, and data sharing may have significant implications on the health of individuals, particularly homeless and underserved
- Our team is working on developing real world applications and evidence to separate hype from reality



Rethink **COMMUNITY**

Rethink **CARE**

Rethink **HEALTH**

Rethink **Everything**

✉ anjum.khurshid@austin.utexas.edu

🐦 [@Akhurshid1](https://twitter.com/Akhurshid1)