FROST & SULLIVAN

Global Blockchain Technology Market in the Healthcare Industry, 2018–2022

Healthcare Industry Assesses Blockchain Potential to Optimize Healthcare Workflows and Improve Outcome-based Care Delivery Models

Global Transformational Health Research Team at Frost & Sullivan

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Contents

Contents (continued)

Contents (continued)

Contents (continued)

Contents (continued)

Contents (continued)

Contents (continued)

Contents (continued)

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Executive Summary

Return to contents

Key Findings

Market Overview

- **Blockchain the New Trust Code for Healthcare:** As the healthcare market struggles to find the trade-off between the risk and reward of going digital, the potential application of Blockchain technology provides a timely solution to mitigate some of its pressing needs around trust and security with digital workflows.
- **Key Growth Opportunities:** Early commercial success, mainly across select use cases such as health professional credentialing, medical billing management, contract adjudication, and track-and-trace use cases, coupled with increasing adoption in select geographies, is helping this market grow at a robust CAGR of 61.4% between 2018 and 2022. For example, application of Blockchain across medical billing/Revenue Cycle Management (RCM).
- RCM and drug supply chain management applications demonstrate the highest cost-saving potential in the next 2 to 3 years, while provider credentialing is being explored as one of the early applications by leading payers and providers in the US market.
- **Technology Convergence Potential:** Blockchain technology provides the much-needed trust, security, and auditability for healthcare data exchange, much needed for complementary technologies' application such as Artificial Intelligence (AI) and Internet of Things (IoT) based data marketplace offerings.

Investment Trends

- About 94 healthcare-focused Blockchain technology vendors have raised a total funding of $808.38 million between 2015 and 2019 (Q1), both by Initial Coin Offering (ICO) and traditional Venture Capital (VC) funding channels. Blockchain vendors offering infrastructure and tech consulting, Personal Health Record (PHR), research and clinical trials, decentralized provider network and payment, virtual/ on-demand care, and health data exchange/ marketplace solutions contributed more than 80% of the funding value in this period.
- US companies (HQ) hold the lion's share in terms of healthcare Blockchain funding. However, with favorable government policies, legal ICOs/crypto regulations, and the innovation culture across countries such as; Estonia, Switzerland, UK, Russia, South Korea, and Singapore have managed to attract some of the biggest Blockchain ICO/funding in the last 2 to 3 years.

Future Implications for Healthcare Industry Stakeholders

- Health insurance payers, providers, and pharma companies are expected to be the early adopters of Blockchain systems compared to other healthcare industry stakeholders. In the next 12 to 18 months, leading health systems and private insurance and pharma organizations will move beyond pilot projects using Blockchain for Business-to-business (B2B) enterprise applications. This will lure early adopters that have waited to finally jump on board, creating the much-needed network effect in the healthcare space.
- In future Distributed Ledger Technology (DLT) will be leveraged on by telehealth vendors and tech giants, such as Apple, Amazon, Google, and Microsoft to monetize data science and analytical services with innovative patient-centric care models.
- To realize the true potential of DLT, the healthcare industry needs to prioritize establishing Blockchain working groups/consortia to promote a collaborative ecosystem for exploring and developing focused use cases and governance standards for future commercial scalability and success.

Source: Frost & Sullivan

Scope and Definition

Scope	
Geographic coverage	Global
Study period	2018–2022
Base year	2018
Forecast period	2019–2022
Monetary unit	US Dollars

- A Blockchain (or DLT) is a new data structure that creates trusted, distributed digital ledgers for assets and other data. It is an immutable record of digital events shared peer to peer between different parties. It can only be updated by consensus of a majority of the participants in the system and, once entered, information is very hard to erase.
- This study aims to decipher whether Blockchain technology application in the healthcare space is hyped or real by analyzing the current vendor landscape, funding trends, and commercial adoption by key healthcare stakeholders globally. As a part of this study, Frost & Sullivan's research team analyzed more than 250 vendors to understand their Blockchain products, solutions, projects, functional and application focus for the healthcare industry. To estimate Blockchain market size and future projection, a global analysis of current commercial deployments, major industry collaboration (consortium/working groups) on pilot projects, and funding trends have been undertaken.
- The main purpose of this study is to analyze and call out key growth opportunities for Blockchain technology's application in the healthcare industry. Frost & Sullivan performed a qualitative factor analysis by evaluating critical attributes to assess the 'Market Readiness' and 'Future Industry Value' for identified growth opportunities in the healthcare space. The study also provides an assessment of emerging Blockchain vendor solutions, commercial partnerships/consortia to watch, and select cases studies for the identified top-5 growth opportunities. Finally, it summarizes key success factors and strategic imperatives for Blockchain commercial deployment consideration in the healthcare space.

Source: Frost & Sullivan

Key Questions This Study Will Answer

1. Why does the healthcare industry need Blockchain technology? How does the Blockchain technology lifecycle and innovation adoption roadmap look like?
2. What are the top-5 use cases within the healthcare that are ripe for innovation and can be transformed using Blockchain technology?
3. What are some of the major commercial deployments and pilot projects globally? What approaches are healthcare industry stakeholders taking to implement relevant use cases?
4. Which are the geographic hotspots and what are the select companies-to-action by major Blockchain use cases in the Healthcare space?
5. How is Blockchain technology poised to drive business and care-delivery model innovation?
6. What are some of the Blockchain commercial deployment considerations and strategic imperatives for success?
7. How big is the Blockchain technology market in healthcare? What are the projections for investment versus revenue payback (breakeven analysis)?

Source: Frost & Sullivan

Blockchain in Healthcare—Top 5 Growth Opportunities by Use Case

Blockchain technology may not be the panacea for healthcare industry challenges, but it holds the potential to save billions of dollars by optimizing current workflows and disintermediating some high-cost gatekeepers.

Blockchain Technology in the Healthcare Industry: Top 5 Growth Opportunities by Use Case, Global, 2018–2022

Use Cases	RCM and Claim Adjudication	Healthcare Provider Credentialing	Drug and Device Supply Chain	PHR and Health Data Exchange	Research and Clinical Trials
Key Benefits	• Optimize the administrative burden with DLT-based transparency and auditability for better claims adjudication process. • Integrate DLTs with smart contracts and AI/ML empower payers and providers with near real-time data to design innovative value-based contracts. • Increase data liquidity to promote decentralized health insurance marketplace.	• Eliminate redundant work, while improving coordination and concurrency of data. • Expedite practitioner on-boarding cycle time and reduce revenue forfeitures for hospitals. • The healthcare professional credentialing marketplace model will be a foundation for the emerging virtual care delivery model, as it enables direct recruitment and remuneration for new pre-credentialed nurses.	• Permissioned Blockchain systems increase the provenance for pharma drug supply chain and reduce counterfeits, ensuring compliance with sterilization regulations. • Integration of DLTs with smart contracts Internet of Things (IoT) will increase quality compliance and visibility for temperature-sensitive biologics drugs' logistics. • DLT-based shared service record will provide 'chain of custody' for medical device lifecycle management.	• DLT-based PHR and longitudinal health records improve clinical care coordination. • It increases patients' control over their health data; provides better data integration and reliability for patient engagement initiatives. • Decentralized health data networks improve data liquidity to empower AI and analytics vendors to digest a large amount of data to further validate and scale up their insight platforms.	• DLT-based source data verification and notarization reduce clinical trial outcome switching, data snooping, and selective reporting. • It provides a secure platform to store and manage consent for patients to share personal health information with researchers. • DLT and smart contract based federated research marketplace enables the trade of R&D assets under research commons.
Impact*	**$100 B–$150 B**	**$3 B–$5 B**	**$80 B–$100 B**	**$15 B–$25 B**	**$20 B–$25 B**

*Impact: Indicates potential cost-saving opportunities with successful deployment of Blockchain across these 5 use cases globally.

Source: Frost & Sullivan

Top 5 Growth Opportunities—Commercial Deployments and Projects

Select examples of current Blockchain technology commercial deployments and major pilot projects across identified top 5 growth opportunities in the healthcare space.

Blockchain Technology in the Healthcare Industry: Top 5 Growth Opportunities by Use Case, Global, 2018–2022

Use Cases	RCM and Claim Adjudication	Healthcare Provider Credentialing	Drug and Device Supply Chain	PHR and Health Data Exchange	Research and Clinical Trials
Select Examples	CHANGE HEALTHCARE; LUMEDIC; Providence St. Joseph Health; INSUREUM; ZIXTO; SK telecom; KB; lifeplanet; HSBlox; carynhealth; aver; procivis	synaptic Health Alliance; OPTUM; United Healthcare; MultiPlan; Humana; Quest Diagnostics; aetna; Ascension; PROFESSIONAL CREDENTIALS EXCHANGE; WellCare; HASHED HEALTH; accenture; National Government Services; SPECTRUM HEALTH; Texas Hospital Association	MediLedger; CHRONICLED; Pfizer; McKESSON; Genentech; abbvie; AmerisourceBergen; PREMIER; modum; SWISS POST; SAP; imi Innovative Medicines Initiative; IEEE; NHS National Services Scotland; Spiritus; Edinburgh Napier University	guardtime; E-TERVIS; guardtime; NHS MyPCR; iAM; MEDIBLOC; 3 of Big 5 Health Systems in South Korea; patientory; KAISER PERMANENTE; CORAL HEALTH; Medicalchain	MELLODDY; janssen; AMGEN; AstraZeneca; astellas; BAYER; Boehringer Ingelheim; MERCK; NOVARTIS; SERVIER; Folding@home; distributed computing; CURECOIN; MEDICCOIN; CONSILX; MEDABLE; REDOX; SYNEXUS
Key Geographies	IBM; Health Utility Network; PNC HEALTHCARE; aetna; Cigna; Anthem; HCSC				

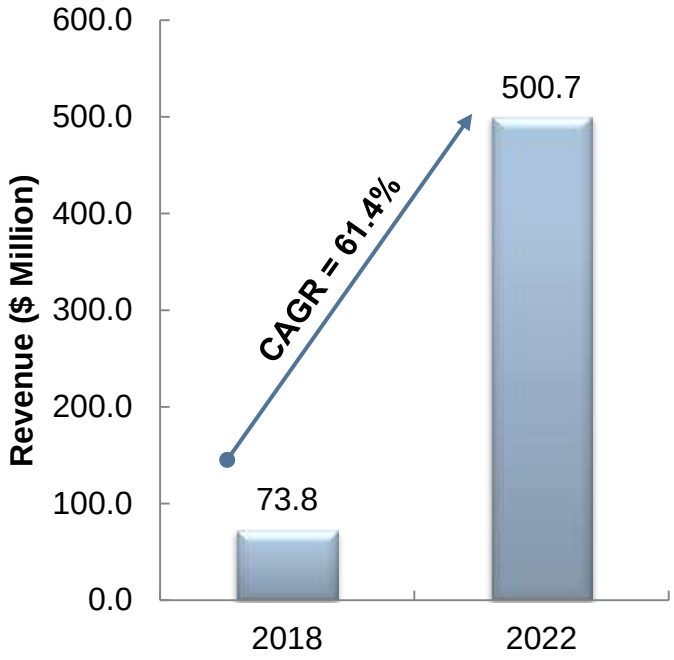
Note: The mentioned companies and collaborations are not exhaustive in nature, but capture some of the major current commercial projects across these use cases. The actual use case focus for the Health Utility Network is still not announced. For more details refer to case studies and vendor profiles in the study.

Source: Frost & Sullivan

Market Overview—Sizing the Blockchain Technology in Healthcare Industry

While relatively immature, Blockchain in healthcare is slowly starting to migrate from pilot Proof of Concept (PoC) to commercial deployments, mainly across select enterprise-level B2B-focused use cases (e.g. credentialing, claim adjudication, supply chain, and so on), and demonstrating initial Return on Investments (ROIs). Health insurance payers, providers, and pharma companies are expected to be the early adopters of Blockchain systems compared to other healthcare stakeholders.

Blockchain Technology in Healthcare: Revenue Forecast Scenario Analysis, Global, 2018–2022



Market Drivers

- **Trusted workflows** minimize current fraud, waste, and abuse plaguing the healthcare industry that cost billions of dollars annually.
- **Decentralized control** promotes disintermediation of high-cost gatekeepers and enables participants on the chain to share the economic benefits from the whole ecosystem without forming a monopoly.
- **Business model innovation** provides new opportunities to improve existing care-delivery workflows and introduce new business models.

Market Restraints

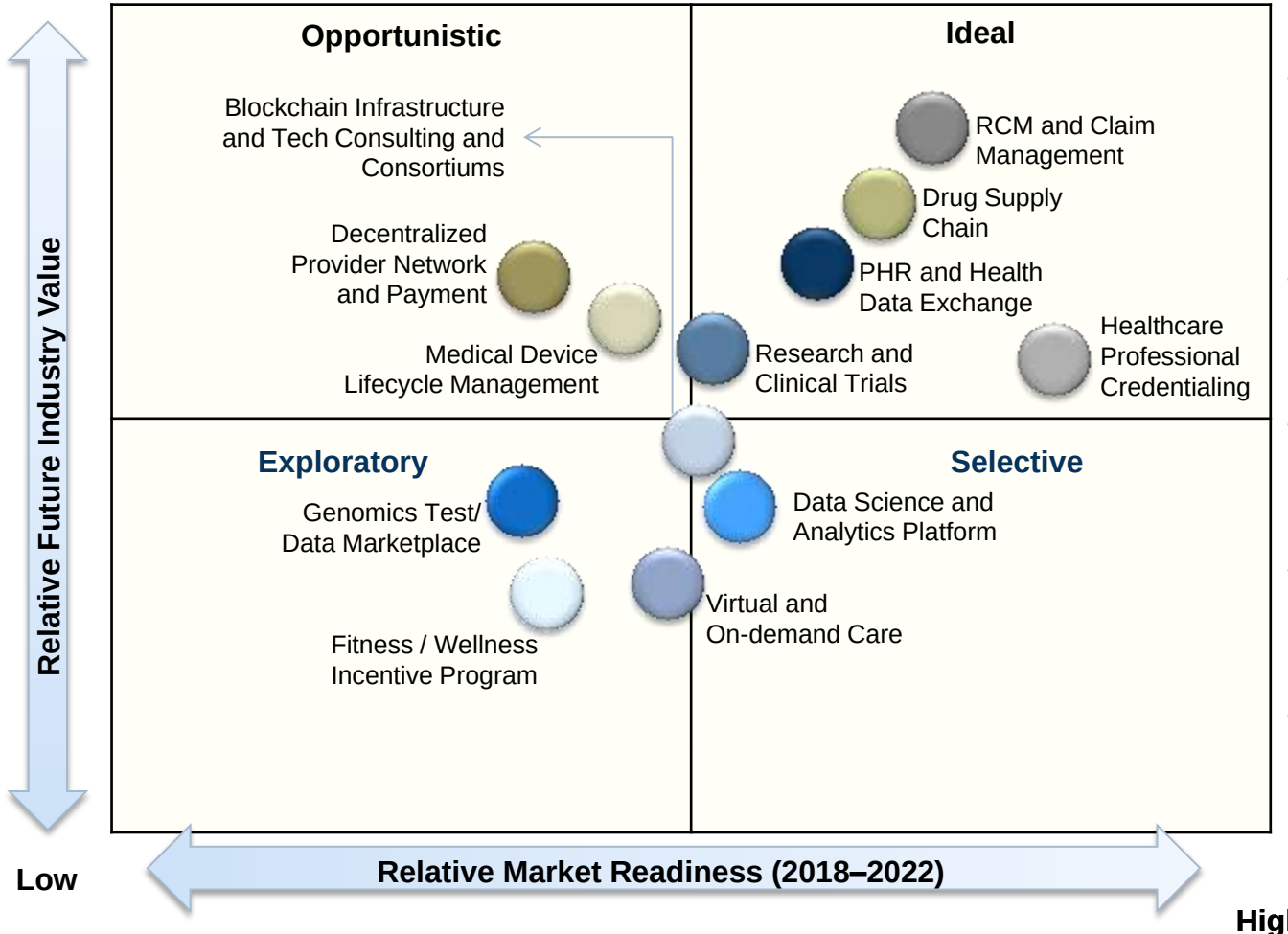
- **Regulatory uncertainty** around cryptocurrency transactions, contract law, and immature legal/policy landscape for DLTs globally may limit large-scale adoption of Blockchain systems, as they are relatively nascent in healthcare.
- **Future scalability of blockchain technology** is a challenge, as verification and validation with DLTs require high computing energy and cannot be scaled for more complex healthcare data.
- **Unproven value with limited commercial deployments** and healthcare industry inertia for new technology are likely to limit the large-scale adoption of Blockchain systems

Note: All figures are rounded. The base year is 2018. Source: Frost & Sullivan

Healthcare Blockchain Opportunity Assessment Framework

What are the top areas in healthcare that are ripe for innovation and that could change healthcare using Blockchain and DLTs?

Blockchain Technology in the Healthcare Industry: Major Use Cases
Opportunity Assessment Framework, Global, 2018–2022



Key: UDI—Unique Device Identity; MDR—Medical Device Regulation

Analyst Perspective:

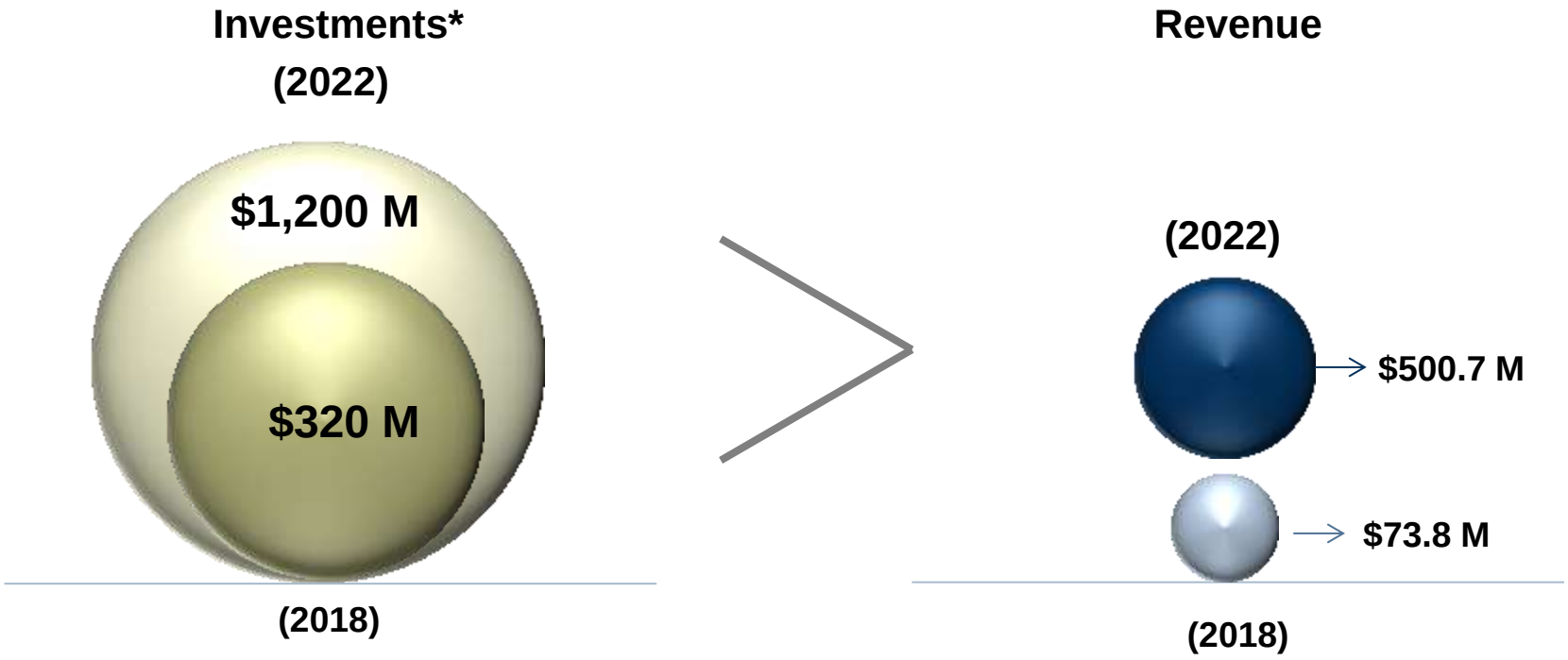
- Provider credentialing is being explored as one of the early applications by leading payers and providers in the US.
- In the near term, auditability around claim adjudication and automation of medical billing activates are the most promising Blockchain applications, especially across developed markets (US and Western EU) with high healthcare spending (more than 10% of GDP).
- PHR is regarded as the holy grail for DLT applications in healthcare, as it offers a fresh approach to healthcare data interoperability by ensuring a trusted and patient-centric data governance approach.
- Blockchain-based chain-of-custody log will help automate track and trace for serialization and geo-tagging process needs, to provide provenance of a pharma drug supply chain and reduce counterfeits.
- Integration of DLTs, smart contracts, and AI/ML will further empower payers and providers to develop innovative contract models that are much needed for value-based reimbursements.
- Unique identifiers for medical devices or assets on Blockchain improve the 'chain of custody' and provenance for effective medical device lifecycle management. This inherently helps medical device manufacturers to efficiently comply with approaching regulatory mandates (e.g., UDI/MDR, cybersecurity).

Source: Frost & Sullivan

Blockchain Technology in Healthcare Industry—Investment Versus Revenue Analysis (Breakeven Analysis)

Key Takeaway: While payback may not be achieved for every dollar invested by 2022, significant momentum will be gathered to achieve a breakeven stage beyond 2022.

Blockchain Technology in the Healthcare Industry: Investments versus Revenue, Global, 2018 and 2022



*The numbers indicate approximate values based on historical finding/investment numbers from 2015-2018 and are subject to change.

Note: All figures are rounded. The base year is 2018. Source: Frost & Sullivan

Introduction and Market Overview

Return to contents

6 Big Themes for Blockchain Technology in Healthcare

Blockchain technology has potential applications in some of the pressing needs of the healthcare industry.

Healthcare Industry Waste, Abuse and Falsification

Trusted workflows to minimize current fraud, waste, and abuse plaguing the healthcare industry and costing billions of dollars annually

Healthcare Business Models

Transform the digital health economy to create new business and monetization models for health asset exchange (e.g., shared/tokenized economy)

Digital Health Inherent Challenges

Distributed network consensus with cryptography techniques to provide an additional layer of trust/security and better framework for data ownership debates

Value-based Care

Trusted workflows with “single source of truth” for radical new possibilities for outcome-based care delivery and reimbursement models

Healthcare Consumerism

Ensures co-creation of trust and self-sovereignty for a patient-centric Blockchain health ecosystem

Precision Medicine Practice

Enables patients to permit access to their anonymized personal health information for research commons and remunerative models

Source: Frost & Sullivan

Mapping Healthcare Industry Challenges to Stakeholders Priorities

Shifting focus from 'What is Blockchain?' to 'Where I Should Invest in Blockchain?'.

Healthcare Industry Challenges

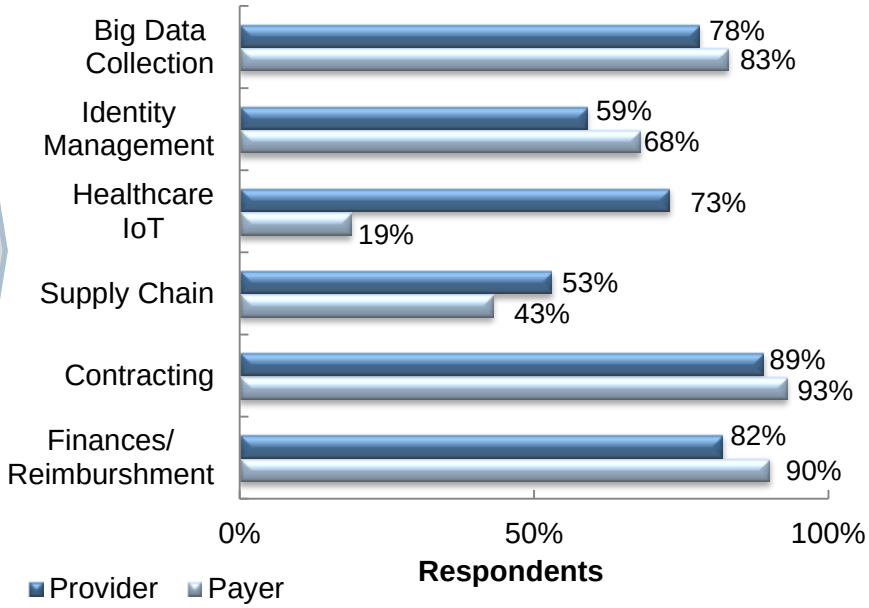
An estimated $455 billion in global healthcare spending is lost every year due to fraud, waste, and abuse.

Challenges	Blockchain Opportunities
Healthcare Frauds	• Medical Billing Frauds • Drug Counterfeiting • Clinical Trial Miss-reporting • Illegal Referrals/Kickbacks • Consumer Deception Fraud
Healthcare Inefficiencies	• Unnecessary Admin Costs • Data Interoperability • Duplication of Efforts • Drug Price Variance
Healthcare Data Privacy	• Cybersecurity • Digital Identity Management • Data Ownership • Data Monetization • Incentivizing Model

Payers and Providers—Priorities

Healthcare payers and providers agree on most plans for deploying Blockchain in the next 12 to 18 months.

Blockchain Technology in the Healthcare Industry: Payers and Providers Priorities, Global, 2017



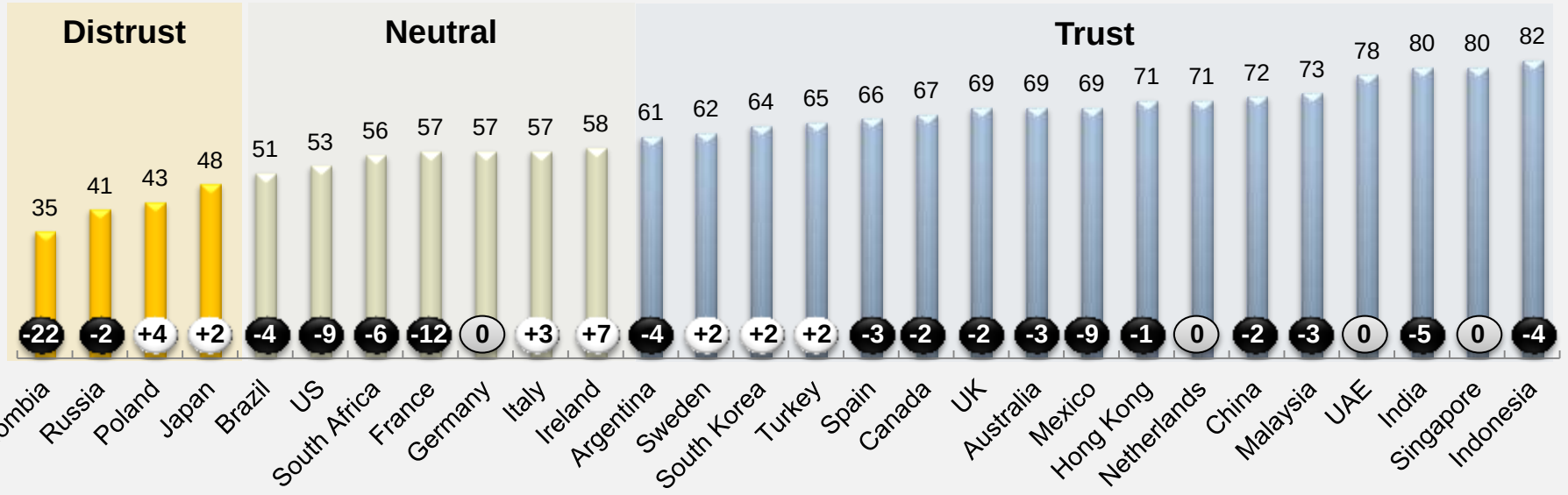
(n)=88 healthcare payers and 276 provider technology executives, managers, and IT specialists.

Source: Black Book Market Research; Frost & Sullivan

Global Healthcare Industry Trust Crisis

Trust in healthcare declined in 17 out of the 28 markets surveyed by Edelman for its 'Trust Barometer'. Additionally, with the advent of digital health concepts, this trust gap is increasing further.

Blockchain Technology in the Healthcare Industry: Healthcare Trust Score for Major Countries, 2018



Source: 2018 2018 Edelman Trust Barometer; Survey Respondents: n= 33,000+ across 28 markets)

3.5 Billion Smartphones (2018)

3.18 Million mHealth apps (2018)

172.2 Million Wearables (2018)

30+ Billion IoT Connected Devices (2020)

Health Data 44 zettabytes (2020)

Source: Frost & Sullivan

Healthcare Digital Transformation—Inherent Challenges and Role of Blockchain?

Blockchain is becoming the new standard for trust and verification of data.

Blockchain Technology in the Healthcare Industry: Healthcare Industry-wide Key Themes and Challenges, Global, 2018–2022

	Health Data Interoperability	Cybersecurity and Digital Identity Management	Value-based Care/ Reimbursement	Data Ownership and Incentivizing Models	Healthcare Consumerism and Patient-centricity
Key Challenges	• Lack of health data interoperability cost **150,000** lives and **$18.6 billion** per year • The goal of a **single trusted platform** to integrate clinical and personal health data for complex analytics has not been reached.	• Healthcare data worth **10 times the price** of credit card data in black market • Global healthcare cybersecurity market expected to cross **$10 billion** mark by **2022**	• Medical billing frauds contribute **5%–10%** of the healthcare cost • WHO estimates **counterfeit drugs** market up to **$200bn** globally.	• **8 out of 10 patients** do not know who has access to their health information • Global healthcare Big Data and analytics market will be $**7.50 billion** by **2020**	**A majority** of consumers track their **health symptoms** and appreciate receiving customized alerts/news feeds post care.
Role of Blockchain	• Access to historic and real-time patient data on Blockchain • Identity management with predefined user access rules for Peer-to-peer (P2P) networking • Store genomics and user-generated data securely, with access control • Maintain universal health records and identities	• Encryption and permanent ledger of patient-generated health data • Medical device data integration and security to enable remote/home care • Unique identifiers for medical on shared ledger system to automate maintenance and management	• Automate claim processing and reduce admin costs • Automate underwriting and policy insurance • Improve claimant and beneficiary KYC • Drug supply chain provenance at individual product/drug level • Improve pharma supply chain finance	• Secure and selective access to patient-generated health data • Share anonymized personal health data under research commons and genomic data marketplace models • Directly participate in medication adherence and loyalty programs to avail incentives	• Increases patients' control over their health data to improve engagement across initiatives • Pay for outcomes and incentive-based behavioral health programs, leveraging on smart contracting features

Source: Frost & Sullivan

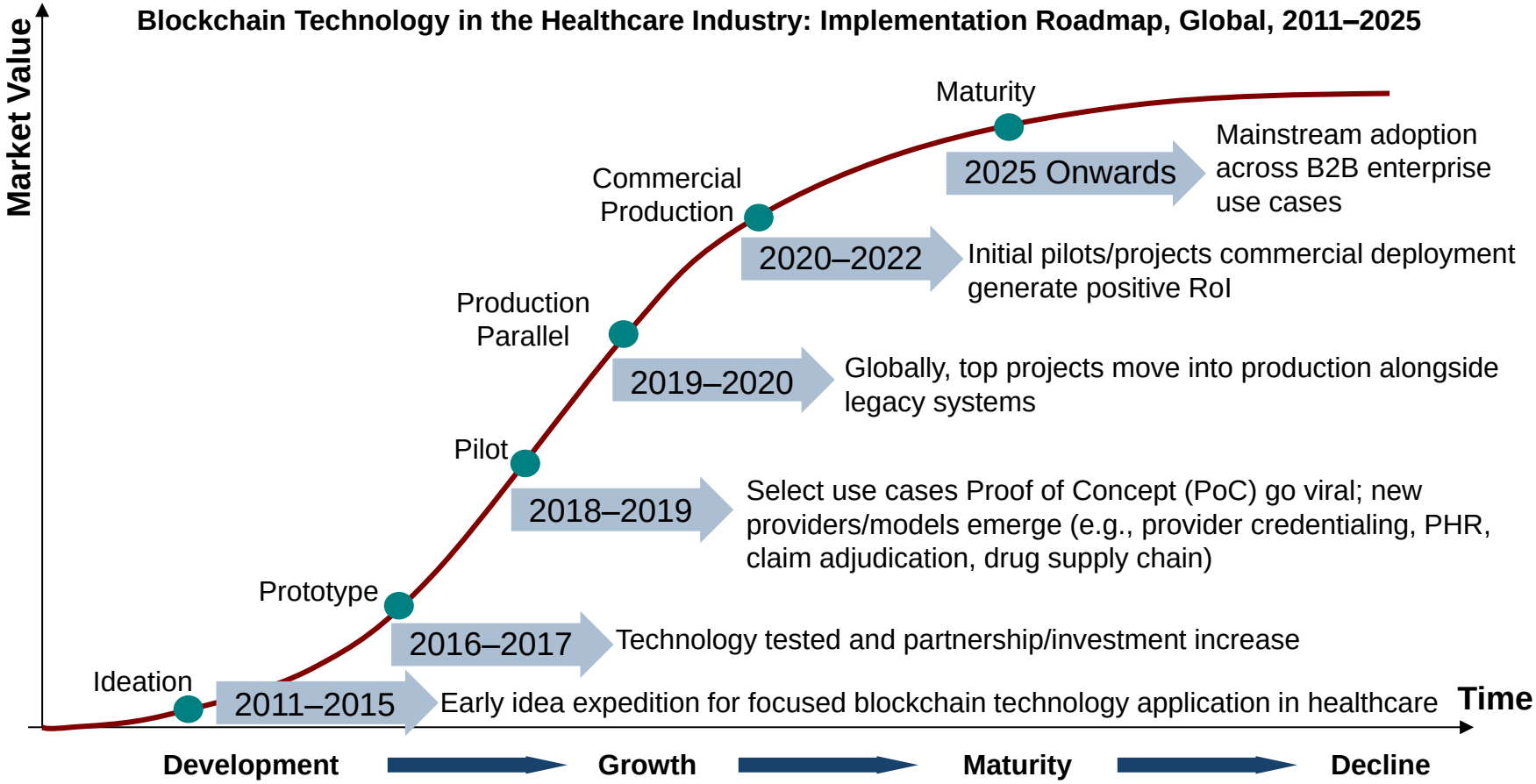
Blockchain and DLTs Journey in Healthcare Space

Return to contents

Blockchain Technology Implementation Roadmap in Healthcare Industry

Analyst Perspective: In the next 12–18 months, leading health systems and private insurance and pharma organizations will move beyond pilot projects using Blockchain for B2B enterprise applications. This will lure early adopters who have waited to finally jump on board, creating the much-needed network effect in the healthcare space.

Blockchain Technology in the Healthcare Industry: Implementation Roadmap, Global, 2011–2025



Source: Frost & Sullivan

Adoption Timeline—Blockchain Technology for Select Healthcare Applications/Use Cases

Blockchain Technology in the Healthcare Industry: Adoption Timeline by Major Use Cases, Global, 2018–2022

ACTIVATION (Efficiency Gainer)	ADOPTION (Network Effect)	BROADER APPLICATIONS (Convergence –Tech/BM)
Immediate	Short-term Future	Long-term Future
Digital Identity Verification/ Management (PHR/NHR)	Blockchain Consortium/ Working Groups	Blockchain-as-a-Service (On/Off Blockchain Computing)
Claims Adjudication and Billing Management (RCM)	Health Data Exchange and Analytics Platform (dApps)	Med Device/Internet of Medical Things (IoMT) Security (Quantified-self)
Professional Credentialing (Provider Directories)	Decentralized Provider Network (Telehealth/On-Demand Healthcare)	Blockchain + AI (ML/NLP) Applications
Drug Supply Chain Provenance (Counterfeiting and Theft)	Health Token Marketplace (Research/wellness incentives)	Blockchain-based Wellness, Personal Coaching (mHealth)
Research and Clinical Trials (e-Consenting, Notarization)	Healthcare Big Data Marketplace (Genomic Data Marketplace)	Universal Health Records and Identities
	IP/R&D Asset Marketplace (Pharma Licensing, Crowdsourcing)	Health Policy Voting
		Blockchain-based Learning Health Systems and Advocates

Key: Certainty of Adoption

High | Medium | Low

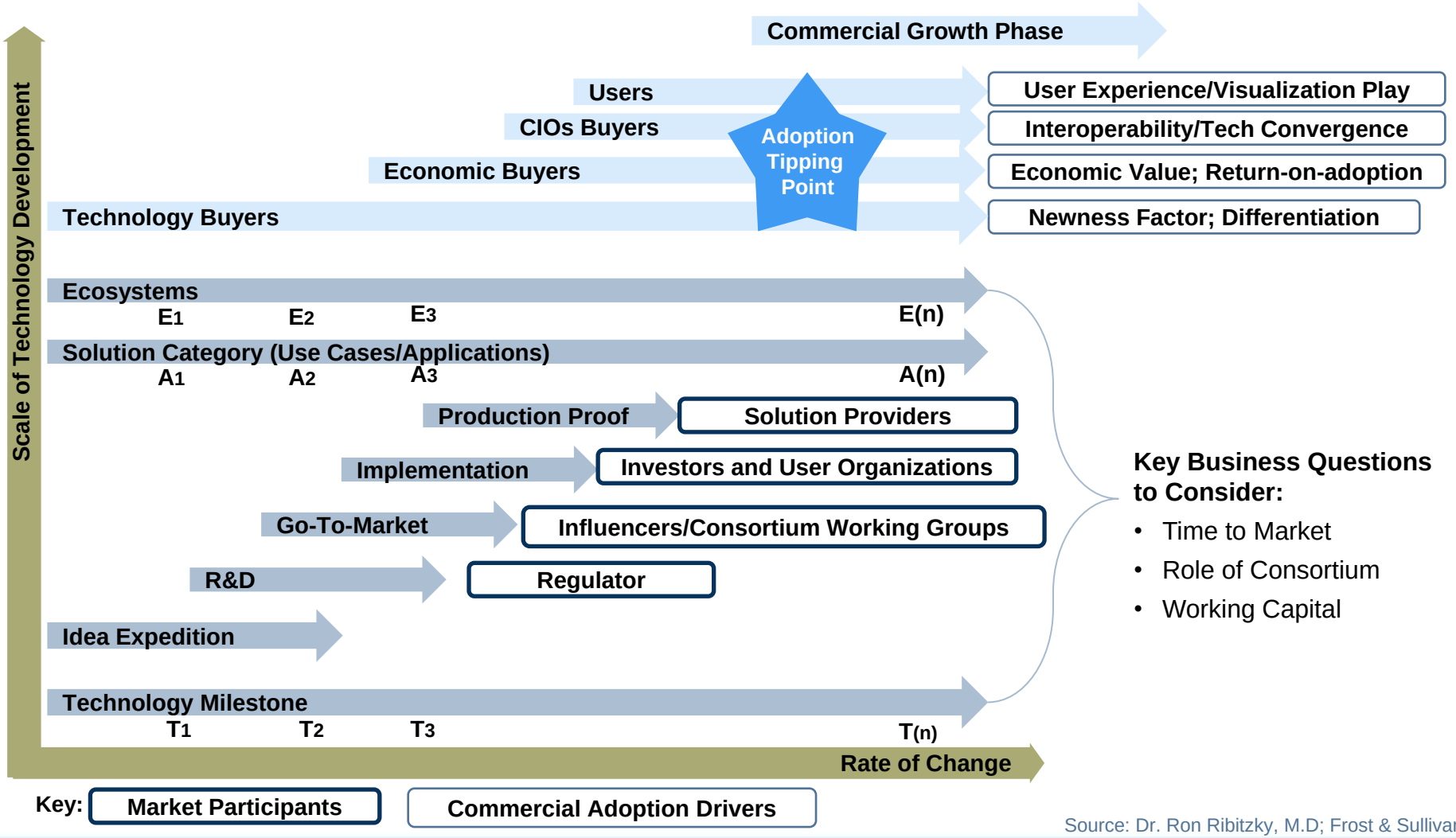
Note: Blockchain system adoption across these healthcare use cases demonstrates more convincing opportunities, albeit at varying degrees of adoption across countries and health systems.

Source: Frost & Sullivan

Blockchain Technology Life Cycle and Innovation Adoption Roadmap

Analyst Perspective: By the end of 2019, 5%–10% of the healthcare-focused enterprise B2B Blockchain applications will move from the pilot stage to partial/limited commercial availability.

Blockchain Technology in the Healthcare Industry: Innovation Adoption Map, Global, 2018–2022



Key Business Questions to Consider:

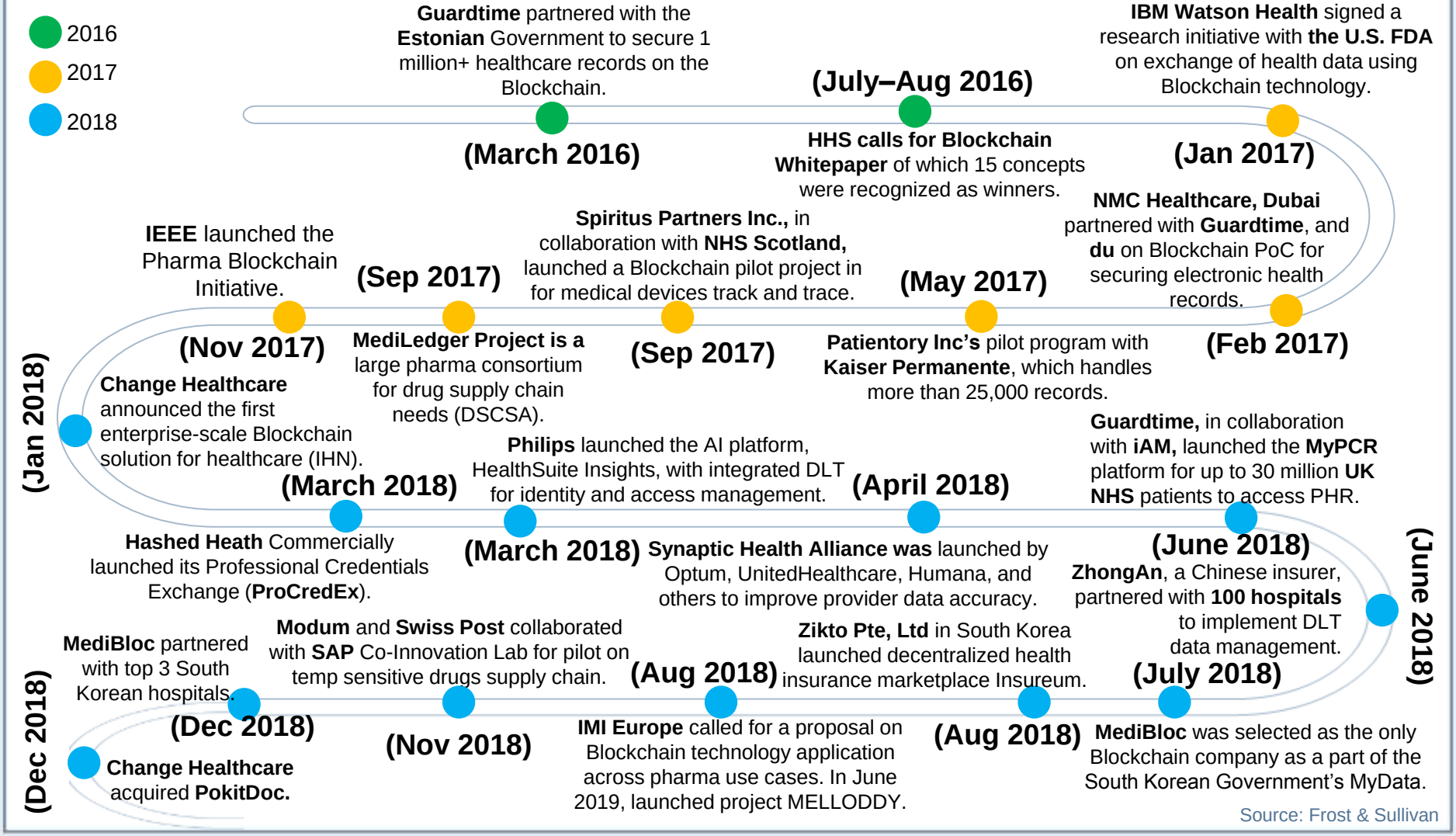
- Time to Market
- Role of Consortium
- Working Capital

Source: Dr. Ron Ribitzky, M.D; Frost & Sullivan

Blockchain Technology Journey in the Healthcare Industry

In the last 5 years, blockchain technology in healthcare has moved from exploratory PoCs to focused commercial deployments; 2018 was a record year for collaboration on healthcare-focused consortia.

Blockchain Technology in the Healthcare Industry: Notable Milestones, Global, 2016–2018



Source: Frost & Sullivan

Evolving Healthcare Blockchain Ecosystem/Use Cases

What are the major applications of Blockchain in healthcare that are being explored by vendors?

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

IBM Bluemix
Microsoft Azure
HEALTHCOMBIX
HSBlox
HYPERLEDGER
DeepMind
healthnexus
CORAL HEALTH
burstIQ
vitalhub

Health Data Access (Universal Records)

guardtime
MEDREC
patientory
mint health
Embleema
IRYO
MEDIBLOC
hearthy
BLOCK M.D.

On-Demand Healthcare (Specialist Network Platform)

MEDICALCHAIN
BitMED
aimedis
well
trusted health.

Pharma Drug Supply Chain and Clinical Trials

iSolve
MediLedger
BLOCKVERIFY
TheLinkLab
CHRONICLED
Peer Ledger
CONSILX
BLOCKPHARMA
INNOPLEXUS

Med Device and IoMT

TIERION
IOTA
Spiritus
NEUROMESH

Identity Management

TRUSTED KEY
guardtime
BRON.TECH
NETKI
accenture

Consortium Tech Partner

HASHED HEALTH
B3i
HYPERLEDGER
DokChain
IMI

Healthcare dApps (Decentralized apps)

patientory
CoinHealth
PointNurse
Bowhead Health
MDSquare
HEALTH wizz
simplyvital health

Claim and RCM

CHANGE HEALTHCARE
HSBlox

Professional Credentialing

PROFESSIONAL CREDENTIALS EXCHANGE
synaptic Health Alliance

Behavioral and Reward Program

DENTACOIN
healthcoin
Genecoin
INSUREUM
DNA.Bits

Genomic Data Marketplace

EncrypGen
YouBase
SHIVOM

Health Analytics

doc.ai
INNOPLEXUS

Note: The list of use cases and vendors are not exhaustive and indicative in nature.

Source: Frost & Sullivan

Major Healthcare Blockchain Consortiums to Watch

Blockchain Technology in the Healthcare Industry: Select Consortiums to Watch, Global, 2018–2019

Consortium Name	Launch Year	Notable Partners	Location (HQ)	Stakeholder Focus	Use Case Focus	Design Pattern	Organizing Force
synaptic Health Alliance	April 2018	Humana, MultiPlan, Optum, Quest Diagnostics, UnitedHealthcare	US	Payers	Provider Directory Data	Data Synchronization	Optum, Humana
PROFESSIONAL CREDENTIALS EXCHANGE	November 2018	Hashed Health, National Government Services, Spectrum Health, WellCare Health Plans, Inc., The Hardenbergh Group	US	Provider, Payer	Practitioner Directory	Asset Exchange	Hashed Health
INSUREUM	June 2019	KB Financial Group, Kyobo Life Planet, SK Planet, AXA, and Asan Medical Center	South Korea	Provider, Payer, 3rd-Party Developer Consumer	Decentralized Insurance Marketplace	Health Data and Asset Exchange	Zitko
MEDIBLOC	December 2018	Seoul St. Mary's Hospital; Seoul National University Hospital; Severance Hospital, Massachusetts General Hospital, US; Kyobo Lifeplanet Insurance Company	South Korea	Provider, Payer	Personal Health Record, Insurance Claim Processing	Health Data and Asset Exchange	MediBloc

Source: https://hashedhealth.com/newsletter-july-2019/; Frost & Sullivan

Major Healthcare Blockchain Consortiums to Watch (continued)

Consortium Name	Launch Year	Notable Partners	Location (HQ)	Stakeholder Focus	Use Case Focus	Design Pattern	Organizing Force
Health Utility Network	June 2019	IBM, PNC Bank, Aetna, Anthem; HCSC; Cigna; Sentara	US	Payer	Not officially announced	Not Officially Announced	IBM
COALESCE HEALTH ALLIANCE	December 2018	NASCO; Express Script	US	Payer	Health Data Exchange	Not Officially Announced	NASCO
REMEDICHAIN	April 2019	Rymed; Temptime/Zebra; Indiana University Health; WakeMed Health & Hospitals; Good Shepherd; Center of Supply Chain Studies; Global Health Policy Institute	US	Pharma	Drug Supply Chain	Multi-business Coordination	Good Shepherd
MediLedger	May 2019	Pfizer Inc.; McKesson Corp; AmerisourceBergen; Corp; Premier; Walmart; AbbVie (US); Roche; SAP, Multichain	US	Pharma	Drug Supply Chain and Chargeback	Multi-business Coordination	Chronicled
Mellody	June 2019	Amgen; Astellas; Bayer; AstraZeneca; Boehringer Ingelheim; GSK; Janssen; Merck KgaA; Novartis; Owkin; NVIDIA; IMI	EU	Pharma	AI for Drug Discovery	Asset Exchange	Owkin and IMI
phuse	April 2018	UCB; Biogen; Medisafe; AstraZeneca; Novartis; J&J	EU		Clinical Trials Patient Data Exchange	Asset Exchange	UCB and Biogen

Source: https://hashedhealth.com/newsletter-july-2019/; Frost & Sullivan

Drivers and Restraints—Blockchain Technology in Healthcare Industry

Return to contents

Market Drivers

Blockchain Technology in the Healthcare Industry: Key Market Drivers, Global, 2019–2022

Drivers	1–2 Years	3–4 Years
Trusted Workflows	H	H
Decentralized Control	H	H
Business Model Innovation	L	M

Impact Ratings: H = High, M = Medium, L = Low

For explanations to drivers, click here

Source: Frost & Sullivan

Market Restraints

Blockchain Technology in the Healthcare Industry: Key Market Restraints, Global, 2019–2022

Restraints	1–2 Years	3–4 Years
Regulatory Uncertainty	H	H
Future Scalability of Blockchain Technology	H	M
Unproven Value with limited commercial deployments	H	M

Impact Ratings: H = High, M = Medium, L = Low

For explanations to restraints, click here

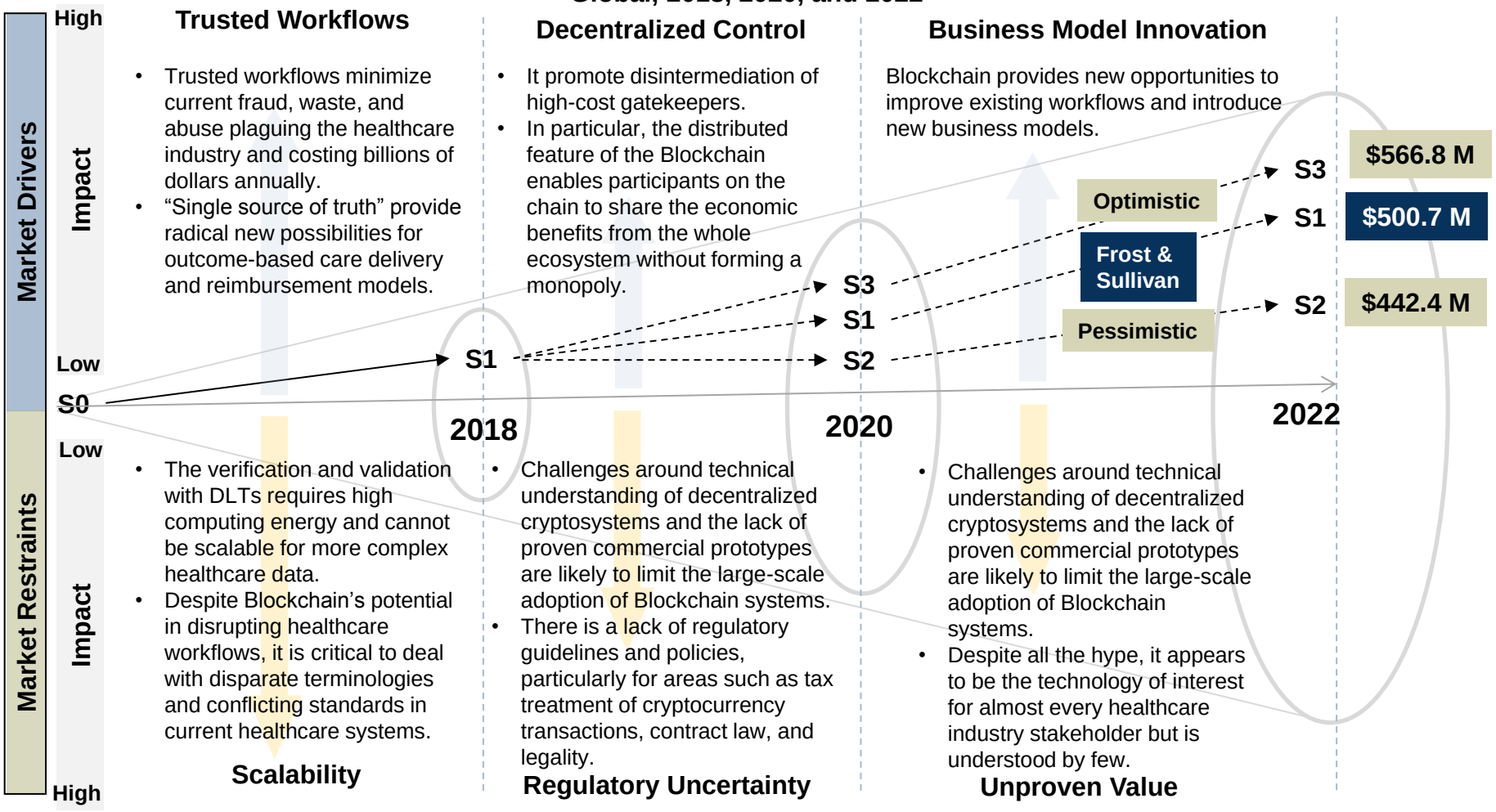
Source: Frost & Sullivan

Growth Environment—Market Forecast

Return to contents

Scenario Contingent Revenue Forecast—2018, 2020, and 2022

Blockchain Technology in the Healthcare Industry: Scenario Contingent Revenue Forecast, Global, 2018, 2020, and 2022

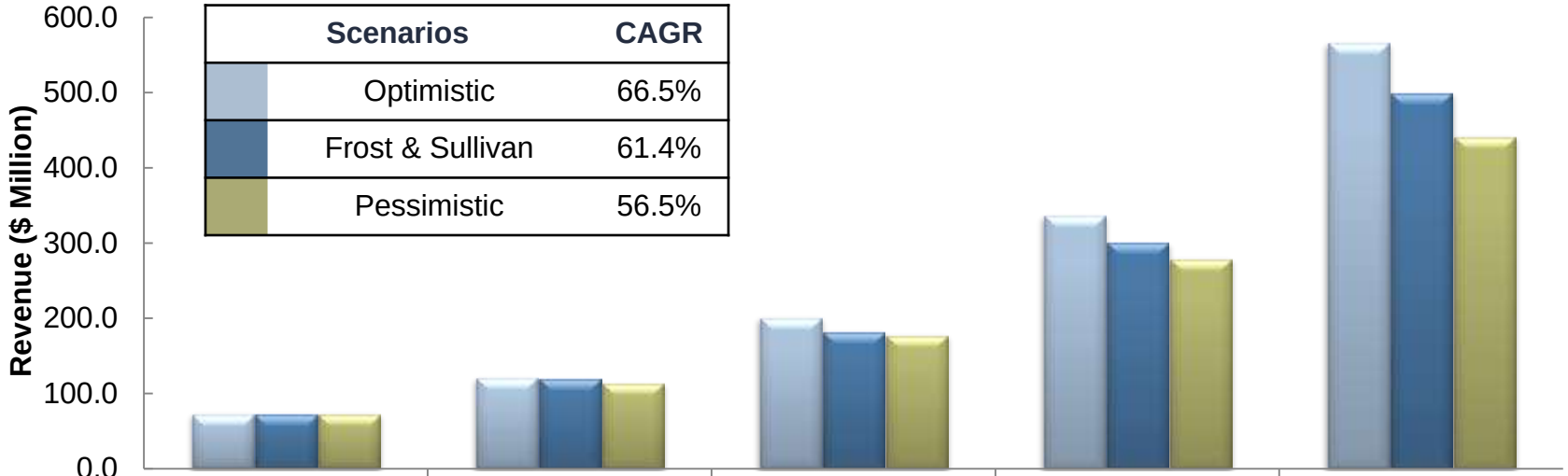


Note: All figures are rounded. The base year is 2018. Source: Frost & Sullivan

Blockchain Technology in Healthcare Industry—Revenue Forecast Scenario Analysis

Key Takeaway: Considering that Blockchain/ DLTs applications are nascent in healthcare space, Frost & Sullivan has taken a contingent scenario based market projection approach. Optimistically, Blockchain technology is anticipated reach $566.8 million by 2020, with successful commercial deployment across payers, providers, and pharma focused use cases, demonstrating early ROI.

Blockchain Technology in the Healthcare Industry: Revenue Forecast Scenario Analysis, Global, 2018–2022



	2018	2019	2020	2021	2022
Optimistic	73.8	121.7	202.0	337.4	566.8
Frost & Sullivan	73.8	120.4	183.0	302.0	500.7
Pessimistic	73.8	114.3	178.4	280.0	442.4

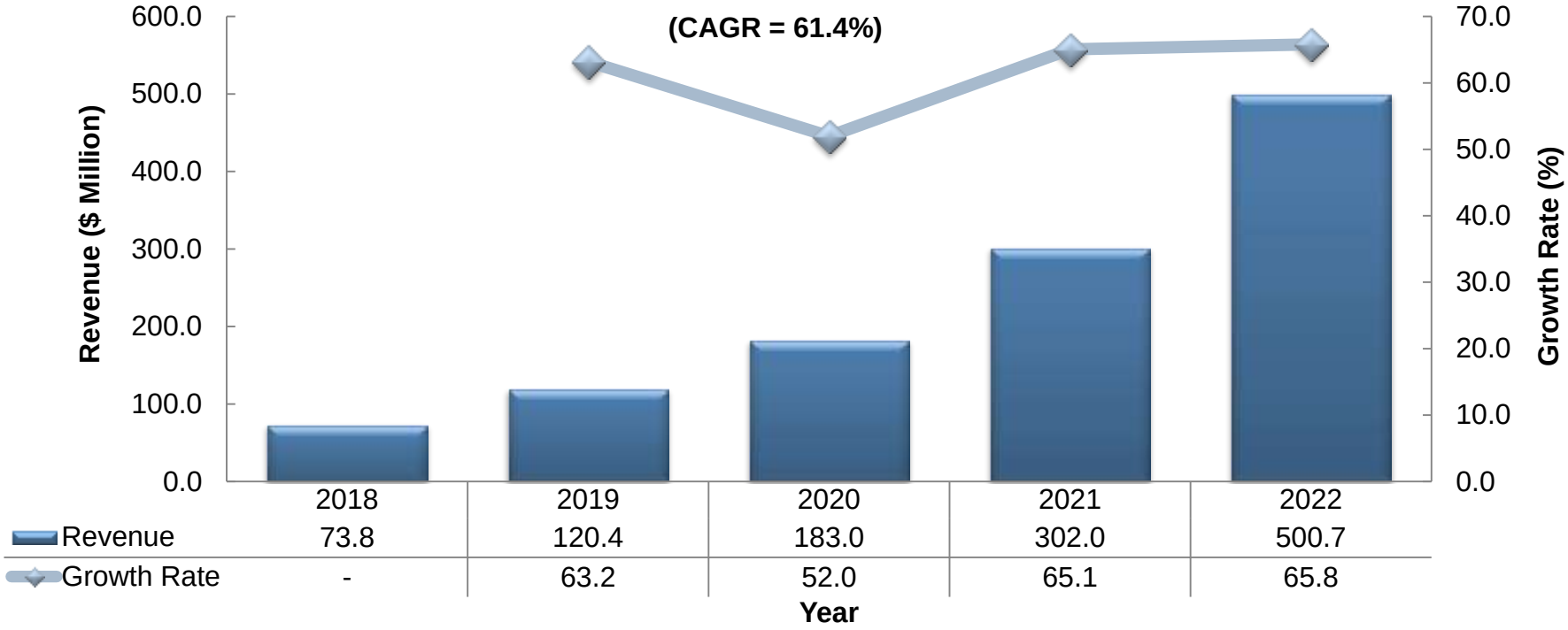
Year

Note: All figures are rounded. The base year is 2018. Source: Frost & Sullivan

Blockchain Technology in Healthcare Industry—Frost & Sullivan Scenario Revenue Forecast

Key Takeaway: Early commercial success, mainly across select use cases, such as health professional credentialing, medical billing management, contract adjudication, and track-and-trace use cases, coupled with increasing adoption in select geographies, is helping this market grow at a robust CAGR of 61.4%.

Blockchain Technology in the Healthcare Industry: Frost & Sullivan Scenario Revenue Forecast, Global, 2018–2022



The market sizing for the based year is based on the analysis of 250+ Blockchain companies globally with healthcare focuses PoCs/MVP/Production ready/soft launch/commercial offerings.

Note: All figures are rounded. The base year is 2018. Source: Frost & Sullivan

Forecast Methodology and Assumptions

Frost & Sullivan projects a base year (2018) market estimate of the global **Blockchain Technology in Healthcare industry** at $73.8 million, with a projection of $500.7 million in 2022; growing at 61.4% CAGR.
The market landscape for Blockchain technology in healthcare is relatively immature and lacks robust industry definitions on market segmentation or proven applications across healthcare industry segments or functions. Also, the vendor landscape for healthcare-focused Blockchain technology or solutions is currently relatively immature and fragmented. For example, based on Frost & Sullivan's analysis of 250 vendors in the healthcare Blockchain space, a large majority (70% to 80%) are still in the PoC and pilot production stage and may not have a commercially available offering.

Research Methodology:

- To mitigate these limitations, Frost & Sullivan undertook a bottom-up research approach, by analyzing 188 vendors' current product and solution lifecycles, along with an analysis of current commercial deployments and industry collaboration (consortia/working groups) globally for focused Blockchain technology solutions and applications for healthcare use cases. This was backed with extensive primary and secondary research to analyze and identify the top functional areas and major growth opportunities by select use cases for Blockchain technology application potential in the healthcare industry. Furthermore, a factor analysis framework is prepared to access identified growth opportunities based on market readiness and future industry value for the market projection period of 2018 to 2022 (refer slides # 47 to 51).

Blockchain Technology in Healthcare Industry Function Focus
Advisory, Development Shops (dev shops), Consortium
Data and Asset Management
Data Science and Analytics
Marketplace
Payments and Claims
Supply Chain Management

Top Blockchain Technology Applications in Healthcare Industry	
Blockchain Infra and Tech Consulting	Research and Clinical Trials
Personal Health Record (PHR)	Decentralized Provider Network & Payment
Genomics Test/Data Marketplace	Data Science and Analytics Platform
Drug Supply Chain	Healthcare Professional Credentialing
RCM and Claim Management	Fitness/Wellness Incentive Program
Medical Device Lifecycle Management	Virtual and On-demand Care

- Additionally, the estimate was validated with existing internal research expertise on the Blockchain technology market in the healthcare space. For forecasting, Frost & Sullivan's in-house market growth estimation model was used which was based on Blockchain technology spend growth drivers and restraints model across identified healthcare applications and use cases. Outcome figures were cross-checked and normalized based on market expectations, such as Blockchain technology adoption trends, potential cost saving opportunities, and last five-year investment trends in the healthcare space.
- The market numbers and forecasts are subject to unforeseen risks such as technological, regulatory, legal, geopolitical uncertainties, and threat of substitutes.

Source: Frost & Sullivan

Revenue Forecast Discussion

Vendor Classification for Market Estimation Consideration: Based on the Blockchain technology/offering lifecycle and company type, the current vendor market can be divided into three broad categories:

- **Pure-play Blockchain Technology Vendors:** This includes core Blockchain technology and advisory companies, such as enterprise Blockchain; Blockchain-as-a-service (BaaS) platform, development shops, consortia, and tech consulting, with niche/main focus on healthcare applications. These vendors generally collaborate with existing healthcare vendors and provider/payer organizations to offer Blockchain technology infrastructure, API development services, technology advisory, and consulting services. Some of these vendor offerings may also compete with healthcare industry B2B enterprise vendors' Blockchain offerings. For most of the commercial-healthcare focused Blockchain vendors, revenues are directly considered for market sizing. For Blockchain vendors beyond healthcare-alone industry focus, a percentage of their current revenue contribution is considered for market sizing. Most of Blockchain vendors at the PoC/pilot production stage do not have commercial offerings but may have revenue streams that are profitable or have not broken even. For such companies, whose revenue information is not available, a standard formula to account for revenue based on average operating expenses and development costs has been considered to account for their revenue contribution toward market estimation.
- **Established Healthcare Industry B2B Enterprise Vendors:** This includes existing healthcare companies with mature products and established provider/payer client networks (e.g., RCM, claim adjudication, billing management, supply chain, HIT systems, and data management solutions), and are currently implementing or exploring Blockchain/DLTs' unique features to optimize operational and process efficiencies with current healthcare digital workflows (B2B/B2B2C). They may either develop an in-house Blockchain application platform or partner with pure-play Blockchain technology vendors. For such companies the ROI of Blockchain is not necessarily from additional or new sources of revenue but more from a value-add service on top of their core offering to differentiate against competition. Some leading vendors include Change Healthcare, SAP, Optum, Philips (HealthSuite), and PNC Healthcare.
- **Emerging Digital Health and Data Vendors:** This generally includes digital health and healthcare data science services start-up companies (e.g., telehealth/telemedicine, teleradiology, mHealth, wearables, genomics data, health digital marketplace, enterprise HIT, healthcare analytics, and healthcare AI) with already commercial products or solutions, or start-ups with Minimal Viable Product (MVP) that are currently implementing or exploring Blockchain/DLTs' unique features as an additional layer for secured and trusted process or data sharing or leverage on the ICO and cryptocurrency payments to created innovative business or care-delivery models. Most of these vendors with emerging digital products and solutions generally charge an additional 5% to 15% on top of the overall price of their core offerings for Blockchain/DLT features. Some examples include MEDIBLOC, aimedis, DNAtix, LifeCODE.ai, doc.ai, Medable, and ConsilX.

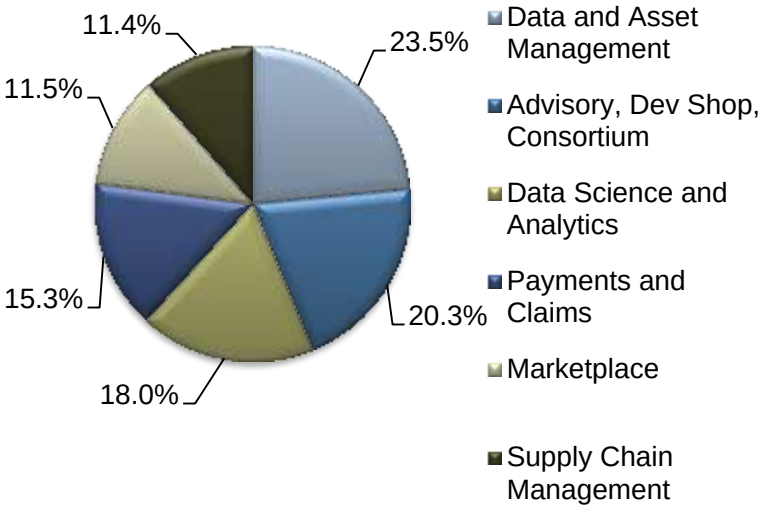
Note: For the purpose of this study open-source Blockchain/DLT protocol vendors and their healthcare-industry specific revenues have not been considered (e.g., Hyperledger Fabric; Ethereum Quorum; Bitcoin; R3 Corda). Also, the revenue for cloud-based BaaS or managed Blockchain service providers (e.g., Microsoft Azure; IBM; AWS Managed Blockchain) has not been considered.

For more details of prevalent revenue models, please click here.

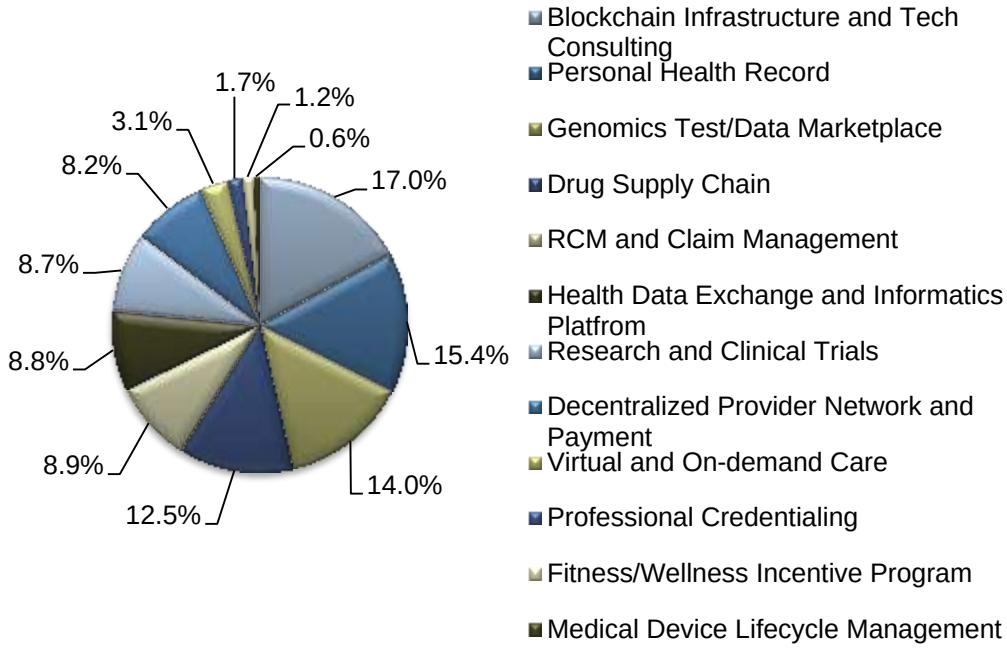
Source: Frost & Sullivan

Blockchain in Healthcare Market Analysis, 2018

Blockchain Technology in the Healthcare Industry: Frost & Sullivan Market Share by Major Functions, Global, 2018



Blockchain Technology in the Healthcare Industry: Frost & Sullivan Market Share by Major Application Types, Global, 2018



Analyst Perspective:

- While relatively immature, Blockchain in healthcare is slowly staring to migrate from pilot PoC to select B2B enterprise functional use cases.
- Healthcare enterprise data management, followed by medical billing and drug supply chain management functions are expected to demonstrate initial ROIs across enterprise-level, B2B-focused Blockchain use cases.

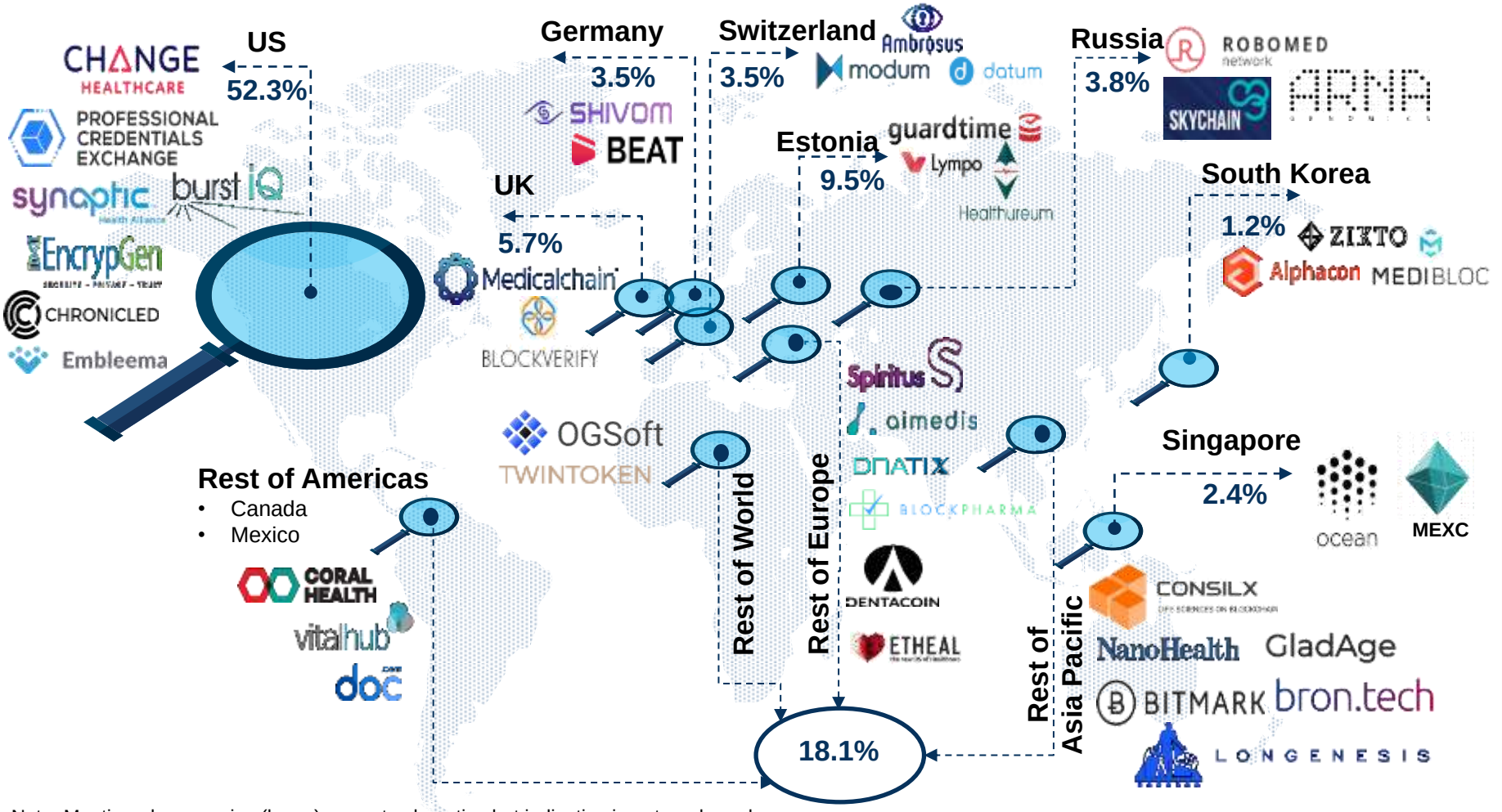
- Globally, Blockchain technology is finding increased adoption for secured and trusted health data transaction applications, where DLT-based PHR is emerging as the foundational application to offer patient-centric health data insights and marketplace applications.
- Application of Blockchain across medical billing/RCM and drug supply chain management applications demonstrate the highest cost saving potential in the next 2 to 3 years. Provider credentialing is the most explored use case in the US market, given the involvement of large provider and payers across current commercial pilot projects and working groups.

Source: www.crunchbase.com; Frost & Sullivan

Blockchain in Healthcare Revenue by Regional Market, 2018

While the US leads in payer- and provider-focused Blockchain applications and collaborations, countries such as Estonia, UK, and South Korea have deployed Blockchain-based PHR and patient identity applications.

Blockchain Technology in the Healthcare Industry: Revenue Market Share by Major Geographic Regions, Global, 2018



Note: Mentioned companies (logos) are not exhaustive but indicative in nature, based on select leading vendors by revenue with commercial Blockchain solutions/pilot projects.

Source: www.crunchbase.com; Frost & Sullivan

Major Regional Market Analysis—Maturity and Major Initiatives

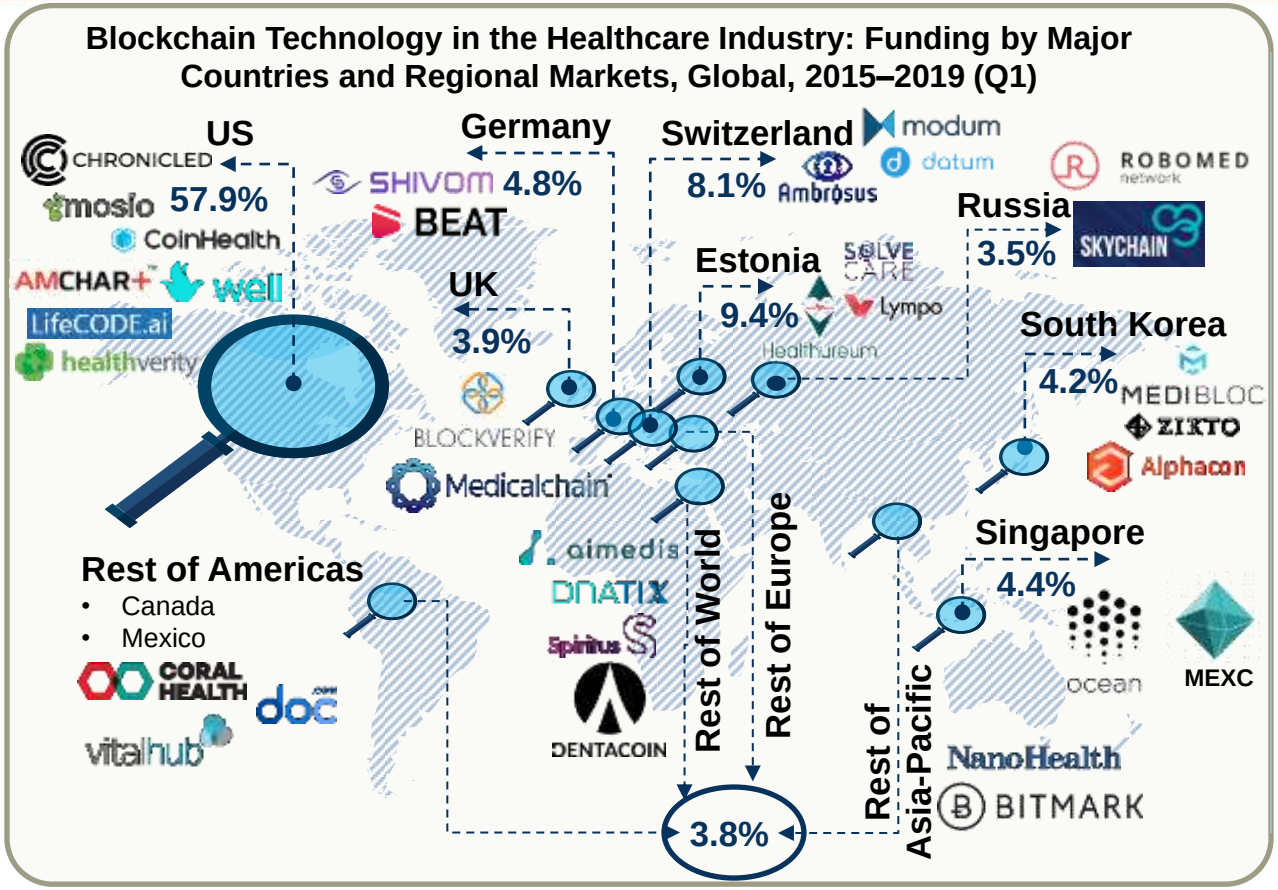
Blockchain Technology in the Healthcare Industry: Major Regional Market Analysis, 2018

Select Countries	Major Use Case Focus	Key Companies to Watch	Analyst Perspective
 **US**	• RCM and Claim Management • Physician Credentialing • Drug Serialization • Research and Clinical Trials • Consortium	Change Healthcare; Hashed Health (Procredex); Synaptic Alliance; MediLedger	• Blockchain technology adoption is relatively high across payer-provider centric B2B enterprise use cases, to promote operational efficiencies. • The US FDA is working closely with leading vendors (e.g., IBM) on pilot projects to explore Blockchain application across health data exchange (EMR), clinical trials, and drug track-and-trace use cases. • Major drug manufacturers and wholesalers are also exploring the Blockchain potential to address approaching drug serialization regulation.
 **Estonia**	• Personal Health Record • RCM and Claim Management • Decentralized Provider Network and Payment	Guardtime; Healthureum; Solve.Care	• In one of the most digitized countries, the Estonian eHealth Foundation works closely with leading local vendor Guardtime, to explore innovative use cases across public health distribution systems. • For example, in collaboration with Guardtime, Estonia is the first country to offer Blockchain-based secure health records to its one million citizens.
 **Switzerland**	• Drug Supply Chain (IoT) • Decentralized Payments • Healthcare ICOs	Ambrosus, modum, Datum Network GmbH	• With a pro-business mindset and favorable regulation, Switzerland is viewed as the global ICO hub. • The country offers a strong vendor base for integrating DLT and IoT applications across the drug supply chain.
 **South Korea**	• Decentralized Health Insurance • Health Data Exchange • Decentralized Provider Network and Payment	Zikto Inc (Insureum); MediBloc	• South Korea is regarded as a major cryptocurrency market, and last year, KMP Health Care Seoul hospital provided the option to pay in cryptocurrency for medical services. • Beyond crypto payments, providers and payers are actively collaborating with innovative Blockchain-based health data platforms and marketplaces to optimize care delivery and payment processes.
 **United Kingdom**	• Personal Health Record • Health Data Exchange • Drug Supply Chain • Medical Device Lifecycle Management	Block Verify; FarmaTrust; Medicalchain SA; Spiritus Partners	• In June 2018, NHS (UK) launched the MyPCR Platform powered by Blockchain technology to provide up to 30 million UK NHS patients with direct access to their primary through the MyPCR smartphone app to effectively manage individual patients' care pathways and medication adherence. • Drug and medical device supply chain are some of the major near-term use case focuses in the UK.

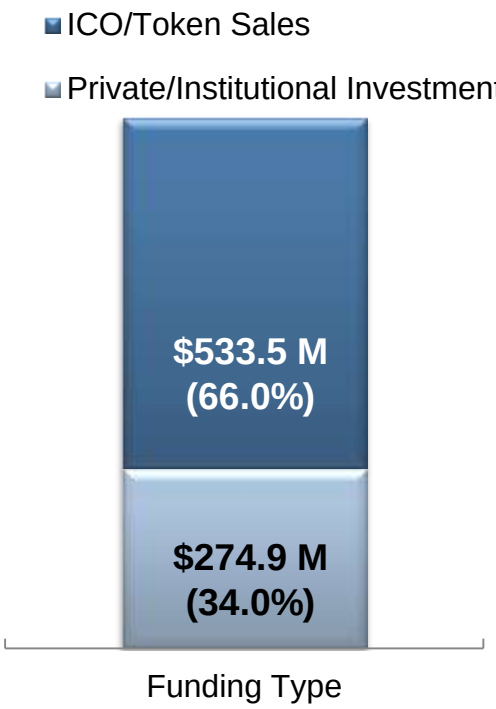
Source: Frost & Sullivan

Blockchain in Healthcare Funding Analysis: 2015–2019 (Q1)

Blockchain Technology in the Healthcare Industry: Funding by Major Countries and Regional Markets, Global, 2015–2019 (Q1)



Blockchain Technology in the Healthcare Industry: Funding Types, Global, 2015–2019(Q1)

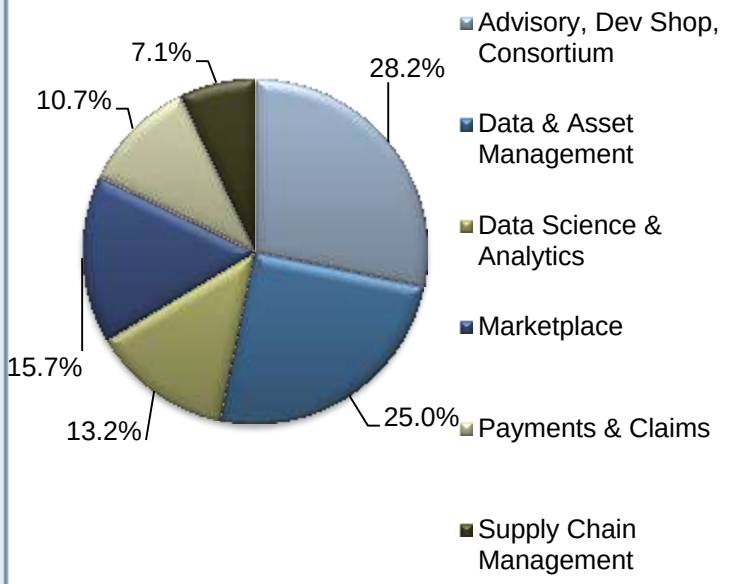


- About 94 healthcare-focused Blockchain technology vendors have raised a total funding of $808.4 million between 2015 and 2019 (Q1), both by ICO and traditional VC funding channels.
- US companies (HQ) hold the lion's share in terms of healthcare Blockchain funding. However, with favorable government policies, legal ICOs/crypto regulations, and innovation culture, countries such as Estonia, Switzerland, the UK, Russia, South Korea, and Singapore, have managed to attract some of the biggest Blockchain ICO/funding in the last 2 to 3 years.

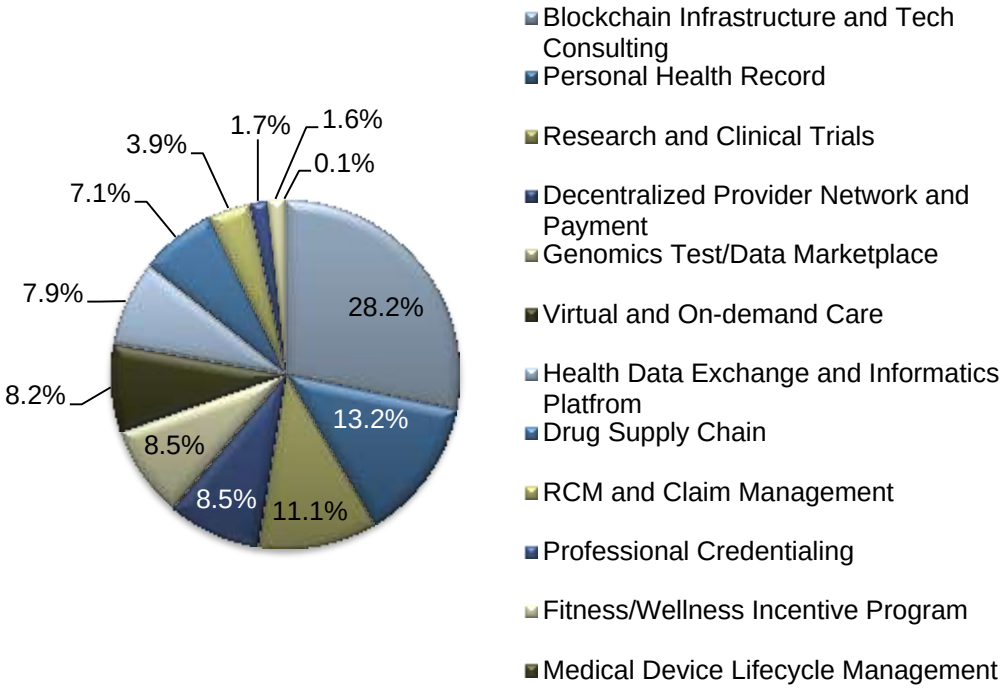
Source: www.crunchbase.com; Frost & Sullivan

Blockchain in Healthcare Funding Analysis: 2015–Q1 2019 (continued)

Blockchain Technology in the Healthcare Industry: Funding by Major Functions, Global, 2015–Q1 2018



Blockchain Technology in the Healthcare Industry: Funding by Major Application Types, Global, 2015–Q1 2019

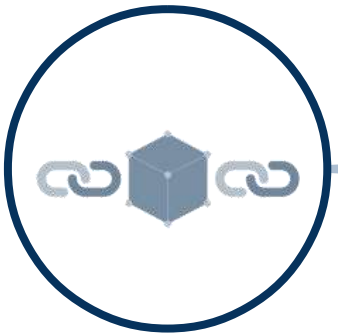


- While ICO remains the major funding source for Blockchain start-ups in the healthcare space, lack of retail protections and regulatory oversight makes it a highly volatile and high-risk option for the investment community, compared to traditional funding options.
- Blockchain vendors offering infrastructure and tech consulting, PHR, and research and clinical trials, and decentralized provider network and payment solutions accounted for more than 60% of the funding value in the given period.

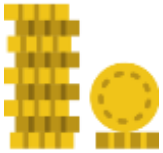
Source: www.crunchbase.com; Frost & Sullivan

Blockchain Solutions Revenue Models in the Healthcare Industry

Blockchain Technology in the Healthcare Industry: Types of Revenue Generators, Global, 2018



Blockchain Revenue



- **Commercial application development:** Developing Applications (dApps), Software Development Kits (SDKs), and other development shop offerings for customers that run on a particular distributed ledger network
- **Consulting:** Providing consulting services to customers seeking to adopt DLT; which can range from ideation and the development of a PoC to a full-production deployment network
- **Enterprise/premium version:** Providing an enterprise version of a free software platform that has additional functionality and enhanced features; maintenance fees: charging for the maintenance of a distributed ledger network codebase
- **Network participation fees:** Charging for granting users access to a particular distributed ledger network
- **Other:** Includes a range of different models that involve, among others, the licensing of proprietary software and the building of partnerships with third-party system integrators

Image Source: Flaticon

Source: Frost & Sullivan

Growth Opportunity Analysis

Return to contents

Blockchain Technology in Healthcare—Major Application Areas

Blockchain Technology in the Healthcare Industry: Major Application Areas, Global, 2018–2022

Functional Areas	Major Use Cases/ Applications	Relevant Healthcare Stakeholders	Analyst Opinion
Payment and Claim	1. Claim Adjudication 2. RCM 3. Value-based Care/Bundle Payment 4. Peer-to-peer insurance 5. Decentralized Payment	Government, Payers, Providers	• In the near term, auditability around claim adjudication and automation of medical billing related activities are the most promising Blockchain applications, especially in the US and Western EU with high healthcare spending (>10% of GDP). • Integration of DLTs, smart contracts, and AI/ML will further empower payers and providers to develop innovation contract models, much needed for value-based reimbursements. • In the mid-long term, decentralized healthcare insurance and payment models are expected to gain prominence by leveraging on DLTs' trusted protocol by accessing individual health data for maintaining a benefits database and promoting consumer-centric insurance programs.
Identity and Data/ Asset Management	1. Personal Health Records (PHR) 2. Provider Credentialing 3. Health Data Exchange 4. eConsenting 5. IP and Asset management	Consumer, Provider, Payer	• PHR is regarded as the holy grail for DLT application in healthcare, as it offers a fresh approach to healthcare data interoperability by ensuring a trusted and patient-centric data governance approach. However, the large-scale commercial deployment of PHR application seems more feasible in European and Asian countries whose data vendor ecosystem is relatively less complex compared to the US market. • Healthcare provider credentialing is a simple, yet profound application of DLTs in the healthcare industry, especially across major health systems where provider credentialing is a fundamental regulatory requirement.
Data Science and Analytics	1. Decentralized Applications (dApps) 2. Telehealth 3. Population Health Management 4. Real World Evidence 5. Data Analytics/Informatics 6. AI in Healthcare	Providers, Suppliers	• DLTs promise to provide the much-needed trust and security for ethical access to individual patient data. For example, dApps, with foundational PHR properties, allow patients to store and share their RWE for population health management. • Blockchain-based decentralized data networks improve data liquidity while empowering AI and analytics vendors/applications to digest a large amount of clinical, operational, and financial data to further validate and scale up their insight platforms. In future DLTs will be leveraged on by telehealth vendors and tech giants, such as Apple, Amazon, Google, and Microsoft, to monetize data science and analytical services with innovative patient-centric business models.

Source: Frost & Sullivan

Blockchain Technology in Healthcare—Major Application Areas (continued)

Functional Areas	Major Use Cases/ Applications	Relevant Healthcare Stakeholders	Analyst Opinion
Healthcare Marketplace	1. Genomics test/data Marketplace 2. Virtual/ On-demand Care 3. Medical Tourism/ Telemedicine 4. Research Commons 5. Drug and Device eCommerce 6. Reward and Incentive Programs 7. Pharma IP & Asset Trading	Provider, Supplier, Consumer, Payer	• Blockchain based decentralized network will create a marketplace for individuals, biobank Direct to Consumer (DTC) test vendors to store, manage, and control access to health data in a secure and trusted environment. • It will enable DTC diagnostic test vendors to securely collect, store, and share sensitive genomic data under crowdsourcing-based research commons and remunerative models, with medical research and clinical trials sponsors. • Telemedicine and virtual care platform providers can leverage on DLT-based cryptocurrency, and smart contracts to effectively monetize user-generated sports and wellness data. • Payers and employers can formulate fitness and wellness reward programs, by adding token-based incentives.
Supply Chain	1. Drug Counterfeiting 2. Serialization and Saleable Return 3. Drug Temperature Control 4. Unique Device Identity Management 5. Device Lifecycle Management 6. Procure-to-Pay	Supplier, Provider	• Immutable hash (#) created on the Blockchain helps in automating serialization and geo-tagging process across production, development, and testing for pharma drug manufacturing facilities. • Maintain immutable historical records of products to detect saleable returns, counterfeit and substandard products and identify the responsible party. • Verifiable source of truth, coupled with IoT sensors, can improve the auditability of temperature-sensitive biologics drugs during transit. • Unique identifiers for medical devices or assets on Blockchain would empower the medical device OEM to provide ‘chain of custody’ and provenance for device lifecycle management.
Tech Advisory, Dev Shops, and Consortium	1. Blockchain-as-a-Service 2. Healthcare Working Groups 3. Healthcare Consortium 4. Enterprise Health IT 5. Tech Consulting 6. Development Shops	Provider, Supplier, Payer	• This includes BaaS models by leading vendors, such as Microsoft (Azure) and IBM, as a part of their cloud-based platform offering for faster development and deployment of desired Blockchain applications. • As Blockchain is a network-dependent technology, healthcare-focused consortia (e.g. Hashed Health) and working groups (Synaptic, MediLedger) will be foundational for future commercial scalability and governance framework.

Source: Frost & Sullivan

Healthcare Blockchain Opportunity Assessment Framework

What are the top areas in healthcare that are ripe for innovation and that could change healthcare using Blockchain and DLTs?

Blockchain Technology in the Healthcare Industry: Major Use Cases
Opportunity Assessment Framework, Global, 2018–2022

Research Methodology Discussion

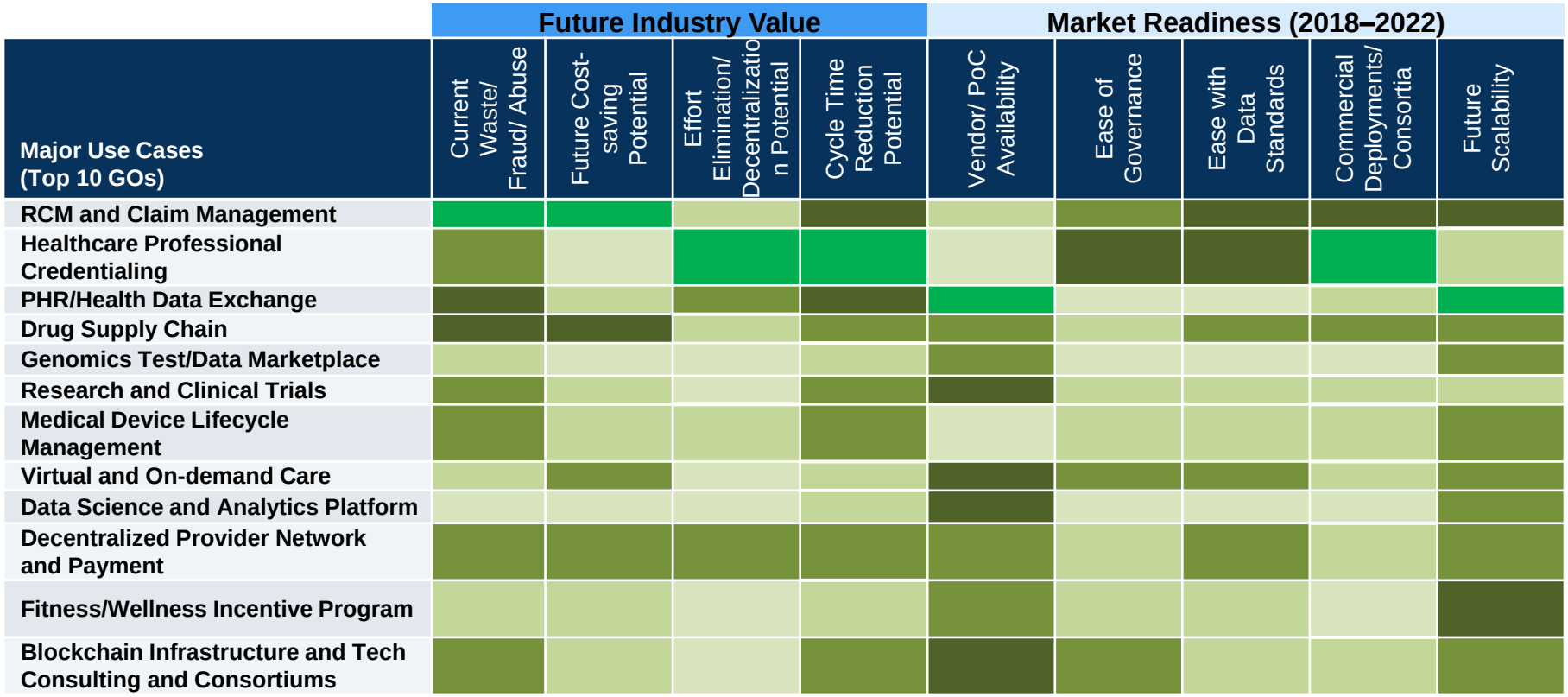
The Healthcare Blockchain Opportunity Assessment framework maps two key criteria that are further broken down into contributing parameters. The criteria are:

- **Market Readiness:** Presented on the X-axis, this indicates the current stage of technological and network development for a specific segment or application focus.
- **Future Industry Value:** Presented on the Y-axis, this indicates the level of strategic industry needs and potential value that Blockchain-based applications will generate.

Source: Frost & Sullivan

Research Methodology Discussion—Factor Analysis

Blockchain Technology in the Healthcare Industry: Factor Analysis for Major Use Cases Opportunity Assessment Framework, Global, 2018–2022



Note: The above scale is based on both qualitative and quantitative factors. Cost-saving potentials are indicative values (not necessarily direct revenue opportunity) that can be achieved by minimizing current waste, abuse, and falsification in the healthcare industry with successful deployment of focused Blockchain solutions.

Source: Frost & Sullivan

Blockchain Application Potential With Multiple Healthcare Stakeholders

Health insurance payers, providers, and pharma companies are expected to be the early adopters for Blockchain systems compared to other healthcare industry stakeholders.

Blockchain Technology in the Healthcare Industry: Growth Opportunities Across Major Stakeholders, Global, 2018–2022





	Governments	Payers (incl. ACOs and MCOs)	Providers Hospitals, Physicians, Pharmacies	Suppliers Pharma, Medical Devices	Consumers
Growth Opportunities	• Value-based care • Healthcare fund allocation • Policy review and voting • Population health management	• Fraud management • Reward-based preventive care • Claims management • Smart contrasts to maintain a benefits database	• Longitudinal health records • Clinical care coordination • Medical research collaborations • Data reconciliation and cybersecurity • Provider credentialing	• Drug supply chain provenance • Device identity management • IP and R&D asset marketplace • Clinical trials notarization • Precision medicine	• Personal health records • Price transparency for drug and healthcare services • Share data for research • Wellness incentives
Indicative Cost Saving Potential	>$75 B	$100 B	$5 B	$50 B	$10 B

Note: The potential cost-saving opportunities are indicative and subject to successful deployment of Blockchain across healthcare stakeholders' relevant use cases globally. Some of the use cases and related cost-saving opportunities overlap different stakeholders (i.e., each cost saving is not mutually exclusive).

Source: Frost & Sullivan

Use Cases 1—Healthcare Payment and Claim Management

Return to contents

Medical Billing Process Inefficiencies and Falsifications—US

US

4.6 million claims submitted per day

20% of claims rejected due to invalid ICD codes

10% of total claims processed are denied

INSURANCE NOTARIZATION AND MEDICAL BILLING FRAUDS

- An estimated **5%–10%** of **healthcare costs** are **fraudulent**, resulting from excessive billing or billing for non-performed services.
- For example, in the **US alone**, Medicare fraud scheme incurred about **$30 million** in losses during **2016**.

BILLING- AND INSURANCE-RELATED INEFFICIENCIES

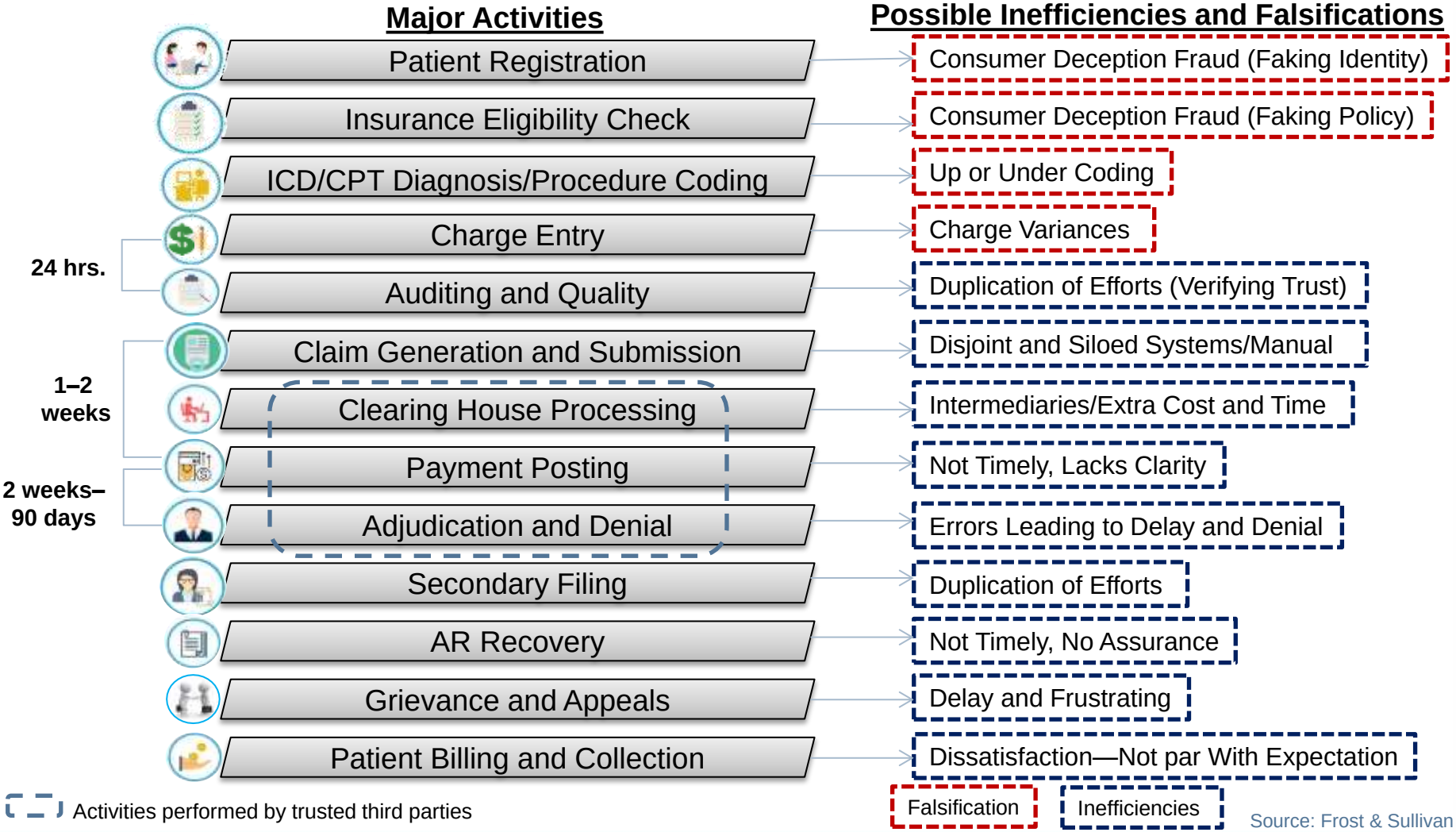
- An estimated **15%–20%** of **healthcare spending** and **processing cost**s are associated with Billing and Insurance (**BIR)** related **activities**.
- For example, in the **US, BIR costs** are projected to reach **$315 billion** by **2018**, up by **100% from 2007**.

Image: Source: https://www.medconverge.com/2016/03/24/ways-to-prevent-medical-billing-fraud/

Source: CMS.gov; 2015; Frost & Sullivan

Current Medical Billing Process—Inefficiencies and Falsifications

Blockchain Technology in the Healthcare Industry: Medical Billing Process Inefficiencies and Falsifications, US, 2018

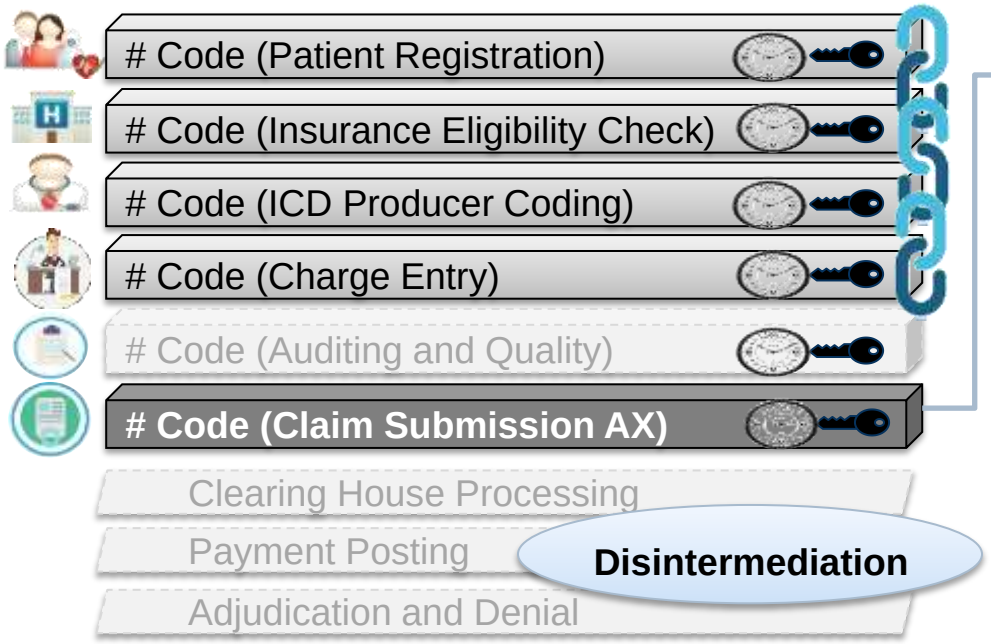


Source: Frost & Sullivan

Blockchain-enabled Medical Billing Process

It enables lesser fraud, faster claims, and smarter processes.

Blockchain Technology in the Healthcare Industry: Blockchain-enabled Medical Billing Process, US, 2018



Broadcast

The claim data is hashed, and broadcasted to the network/ participating nodes in the **distributed digital ledger** 1

Authentication

Participant nodes identify whether the transaction is valid. (i.e., message is signed by the sender and does not break the rules defined in the Blockchain protocol) 2

Smart contract

Smart contract(s) conditional logic is applied, providing the basis for **automatic adjudication** of the claim on Blockchain. 3

Approval

Network participants solve a **cryptography** algorithm to create a consensus mechanism to approve the transaction. 4

Block Chaining

A New 'Block' is added, creating an **immutable** and **timestamped** chain of record for transactions. 5

Source: Frost & Sullivan

Growth Opportunity—Healthcare Payment and Claim Management

Successful Blockchain technology deployment in claims adjudication, billing management, and RCM workflows can potentially save up to $100 billion globally for healthcare industry in the next 5 years.

Applicable Market Segments	Payment and Claim Mgmt.	Professional Credentialing	Drug Supply Chain	Medical Device Lifecycle Mgmt.	PHR & Health Data Exchange	Research and Clinical Trials
Applicable Value Chain Participants	**Government**	**Payers**	**Providers**	**Patients**	**Pharma and Med-Tech Suppliers**	**Emerging IT Vendors**

- Vision and Strategy
- Vision Transformation
- Mega Trends' Impact
- Disruptive Applications
- Business Models
- Current Offerings
- New Capabilities
- Value-add Services
- Vertical Integration
- Geographic Expansion
- Partnerships
- Investment/M&A

Context and Opportunity

- Early applications of Blockchain technology to BIR processes promise to address such inefficiencies by using trusted and transparent systems for every stakeholder.
- Emerging Blockchain systems promise to unlock new economic advantages and streamline workflow interactions by limiting intermediaries and automating transactional services across healthcare service transactions.
- In the mid-to-long term, decentralized healthcare insurance and payment models are expected gain prominence by leveraging on DLTs' trusted protocol by accessing individual health data for maintaining a benefits database and promoting consumer-centric insurance programs.

Call to Action

- RCM can leverage on Blockchain technology solutions to streamline network communications, create crowd-managed policies, automate audits and reporting, and enforce security measures.
- DLT-based source of truth on near real-time claim and transaction data is expected to further empower progressive payers and providers to eventually move away from current historic or retrospective reconciliation (legacy systems), and develop innovative contract models, much needed for a value-based reimbursement paradigm.
- Private insurance payers and employee health programs should leverage on the convergence potential of DLTs, smart contracts, IoT, and RWE to make their reward-based preventive care programs more trustworthy and efficient.

Note: RPM—Remote Patient Monitoring

Source: Frost & Sullivan

Company to Watch—Change Healthcare

Blockchain-powered IHN provides Change Health and its clients greater efficiency to optimize administrative cost and time, and transparency for better auditability and traceability related to claims adjudication process.

Business Description

- **Change Healthcare** is a leading provider of RCM, claim management, and clinical information exchange solutions in the US market. The company pioneered the deployment of commercial enterprise-scale Blockchain technology called the Intelligent Healthcare Network™ designed to speed claims lifecycle management transparency.
- **Quick Facts:**
  - Change Healthcare's client network covers 2,100 payer connections, 5,500 hospitals, 117,000 dentists, 800,00 physicians, and 600 laboratories.
  - It processed $1 trillion in claims in 2017, and manages up to 50 million transactions per day.

Healthcare Focus Areas	
Healthcare Use Case Focus	• **Claim Adjudication** • RCM • B2B Clinical Data Exchange • Patient and Caregiver Engagement
Target Customers	• Health Insurance • Providers

Key Blockchain Solutions Deployment Stages and Healthcare Partnerships

Commercially Deployed: Intelligent Healthcare Network™

- In January 2018, Change Healthcare announced the general availability of IHN, the first enterprise-scale Blockchain solution for healthcare.
- Currently, the IHN Blockchain platform is capable of processing more than 50 million claim events per day. This superior capacity and speed make IHN a highly scalable Blockchain technology for managing daily national transaction load and throughput requirements compared to the traditional insurance eligibility check that can take 7 to 14 days to get results.

Recent Partnerships/M&As: To expand its Blockchain capabilities and scale into other application areas, Change Healthcare has been taking both organic and inorganic routes in the last few months. Examples of recent best-of-breed collaborations include:

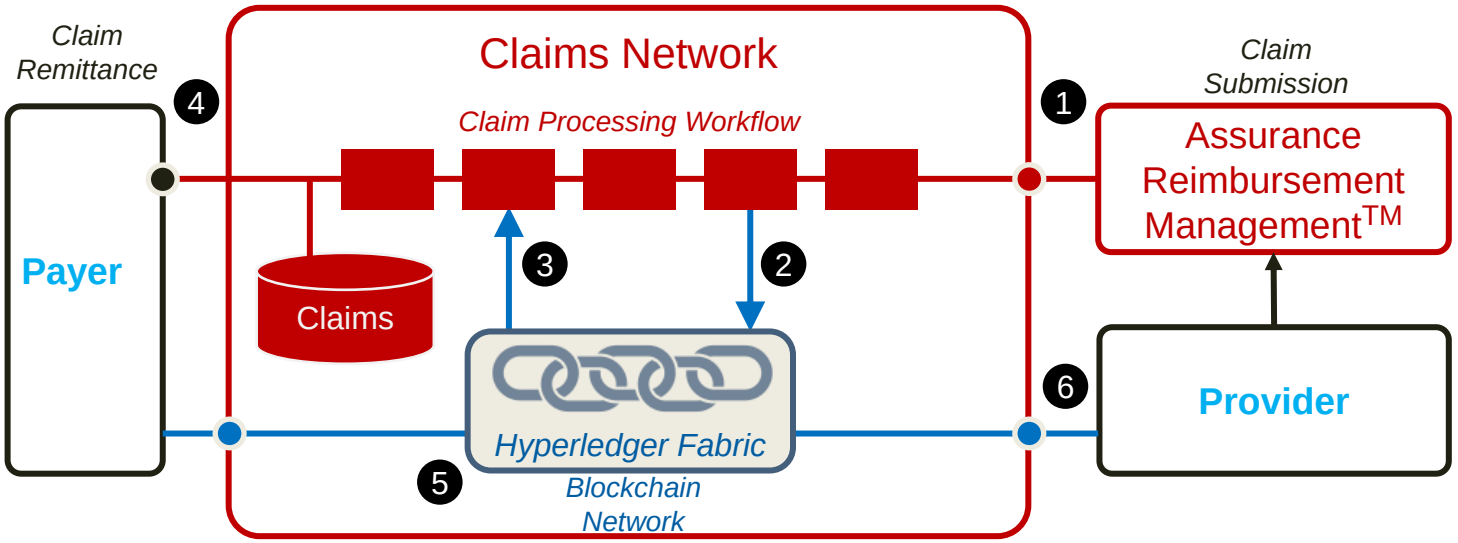
- November 5, 2018: Partnered with **TIBCO Software** to build a smart contract system using the Change Healthcare IHN Blockchain technology, and enabled health plans and its financial partners to easily develop and deploy smart contract-based processes that automate events across the healthcare transaction processing lifecycle
- December 18, 2018: Acquired the Intellectual Property (IP) and other key assets from **PokitDok, Inc.,** a leading Blockchain platform-as-a-service company for healthcare; has plans to further extend the capabilities and technology leadership across digital health, telemedicine, and other new, disruptive care models that support value-based, patient-centric healthcare, with the integration of PokitDok APIs and IP assets to the IHN platform
- January 8, 2019: Partnered with **Experian Health** to integrate and co-develop industry-leading patient identity management solutions and solve persisting challenges around duplication of patient identification, patient engagement, and care coordination

Source: Change Healthcare; Frost & Sullivan

Company to Watch—Change Healthcare (continued)

The IHN solution is aimed at simplifying manual administrative interactions between payers and providers.

Operating Model: Intelligent Healthcare Network™ (IHN) With Blockchain for Claims Management Transparency



❶ Claims submitted for payment by provider
❷ Claims network workflow writes claim lifecycle events to Blockchain
❸ Blockchain events trigger claims Network workflow activity
❹ Claims submitted to payer for processing
❺ Blockchain maintains real-time immutable record of claim lifecycle
❻ Provider accesses claim status from Blockchain through API

Claims Network Components
Blockchain Components
Customer Components

Acquisition

pokitdok
Healthcare API Platform

External Partners

TIBCO
Smart Contract System

experian. health
Patient Identity Management

aws
Cloud-based Offering

HYPERLEDGER
Blockchain Framework

Analyst Perspective: Frost & Sullivan finds Change Healthcare's IHN Blockchain solution to be by far one of the largest successful commercial deployments of Blockchain technology in healthcare B2B enterprise applications, demonstrating much-needed transparency and efficiency for better auditability and traceability around the claim management process. Despite Blockchain technology application's nascence in the healthcare space, early success of IHN holds the potential to replace claims clearinghouses and decrease the need for prior authorization. Furthermore, Change Healthcare's progressive approach to further integrate the potential application of Blockchain across RCM, clinical data exchange, and patient and caregiver engagement use case solutions would provide the company a unique competitive edge.

Source: Change Healthcare, Frost & Sullivan

Company to Watch—HSBlox

HSBlox leverages on Blockchain/DLT and ML technologies to provide smart contract solutions for automating healthcare payment and claim management workflows and decreasing administrative costs.

Business Description

- HealthshareBlox, LLC (HSBlox) is a technology start-up that combines machine learning and Blockchain (or DLT) to address the healthcare industry's demand for secure, real-time information sharing and interventions.
- In May 2018, HSBlox received SOC 2 Type II Certification for its Distributed Ledger Platform (conducted by Grant Thornton LLP). The audit affirms that HSBlox's information security practices, controls, policies, procedures, and operations meet the SOC 2 standards for security, availability, privacy, and confidentiality trust principles.

Healthcare Focus Areas	
Healthcare Use Case Focus	• RCM and Claims Management • Longitudinal Patient Records • Episodic and Bundle Payment • Clinical Trial Sample Tracking
Target Customers	• Health Insurance • Providers • Pharmaceutical

Key Blockchain Solutions Deployment Stages and Healthcare Partnerships

Commercial Pilot:

- **HSBSuite™:** In March 2019, CarynHealth, the small business association health plan brand of Association Health Plans of America, LLC ("AHPA") partnered with HSBlox's to run DLT-based HSBSuite™ smart contract solutions, and bring automation, transparency, and real-time permissioned disclosure of data, especially for the small employer health benefits plans marketplace. CarynHealth has plans to launch its initial health plans in the US across 2 states (Georgia and Arizona), and deploy HSBSuite™ smart contract solutions in the second quarter of 2019.

Soft Launch: RevBlox™ and Digital Sample Manager (DSM)

- **RevBlox™**, released in March 2018, is a patent-pending solution that leverages on ML and Blockchain (private DLT), to augment providers in reducing claims denials and secure payment of patient's financial responsibilities for care.
- **Digital Sample Manager (DSM):** In Jan 2019, HSBlox launched the DSM solution that leverages on Blockchain to improve clinical trials' supplies visibility, transparency, and tracking. The solution is expected to provide end-to-end sample tracking and real-time status updates to all chain-of-custody entities.

Key Partnerships:

- In December 2017, HSBlox partnered with **Aver Inc.** to integrate HSBlox's Blockchain-based smart-contract enabled, episodic payment solution CuraBlox™ into Aver's episode-of-care administration, analytics, pricing, and network contracting solutions. The companies have identified initial clients for the administration of knee, shoulder, and maternity bundles.
- In December 2017, HSBlox partnered with **Procivis,** a Swiss Blockchain venture, to integrate HSBlox's Blockchain-based healthcare administration focused on smart contract solutions, with Procivis' advanced DLT authentication application.

Source: HSBlox, LLC; Frost & Sullivan

Company to Watch—HSBlox (continued)

HSBlox's portfolio of innovative solutions aims to drive efficiency, transparency, and accountability across healthcare payment and care coordination workflows.

HSBlox's Major Solutions Leveraging the Convergence Potential of ML and Blockchain Technologies

RevBlox™

- It proactively evaluates and scores claims using a combination of ML and rules-based edits, prior to clearinghouse or payer submission.
- Healthcare providers benefit from significantly improved coding accuracy, time to revenue, and decreased administrative costs.
- The ML capability can be applied across specialties without the need for specific human knowledge of a given specialty.

SmartMPI™

- It is designed to deliver Enterprise Master Patient ID (EMPI) that identifies potential duplicates with extraordinarily high accuracy.
- It uses proprietary ML algorithm and analyzes and consolidates data from multiple systems to create a longitudinal patient record.
- It can be implemented in a vendor- or client- specific environment and can process more than 1 million records in less than 10 minutes.

CuraBlox™

- It incorporates the HSBlox Smart Contract Library and DLT smart contracts to ease the administrative burden and accelerate episodic bundled payment models.
- It offers an integrated workflow, smart contract automation, and real-time data delivery, enabling transparency and care coordination,
- It helps to improve patient outcomes and provider incentives with episode metrics and measurable outcomes.

Machine Learning (ML) + Blockchain/ private distributed ledger technology (DLT)

HSBlox's Partnership Program:

- Reseller Partners: White-label/data-as-a-service options, where HSBlox is OEM
- Referral Partners: With trusted advisor engagements
- Pilot Program: Designed by HSBlox with input from client partners

Analyst Perspective: Considering the prevailing administrative inefficiencies with healthcare payments and claims workflows, Frost & Sullivan finds HSBlox's portfolio of solutions timely and expects such enterprise-focused workflow optimization Blockchain use cases to gain increased market adoption in the near term. However, unlike other technologies, the commercial success of Blockchain solutions depends on network scalability. To leapfrog to the next level, HSBlox will need to start pilot programs with few large provider and payer organizations to demonstrate real-world benefits.

Image Source: HSBlox, LLC

Source: HSBlox, LLC; Frost & Sullivan

Company to Watch—Insureum by ZIKTO

Zikto Inc, a provider of posture-tracking fitness wearable, integrates Blockchain technology to offer a decentralized health insurance marketplace called Insureum.

Business Description

- Zikto Pte, Ltd. is a South Korea based health technology start-up that offers posture-tracking fitness wearable devices (e.g., Zikto Walk) and a multiple-device data integration platform.
- The company has created a decentralized health insurance marketplace called Insureum to connect healthcare insurance payers, providers, consumers, and third-party mHealth solution developers to trade insurance-related health and lifestyle data in an easy but secure way.

Healthcare Focus Areas	
Healthcare Use Case Focus	• Fitness and Wellness • Research Commons • Reward and Incentive Programs
Target Customers	• Health Insurance • Providers • Consumer

Key Blockchain Solutions Deployment Stages and Healthcare Partnerships

- **Commercial Pilot: Insureum—Blockchain-enabled Decentralized Health Insurance Marketplace**
  - In August 2018, Zikto announced the availability of the Minimal Viable Product (MVP) for Insureum protocol. It also launched the Insureum token (ISR), and raised $18.50 million mainly from private/institutional investors.
  - Currently, Zikto is developing the Insureum partnership ecosystem, mainly focusing on insurance companies, users, and 3rd parties, and has plans to open the marketplace for dApp developers by the end of 2019.
- **Key Benefits to Healthcare Stakeholders:**
  - The Insureum marketplace provides payer organizations with personalized health data to create better policies.
  - Health wearables and mobile app vendors are incentivized to join the Insureum marketplace.
  - Users/policyholders get the option to share/trade their anonymized data on Insureum's marketplace and get rewarded, which they can later use to pay their insurance premium or even do online shopping.
- **Key Partnerships:** Zikto has so far partnered with some of the leading South Korean insurance and financial conglomerates and hospitals, such as KB Financial Group, Kyobo Life Planet, SK Planet, AXA, and Asan Medical Center (Hospital).
- **Investments:** In May 9, 2018, it secured a KRW 500 million (US$462,278) fresh funding from The Wells Investment, a local venture capital firm specializing in healthcare and biotech, to further build its Insureum DLT ecosystem. Till date, it has secured a total of KRW 3.8 billion (US$ 3.5 million) investment from multiple investors.

Source: ZIKTO; Frost & Sullivan

Company to Watch— Insureum by ZIKTO (continued)

The Insureum marketplace aims to bridge the technology gap between the healthcare insurance industry, 3rd-party developers of digital health solutions and consumers/policyholders.

Main Stakeholders in the Insureum Protocol

Developer: Develop app/services based on the insurer's request, gathering, processing, and providing the user data under consent.

Insurer: Develop digital products and reduce costs based on the user's data and automation

Sales Agencies: Sell and distribute digital insurance products to the users based on their preference.

Database Provider: Using a distributed database will ensure the efficiency and security of the data storage and transactions.

Inspector: Investigate on claims and related data, providing claim management services.

User/Policyholder: Sell anonymized lifecycle data through 3rd parties and pay insurance premium using rewards (Insureum token).

Current Partnership Ecosystem

현대해상 · KB 국민카드 · AXA · SK planet · 서울아산병원 Asan Medical Center · Tokenomia · coinplug · GC 녹십자 · lifeplanet · LINE

Analyst Perspective: Frost & Sullivan's research suggests that lifestyle and health data driven interactive health insurance plans will continue to gain popularity globally, as they enable insurance companies to personalize premiums by stratifying health risks and reward programs. Blockchain-based decentralized health insurance marketplaces (e.g., Insureum) provide payer organizations with a trusted protocol to access individual health data, and promote consumer-centric insurance programs that incentivize individuals for adhering to healthy habits/lifestyle. This will also open up new business opportunities for wearable OEMs, mobile apps, and health data aggregators to collaborate on such decentralized marketplaces.

Source: ZIKTO; Frost & Sullivan

Company to Watch—Lumedic (Acquired by PSJH Hospital Network)

Case Example: How Blockchain technology can transform the process across provider-payer systems?

Industry Challenge

Based on industry estimates, inefficiencies with current RCM processes costed more than $315 billion to US health systems in 2018. These inefficiencies are largely attributed to complex workflows and manual processes, leading to increased administrative costs and delay in revenue cycle time.

Deal Analysis: Application of Blockchain to Transform RCM Process Across Provider-Payer Systems

(Providence St. Joseph Health acquired Lumedic)

Providence St. Joseph Health

A leading health system in the US, with 51 hospitals and more than $23 billion in revenue

+

LUMEDIC

Provides an RCM platform built on Blockchain and machine learning

=

The acquisition of Limedic makes Providence St. Joseph the first integrated provider-payer system with a scalable Blockchain tool for RCM.

Business Objective: Providence St. Joseph Health (PSJH) is undertaking an organization-wide initiative to transform the RCM process by integrating advanced technologies, such as Blockchain and AI, to optimize financial interfaces between payers and providers. As a part of this initiative, PSJH recently acquired Lumedic, a provider of RCM platform based on Blockchain technology, with the aim of streamlining data sharing and improving claims processing.

Deal Synergy:

- Lumedic's intelligent RCM platform integrates advanced technologies, such as DLT, smart contracts, and ML to create a better and trusted experience for providers, payers, and patients around payment and claim management processes.
- PSJH aims to leverage on Lumedic's intelligent RCM platform to accelerate the development of a broad set of RCM offerings, spanning across the care continuum to eventually optimize operational complexities and administrative costs. As per PSJH, the first generation of improvements to RCM will integrate functionality such as scripts and bots, speeding up existing processes.
- In the near term, Lumedic will work with PSJH to further expand its intelligent RCM network partnerships with providers, insurers, and other healthcare stakeholders.

Analyst Perspective: Frost & Sullivan believes that DLT/Blockchain technology provides progressive RCM vendors and provider organizations the opportunity to simplify and automate workflow through smart contracts with defined source of truth and mutual consensus of all parties before a care episode begins. In future, DLT and ML based intelligent RCM platforms will exceed beyond current automation technologies based RCM platforms that have scope to only automate existing manual workflows.

Source: Providence St. Joseph Health; Frost & Sullivan

Consortium to Watch—Health Utility Network

IBM and PNC bank are the leading healthcare payers working groups in the US.

Health Utility Network: Blockchain Network Collaboration to Develop and Pilot Focused Healthcare Use Case

Technology Partners

IBM

BaaS Platform and Tech Advisory Services

PNC HEALTHCARE

RCM, Treasury, and Capital Management

Healthcare Payers Blockchain Working Group

aetna™ Anthem HCSC Health Care Service Corporation

Cigna SENTARA

These providers combined account for close to 100 million healthcare plans.

- **Working Group Objective:** IBM-led Health Utility Network aims to create a healthcare payer-focused consortia for experimenting and piloting relevant Blockchain technology applications to optimize billing-related high administrative costs and errors. At its core, Blockchain technology will help improve transparency and interoperability for network members to exchange sensitive health data in a permissioned, controlled environment.
- **Major Use Case Focus**: Some of the initial Blockchain pilots that the network is exploring include, insurance claim and payment processing, permissioned healthcare information exchanges, and provider directories for credentialing need.
- **Future Plans:** Participating companies in the health utility network are committed to explore and develop potential use cases leveraging on Blockchain technology across healthcare payer workflows, and have plans to scale the network by adding new members to the existing working group with interests in the future.

Analyst Perspective: Apart from creating in-house Blockchain technology capabilities, healthcare RCM vendors and payers can consider collaborating with leading BaaS platform providers to minimize cost and time associated with developing Blockchain infrastructure. In the above example, the network members enjoy instant access to IBM's Blockchain platform to fast-track their pilot application development. More importantly, approaching such pilot application in a collaborating consortia model helps to efficiently formulate robust governance and consensuses framework, much needed for future scalability and commercial success.

Source: IBM; Frost & Sullivan

Short Profiles of Select Companies to Watch

- Curisium Inc., a US-based healthcare technology and services company, offers Blockchain-based software-as-a-service platform to allow payers, providers, and life science companies to efficiently and securely engage in innovative, patient-centric, value-based contracts.
- The contracting platform provides a single source of truth based on Blockchain technology to automate data extraction, cleansing, analysis, and adjudication of both medical and pharmacy claims.
- The company secured a funding of $3.5 million financed by Flare Capital Partners, Sanofi Ventures, and Shuttle Fund, among others to scale its contracting platform.

- Appley Health Inc. is a US start-up leveraging on Blockchain technology to create a decentralized healthcare ecosystem for self-funded employer health plans.
- In July, 2018 the company launched the beta version of its patent-pending Blockchain platform that aims to disintermediate intermediaries and offer direct, peer-to-peer contracting for accessing provider networks at reduced cost for self-funded employer health plans and their beneficiaries.

Source: Frost & Sullivan

Use Cases 2—Healthcare Professional Credentialing

Return to contents

Healthcare Professionals Credentialing Challenges

It costs more than $2.1 billion annually to hospitals, doctors, and health insurers in the US alone.

Industry Need

- Healthcare provider credentialing is becoming a fundamental requirement across many countries, requiring hospitals, health plans, health networks, and insurers providers to ensure greater patient safety, reduce costs, as well as protect healthcare institutions from harm.
- For example, in the US, in state and federal laws, credentialing of physicians is regarded as a standard of care and mandates health plans and hospitals to periodically update provider directories by verifying and validating the qualifications of licensed healthcare professionals and assessing their backgrounds.

A CMS audit found that 52.6% of listed locations on provider directories had inaccuracies.

Industry Challenges

Current centralized models for credentialing rely on manual processes, creating data silos leading to duplicative outreach, which in turn increases maintenance cost, and possible penalties due to errors and non-compliance. For example;

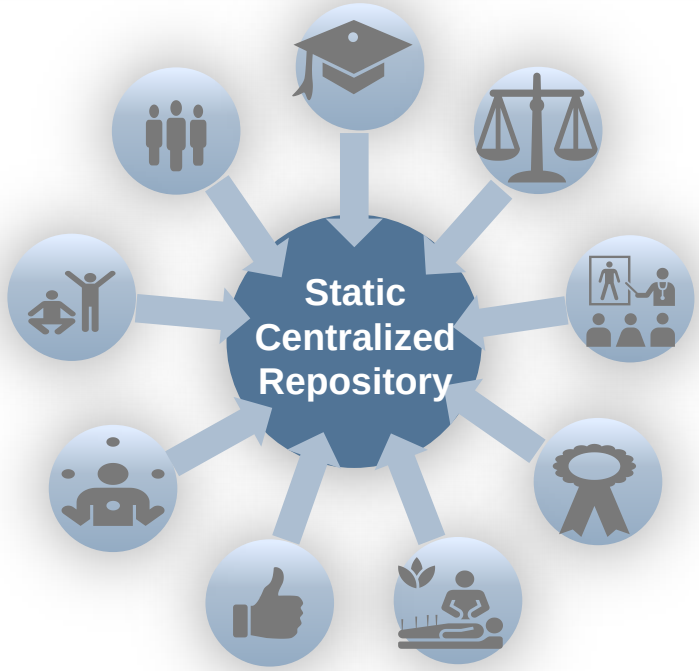
- It costs more than $2.1 billion annually to hospitals, doctors, and health insurers in the US alone. On an average, providers are affiliated with 20 health plans and often have to make updates with each health plan individually. Additionally, some state and federal laws require insurers to contact and update provider directories as often as every quarter or biannual basis.
- According to an industry survey by Enclarity, a LexisNexis Company, 30% to 40% of a payer's provider records contain errors or missing records. As per the Medicare Advantage program, high error rates in physician directories can cost health plans up to $25,000 penalties per day per beneficiary.
- Inefficiencies with the current credentialing model also create bottlenecks in enrolment timelines. In hospitals alone, it is estimated that for every day a physician's employment or contracting is delayed, the organization forfeits $7,500 in net revenues.

Source: Frost & Sullivan

Limitations With Current Healthcare Professional Credentialing Models

Current provider credentialing systems are archaic, slow, inefficient, which makes provider credentialing one of the biggest compliance issues for hospital practices.

Current Centralized Models for Credentialing



Provider/ Health Systems

Payer

Credentialing Organization

Limitations With the Current Model:

- **Inefficient data collection:** Manual processes create inefficiencies and take up to 5 to 6 weeks to credential a clinician.
- **Duplicate records**: The present model encourages potentially duplicative outreach and creates data silos.
- **Data inaccuracies:** As per the US CMS audit report, about 97% of provider information was inconsistent between NPPES and PECOS.
- **Penalties for non-compliance**: Medicare Advantage fines can cost up to $25,000 of penalties per day per beneficiary.
- **Create recruitment delays:** Inefficient credentialing systems affect practitioner recruitment, staff appointment, and insurer contract enrolment processes, impacting hospital revenue.

Key: Healthcare Professional Credential and Privileging Verification Data Types

Education | State Practice Acts | Training | Licensure | Experience | Competence | Judgment | Health Status | Other Affiliation

Key: NPPES—National Plan and Provider Enumeration System; PECOS—Provider Enrollment, Chain and Ownership System

Source: https://oig.hhs.gov/oei/reports/oei-07-09-00440.pdf; Frost & Sullivan

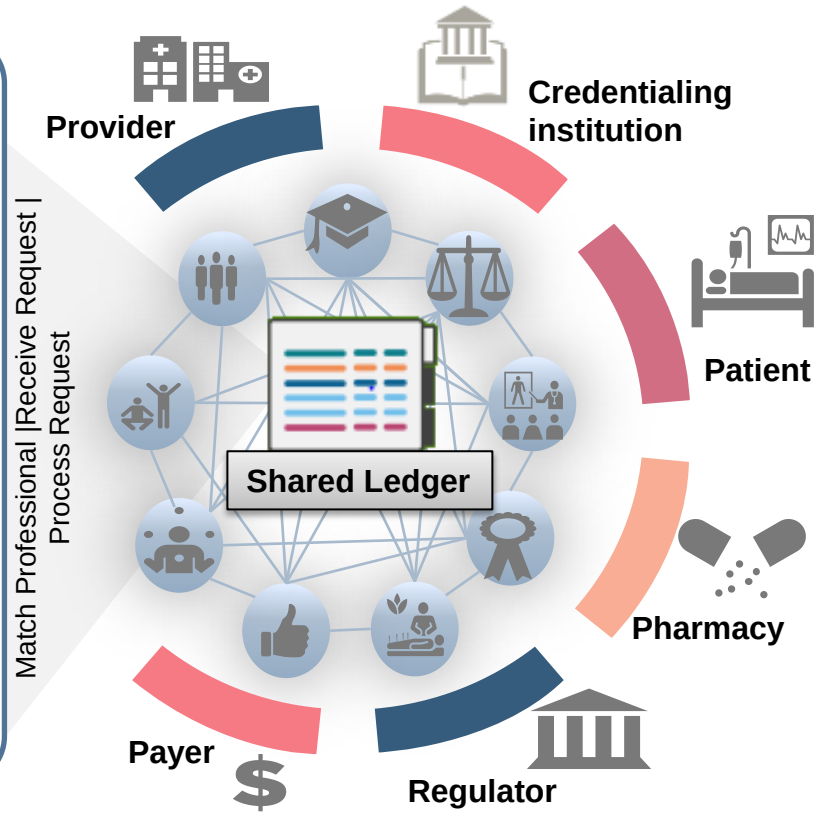
Blockchain-based Healthcare Professional Credentialing Process

Blockchain systems allow interconnected, verified, and fluid data exchange between all members of the network. As per industry estimates, up to 75% of the cost can be eliminated with one single source of truth.

Blockchain Technology in the Healthcare Industry: Solution for Healthcare Professional Credentialing, Global, 2018–2022

Types of healthcare professionals

- Physicians
- Nurses
- Allied health professions



1. Provider authenticates with Blockchain and updates own personal information.
2. Authenticated and authorized credentialing institution sends updates of provider status.
3. Data is validated by the trusted network and made available to the healthcare ecosystem.
4. Payer, health systems, regulators, and patients access updated data for reducing error, fraud, and regulatory sanctions.

Key: Healthcare Professional Credential and Privileging Verification Data Types

Education | State Practice Acts | Training | Licensure | Experience | Competence | Judgement | Health Status | Other Affiliation

Source: Frost & Sullivan

Growth Opportunity—Healthcare Professional Credentialing

Successful deployment of DLT-based professional credentialing solutions across large provider and payer networks can reduce the physician credentialing process cost by 60% to 70% in the next 3 to 5 years.

Applicable Market Segments	Payment and Claim Mgmt.	**Professional Credentialing**	Drug Supply Chain	Medical Device Lifecycle Mgmt.	PHR & Health Data Exchange	Research and Clinical Trials
Applicable Value Chain Participants	Government	Payers	Providers	Patients	Pharma and Med-Tech Suppliers	Emerging IT Vendors

- Vision and Strategy
  - Vision Transformation
  - Mega Trends' Impact
  - Disruptive Applications
- Business Models
  - Current Offerings
- New Capabilities
  - Value-add Services
  - Vertical Integration
  - Geographic Expansion
- Partnerships
  - Investment/M&A

Context and Opportunity

- Provider credentialing is being explored as one of the early applications by leading payers and providers in the US market.
- DLT application to physicians credentialing workflows eliminates redundant work, improves the coordination and concurrency of data, and helps to avoid penalties for non-compliance.
- In the next 3 to 5 years, the healthcare professional credentialing marketplace model will be foundational for the emerging virtual care delivery model to directly recruit and incentivize new pre-credentialed nurses.
- DLT-based professional credentialing networks/platforms can potentially create a direct threat of substitutes for healthcare staffing agencies' line of business, such as agency fees for verifying and on-boarding certified doctors and nurses.

Call to Action

- Large health systems and provider networks should consider collaborating with emerging professional credentialing networks and working groups to expedite practitioner on-boarding cycle time and reduce revenue forfeitures for hospitals.
- Telemedicine and tele-radiology platform providers providing virtual and on-demand care should consider integrating DLT-based professional credentialing features to verify and on board certified doctors and nurses, which in turn, will increase the reputation and compliance with regulatory needs.
- Staffing agencies and professional training/ certification institutions should view DLT-based professional credentialing solutions as a natural extension to their business value proposition, both from future expansion and sustainability.

Note: RPM—Remote Patient Monitoring

Source: Frost & Sullivan

Case Example—Commercial Blockchain Healthcare Professional Credentialing Networks

Blockchain Technology in the Healthcare Industry: Major Consortia to Watch for in the Healthcare Professional Credentialing Space, US, 2018

	PROFESSIONAL CREDENTIALS EXCHANGE	synaptic Health Alliance
About	• In March 2018, Tenon (a process reengineering and development company) partnered with Hashed Health (a leading healthcare-focused Blockchain technical solutions provider) to launch the Professional Credentials Exchange (ProCredEx) to make the healthcare professional credentialing process more trusted, simple, and efficient.	• In April 2018, leading healthcare payer and provide organization (Humana, MultiPlan, Optum, Quest Diagnostics and UnitedHealthcare) announced the launch of Synaptic Health Alliance to explore how technologies such as Blockchain can be applied to solve the healthcare industry's pressing needs.
Scope	• Professional Credentialing Platform: ProCredEx is a cloud-based digital marketplace platform for exchanging verified healthcare professionals' credentials. At the core, it deploys DLT solutions, coupled with data science and AI technologies to guarantee that the marketplace approach provides participating members with both secured access to verified credential information and a means to contribute verified information for other members to acquire. • ProCredEx allows authorized members to define the specific data, artifacts, rules, and validation checks for the distribution and maintenance healthcare professionals requiring credentials	• Provider Directory data exchange: The first project of Synaptic Health Alliance will explore Blockchain technology potential in tackling the inefficiencies, duplicative process, and high admin cost associated with maintaining physician directories with up-to-date demographic information about physicians and other providers. • At this time, only a limited number of companies will be selected by the alliance as a founding member. At present, Synaptic provides a permissioned, cooperatively-owned Blockchain "utility" with nodes for contributing and consuming provider demographic data.

Source: Frost & Sullivan

Case Example—Commercial Blockchain Healthcare Professional Credentialing Networks (continued)

	PROFESSIONAL CREDENTIALS EXCHANGE	synaptic Health Alliance
Commercial Partnerships	In November 8, 2018, ProCredEx launched the partner program with a group of five leading health care providers, and currently has at least 7 network partners as part of its professional credentialing exchange National Government Services WellCare Health Plans accenture SPECTRUM HEALTH Texas Hospital Association Hardenbergh Group	Synaptic health alliance's 7 founding members are as follows: OPTUM UnitedHealthcare Humana MultiPlan Quest Diagnostics Ascension aetna
Key Features and Benefits	• Reduce average cycle times for individual credentialing episodes • Expedite practitioner on-boarding cycle time • Reduce revenue forfeitures • Provide timely updates to practitioner data and accurate directory data • Simplify the credential gathering and verification process • Eliminate redundant work, while improving coordination and concurrency of data	• A Blockchain data exchange marketplace and application • A model for incentives to drive positive contribution and consumption behaviors across all participating organizations • An administrative cost-savings model to be used by all participating organizations to measure results • Use Quorum, an enterprise-focused version of Ethereum

Source: Frost & Sullivan

Short Profiles of Select Companies to Watch

- SnapNurse is an Atlanta, US, based provider of an on-demand nursing services platform. The company currently has more than 3,500 certified nurses in its network across the US, Europe, and select Asian countries.
- SnapNurse leverages on Blockchain technology to verify and credential certified nurses in its network. The company also offers online credentialing services to nurses who want to join its on-demand nursing services platform.
- The company also offers NurseToken to hospitals to streamline the recruitment of new pre-credentialed nurses directly on its platform and incentivize nurses without any additional agency costs to hospitals.

- Intiva Health is a Texas, US, based healthcare career management platform provider that provides free ACCME-accredited CME/CEU courses for nurses and physicians on any device, including board preparation, state-required courses, and MOCs.
- In March 2019, Intiva launched its credential management and verification service called **Ready Doc**™ that uses hashgraph DLT to provide a more-efficient, less-expensive way to verify and share medical credentials.
- Healthcare professionals can digitally upload their credentials for facilities to review. Once verified by the first facility, Ready Doc creates a decentralized timestamped, and immutable record, using a DLT consensus algorithm.

Analyst Perspective: With increasing virtualization of care models, Frost & Sullivan believes that the credentialing marketplace model will be a foundation for the emerging virtual care delivery model, to directly recruit and incentivize new pre-credentialed nurses and ensure regulatory compliance while avoiding agency cost.

Source: Frost & Sullivan

Use Cases 3.1—Drug Supply Chain

Return to contents

Pharma Drug Supply Chain Challenges

The drug supply chain has become increasingly complex with ever-increasing threats of counterfeiting, cargo theft, and the challenge of keep up with changing regulatory and safety requirements.

Biologics and cell therapies require time- and temperature-controlled transport.

With the portfolio of drugs shifting toward temperature-sensitive biologics drugs, the need for quality compliance for cold-chain logistics and visibility from API to final drug delivery is becoming critical.

Pharmaceuticals companies incur an estimated annual loss of up to $200 billion due to counterfeit drugs globally.

- About 30% of the drugs sold in developing regions, such as Africa, Latin America, and parts of Asia, are considered counterfeit.
- On an average, medicines worth $33.5 million are stolen in cargo theft each year in European markets.

As per the US CDC, on an average more than 130 people die due to drug overdosing cases each day.

- In 2017, reportedly, there were 1.7 million cases of substance-use disorders related to prescription opioid pain relievers in the US.
- Lack of supply-chain visibility results in costly lawsuits for pharma manufactures, creating a negative brand name.

Lack of global standards and erratic landscape for global drug serialization and traceability regulation requirements makes it a daunting task for drug manufacturers, licensers, distributors, and dispensers to ensure compliance.

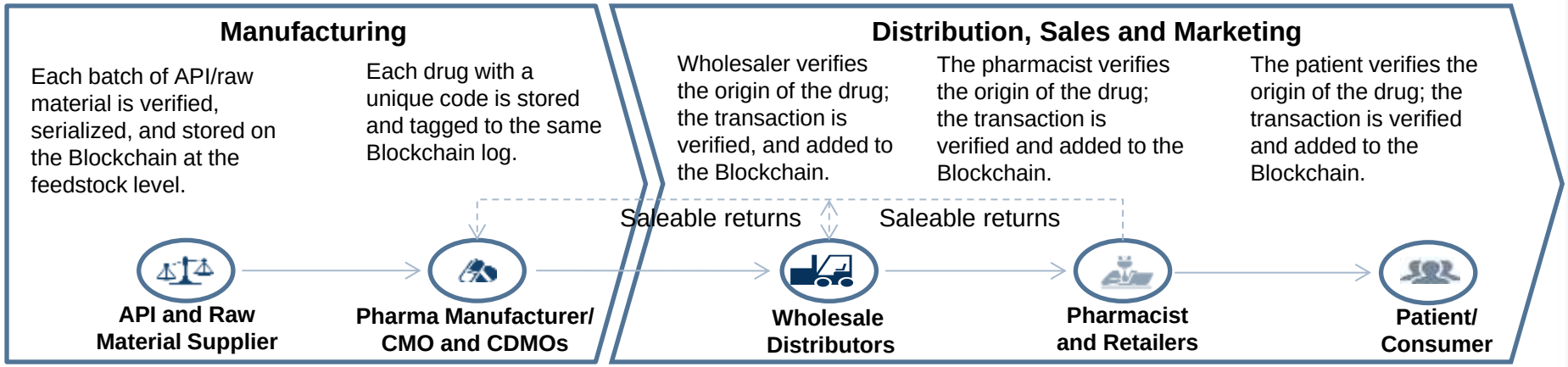
- Health authorities in more than 40 countries, including the US (DSCSA), EU (Falsified Medicines Directive), China (CFDA), and Brazil (RDC 54) have some form of enacted/ approaching serialization requirement mandates for drug supply to protect patient safety and ensure product integrity. (e.g., US DSCSA November 2019 verifiable saleable returned products at a package level).
- However, lack of interoperability and standardization issues with existing serialization or track-and-trace systems creates critical concern for drug manufacturers.

CDC—Centers for Disease Control and Prevention

Source: Frost & Sullivan

Potential Impact of Blockchain Across the Drug Supply Chain

Blockchain Technology in the Healthcare Industry: Drug Supply Chain and Key Entities Involved*, Global, 2018–2022



Key Benefits

- Immutable hash (#) created on the Blockchain helps in automating serialization and geo-tagging the process across production, development, and testing by manufacturing facilities.
- Smart contract automate the auditing of outsourced contract manufacturing process and quality compliance with the Blockchain's verifiable source of truth.
- Blockchain-based smart contracts enable autonomous applications for due diligence, inventory management, and recall process.
- Blockchain can enable the implementation of an electronic regulatory submission interoperable system for marketing authorization submissions and updates to global regulatory authorities.

- Blockchain-based chain-of-custody log can track each step of the supply chain, starting from input raw material/API to final drug delivered to patient.
- It can maintain immutable historical records of products to detect saleable returns, counterfeit, and substandard products and identify the responsible party.
- It can verify supply chain provenance with real-time disclosure and alert systems of the entire product path, both up or down the supply chain.
- It can increase visibility for estimating the impact of various marketing alliances and promotional campaigns, such as rebates, co-paid ads, and coupons, while boosting sales of individual drugs.
- Post-marketing processes, such as Adverse Drug Reactions (ADR) and safety monitoring, are more efficient.
- Blockchain-based trusted workflows help run incentive-based medication adherence programs and reward them with crypto tokens on compliance.
- It helps in leveraging post-marketing research findings as an input for future R&D, especially for precision medicine.
- It provides new marketing channels (e.g., online sales, direct to consumer).

*Not exhaustive Key: API—Active Pharmaceutical Ingredient

Source: Frost & Sullivan

Growth Opportunity—Drug Supply Chain Provenance

Blockchain-based chain-of-custody log to track each step of the supply chain can check the counterfeit drug challenge and potentially save $200 billion for the pharmaceutical industry.

Applicable Market Segments	Payment and Claim Mgmt.	Professional Credentialing	**Drug Supply Chain**	Medical Device Lifecycle Mgmt.	PHR & Health Data Exchange	Research and Clinical Trials
Applicable Value Chain Participants	Government	Payers	Providers	Patients	Pharma and Med-Tech Suppliers	Emerging IT Vendors

- Vision and Strategy
- Vision Transformation
- Mega Trends' Impact
- Disruptive Applications
- Business Models
- Current Offerings
- New Capabilities
- Value-add Services
- Vertical Integration
- Geographic Expansion
- Partnerships
- Investment/M&A

Context and Opportunity

- Blockchain-based track-and-trace systems help automate serialization, and the geo-tagging process needs to increase auditability and provenance for pharma drug supply chain and reduce counterfeits.
- Integration of DLTs with smart contracts IoT will increase quality compliance and visibility for temperature-sensitive biologics drugs logistics.
- Notarization of supply-chain tractions with Blockchain's single source of truth, allows regulators to audit or request information without much administrative efforts.
- Authorized supply-chain participants, manufacturers, distributors, health systems and pharmacies, that can handle products get secured access control for increased visibility and collaboration.

Call to Action

- Pharma manufacturers and wholesalers should create a global collaborative network to utilize permissioned Blockchain solutions (e.g., MediLeger and SAP Collaboration Hub) to address approaching serialization regulatory mandates globally across more than 40 countries. To obtain the fullest potential of DLTs, pharma companies should consider deploying Blockchain, both at the upstream and downstream supply chain process (i.e., from API to final product level).
- Cold-chain logistics/3PL providers should collaborate with IoT vendors to explore and develop Blockchain solutions for temperature-controlled logistics to increase auditability and quality compliance.
- With high level of outsourcing, pharma companies can integrate DLT-based smart contracts with their SRM system to automate the auditing process for contract manufacturing vendors' performance and quality compliance.

Note: RPM—Remote Patient Monitoring

Source: Frost & Sullivan

Company to Watch— MediLedger project by Chronicled Inc.

Permissioned Blockchain can track and trace regulations to provide provenance of a pharma drug supply chain and reduce counterfeits.

Business Description

- Chronicled, Inc. is a provider of Blockchain and IoT-based supply chain solutions to multiple industries.
- In 2017, Chronicled initiated the MediLedger project by bring in leading pharmaceutical manufacturers and wholesale distributors in the US market to explore Blockchain applications to meet DSCSA serialization requirements in the US market.

Healthcare Focus Areas

Healthcare Use Case Focus	• Track-and-trace system for serialization regulation • Contracting and chargebacks
Target Customers	• Pharma supply chain participants

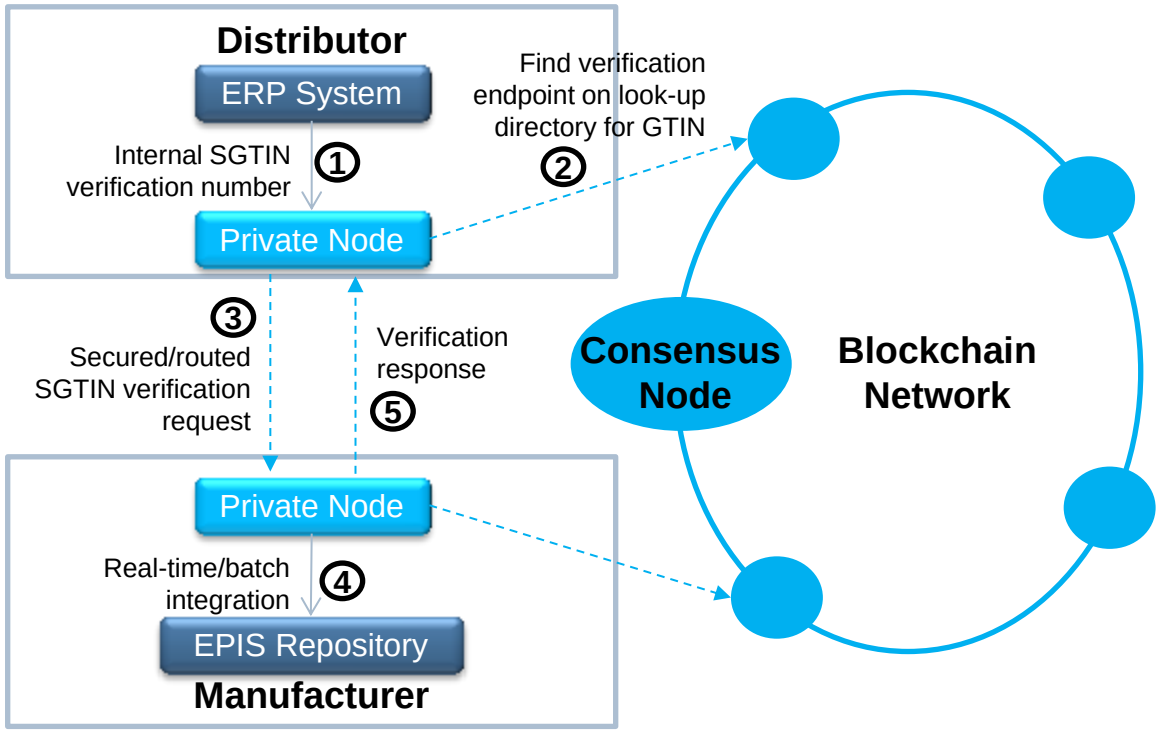
Key Blockchain Solutions Deployment Stages and Healthcare Partnerships

- **Commercial Pilot Tested: MediLedger Project for Drug Supply Chain**
  - As of 2018, the MediLedger working group had successfully developed and tested 3 protocols that are available now, which include, Product Verification System (PVS) for DSCSA Saleable Returns, Industry Look Up Directory, and Verification Router Service.
  - The company has plans to go live in October 2019, for these 3 products. Some of the leading participants involved in MediLedger's pilot projects include, AbbVie US, AmerisourceBergen, Roche/Genentech, McKesson, and Pfizer. Recently, retail giant Walmart also joined MediLedger's pharmaceutical consortium.
  - In May 2019, MediLedger announced a second working group on Contracting and Chargebacks use case and has plans to finalize the design and begin testing this protocol in Q3 2019. Some leading companies collaborating on this project include Pfizer Inc., McKesson Corporation, AmerisourceBergen Corporation, and Premier Inc.
  - As of May 2019, Chronicled had 40 employees, 10 patents, and had managed to raise $16 billion funding.
- **Key Partnerships:**
  - At present, the MediLedger project has an established network of more than 20 companies, including large pharmaceutical manufacturers, virtual manufacturers, contract manufacturers, re-packagers, wholesale distributors, third-party logistics companies, and major retail pharmacy chains.
  - In June 2019, the MediLedger Project announced its participation in the US FDA sponsored pilot program, for assisting drug supply chain stakeholders for approaching DSCSA Saleable Returns and interoperable requirements by 2019 and 2023, respectively.

Source: MediLedger; Frost & Sullivan

MediLedger's Blockchain Based Returns Product Verification System (PVS) for Saleable Returns US DSCIS Requirement

Operating Model—MediLedger Project's GTIN Lifecycle Management Solution



Current Partnership Ecosystem

PVS Working Group

AbbVie US, AmerisourceBergen, Roche/Genentech, McKesson, Pfizer, Walmart

Contracting and Chargeback Working Group

Pfizer Inc., McKesson Corporation, AmerisourceBergen Corporation, and Premier Inc.

Tech Partners

SAP, Multichain

Pricing Model: The company plans to offer free licensing for the upcoming PVS Saleable Returns solution, based on the number of transactions.

Analyst Perspective: Considering 2% to 3% of total drug sales are saleable returns, Frost & Sullivan finds the application of MediLedger's Blockchain-based look-up directory solution (PVS) a scalable and secured solution that efficiently integrates with existing ERP or ICD verification routing server systems to augment pharma manufacturers and wholesalers in complying with approaching US DSCSA (November 2019) requirements. For example, with past pilot runs, the company has proven the verification response time of 100 milliseconds or less within the same region and 400 milliseconds for coast-to-coast verifications that address the latency issue with competing solutions. MediLedger follows GS1 globally accepted standards for business and barcodes. The Smart Contract feature on MediLedger provides flexibility with a consensus mechanism, where wholesalers with the ownership of private nodes can identify non-direct purchases and manufacturers to make interim changes in marketing authorization. **With strong industry wide-collaboration and proven Blockchain solutions, Chronicled anticipates that 60% to 70% Saleable Returns transactions in the US will be managed on the MediLedger platform in next 12 to 18 months.**

Source: MediLedger; Frost & Sullivan

Case Study—Blockchain for Monitor Temperature Sensitive Medicines

Modum estimates that the DLT and IoT based drug temperature monitoring system can reduce per shipment cost up to 60% for specific biologics drug classes with high-volume transactions.

Industry Need

About 200 million pharma shipments are handled annually in the European region. Interestingly, 90% of shipment volume happens as a last-mile delivery between distributors and dispensers (e.g. hospitals and pharmacies), compared to 10% between pharma manufacturers and distributors. This makes last-mile drug shipment a complex and fragmented process, lacking trust and supply chain provenance. This issues heightens especially for temperature-sensitive biologics drugs, creating supply chain disruptions and quality compromises.

Case Study: Co-innovating IoT and Blockchain Solution to Monitor Temperature-sensitive Medicines

SWISS POST — Temperature-monitored shipments and logistics service provider

modum — Provides pharma-certified IoT-based monitoring and data-logger systems

SAP — Co-innovation partner to build and deploy Blockchain solution for temperature-controlled logistics across its pharmaceutical customer base (SAP Cloud Platform for Life Sciences)

How it Works?

1. Swiss Post provides **ThermoCare boxes**, a standard packaging service to ensure shipment of medicines kept within a specified temperature range.
2. Modum offers IoT sensors called **MODSense** that can be placed inside a package and programed to record and store with the permitted temperature range offline, while it is in transit.
3. A checksum entry is created on the Blockchain-based **SAP Cloud Platform**, to store information on a mutually agreed smart contract.
4. At each delivery point, individual shipment's barcode is scanned, and **MODlink** integrates the respective sensor data with different IT systems in the supply chain ecosystem to verify with Blockchain shared ledger on SAP Cloud Platform.
5. Blockchain-based **smart contracts** are automatically executed to verify compliance to process invoice or request to send product again.

- **Commercial Deployment Stages:**
  - In the past 4 years, modum has completed 3 pilots in the European region by successfully monitoring multiple temperature loggers, capturing in excess of 500,000 data, involving less-complex shipments between SME pharma producer and wholesaler, to large-scale last-mile shipment between wholesaler and several clinics and pharmacies, and even with 3PL and mail-order pharmacy.
  - In 2017, Modum collaborated with Swiss Post to integrate its IoT-based temperature-logging devices within Swiss Post's track-and-trace system.
  - In November 2018, it started a pilot in collaboration with SAP Co-Innovation Lab to develop a proof of concept and enable it to implement it for the customer, in this case Swiss Post.
- **Future Strategy:** Leveraging on its strong collaboration, Modum will continue its focus to establish a strong market position in Europe. The company is currently working with multiple pharma distribution customers across the UK, France, Germany, Turkey, and Vietnam.
- **Pricing Model**: It is a pay-per-shipment" model (up to $10 per shipment).

Source: modum.io; Frost & Sullivan

Public-private Blockchain Consortium to Watch

innovative medicines initiative	IEEE
• IMI is a public-private partnership between the EU and the European pharmaceutical industry represented by European Federation of Pharmaceutical Industries and Associations (EFPIA). • In August 2018, it announced a call for proposal on Blockchain technology application across a common Blockchain ecosystem for pharmaceutical development, manufacturing, and distribution. • IMI pharma Blockchain consortium helps members to evaluate, design, and accelerate the adoption of Blockchain across the drug supply chain and clinical trials. • The project is funded both by the industry and EU grants	• In November 2017, IEEE launched the Pharma Blockchain Initiative to evaluate DLTs for securing and optimizing the pharmaceutical supply chain. • At present, the consortium is working on Blockchain pilots to achieve compliance with the FDA's Drug Supply Chain Security Act (DSCSA) and combating counterfeit medicines.
Key Network Partners Pfizer, janssen, ucb Pharma, BAYER, J&J, abbvie, novo nordisk, NOVARTIS, SANOFI	**Key Network Partners** Pfizer, J&J, BAYER

Analyst Perspective: Given that the pharma drug supply chain is complex with multiple stakeholder involvement, governance challenges around Blockchain technology necessitate building a consortium with representative pharma supply chain parties that can agree on consensus mechanism rules before a solution is even developed. Among drug supply chain participants, leading global pharma manufacturers show the greatest propensity to join consortia and explore the Blockchain technology potential.

Source: Frost & Sullivan

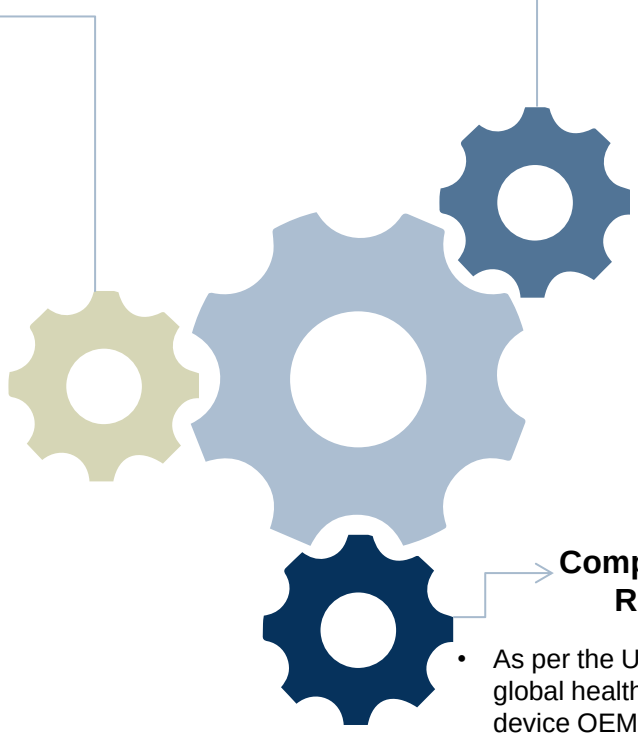
Use Cases 3.2—Medical Device Supply Chain

Return to contents

Medical Device Safety and Quality Challenges

Medical Device Servicing and Lifecycle Management

- Increasing volume and complexities of medical devices used across healthcare settings make it a daunting task to ensure safety, security, and compliance for medical devices servicing and lifecycle management
- For example, large hospitals, on an average, incur a loss of $4,000 per bed, each year from theft or loss of equipment, while misplaced equipment results in a loss of $8,000 per bed.
- Lack of trusted systems and standoff between OEMs, hospitals, and Independent Service Organizations (ISOs) on medical device servicing create increased quality and safety risk. Based on industry estimates, medical device OEMs lose 7% to 9% of revenue due to fines, litigations, and reputational damage.



Pre- and Post-market Management of Cybersecurity in Medical Devices

- Like any other IT system, a majority of connected medical devices with embedded software and supporting infrastructure is susceptible to cybersecurity threats.
- Particularly, home and remote monitoring devices and medical devices, such as pacemakers, dialysis devices, and insulin pumps, that are connected to external network systems can be hacked and compromised.
- As regulators recognize cyberattacks risks, cybersecurity is becoming a regulatory imperative for device manufacturers. For example, the FDA has issued several warning letters to leading device OEMs, such as Hospira, Abbott (St Jude Medical Inc.), and Medtronic, for potential cybersecurity risks.

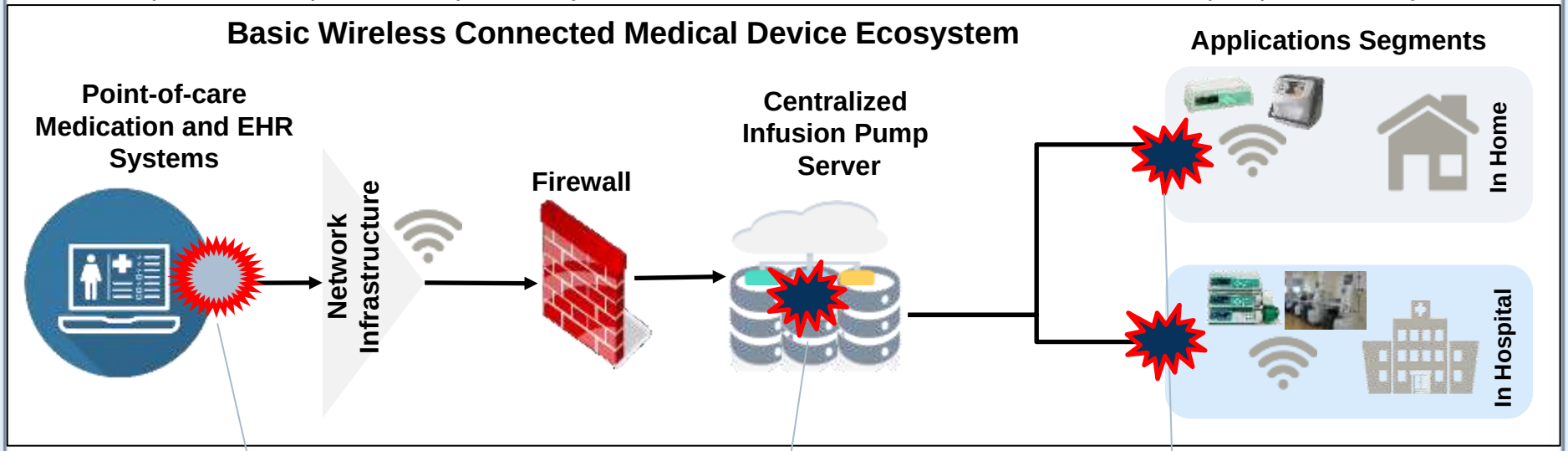
Compliance With UDI Requirements

- As per the Unique Device Identification (UDI) mandate by major global health authorities, such as US FDA and EU MDR, medical device OEMs are accountable to ensure complete traceability of their devices.
- However, current inventory and device identity management systems are not efficient or reliable (lack trust) to register and track the point of failure and accountability.
- In case of any such deficit or malfunction, the medical device OEM must prove that it is not responsible for the mistakes else it is liable to pay hefty fines, recall devices, and even stop future commercialization.

Source: Frost & Sullivan

Connected Medical Device Cybersecurity Vulnerabilities With Current Systems

Case Example: Possible point of compromise/cyberattack with current connected network of infusion pumps/home dialysis machine



Cyberattack pathway to compromise hospital information management system (EHR/health records)

Single point of failure—compromise of communications module and therapeutic module of infusion pumps in the network (e.g., manipulating dosage or flow rates).

- Manipulation of effective safety measures (e.g., drug library)
- Patient and device identity theft
- Improper 3rd-party connections

Key: Possible Point of Compromise/Cyberattack

Device/Endpoint (Infusion Pump) Vulnerabilities

Information/Data Vulnerabilities

"Despite the segmented design, it may be possible for an attacker to compromise the communications module and the therapeutic module of the pump."

Industrial Control Systems Cyber Emergency Response Team (**ICS-CERT**)

Source: Frost & Sullivan

Blockchain-based Secure and Trustless Connected Device Ecosystem

Case Example: How Blockchain improves trust and security with the current network of connected infusion pumps/home dialysis machine

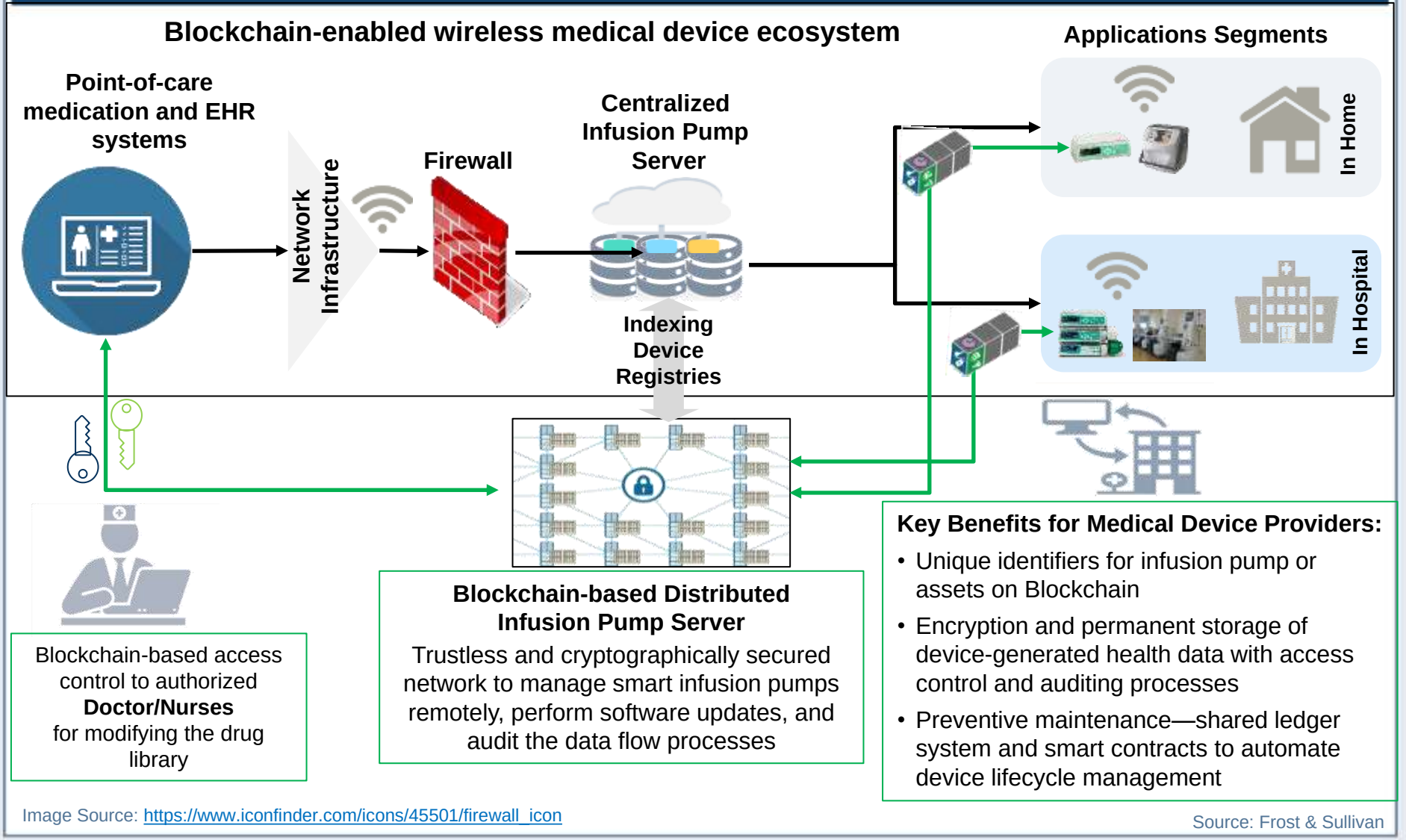


Image Source: https://www.iconfinder.com/icons/45501/firewall_icon

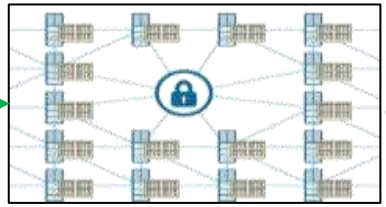
Source: Frost & Sullivan

Case Example—Role of Blockchain in Atrial Fibrillation (Afib) Device Identify Management and Maintenance Monitoring

Robert (patient), with atrial fibrillation, is having an Afib device implanted.

2

A UDI is created by the OEM to register the device on the DLT system.



3

Once registered, a unique code (#) is created and stored on the DLT system, along with the device UDI and other relevant information.

1

Company XYZ manufactures the Afib device with a unique serial number

Value Proposition

- **Device Identity Management**: DLT-based UDI management system increases the auditability and tractability of the implant device on an immutable digital ledger, anytime by appropriate participants.
- **Device Data Access Control:** Access control and smart contract features, enable Robert (patient) and his cardiologist to record and read device-generated data (e.g., heat rate variability), along with Roberts' PHR to improve care coordination.
- **Device Lifecycle Management:** DLT-based shared service record for the device enables all involved parties, such as OEMs, independent service organizations, and telecardiology units to record the evidence of possible service actions across the device lifecycle.
- **Preventive Maintenance:** DLT systems, coupled with ML/predictive analytics augment the care team and device OEM with real-time dashboard manage to effectively manage medical device alarm systems (false positive/false negative) for prioritizing high-risk patients or possible device malfunction and recalls.

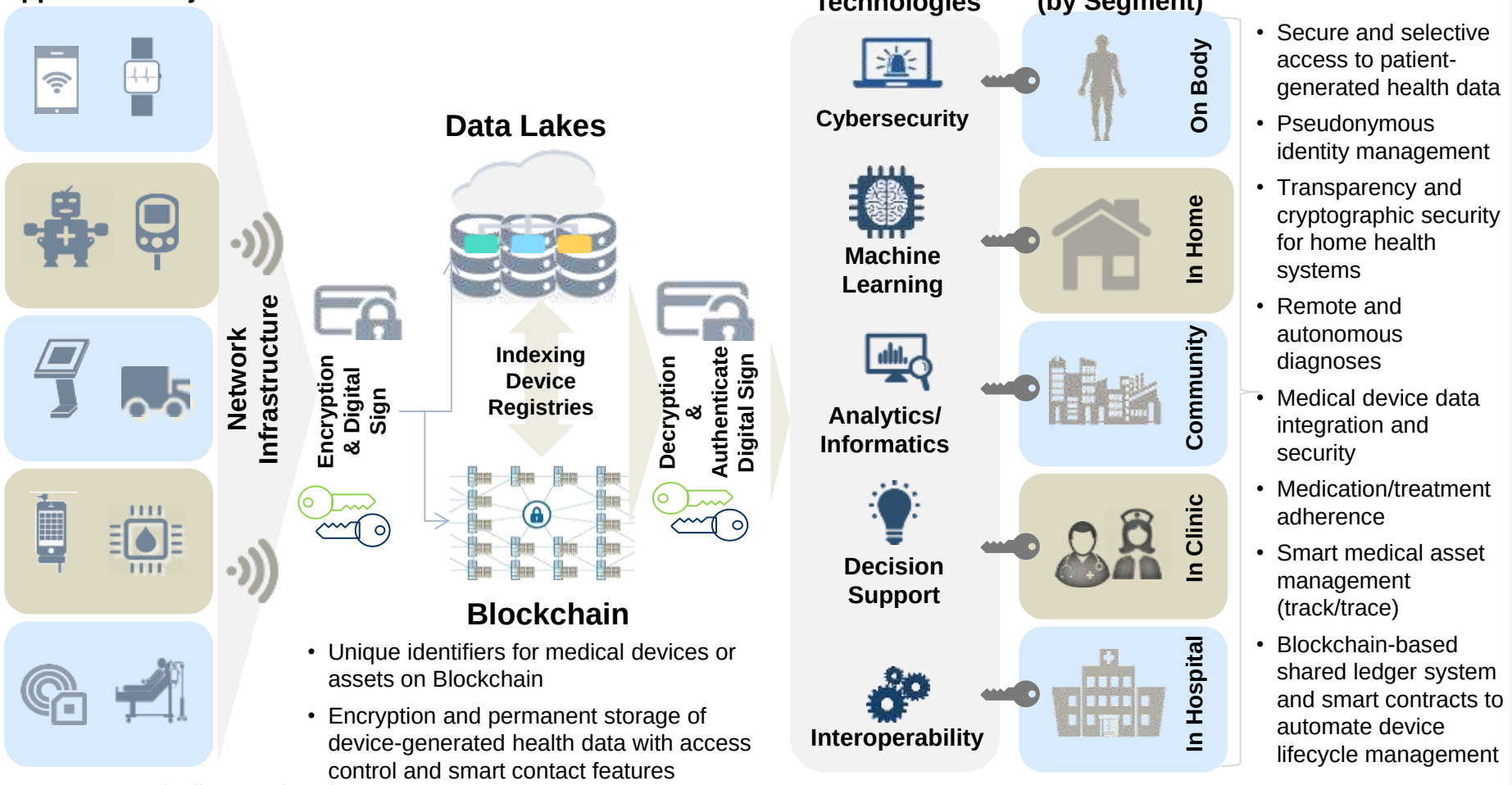
Image Source: https://oneheartcardiology.com.au/carousel_slide/implantable-loop-recorder-1/

Source: https://leadersneedpancakes.com/page/16/; Frost & Sullivan

Potential Impact of Blockchain Across the IoMT Value Chain

Due to privacy and security issues, medical device manufacturers only have 20% to 30% of their IoT medical devices connected in the hospital.

Blockchain Technology in the Healthcare Industry: Potential Impact Across the IoMT Value Chain, Global, 2018–2022



- Unique identifiers for medical devices or assets on Blockchain
- Encryption and permanent storage of device-generated health data with access control and smart contact features

Note: Representative list, not exhaustive

Source: Frost & Sullivan

Growth Opportunity—Medical Device Lifecycle Management

DLTs can be employed to efficiently improve security and traceability of connected devices for safety, quality and compliance; and the needed trust to share device generated data to improve care coordination.

Applicable Market Segments	Payment and Claim Mgmt.	Professional Credentialing	Drug Supply Chain	**Medical Device Lifecycle Mgmt.**	PHR & Health Data Exchange	Research and Clinical Trials
Applicable Value Chain Participants	Government	Payers	Providers	Patients	Pharma and Med-Tech Suppliers	Emerging IT Vendors

- Vision and Strategy
  - Vision Transformation
  - Mega Trends' Impact
  - Disruptive Applications
- Business Models
  - Current Offerings
- New Capabilities
  - Value-add Services
  - Vertical Integration
  - Geographic Expansion
- Partnerships
  - Investment/M&A

Context and Opportunity

- According to regulators (e.g., FDA), like any connected device, medical devices with network connectivity, operating systems, and software, such as PET and CT scanners, MRI machines, infusion pumps, dialysis machines, and wearables, have been found to be increasingly susceptible to hacking.
- Blockchain could provide significant cost savings by streamlining the secure tracking and management of billions of medical devices.
- Medical device lifecycle management is complex, given the volume and changes in location and ownership, and reliance on 3rd parties to perform maintenance and repairs.
- Approaching regulatory requirement, such as UDI in the US and MDR in the EU, makes it critical to ensure complete traceability of their devices, especially when medical device OEMs are accountable.

Call to Action

- If all production and ongoing usage or maintenance-relevant data are recorded in a Blockchain, its immutable and trusted workflow with a "single source of truth" would empower medical device OEMs with complete traceability (both pre and post marketing) and evidence on accountability for any malfunction in a device.
- Medical device OEMs should explore the potential of DLT and smart contracts to make the medical device lifecycle management process more auditable, trusted, and automated. For example, Spiritus Partners' DLT-based shared device and service registry will efficiently provide traceable, verifiable, and actionable records of a medical device's safety, quality, and compliance status.
- Trusted Blockchain systems improve integrity and auditability of health data from wearables, sensors, mobile apps, and other IoMT devices.

Note: RPM—Remote Patient Monitoring

Source: Frost & Sullivan

Company to Watch— Spiritus Partners Inc.

Spiritus Partners' DLT- and analytics-based digital shared service record solutions works at the intersection of clinical asset management, decontamination, and sterilization services, and infection control.

Business Description

- In 2017, **Spiritus Partners Inc.** started its operation by establishing a development center in Scotland to develop a DLT-based enterprise platform to manage the safety and security of medical devices across their operational lives.
- Spiritus is supported by a Scottish Enterprise grant of $645,000, and a $268,466 grant from the Scottish Government.

Healthcare Focus Areas	
Healthcare Use Case Focus	Medical device shared service record and life cycle management
Target Customers	• Health systems • Medical device OEMs • ISOs

Key Blockchain Solutions Deployment Stages and Healthcare Partnerships

- **Commercial Pilots (On-going):**
  - In Sep 2017, Spiritus announced the launch of its Blockchain-enabled pilot project in collaboration with Edinburgh Napier University, NHS National Services Scotland and industry collaborator. In the last few months, the pilot project has demonstrated the value of DLT and data analytics solutions in tracking the chain of custody of connected medical devices throughout its lifecycle, especially for devices and implants to monitor chronic conditions, such as asthma, diabetes, heart disease, and neurodegenerative disorders.
  - As a part of their go-to-market strategy, Spiritus is developing health systems network partnerships (a minimum viable ecosystem), which is acting as the center of excellence to run beta tests of their enterprise platform solutions. The company also has business development operations in New Jersey, US, and is currently exploring opportunities with major health systems on medical device cybersecurity management.
  - In the next 1 to 2 years, the company has plans to expand the scope of its DLT-based medical device shared service record applications across critical activities such as credentialing artifacts, attestation by service engineers, and standards (ISO, UDI, MDR).

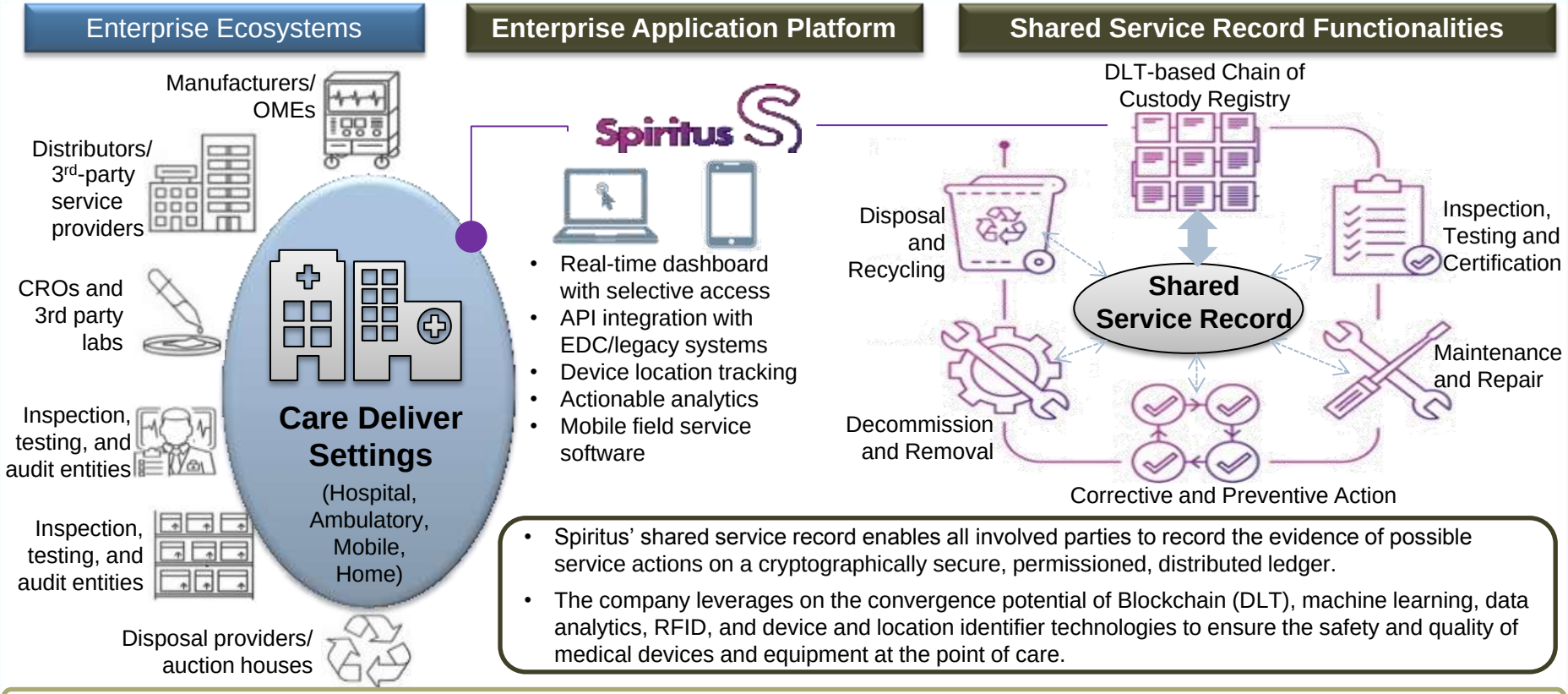
Key Partnerships:

- The API solutions on Spiritus enterprise platform are Blockchain protocol agnostic. In the recent past, Spiritus migrated from Ethereum to Hyperledger, as the latter provides better opportunity to work around challenges on communities such as Hyperledger HWG.
- Other key technology partners include Microsoft (Azure), ESRI (Arc GSI), and GS1 (identifier and standards).

Source: Spiritus Partners; Frost & Sullivan

Company to Watch— Spiritus Partners (continued)

The company provides Blockchain-based shared service record to ensure optimal device lifecycle management.



- Spiritus' shared service record enables all involved parties to record the evidence of possible service actions on a cryptographically secure, permissioned, distributed ledger.
- The company leverages on the convergence potential of Blockchain (DLT), machine learning, data analytics, RFID, and device and location identifier technologies to ensure the safety and quality of medical devices and equipment at the point of care.

Analyst Perspective: Considering increasing regulatory and supply chain complexities for connected medical devices, Frost & Sullivan finds Spiritus' DLT-based shared service record a timely solution to provide much needed 'chain of custody' and provenance for medical device lifecycle management. Integration of a DLT-based trusted system with analytics and visualization would provide real-time dashboard for individual assets and will minimize the standoff between OEMs, hospitals, and independent service organizations on medical device servicing. Frost & Sullivan believes such solutions can augment the medical device industry to comply with regulatory changes (UDI/MDR, post marketing surveillance, horizon scanning), and avoid potential litigations, fines, and reputational damage. Additionally, with increasing competition-driven commoditization of medical devices such Blockchain solutions can provide a differential value position for OEMs in a value-based care model.

Image Source: www.spirituspartners.com

Source: Spiritus Partners; Frost & Sullivan

Major Medical Device Manufacturers Exploring Blockchain

PHILIPS
Healthcare

- Philips is one of the medical device pioneers and has been exploring DLTs as a part of its Blockchain Research Lab since 2016 with early Blockchain partners such as Gem and Tierion.
- In March 2018, Philips launched its AI platform called HealthSuite Insights which integrates Blockchain technology for ensuring identity and access management.
- Philips also reported exploring private or consortium Blockchain, which will be available to a limited number of parties. One of these pilot projects involves "verifiable data exchange" use case, to ensure identity management, trust, and auditability for sharing anonymized clinical data between researchers in a network of hospitals.

Medtronic

- Of late Medtronic has been the most vocal medical device company on the potential of Blockchain in the healthcare space. The company hosts a Blockchain thought leadership page on its company portal.
- Medtronic, in collaboration with US FDA, has entered into an agreement with Yale University to develop methods for post-market surveillance of medical devices leveraging on Blockchain technology.
- Under a separate collaboration with J&J (Janssen) it has an agreement with Yale University, to develop methods of clinical trial data sharing.

Source: Frost & Sullivan

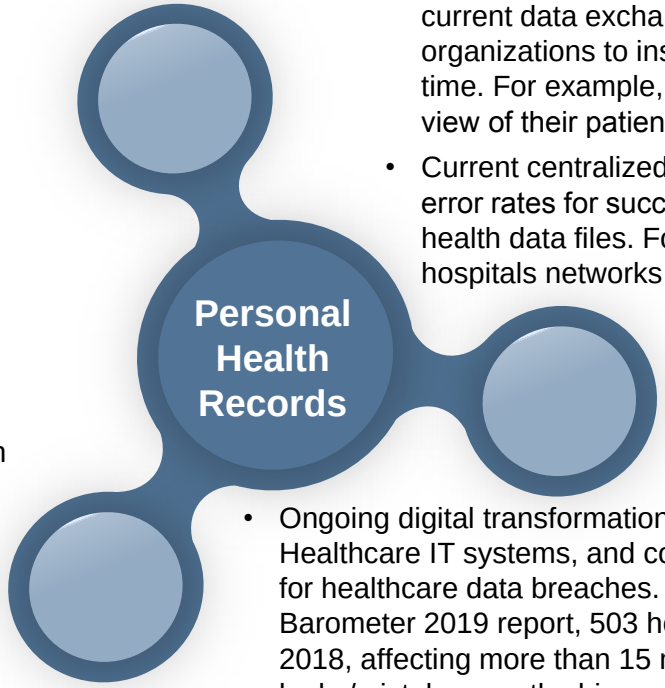
Use Cases 4—PHR and Health Data Exchange

Return to contents

Healthcare Data Exchange, Access, and Ownership Challenges

Health Data Interoperability Challenge

- About $200 billion is wasted due to lack of interoperability with current data exchange systems, preventing payer and provider organizations to instantly access the right information at the right time. For example, 46% of US clinicians do not have a complete view of their patients' health history and records.
- Current centralized health IT systems create silos and increase error rates for successful identification or integration of a patients' health data files. For example, such error can be as high as 25% for hospitals networks and 50% to 60% outside hospital networks.



Health Data Ownership and Monetization Debate

- With increasing consumer awareness, data-ownership debates are getting intensified with each passing day (who owns my data and how are they monetizing it?).
- For example, recently the governments of the Netherlands and Finland legislated that individuals have an absolute right to their health records.
- Lack of access and control over individual self-data limits the full potential of preventive-care programs and, more importantly, sharing personal data with medical research for concepts such as precision medicine and population health research.

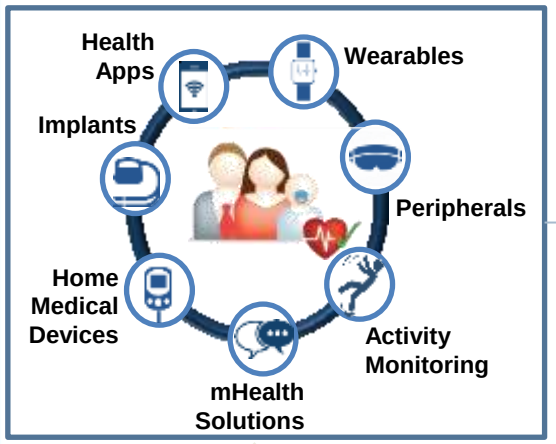
Health Data Regulatory Changes and Cybersecurity Threats

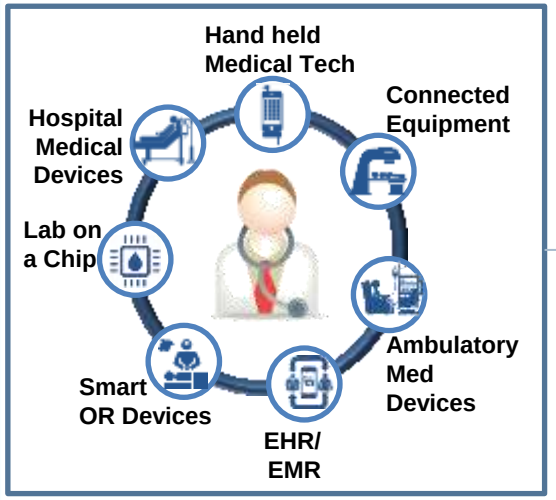
- Ongoing digital transformation of the healthcare industry with fragment Healthcare IT systems, and connected devices increase vulnerable endpoints for healthcare data breaches. For example, as per the Protenus Breach Barometer 2019 report, 503 health data breaches were reported to HHS in 2018, affecting more than 15 million patient records. Furthermore, insider leaks/mistakes are the biggest loop holes with current centralized models for compromising private health information compared to breaches from outside.
- Likewise, increasing regulatory scrutiny and evolving standards (e.g., HIPPA, HITRUST, and GDPR) to prevent unauthorized disclosure of protected health information create a pressure to keep up with this requirement and avoid substantial fines. For example, the final settlement of Anthem's privacy violation lawsuits at $16 million in October 2018 indicates the degree of repercussion on healthcare companies from cyberattacks.

Source: Frost & Sullivan

Blockchain Potential Impact across Healthcare Data Exchange and Interoperability Value Chain

Patient Generated Data





Clinical Data and Health Records

- Stores different types of health data (e.g., images, genomics, and lab reports)
- Consists of structured and unstructured data
- Information is encrypted and digitally signed

Encryption and Digital Sign

Data Lakes

Indexing

Blockchain

- Consists of a complete indexed history, patient's unique identifier, and an encrypted link to a health record
- Time stamp on each record
- All patient records (historical) remain together and stay with the patient
- Patient to control whom to give permission to share the data

Decryption and Authenticate Digital Sign

Health Analytics and IoMT

Providers use health application to access health data

Providers

Patient

Patients use mobile devices to assign access permission to data and to provide a public key.

Blockchain network consensus enables disintermediation to automate claim adjudication and payment processing with predefined smart contracts.

Payers

Pharma/ Research

Distributed patient consent for research/clinical trials enables data sharing, audit trials, and clinical safety analyses.

Source: www.healthit.gov; Frost & Sullivan

Growth Opportunity—PHR and Health Data Exchange

At its core, Blockchain would offer the potential of a shared platform that decentralizes health data exchange ensuring access control, authenticity, and integrity of protected health information.

Applicable Market Segments	Payment and Claim Mgmt.	Professional Credentialing	Drug Supply Chain	Medical Device Lifecycle Mgmt.	**PHR & Health Data Exchange**	Research and Clinical Trials
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- Partnerships
- Investment/M&A

Context and Opportunity

- Lack of interoperability costs 150,000 lives and $18.6 billion per year. PHR is regarded as the holy grail for DLT application in healthcare industry, as it offers a fresh approach to healthcare data interoperability by ensuring a trusted and patient-centric data governance approach.
- However, large-scale commercial deployment of PHR application seems more feasible in European and Asian countries where the data vendor ecosystem is relatively less complex compared to the US market.
- Blockchain is considered as the catalyst for trusted digital workflows and its convergence with other merging technologies (e.g., AI, analytics, and IoMT) and care delivery models (e.g., telemedicine, teleradiology) is expected to create decentralized learning systems

Call to Action

- Healthcare data vendors can use DLT-based longitudinal health records, including inpatient, ambulatory, and RPM data are expected to improve clinical care coordination; and help physicians to effectively manage emergency medical situations.
- Blockchain-based PHR vendors find telehealth services a natural extension to offer data-driven insights and healthcare services to their patient community.
- Blockchain-based decentralized data networks improved data liquidity while empowering AI and analytics vendors/applications to digest a large amount of clinical, operational, and financial data to further validate and scale up their insight platforms.
- Telehealth vendors can leverage on DLT-based cryptocurrency and smart contracts to effectively monetize user-generated sports and wellness data.

Note: RPM—Remote Patient Monitoring

Source: Frost & Sullivan

Company to Watch—Guardtime

Guardtime is the leading vendor when it comes to large-scale successful commercial deployment of Blockchain technology for health data security and access solutions.

Business Description

- **Guardtime** is one of the largest enterprise Blockchain companies by revenue, headcount, and actual customer deployments globally.
- It offers a proven and scalable HSX Platform, built on its proprietary KSI Blockchain technology for developing integrated healthcare-focused software APIs such as PHR, access (consent) management, clinical trial patient engagement, outcomes based contracting, medication adherence, and drug supply chain.

Healthcare Focus Areas

Healthcare Use Case Focus	• PHR • Universal health identity • Clinical trials
Target Customers	• Government/health systems • Health insurance • Pharma and medtech

Key Blockchain Solutions Deployment Stages and Healthcare Partnerships

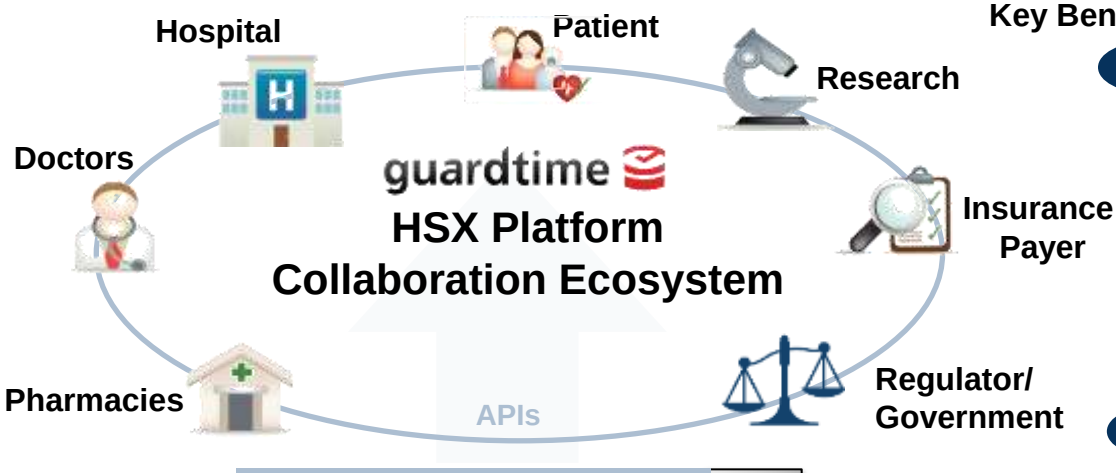
- **Successful Commercial Deployments:**
  - **Estonian National Health Care:** Guardtime collaborated with the Estonian eHealth Foundation in 2016 to secure the health records of 1 million Estonian citizens using its proprietary KSI Blockchain platform. KSI Blockchain instrumentation enables users of the patient information system to be 100% certain of the accuracy of all the retrieved records.
  - **NHS (UK) MyPCR Platform:** In June 2018, Guardtime, in collaboration with Instant Access Medical (iAM) and Healthcare Gateway, launched a Blockchain-based PHR called the MyPCR platform for NHS patients in the UK. The MyPCR platform is GDPR-complaint and provides up to 30 million UK NHS patients with instant access to their primary care information, personal care pathways, and medication adherence support through their smartphones.
  - **NMC Health Partners:** In January 2017, NMC Health, the UAE's largest private-sector healthcare provider catering to more than 11,000 patients a day, announced a partnership with UAE-based telecom provider "du" to deploy Guardtime's KSI Blockchain technology in the UAE.
- **Key Partnerships:**
  - In September 2018, Guardtime announced a partnership with **SUMMUS Global**, an expert physician network and concierge service provider, to develop on-demand virtual health concierge services for the Asian market. The Telehealth platform will be built on the HSX Platform to provide GDPR-compliant Blockchain technology for a secure and updatable medical records management system that can be integrated with existing healthcare provider networks globally to exchange healthcare data and images.
  - In October 2018, Guardtime integrated its KSI Blockchain protocol with **EPIC's EHR System to** improve interoperability across healthcare institutions by providing an immutable chain of evidence for a healthcare record throughout its lifecycle.
  - Other partnerships include DIGITAL MANAGEMENT, LLC and Ernst & Young.

Source: Guardtime; Frost & Sullivan

Company to Watch—Guardtime HSX platform

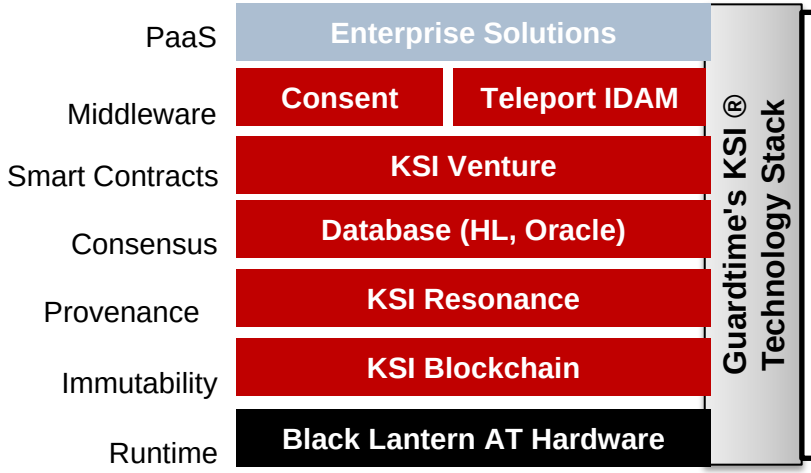
Guardtime's HSX platform provides a single version of trusted information to increase the collaboration between patients, providers, payers, regulators, and pharma companies to promote effective patient care.

Guardtime uses federated/decentralized data management principles and technology stack to bridge the data gaps across the entire health ecosystem while maintaining the integrity of data and legitimacy/autonomy guarantees for every system participant. It enables every stakeholder to see the necessary information across the whole healthcare system while preserving the privacy and integrity of everyone.



Key Benefits of KSI Blockchain Based HSX Platform

1. Integrity: transparency and auditability of data
2. Provenance and auditing: compliance with privacy regulations
3. Consent: personal control of health data access by various entities
4. Exchange: Improvement of data visibility and liquidity management
4. Reporting: making data "visible" for secondary use in RWE research



The Guardtime HSX technology stack has 3 core layers of functionality:

- **APIs:** To enable clients to immediately take advantage of the Blockchain technology through APIs for data integrity, data provenance, anonymization, consent, and identity mapping, still using legacy systems
- **Applications Development:** To help clients develop customized applications on top, including, clinical trial patient acquisition, patient consent and signing, and patient monitoring, among others
- **Transport:** To provide connectivity and integration with major EHR systems (EPC, Cerncer) with directory services and seamless transfer of health data with Blockchain-based guarantee for immutability and provenance.

Source: Frost & Sullivan

Company to Watch—MEDIBLOC

MEDIBLOC provides DLT based on an open-source healthcare data exchange platform to securely integrate siloed individual health data across different institutions' EHR/health IT systems and connected devices.

Business Description

- Founded in 2017, **MEDIBLOC** is a South Korean start-up, that offers open-source healthcare data exchange platform built on Qtum-based Blockchain to securely integrate siloed individual health data across different institutions health IT systems and connected devices.
- The company offers open-source API and SDK for developing smartphone applications for patient-centric health data exchange services on MEDIBLOC platform.

Healthcare Focus Areas	
Healthcare Use Case Focus	• PHR • Clinical trials • Telemedicine
Target Customers	• Government/health systems • Health insurance • Pharma clinical trials/research

Key Blockchain Solutions Deployment Stages and Healthcare Partnerships

Minimum Viable Product Release and ICO Launch:

- In December 2018, MEDIBLOC released the full version of its healthcare data platform for applications including PHR, cryptocurrency transaction, Blockchain ID, and information sharing system. The core platform has been tested across multiple PoCs conducted in cooperation with leading South Korean medical institutions and businesses.
- MEDIBLOC launched its ICO called Meditoken (MED) in November 2017 to incentivize patient and vendors to participate on the healthcare data platform. As a part of this ICO round, MEDIBLOC sold about $30 million worth ER20 tokens (MED).
- In August 2018, it launched its medicine management application called YOL. It comes with a prescription-sharing rewarding program, and users of YOL can receive MED as an incentive for providing their medical data and experience.
- In April 2019, MEDIBLOC platform solution was implemented at Kyung Hee Dental Healthcare Center (KHDHC) which provided a Blockchain-powered comprehensive dental examination and care coordination system.

Exploratory Commercial Pilots:

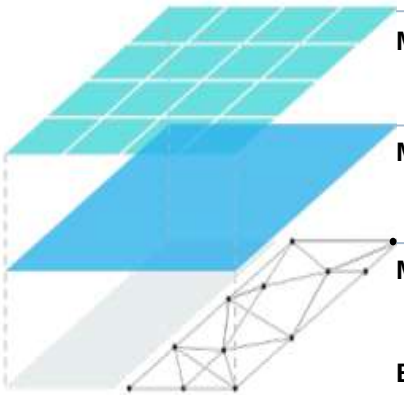
- **Hospital Provider Network:** In the last 2 years, the company has collaborated with 11 medical institutions, including 3 out of the big 5 hospitals and in South Korea and the Massachusetts General Hospital (MGH) of Harvard Medical School, in the US, to test and develop the commercial version of its PHR platform.
- **MyData project held by Korea Data Agency:** In May 2019, MEDIBLOC was the only Blockchain company selected to be a part of the South Korean Government's MyData project initiative. Backed with a funding of US$ 1 million (toward MEDIBLOC and Samsung Fire and Marine Insurance), MEDIBLOC aims to develop multiple Blockchain-based patient-centered healthcare data application by November 2019 such as healthcare check and information exchange services, participation in clinical research, and health promotion coaching based on lifelong data and medical records among others.
- **Health Insurance:** In September 2018, it collaborated with Kyobo Lifeplanet Insurance Company to develop Blockchain-based insurance products and claim processing system.

Source: MEDIBLOC, Frost & Sullivan

MEDIBLOC—Decentralized PHR platform

Beyond current B2B offerings, MediBloc has plans to develop B2C services and applications that allow patients to record and manage their own medical data in the most convenient and safe manner.

MEDIBLOC Platform—Healthcare Data Platform Technology Stack



MEDIBLOC Apps	Health Report Automatic Insurance Claim Data Exchange
MEDIBLOC Services	Identification Data Indexing MED Token
MEDIBLOC Core	Data Network
Blockchain	Qtum

Image Source: MEDIBLOC Whitepaper

MEDIBLOC Network Partnerships

Large Medical Institutions in South Korea

Seoul St. Mary's Hospital; Seoul National University Hospital; and Severance Hospital

Other Hospitals partners in South Korea

Seoul Medical Center; Hanyang University Medical Center; Kyung Hee Dental Hospital; Oracle Medical Group; Chonnam National University Hospital; and Bestian Foundation.

Leading Health System in the US

Massachusetts General Hospital (MGH) of Harvard Medical School

Health Insurance Provider in South Korea

Kyobo Lifeplanet Insurance Company; PolicyPal Network

MEDIBLOC - Decentralized PHR platform Functionality and Access Control by Major Healthcare Stakeholders

PHR Functionalities	Individual/ Patient	Healthcare Provider	Data Researcher
Read and write	Full access	All possible	Only permission-based access
Read others' healthcare data	No access without the consent of the account owner (option to disclose to family)	• Access for emergency situation; account owner consent required. • Marked "access request by a healthcare provider@	• Account owner consent required • Marked "access request by data researcher"
Write on others' healthcare information	• No access without account owner's consent (optional for family). • Marked "Patient-Generated Record"	Only possible with account owner's approval and marked as healthcare provider-generated record	• Only with account owner's approval • Marked as non-healthcare professional generated record

Analyst Perspective: Frost & Sullivan finds that MEDIBLOC is one of the most successful Blockchain vendors to demonstrate the decentralized PHR platform application across several exploratory commercial pilots in South Korea. The company's local focus and growing partnership network with leading medical institutions, businesses, and the government in South Korea, position MEDIBLOC as one of the most promising Blockchain vendors in the country to watch.

Source: MEDIBLOC, Frost & Sullivan

Use Case 5—Research and Clinical Trials

Return to contents

Medical Research and Clinical Trial Challenges

Reproducibility, data sharing, personal data privacy concerns and patient enrolment in clinical trials are huge medical challenges for contemporary medical research and pharma clinical trials.

eSource data integrity and provenance for regulatory purpose

- Clinical trial sponsors spend up to 25% of the entire **clinical trial** budget for Source Data Verification (SDV) to ensure integrity and provenance for collected data for regulatory needs.
- Increasing preference for eSource and RWE data heightens the cost and process complexities related to ethical data collection and management, IT system integration, and reproducibility.

Limited secondary research due to under reporting of clinical trial data

- As per estimates, 50% of all clinical trials go unreported, and investigators often fail to share their study results (e.g., nearly 90% of the trials on ClinicalTrials.gov lack results).
- This creates crucial safety issues for patients and knowledge gaps for healthcare stakeholders and health policy makers.

Clinical trials patient recruitment and engagement

- About 80% of pharma clinical trials do not meet enrolment deadlines, resulting in an average loss of up to $1.3 million per day for a given drug candidate.
- According to industry estimates, due to lack of patient-centric trial deigns, up to 35% of patients drop out of clinical trials.

Patient consent management to access individual RWD for research

- The clinical trial process is subjected to interim protocol amendments, which makes patient consent collection a dynamic and challenging process.
- Increasing trend of precision and population research concepts create serious concerns with current consent management process. For example, based on industry estimates, there is little or no expressed consent for a majority of clinical biobanks and RWE platforms sharing research, data/material sharing to other groups, especially industry.

Source: Frost & Sullivan

Blockchain's Potential Impact on the Drug Development Value Chain

Blockchain helps in driving unprecedented collaboration between participants and researchers to drive innovation in medical research for concepts such as precision medicine and population health research.

Blockchain Use Cases/Benefits: Drug Development Value Chain by Major Activity*, Global, 2018–2022

	Drug Discovery	Preclinical	Clinical Development	Regulatory Approval (Post Marketing)	Manufacturing and Distribution	Patients
	Managing R&D assets and IPs on the Blockchain	Smart contracts with external partners (e.g., in-licensing, CRO, academia, etc.)	Smart contracts to increase data integrity and patient consenting process	Better and faster regulatory compliance and approvals	Better demand visibility and supply chain optimization with disintermediation	Bilateral communications/ transactions with all industry participants
Key Benefits	• DLT-based privacy-preserving systems to promote collaborative research • Better IP management—proof, protection, sharing, and monetization • Faster discovery cycle	• Smart IP platform for peer-to-peer IP sharing • Royalty payment and copyright management • Facilitates tech transfer offices for IP transactions • Due diligence and commercialization • IP protection and publication	• Increases integrity and provenance for transmission of clinical trial data • Peer-to-peer data sharing with eConsenting features • Secure access to EHR and population genomic data • Data integrity and access control	• Data sharing and tracking • Verification with smart contracts • Record management for methods and results • Protocol documentation • IP registration and exchange • Proof of existence for patent filing	• Digital track and traceability • Payment transactions across the supply chain • Inventory management systems • Expedited drug recalls • Regulatory compliance requirements	• Access to patient health records • Counterfeit protection • Digital identity for privacy and authenticity • Medication adherence and IoT monitoring • Smart contracts and health insurance • Incentive management

Key: Potential Impact/Opportunity

High → Low

*The list is not exhaustive

Source: Frost & Sullivan

Growth Opportunity—Research and Clinical Trials

At its core, Blockchain would offer the potential of a shared platform that decentralizes health data, ensuring access control, authenticity, and integrity of protected health information.

Applicable Market Segments	Payment and Claim Mgmt.	Professional Credentialing	Drug Supply Chain	Medical Device Lifecycle Mgmt.	PHR & Health Data Exchange	Research and Clinical Trials
Applicable Value Chain Participants	Government	Payers	Providers	Patients	Pharma and Med-Tech Suppliers	Emerging IT Vendors

- Vision and Strategy
- Vision Transformation
- Mega Trends' Impact
- Disruptive Applications
- Business Models
- Current Offerings
- New Capabilities
- Value-add Services
- Vertical Integration
- Geographic Expansion
- Partnerships
- Investment/M&A

Context and Opportunity

- Clinical trials are slow and expensive processes. Lack of trusted systems creates source data integrity and patient engagement challenges.
- DLT systems ensure patient-centricity by providing patients' control over their health data; better data integration, and reliability for patient engagement initiatives.
- A Blockchain-based decentralized network will create a marketplace for individuals and biobank DTC test vendors to store, manage, and control access to health data in a secure and trusted environment.
- It provides researchers a secure platform to store and manage consent for patients to share personal health information and RWD with researchers and pharma clinical trials.

Call to Action

- Clinical trial sponsors and regulators can use DLT-based source data verification and notarization to reduce the clinical trial outcome switching, data snooping, and selective reporting.
- Clinical trial IT vendors should leverage on smart contract features on DLT-based consensus mechanism to make eConsenting and remunerative models' features more auditable while accessing anonymized universal health records/EHRs for research commons.
- Research institutions, pharma, and academia can leverage on the Blockchain technology to develop privacy-preserving federated data sharing models for collaborative research (e.g. Project MELLODDY).

Note: RPM—Remote Patient Monitoring

Source: Frost & Sullivan

Project MELLODDY – AI and Blockchain based Research Consortium to Accelerate Drug Discovery

Consortium Members	Technology Partners
Pharmaceutical companies: Amgen, Astellas, AstraZeneca, Bayer, Boehringer Ingelheim, GSK, Janssen Pharmaceutica NV, Merck KgaA, Novartis, and Institut de Recherches Servier **Academic institutions** KU Leuven, Budapesti Muszaki es Gazdasagtudomanyi Egyetem	**DLT/Subject matter experts:** Owkin, Substra Foundation, Loodse, Iktos **Cloud and ML Infrastructure:** AWS (Cloud), and NVIDIA (ML chipset manufacturer)

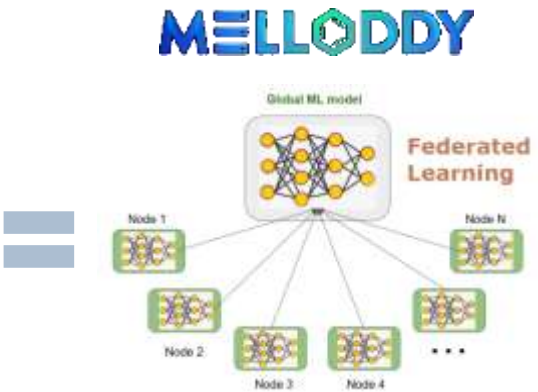


Image Source: https://www.biopharmatrend.com/post/97-pharma-companies-join-forces-to-train-ai-for-drug-discovery-collectively/

- **Objective:** Project MELLODDy is a Blockchain working group collaboration between leading global pharmaceutical manufacturers, technology, and academic institutions operational across Europe and funded by IMI. The project aims to develop a privacy-preserving federated machine learning DLT-based platform to efficiently and accurately create predictive models for drug compound discovery.
- **Technology Partners:** The MELLODDY consortium will use Owkin's Blockchain architecture technology called Substra, that provides a private Blockchain framework to ensure full traceability and auditability for ML orchestration on distributed and sensitive data. The platform uses AWS cloud infrastructure to execute a large-scale ML algorithm and NVIDIA ML technology.
- **Consortium Members:** The federated research network is already backed by 10 large pharma companies and some academic institutions that have agreed to share annotated chemical library databases to feed and train the ML platform for predicting the next drug candidates.

Analyst Perspective: Frost & Sullivan finds Project MELLODDY as an industry best practice, leveraging on the convergence potential of emerging Blockchain and AI technologies to promote collaborative research models and optimize the drug discovery process. The DLT-based federated network architecture will allow each participating pharma company to train the ML model locally on their own data, and only share the updated weights of the model (without the actual dataset) with the centrally hosted server to promote a federated learning system. If successfully deployed and scaled, MELLODDY is anticipated host the largest collection of small molecules with defined biochemical or cellular activity to transform AI-driven drug compound targeting and analysis research space.

Source: Frost & Sullivan

Select Companies to Watch

Blockchain Technology in the Healthcare Industry: Research and Clinical Trials C2A, Global, 2018

Company	Use Case	Product	Applications
CONSILX	Clinical Trial eConsenting, eSource/Data notarization, Supplies Tracking	LifeLedger	• LifeLedger™ v1.0 is a patient-centered platform that offers integrated consent management and patient engagement through real-time interaction and clinical supplies tracking in a single application. • The platform leverages on a cohort of technologies with Blockchain as the backbone for automatic and secured data aggregation to improve interoperability and research collaboration, resulting in enhanced efficiency and compliance across the clinical trial process. The platform also uses an AI-based algorithm and identifies potential patients based on inclusion/exclusion criteria. • Future plans include the creation of a Blockchain-based community for collaboration and selective data sharing across pharma for faster clinical development and commercialization of future drugs.
MEDABLE	Clinical Trial data sharing for RWE	INSIGT Network	• In March 2018, Medable announced the INSIGHT Network, a Blockchain-powered platform that enables auditable, transparent medical data exchange, and aligns incentives among patients, medical researchers, and biopharmaceutical companies for self-directed RWE data sharing. • With more than 15 million patients data and in excess of 6,000 clinical trials' experience, the company has developed an RWE-based digital twin of human health and disease called "Digitome", which provides foundational RWE application for digital biomarkers, therapeutics, and population-level research insights.
ENOME	Consent Management	E-Nome	• E-Nome is a secure platform to store and manage consent for access to health data. The company offers NSA-level end-to-end encryption with an immutable Blockchain audit trail for a GDPR, HIPAA, and APP compliant data transfer system. • The Garvan Institute of Medical Research (Sydney) has signed a memorandum of understanding with E-Nome Pty Ltd, an Australian technology start-up driving the application of Blockchain technology to the secure storage of health records.

Source: Frost & Sullivan

Key Conclusion
Blockchain Commercial Deployment Consideration and Strategic Imperatives

Return to contents

Litmus Test for Blockchain Appropriateness for Healthcare Digital Workflows

Blockchain Technology in the Healthcare Industry: Key Questions for Appropriates Assessment, Global, 2018

1	Where does your data currently live?	Central Repository	Many Different Places	Fed From Outside	
2	Would you benefit from data immutability?	Yes		No	
3	At what scale do you share data?	Inter Organizational	Inter Departmental	General Public	Regulators
4	Do you require confirmation of data changes by another participant?	Yes		No	
5	Are there ever discrepancies in your data?	Yes		No	
6	Do you need to confirm your data to a third party/regulator?	Yes		No	
7	Is this a use case that can be more efficiently solved with other technologies (excluding DLTs)?	Yes		No	

Key: **Ideally Suited** | **Somewhat Aappropriate** | **Not Appropriate**

Source: LUXOFT; Frost & Sullivan

Seven-step Investment Evaluation for Blockchain Solution

Considering that most Blockchain projects and vendors' solutions are at an early stage, it is essential for healthcare buyers to undertake a thorough assessment to invest or engage with the most promising options.

Blockchain Technology in the Healthcare Industry: Investment Evaluation Parameters, Global, 2018

Factor Consideration	Key Questions	Criticality
Industry Need	Do the problems in the industry which the Blockchain project plans to solve, really exist? Does the project/solution offer the best in its segment? Does the project team show thorough understanding of the healthcare industry?	
Business Need	Is Blockchain a solution to a specific market problem? Does the project show an operating business model and scalable solution? Does the team already have a working product that it sells to its customers? Did the team present a clear roadmap and financial plan?	
Technical	Is the Blockchain/DLT technology trusted for network members? Is the project/solution agnostic to DLT protocols and legacy systems? What is the consensus mechanism for network participants (nodes)? Does the project leverage on converging technologies beyond DLTs?	
Economic	Does the project have an associated token offering to incentivize network participants? Are project tokens protected from market manipulations? Is there a solid asset or value base to protect current holders from devaluation?	
Legal	Is the legal structure of the company transparent? Did the project take preventive measures to avoid local/global regulatory considerations?	
Project Team and Support	Does the project team have considerable experience, and it is well known in professional circles? Does the project have a strong advisory board team? Are large venture investors focused on Blockchain start-ups investing in the project?	
Popularity	Is this project popular in social networks and thematic communities? Is the project widely discussed in Blockchain news resources? Is the project associated with well-known healthcare working groups or consortia?	

Note: Factor considerations and their degree of criticality are indicative for the industry and may vary for individual projects.

Source: Digrate; Frost & Sullivan

Blockchain Technology Convergence Potential

While Blockchain provides an additional layer of trust, security, and auditability for the healthcare data-to-intelligence journey, AI can manage Blockchain systems more efficiently than humans.

Blockchain Technology in the Healthcare Industry: Technology Convergence, Global, 2018

Blockchain Technology Convergence Potential

Health Data Management

- Data sharing is the first benefit of Blockchain. It promotes PHRs/ longitudinal health records to improve the clinical care coordination.
- It eliminates the burden and cost of data reconciliation and facilitates care coordination with seamless health data exchange across health systems.
- It increases patients' control over their health data and provides better data integration and reliability for patient engagement initiatives.

guardtime
MEDIBLOC
CORAL HEALTH
Embleema
Medicalchain
BITMARK

Artificial Intelligence

- Blockchain improves data liquidity to empower AI and analytics vendors/applications to digest a large amount of clinical, operational, and financial data to further validate and scale up their insight platforms.
- DLTs, coupled with smart contract features, can improve AI models' integrity by minimizing possible data bias, falsification, and data bridge risks.
- Convergence of Blockchain and AI will provide healthcare stakeholders a new federated learning system to promote medical research.

OWKIN
aimedis
AMCHART
LifeCODE.ai
LONGENESIS
aidoc
INNOPLEXUS
OASIS LABS

Internet of Things

- Unique identifiers for medical devices and assets on a Blockchain-shared ledger system automates maintenance and management activity.
- Trusted Blockchain systems improve integrity and auditability of health data from wearables, sensors, mobile apps, and other IoT devices.
- Integration of Blockchain with IoT-based temperature-logging devices can improve the quality compliance and auditability for a drug supply chain.

ZIKTO
modum
Ambrosus
datum

Source: Frost & Sullivan

Blockchain Driving Care Delivery Innovation

In the future, DLTs will be used by telehealth vendors and tech giants, such as Apple, Amazon, Google, and Microsoft, to monetize data science and analytical services with innovative patient-centric care models.

Blockchain Technology in the Healthcare Industry: Business Model Innovation, Global, 2018

Blockchain Driving Care Delivery Innovation

Telehealth/ Telemedicine

- Blockchain-based PHR vendors find telehealth services a natural extension to offer data-driven insights and healthcare services to their patient community.
- Telemedicine platforms leverage on DLTs and smart contracts to provide a decentralized provider network for on-demand care services such as diagnosing, second opinion, and medical tourism.
- DLT-based token currency can be used to directly purchase/sale healthcare services to reduce administrative cost and burden.

aimedis, ROBOMED network, HealthSapiens, ETHEAL, PointNurse, well, DENTACOIN

Tele-radiology

- Blockchain provides a trusted decentralized platform for storing and sharing imaging data such as CT scans, MRIs, and conventional radiographs with an authorized network of radiologist and providers.
- With the increasing trend of radiology service outsourcing to best-cost destination, DLT-based smart contracts help execute a performance-based service payment for radiologist services.
- Blockchain improves data liquidity and auditability for teleradiology platforms with integrated AI capabilities.

MDW, DeepRadiology, secant healthcare (Smarter. Faster. Better.), MEDIBLOC

Healthcare Marketplace

- Genomics and DTC diagnostic test vendors use Blockchain to securely collect, store, and share sensitive genomic and medical data under crowdsourcing-based remunerative models with medical research and clinical trial sponsors.
- Wearable and mHealth vendors leverage on dApp solutions to allow patients to store and share their RWD, fitness, and wellness data by adding token-based incentives targeted toward payers and employer health programs.

ZIKTO, healthverity, Lympo, mosio, luna DNA, Nebula Genomics, CoinHealth

Source: Frost & Sullivan

Blockchain's Possible Business Models Across Healthcare Use Cases

Blockchain provides new opportunities to improve existing workflows and introduce new business models.

Blockchain Technology in the Healthcare Industry: Business Models Framework, Global, 2018–2022

	Semi-public/Consortium Network	Fully Private/Consortium Network
Create New Business Models	• Healthcare OpenBazaar • Health Policy Voting • Health Token/Coin: HSN, Research, Wellness Incentives, Big Data • Blockchain-based Wellness, Personal Coaching	• Decentralized Autonomous Organizations (DAOs) • Decentralized Applications (dApps) • Decentralized Bidding • Blockchain-as-a-Service (BaaS) • Blockchain-based Learning Health Systems and Advocates
Complement Existing Business Models	• Digital Identity Verification/Management • National Medical/Health Records (authenticity and integrity) • Peer-to-peer (P2P) Insurance • IoMT: Quantified Self-data Standards • eConsenting: Research Commons	• Smart Contracts: Vendor Request for Proposal (RFPs)/Contracts • Drug Supply Chain Provenance • Claims Adjudication and Billing Management • Revenue Cycle Management • IoMT: Medical Asset Management • Health Data Exchange

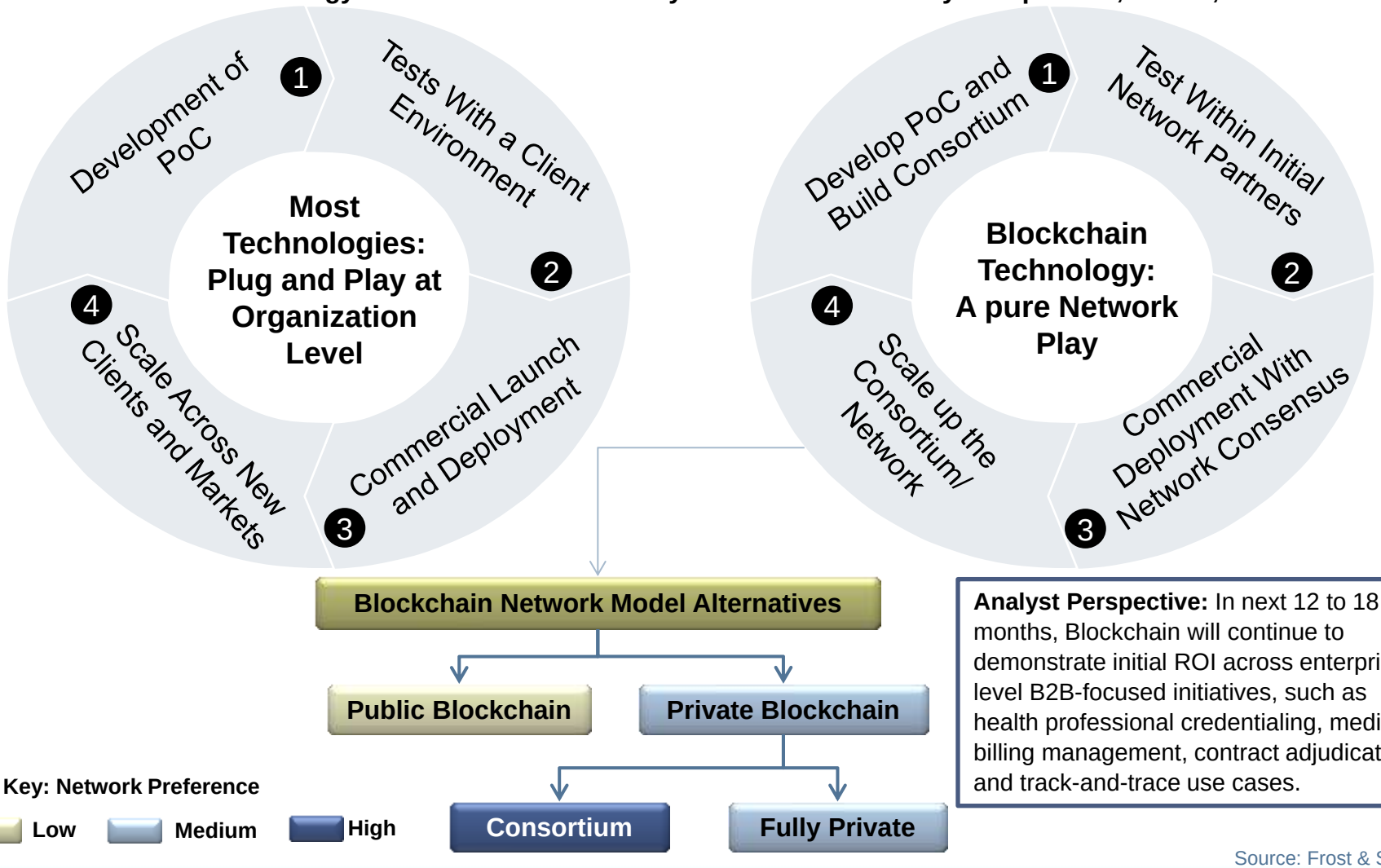
Note: The list of applications/use cases and business models is not exhaustive but indicative in nature.
Some of these use cases and business models are not exclusive to each other.

Source: Frost & Sullivan

Blockchain—A Commercial Journey With a Difference

The healthcare industry needs to prioritize forming consortia to promote a collaborative ecosystem for exploring and developing focused DLT use cases and governance standards for future commercial scalability and success.

Blockchain Technology in the Healthcare Industry: Commercial Journey Comparison, Global, 2018



Analyst Perspective: In next 12 to 18 months, Blockchain will continue to demonstrate initial ROI across enterprise-level B2B-focused initiatives, such as health professional credentialing, medical billing management, contract adjudication, and track-and-trace use cases.

Source: Frost & Sullivan

Strategic Imperatives—Blockchain Application Potential With Multiple Healthcare Stakeholders

Physicians/Care Providers
- Complete view of individual health history with longitudinal health records
- Improves clinical care coordination—help physicians in effective management of emergency medical situations
- Greater collaboration with research communities
- Safe streamlining of EHR information—transfer relevant patient data from one provider to another

Pharma/Clinical Research
- Increases drug supply chain provenance; check drugs counterfeiting
- Managing IP and R&D asset transactions on Blockchain
- Optimizes overall marketing efforts and reduce leakages
- Access to anonymized, medical metadata
- Clinical trial integrity and provenance of data trails

Hospitals and ACOs
- Eliminates the burden and cost of data reconciliation, resulting in seamless health data exchange across health systems
- Facilitates a care coordination for population health management
- Improves Revenue Cycle Management (RCM) and reduce payment disputes/frauds
- Promotes value-based care platforms: pay for outcomes with smart contracts
- Optimizes utilization for healthcare capacity and resources

Patients/Consumers
- Increases patients' control over their personal health data
- Direct payment of incentive and health tokens toward positive and healthy behavior (HSN/health wallets)
- Promotes concepts such as quantified-self and DIY health
- Price transparency for drug and healthcare services
- Share data for research commons under remunerative models

Government and Payers
- Increases collaborations across government-driven services
- Pooled real-time population risk
- Improves inefficiencies in Billing and Insurance-related (BIR) activities
- Smart contracts to maintain a benefits database to determine patient insurance and premiums

Source: Frost & Sullivan

Blockchain Implementation Challenges in Healthcare

Blockchain systems could be expensive and managing the network consensus could be difficult; the industry needs to find a deployment trade-off across potential healthcare use cases.

Nascent technology: Challenges around technical understanding of decentralized cryptosystems and the lack of proven commercial prototypes are likely to limit the large-scale adoption of Blockchain systems.

Standardization and terminology issues: Despite Blockchain's potential to disrupt healthcare workflows, it is critical to deal with disparate terminologies and conflicting standards in current healthcare systems.

Inefficiencies in the current Blockchain system: The verification and validation with Bitcoin requires high computing energy and cannot be scalable for more complex healthcare data.

Industry inertia to new technology: The healthcare industry's inertia to implement new technologies and, more importantly, conflicting interest among incumbents owning health data in silos are likely to be big hurdles.

Integration concerns: There are technical, operational, governance, and economic challenges in integrating a Blockchain system with existing healthcare IT systems. Companies need to access their strategic imperatives and prioritize Blockchain system implementation across select use cases.

Negative news: Due to recent security breaches involving Bitcoin as ransom money, Blockchain technology has a negative perceived image that could curtail its adoption for managing sensitive health data in the near future.

Source: Frost & Sullivan

Blockchain in Healthcare—Implementation Challenges by Use Case

Despite the potential of Blockchain to disrupt healthcare workflows, it may not be the universal solution for managing conflicting data standards with disparate terminologies in the healthcare industry.

Blockchain Technology in the Healthcare Industry: Implementation Challenges by Use Case, Global, 2018–2022

Use Cases	RCM and Claim Adjudication	Healthcare Provider Credentialing	Drug and Device Supply Chain	PHR and Health Data Exchange	Research and Clinical Trials
Key Implementation Challenges	• Technical, operational, governance, and economic challenges in implementing Blockchain systems • Limited end-to-end ecosystem partnerships • Lack of standardization in healthcare terminologies and medical billing codes • Scalability issues with limited proven prototypes and commercial deployments	• Simple, yet narrow application focus reduces future value for vendor participation • Technical, operational, governance, and economic challenges for future application scalability • Expanding network participants, both from individual provider/payer and other competing working groups	• Inefficiencies in the current Blockchain system and scalability issues (i.e., tradeoff between transaction volume and computation power needed per transaction) • Integration concerns with exiting systems and high switching cost • Current Blockchain systems not ideal for high-performance milestone transactions	• Creating a non-competing consensus between EHR/HIE vendors • Setting up a national master patient index in mature markets such as the US • Disparate terminologies and conflicting standards in current healthcare systems • Issues around regulatory compliances (e.g., HIPPA, EU DPR), data ownership, and patient consent	• High initial capital costs to deter adoption • Issues of patient consent for data access and ownership • May not be suitable for dealing with high-volume data (e.g., genomics) • Risk of building new data silos, where customers rent access from vendors • Creating consensus against competing pharma stakeholders
Impact*					

Key: Degree of Implementation Challenges

High → Low

Source: Frost & Sullivan

Key Question to Consider

Is Blockchain the missing puzzle in the healthcare industry's digital transformation journey?

1. Do you see digital transformation as a strategic priority?
2. Are your current digital workflows/solutions efficient, secured, and trusted?
3. What role does Blockchain have in your company's digital transformation success?

Five Big Themes in the Healthcare Industry and Role of Blockchain Technology

Strategic Priorities

Medtech	Pharma	HIT/Data/Tech Vendors
• Device Identity Management (UDI) • Pre and post market management of cybersecurity in medical devices • Supply chain integrity	• Drug counterfeiting • Patient-centric distributed clinical trial designs (eConsenting) • Research common models	• Data interoperability • RCM/billing management tools • Data monetization models • Physician credentialing

What use cases I can leverage now versus the next 5 years?

What are the key deployment/ implementation challenges to consider?

What would I gain post the implementation (ROI)?

Source: Frost & Sullivan

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Appendix

Return to contents

List of Abbreviations and Acronyms

DLT	Distributed Ledger Technology
PHR	Personal Health Record
IoT	Internet of Things
ICO	Initial Coin Offering
AI	Artificial Intelligence
ML	Machine Learning
RCM	Revenue Cycle Management
PoC	Proof of Concept
MVP	Minimum Viable Product
P2P	Peer-to-peer
KYC	Know Your Client
dApp	Decentralized Application
PHR	Personal Health Record
RWE/RWE	Real World Evidence/ Real World Data
UDI	Unique Device Identity
MDR	Medical Device Regulation
NHR	National Health Record
NLP	Natural Language Processing
API	Application Programming Interface

ICO	Initial Coin Offering
BaaS	Blockchain-as-a-Service
IMI	Innovative Medicine Initiative
NHS	National Health Service
FDA	Food and Drug Administration
SDK	Software Development Kit
OEMs	Original Equipment Manufacturer
CMS	Centers for Medicare and Medicaid Services
DSCSA	Drug Supply Chain Security Act
CFDA	China Food and Drug Administration
CDC	Centers for Disease Control and Prevention
CMO	Contract Manufacturing Organization
CDMO	Contract Development and Manufacturing Org.
IEEE	Institute of Electrical and Electronics Engineers
CRO	Contract Research Organization
IoMT	Internet of Medical Things
RPM	Remote Patient Monitoring
HIT	Health IT

Source: Frost & Sullivan

Drivers Explained

Trusted Workflows

- Trusted workflows minimize current fraud, waste, and abuse plaguing the healthcare industry and costing billions of dollars annually.
- “Single source of truth” provides radical new possibilities for outcome-based care delivery and reimbursement models.

Decentralized Control

- It promotes disintermediation of high-cost gatekeepers.
- In particular, the distributed feature of the Blockchain enables participants on the chain to share the economic benefits from the whole ecosystem without forming a monopoly.

Business Model Innovation

- Blockchain provides new opportunities to improve existing workflows and introduce new business models.

Source: Frost & Sullivan

Restraints Explained

Regulatory Uncertainty

- Challenges around the technical understanding of decentralized cryptosystems and the lack of proven commercial prototypes are likely to limit the large-scale adoption of Blockchain systems.
- There is a lack of regulatory guidelines and policies, particularly for areas such as tax treatment of cryptocurrency transactions, contract law, and legality.

Future Scalability of Blockchain Technology

- Verification and validation with DLTs require high computing energy and cannot be scalable for more complex healthcare data.
- Despite Blockchain's potential in disrupting healthcare workflows, it is critical to deal with disparate terminologies and conflicting standards in current healthcare systems.

Unproven Value With Limited Commercial Deployments

- Challenges around the technical understanding of decentralized cryptosystems and the lack of proven commercial prototypes are likely to limit the large-scale adoption of Blockchain systems.
- Despite all the hype, it appears to be the technology of interest for almost every healthcare industry stakeholder but is understood by few.

Source: Frost & Sullivan

Top 3 Platforms for Successful Smart Contract Development

Blockchain Technology in the Healthcare Industry: Comparison of Select Smart Contract Development, Global, 2018

Characteristic	Ethereum	Hyperledger Fabric	R3 Corda
Type	• Generic blockchain platform	• Modular blockchain platform	• Specialized distributed ledger platform for financial industry
Permission	• Permissionless, public or private	• Permissioned, private	• Permissioned, private
Consensus	• Mining based on proof-of-work; • Ledger level	• Flexible; • Transaction level	• Specific (i.e. notary nodes); • Transaction level
Smart Contracts	• Smart contract code (e.g. Solidity)	• Smart contract code (e.g. Go, Java)	• Smart contract code (e.g. Kotlin, Java); • Smart legal contract
Currency	• Ether; • Token via smart contract	• None; • Currency and tokens via chaincode	• None

Source: https://www.n-ix.com/top-3-platforms-successful-smart-contract-development/, Frost & Sullivan

Case Example—Synaptic Health Alliance Governance and Pricing Model

Blockchain Technology in the Healthcare Industry: Pricing Model for Synaptic Health, US, 2018

SYNAPTIC HEALTH ALLIANCE MEMBERSHIP

Governance & Structure

The Alliance is governed by an Executive Team (ET), with a Project Management Office (PMO) and a Day-to-Day Execution Team (DET) reporting on the activities to the ET.

- **Executive Team:** A team of senior executives from each founding organization to facilitate expedient decisions on behalf of the healthcare alliance and individual organizations. This group guides the Alliance work groups to ensure alignment with the objectives of the alliance. Decisions will be made by the ET but do not require unanimity.
- **Day-to-Day Execution Team:** A team of leaders from each founding organization to facilitate expedient sharing of cross-organizational perspectives. The DET ensures active participation of each founding organization.
- **Project Management Office:** A cross-organization team tasked with setting and maintaining project management standards for the Alliance. The PMO oversees and drives adherence to project plans, timelines and deliverables of the various work groups. This groups acts as a central source for status reporting and tracking.

Participation

	Founder Member	Associate Member	Services Partner	Advisory Member
Annual Fee	$100,000*	$25,000	$50,000	–
Node Hosting	✓	✓	✓	
Voting Member	✓	Associate members will have a voice in decisions, but no voting power		Advisory members will provide expertise and advice, but have no voting power
New Member Approval	✓			Advisory members will provide expertise and advice, but have no approval power
Included in Initial Pilot	✓			✓
Governance Strategy Input	✓			Advisory members will provide expertise and advice, but have no approval power
Anti-Trust Documentation Input	✓			Advisory members will provide expertise and advice, but have no approval power
Chair Workstreams	✓			
Create Workstreams	✓			
Propose New Workstreams	✓	✓	✓	✓
Participate in Workstreams	✓	✓	✓	✓
Access to Source Code	✓	✓		
Participate in Workstreams	✓	✓		

* Alliance reserves the right to amend annual fee by executive team vote

Source: https://cdn2.hubspot.net/hubfs/4801399/18-SYN-001-Synaptic Website/downloads/Synaptic_Health_Alliance_Prospectus.pdf; Frost & Sullivan

Vendor Universe for Blockchain Technology in Healthcare

Development Shops, Tech Advisory, Consortiums
23 Consulting
Aenco
Bitmark Health
BlockCypher
Blockstack
Bron.tech
CareChain AB
Consensys Inc.
Datum Network GmbH
Ernst & Young GmbH
Factom
Gem Health
Guardtime
Hashed Health
HealthLinkages
HIE of One
Lusoft
Oasis Labs
Ocean Protocol
OpenMined
R3
Sovrin

Data & Asset Management		
AHA Health	Kalibrate Blockchain	SIA
AICOSOFT	Litra	Simply Vital Health
Akiri Inc.	Lumenus	SmartHealthcare
AMCHART	Mahra	SnapNurse
Beat	MedChain	SSOT Health
BioLife	MediBloc	Stem Cell Innovations
BurstIQ	Medicalchain SA	The Patient Data Network
ConsilX	MediChain	TimiHealth (Timicoin)
Coral Health R&D Inc.	medicohealth	Trusted Key Solutions
Dentix Global	Mediconnect	VitalHub Corp. (TSXV:VHI)
dHealthNetwork	MediLOT Technologies	VoxelX
Dovetail Lab (acquired by EMIS Group)	MEDNETWORK PRIVATE LIMITED	Youbase
ELCoin	MedRec	Synaptic Health Alliance
Emrify Health Passport	minthealth	
Enome	MyMedis	
Escobarcoin	NanoHealth	
Genomes.io	Netki	
H+	OGSoft Solutions Ltd	
Hayver	ONEBIO	
Health Linkages	Open Health Network	
Health Wizz	Optima Curis	
Healthbase	Oracle	
HealthHeart	PatientDirected.io	
Hearthy	Patientory	
Hu-manity.co	Potion Owl	
Hwarp	ProCredEx (Hashed Health spin-off)	
Ingeniciel	Proof.Work	
Intiva Health	Robomed Network	
IRYO.IO	Secant Healthcare Inc.	

Supply Chain Management
Ambrosus
Block Verify
BlockMedx
BlockPharma
BlockRx (by iSolve)
Chronicled Inc. (MediLedger)
DentalFix
FarmaTrust
GANA
HealCoin
MediLedger
MedXchange
modum
NeuroMesh
Spiritus Partners Inc.
Synthium Health
TEST
The LinkLab
Tierion

Source: Frost & Sullivan

Vendor Universe for Blockchain Technology in Healthcare (continued)

Data Science & Analytics	
AIDOC Foundation	LifeCODE.ai
aimedis	Linda Healthcare
Boltt Coin	Luven Diagnostic
BowheadHealth	Med Layer
BreastWeCan!	Medable Insight
Curaizon (CuraTokens™)	Medic Coin
CuresToken	NAM
DeepRadiology	Open Longevity
DNAtix	Optima Curis Inc.
doc.ai	PeerAtlas
Elige.re	SciCoins
Embleema, Inc.	ScriptDrop
Eterly	Shivom
Faima	Skychain
Farasha	STEM CELL COIN
GYM Rewards	TeamMate
HealPoint	trustedhealth
Health FX	TwinToken
Hi:Health	VR MED
Innoplexus AG	Witty Health Inc
Lancor Scientific	Yoo-Mi PHA
LenusChain	Youthereum

Marketplace	
Alphacon Network (Alphacon Network Foundation Ltd.)	HealthDex
ARNA Genomics	HealthSapiens
Blodon (BloodChain)	HealthVerity
Care4Me (owned by Helios Health Group, Inc.)	Highmark Global
CareParrot	hit Foundation
Citizen Health	Hypertrust X-Chain
CLC Foundation	IncentHealth
Clinical Blockchain	LifesDNA
Clinicoin	Longenesis
CoinHealth LLC	LunaDNA, LLC
CoinMD	Lympo
Computable Labs	MDsquare
Consent.Global	MedCredits
CoverUs	MedicalBlockchain
Cryogen	MedicalDAO
CureCoin	Mosio
DEIP	Nano Vision
Dentacoin	Nebula Genomics
Dermavir (ICO by Genetic Immunity, Inc.)	NWP
Doc Coin	Opu Labs
Doc.com (Docademic)	PointNurse (Nursecoin)
Doctor Smart	SweatCo
eHealth First	Well, Inc.
Encrypgen	WLTH
Etheal	XMED Chain
GladAge	Zealeum
Grapevine World	Zenome
Health Monitor	Zikto Inc (Insureum)

Payment and Claim Management
Appley Health
Blüpass
CareX Blockchain Platform (Acquired by Paragon Blockchain Inc.)
Change Healthcare
Curisium
DAYS HealthCare Economy
Decent
Digipharm
EarthMedz
Healthcombix
Healthureum
HSBlox, LLC
Kinect Hub
Lumedic (acquired by Providence St. Joseph Health)
MD Tokens
MediBond
Medicoin
Mexc
NurseToken
ScalaMed
Solve.Care
Tides
Universal Health Coin
Veris Foundation

Source: Frost & Sullivan

List of Exhibits

List of Exhibits (continued)

List of Exhibits (continued)

List of Exhibits (continued)

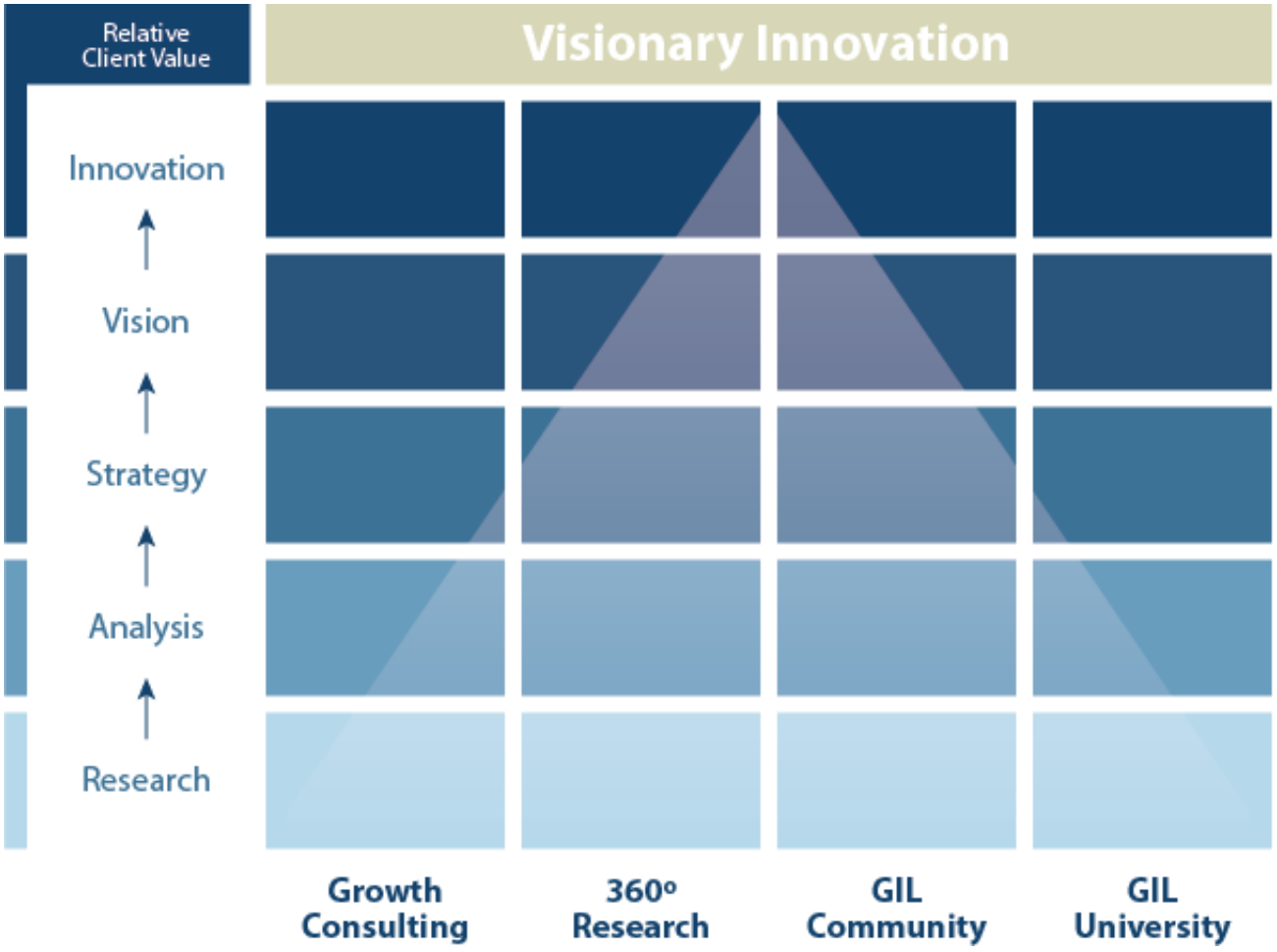
The Frost & Sullivan Story
The Journey to Visionary Innovation

Return to contents

The Frost & Sullivan Story

Value Proposition—Future of Your Company & Career

Our 4 Services Drive Each Level of Relative Client Value



Global Perspective

40+ Offices Monitoring for Opportunities and Challenges

Industry Convergence

Comprehensive Industry Coverage Sparks Innovation Opportunities

Aerospace & Defense

Measurement & Instrumentation

Consumer Technologies

Information & Communication Technologies

Automotive Transportation & Logistics

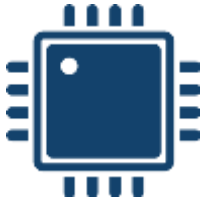
Energy & Power Systems

Environment & Building Technologies

Healthcare

Minerals & Mining

Chemicals, Materials & Food



Electronics & Security

Industrial Automation & Process Control

360º Research Perspective

Integration of 7 Research Methodologies Provides Visionary Perspective

Implementation Excellence

Leveraging Career Best Practices to Maximize Impact

Our Blue Ocean Strategy

Collaboration, Research and Vision Sparks Innovation