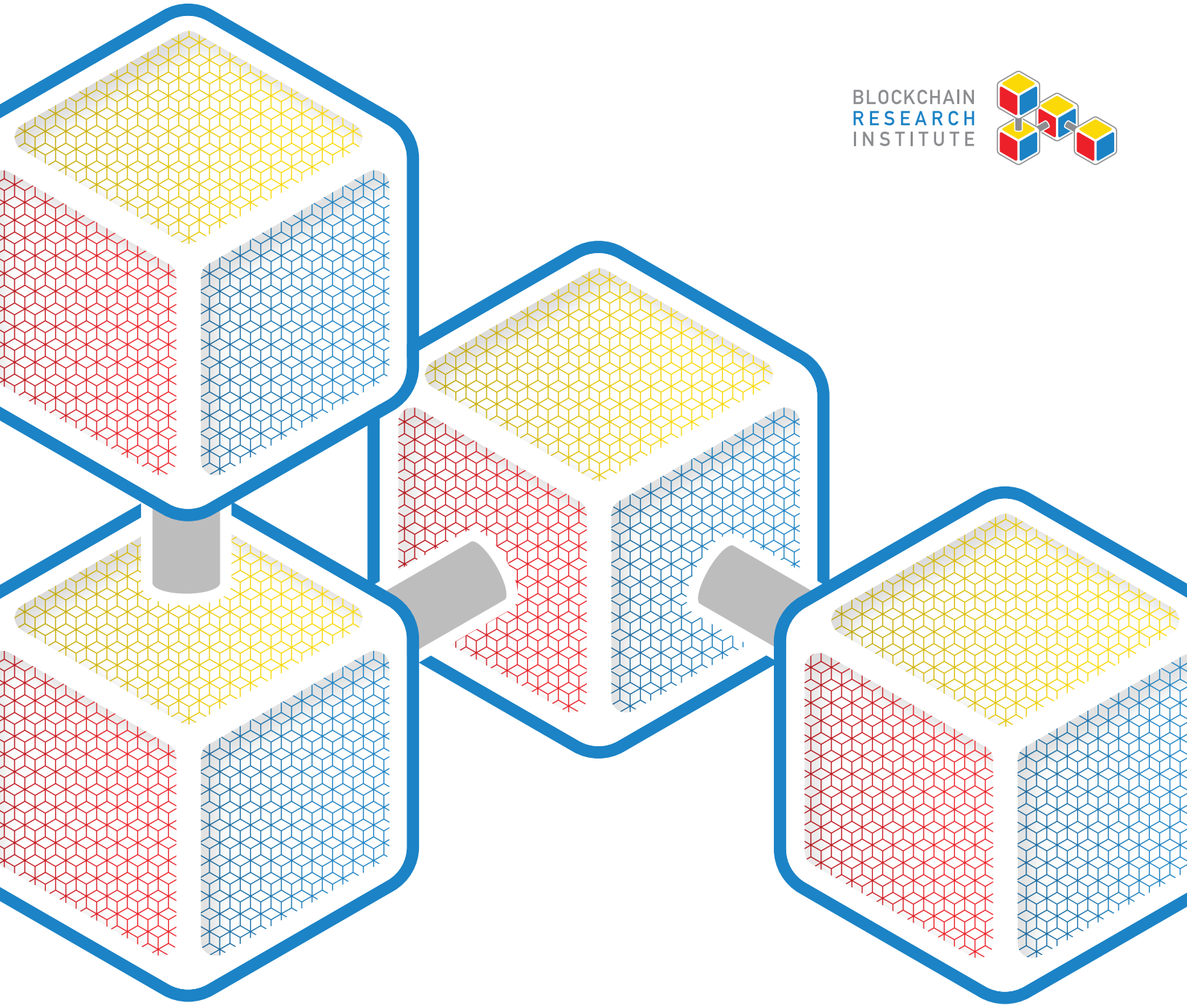


BLOCKCHAIN RESEARCH INSTITUTE

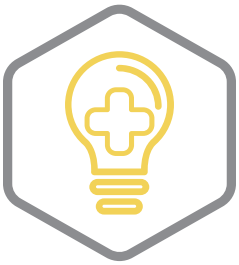
BLOCKCHAIN SOLUTIONS IN PANDEMICS

A Call for Innovation and Transformation in Public Health

Don Tapscott and Alex Tapscott
Blockchain Research Institute

April 2020

A BLOCKCHAIN RESEARCH INSTITUTE SPECIAL REPORT



Realizing the new promise of the digital economy

In 1994, Don Tapscott coined the phrase, "the digital economy," with his book of that title. It discussed how the Web and the Internet of information would bring important changes in business and society. Today the Internet of value creates profound new possibilities.

In 2017, Don and Alex Tapscott launched the Blockchain Research Institute to help realize the new promise of the digital economy. We research the strategic implications of blockchain technology and produce practical insights to contribute global blockchain knowledge and help our members navigate this revolution.

Our findings, conclusions, and recommendations are initially proprietary to our members and ultimately released to the public in support of our mission. To find out more, please visit www.blockchainresearchinstitute.org.

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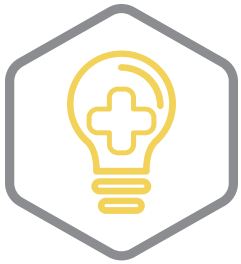

Executive summary

Blockchain: An idea that has become a necessity

The economic costs of COVID-19 are devastating, on a scale perhaps never seen in modern times. At this stage, the human costs are unfathomable.

This is one of those rare turning points in history. The COVID-19 pandemic will profoundly change our economy, our behavior, and society. Some leaders who failed the test will lose their jobs. Some governments that failed their people will lose their power. Many institutions will come under scrutiny and, we hope, change for the better.

The economic costs of COVID-19 are devastating, on a scale perhaps never seen in modern times. At this stage, the human costs are unfathomable.

The goal of this report is to facilitate positive change. The Blockchain Research Institute's mission is to help "realize the *new promise* of the digital economy." It's a new promise because we're in a new second era of the digital age, where technologies like artificial intelligence (AI), the Internet of Things (IoT), augmented and virtual reality (AR/VR), biotech, and above all, blockchain are providing leaders with an unprecedented set of opportunities. These technologies have not stormed the world; rather, they've developed slowly in an uneven and combined or complementary manner.

But, as our research shows, these technologies are now relevant as never before, not just to business and the economy but the future of public health and the safety of global populations. Traditional systems have failed and it's time for a new paradigm. To build on Victor Hugo, "Nothing is more powerful than an idea that has become a necessity."[1]

Pandemics and blockchain projects: A framework

Given the urgent need for global solutions, the Blockchain Research Institute convened a virtual roundtable of experts on 26 March 2020. It was an extraordinary group—30 people from five continents (Appendix B). We discussed the challenges of COVID-19 and the possibilities of using blockchain technologies in areas of need. In this report, we develop a framework for facing COVID-19 together. (See Figure 1, page 8.) We identify use cases where innovators are already deploying blockchain to fight the pandemic; and we argue that, in cases such as data governance, blockchain is a necessary component of our public health infrastructure and rapid response system. The report details these five areas for action.

1. Self-sovereign identity, health records, and shared data

Data is the most important asset in fighting pandemics. If any useful data exists now, it sits in institutional silos, inaccessible to individuals and other stakeholders.

Data is the most important asset in fighting pandemics. Without it, we can't answer critical questions: Who are infected? Where have they traveled? If any useful data exists now, it sits in institutional silos, inaccessible to individuals and other stakeholders. We need better access to the data of entire populations and a speedy consent-based data sharing system. The trade-off between privacy and public safety need not be so stark. Through self-sovereign identities where individuals own their health records and can freely volunteer it to governments, clinicians, drug companies and others, we can achieve both. This section covers the work of roundtable participants Brian Magierski of Care to Cure and the Care Chain collaboration, Axel Schumacher of Shivom and the Multi-Omics Data Hub Consortium, Preeti Gandhi and Hanumanthu "Hanu" Rao of Tata Consultancy Services; MIT's Alex "Sandy" Pentland's latest work, thanks to Irving Wladawsky-Berger; Monty C.M. Metzger's EndCoronavirus.net initiative; the VestChain app in use in Hangzhou and the Civitas app in Honduras.

2. Just-in-time supply chain solutions

Supply chains are critical infrastructure for our globally connected economy, and COVID-19 has put them under tremendous strain, exposing potential weaknesses in their design. We must build supply chains that are transparent, where information can be accessed quickly, and where participants can trust that information about goods are accurate. This section covers the work of roundtable participants Dr. Philip Baker of Good Shepherd Pharmacy and RemediChain, Vinay Gupta of Mattereum, Jim Regenor of VeriTX and Rapid Medical Parts; Hyperchain and Alipay in Zhejiang province; and the potential of Trust Your Supplier, thanks to Gennaro "Jerry" Cuomo. Blockchain serves as a "state machine" that allows us to know the state of not only our suppliers but also the assets themselves.

3. Sustaining the economy: How blockchain can help

The health crisis has become a financial crisis, gumming up supply chains, closing off access to credit, and raising the alarm of counterparty risk.

If supply chains are the machinery of global commerce, then money is its lubricant. Yet, money itself has been a source of confusion and strain during this crisis. First, cash has been criticized as a carrier of the disease, and the drumbeat to abolish it altogether is growing louder. This section highlights the what, why, and how of global digital cash. Second, the health crisis has become a financial crisis, gumming up supply chains, closing off access to credit, and raising the alarm of counterparty risk. This section covers blockchain-based financing solutions such as Foxconn's Chained Finance that are correct, real time, and flexible. Third, insurance and risk management has been mishandled at business and personal levels. We must rethink ways to protect people and business from catastrophic risk. Fourth, decentralized models of governance, organization, and problem-solving can not only cut the costs of healthcare delivery but also transform how nongovernmental

organizations (NGOs), governments, and individual donors contribute money and other resources to the fight against COVID-19. This section covers the work of roundtable participants David Hanekom of Solve.care Global, Jarred Winn and Helen Hai of Binance, and James Duncan of Abridged.

4. A rapid response registry for medical professionals

If every professional had verifiable and trusted professional information, then we could resolve this talent management paradox and get people to where we needed them.

Front-line medical professionals are the heroes and our last line of defense. Yet hospitals can't onboard people fast enough. This is not for lack of talent; it's the inability to find them. That's what Glass Bead Consulting's Andrew Spence calls the "talent management paradox," where organizations continuously struggle to tap into the pool of skilled people looking for work. How does blockchain solve this? By streamlining coordination among different geographies, departments, and certification bodies so that process becomes more efficient and transparent. Convoluted criteria checks, redundancies in the certification process, and the processing of documents all slow down (re)licensing. If, as part of a self-sovereign identity, every professional had verifiable and trusted professional information, then we could resolve this talent management paradox and get people to where we needed them, saving lives and starting jobs in the process. This section covers the work of ODEM, ProCredEx, and other distributed ledger initiatives.

5. Incentive models to reward responsible behavior

How do we encourage policymakers, governments, businesses, and other institutions to prepare for the inevitable?

People respond to incentives. That's the consensus among behavioral economists and a theme of much public policy: How do we improve individual and business accountability during a crisis? What kinds of incentives do we need to manifest behaviors that will prevent viral outbreaks from rocketing into pandemics or mitigate the damage that pandemics cause—without compromising privacy or liberty? This section covers the Heart and Stroke Foundation of Canada's collaboration with Interac and University Health Network's pilot with IBM. Government must be aligned, too. How do we encourage policymakers, governments, businesses, and other institutions to prepare for the inevitable by keeping supplies on hand, designing a strategy for handling public health crises, or reserving funds for swift response? Cryptoeconomics can help with alignment, according to Drs. Cathy Barrera and Stephanie Hurder: blockchain serves as a mechanism to synch up the incentives of stakeholder groups around issues and activities, changing patterns of behavior in the process.

An action plan for the new paradigm

Many of these changes are beyond the timeframe of this round of COVID-19. But many can be implemented quickly. To have an impact on the current pandemic, the community must address such implementation issues as standards and interoperability, governance, and leadership from governments, the private sector, and civil society. Heather Flannery of ConsenSys Health underscored the role of bioethics, and Brian Behlendorf of Hyperledger advocated for such

principles as "confidential computing" and "openable networks." Bob Wolpert of Golden State Foods, Jason Kelly of IBM, Dale Chrystie of FedEx, and Tanya Woods of the Chamber of Digital Commerce Canada all suggested a new collaborative approach. Phrases like "coopetition," "team of rivals," "team of teams," and "bold systems thinkers" circled round the virtual table.

Every national government should create an emergency task force on medical data to start planning and implementing blockchain initiatives.

Drawing from the insights of participants David Jaffray of MD Anderson Cancer Centre, Katie Crenshaw and Mari Greenberger from HIMSS, James Tennant of ISED, David Houlding of Microsoft, Ian Putter of Standard Bank, Eric Hoskins of the Federal Advisory Council on the Implementation of National Pharmacare, Raphael Yahalom of MIT and Oxford-Hainan Research Institute, Mike Jacobs of Optum, Nadia Hewett of the World Economic Forum, and Michael Green of Canada Health Infoway, the report outlines recommendations for each stakeholder.

Governments must wake up to the blockchain opportunity. Every national government should create an emergency task force on medical data to start planning and implementing blockchain initiatives. They can stimulate the development of technology firms working on the solutions described here. They can act as a model user of these important platforms and applications. They must focus on the supply side of the market for data, not just the demand side. That means passing legislation to mobilize stakeholders around creating self-sovereign identities and citizen-owned health records. They should pilot blockchain incentive systems for motivating people to behave responsibly. They should partner with medical professional associations and other players to implement blockchain credential systems. Governments have the world's largest supply chains, many involved in producing critical medical provisions. They should rapidly pilot asset chains as described herein. Central banks should move swiftly to create a fiat digital currency in their country and the International Monetary Fund should provide leadership in rolling these into a global, hegemonic, synthetic digital currency.

The report also provides recommendations for the private sector and civil society. Given the need for immediate action on these recommendations, we've made this report available to the public under a Creative Commons license. To do our part, we've launched a set of research projects related to the pandemic, public health, and the economic recovery. We'll deliver results to our members through a series of reports, webinars, videos, infographics, and data sets over the coming months. Please stay tuned, sign up for our newsletter, and check out our special web page dedicated these efforts:

- BRI newsletter: www.blockchainresearchinstitute.org/newsletter
- BRI resources: www.blockchainresearchinstitute.org/blockchain-and-pandemics

COVID-19: The challenge of pandemics

"The next outbreak? We're not ready," said Bill Gates in his prophetic TED talk of March 2015. The talk has soared from 18 million to over 25 million views in the last week.[2]

Despite the warnings, the world was oblivious, some nations and leaders more than others, and now we're paying the price.

Of course, Gates was right to say that a pandemic of this size was inevitable, and he wasn't the only one. Since Gates' talk, experts have pointed to research that warned of the danger much earlier and produced scores of new works to sound the alarm.

But the world was oblivious, some nations and leaders more than others, and now we're paying the price. As we draft this report, the number of new cases and deaths is exploding.

The spread of the virus has a lot to do with data. Rather, the lack of it. Clinicians, epidemiologists, and government authorities have been working in the dark. Most Western countries had virtually no testing in the early weeks of the outbreak. As Ed Yong wrote in *The Atlantic*:

> *The testing fiasco was the original sin of America's pandemic failure, the single flaw that undermined every other countermeasure. If the country could have accurately tracked the spread of the virus, hospitals could have executed their pandemic plans, girding themselves by allocating treatment rooms, ordering extra supplies, tagging in personnel, or assigning specific facilities to deal with COVID-19 cases.*[3]

The pandemic revealed deep structural inadequacies in our health systems but also in our supply chains. Everywhere systems based on decades-old technologies caused severe shortages in protective equipment from masks and gloves to ventilators. Driven by fear and lack of transparency in supply chains, consumers panicked, emptying shelves of staples. With some consumers hoarding years' worth of toilet paper, surely at least one wealthy person said, "Let them use bidets." The bidet market soared, only to be hit by shortages, too.

The pandemic revealed serious deficiencies in our systems for innovation, commerce, technology infrastructure, and data governance.

While exposing a failure of institutions and leadership, the pandemic revealed serious deficiencies in our systems for innovation, commerce, data governance, and technology infrastructure. Now's as good a time as any to understand these, not just to help avoid pandemics in the future but to help us move through this crisis, which surely will continue for some time.

How do we get better data about an outbreak and our responsiveness to it? How can we increase the reliability of our supply chains and our logistics, transport, and payment systems? How can we better ensure the authenticity and provenance of medical products and medications as well as the credentials and readiness of medical personnel? How can we build better transparency into systems to help rebuild consumer and citizen trust? How can we track citizens who have tested positive without undermining their rights? How can we make retail commerce safer? How do we better incentivize citizens to

behave more responsibly? Can we move to a new paradigm in health records that are both private and owned by citizens but also provide the critical data that experts and authorities need to manage a crisis? How do we build better sanitation infrastructure and encourage citizens to care more about their wellness? Is now the time to eliminate that germ-loaded vestige of the preindustrial economy—cash?

Is now the time to eliminate that germ-loaded vestige of the preindustrial economy—cash?

It turns out that a next generation of technology that includes AI and IoT and centers on blockchain could help leaders to usher in a new era of public health and responsiveness to the communicable medical crises that will increasingly plague us on this ever shrinking planet.

A framework for action

This report focuses on five areas—identity and data governance, supply chain and manufacturing, money and financial services, healthcare talent management, and incentives for behavioral change—in which innovators in both public and private sectors have already demonstrated blockchain's utility in addressing the challenges we face (Figure 1).

Figure 1: Framework for action in the fight against COVID-19

Self-sovereign identity and shared data

Data is perhaps the most powerful asset in fighting pandemics. If governments, clinicians, and citizens had access to data about a virus, they could take effective steps against it. We need data about what, where, when, how, who—*how many* people are infected, *where* are they located, *when* were they infected (and when did they recover), *how* were they infected, and *who* else did they contact?

The countries with good access to such data—China, South Korea, and Singapore, for example—have had some measure of control over this coronavirus. Since they had experienced SARS or MERS, they were much faster to ban travel, impose quarantine, and enforce social distancing.[4] Now Hubei province in China has lifted travel bans, and shopping malls in Wuhan are reopening under banners, "Wuhan is back!"[5] Countries with poor data—Italy, Spain, and now the United States—have fared much worse.

The countries with good access to data—China, South Korea, and Singapore, for example—have had some measure of control over this coronavirus.

But getting good data these days comes at a high cost to privacy and individual rights. Brian Magierski, CEO and founder of Care to Cure, observed that the virus spread like wildfire where civil liberties reign supreme, whereas governments that more rigorously controlled the viral contagion did so at the expense of these liberties.[6]

For example, Chinese authorities slowed and eventually impeded the spread of the virus through mass surveillance and big data analytics combined with propaganda. Let's start with the surveillance. There are an estimated 170 million closed-circuit television cameras in China, roughly one camera per dozen citizens.[7] These continually stream video into a centralized system that applies facial recognition software and other AI to identify people within their database and check their whereabouts against their identities—which is all the easier because it's a *real-name system*, meaning that citizens must use their government-issued IDs to buy mobile SIM cards, open social media accounts, and travel by air or rail. No pseudonyms.

Work Chinese Industrial Professional *by Pixabay, no date, used under Pexels license of 4 April 2020. Adapted and resized to fit.*

China managed to save countless lives and instill pride in its citizens for their unified response, compared to the seemingly impotent efforts of the West.

So if the Chinese lawfully buy SIM cards, the government can track citizens by their mobile devices.[8] In Hangzhou, authorities deployed security staff wearing Rokid smart glasses with augmented reality. As they roamed the streets, security officers could check the temperatures of several hundred people in only a few minutes.[9] (Apparently, the Rokids can even detect flatulence. So much for anonymous gas transactions.[10]) During the total lockdown, people needed special permission to travel outside their immediate neighborhood. If they were caught on camera but didn't have permission to be where they happened to be, then the police showed up. If they ventured beyond the nearest grocery store, they got a phone call from the police.[11] Combined with a campaign of collective action and personal sacrifice, China managed to save countless lives and instill pride in its citizens for their unified response, compared to the seemingly impotent efforts of the West.[12]

Let's remember—George Orwell's *1984* was a novel, not a playbook. While effective, such techniques raise far-reaching questions about privacy and civil liberties—who gets to collect data, how, and for what use in the digital age? "We don't need to see it as a public health versus privacy debate. We can see it as a continuum," suggested Preeti Gandhi and Hanumanthu "Hanu" Rao of Tata Consultancy Services (TCS). "The ongoing work at countries like South Korea, Singapore, and others shows that people are willing to give up some their privacy for a common good."[13]

Blockchain opens a new world of possibilities that shift control to individuals. In the city of Hangzhou in Zhejiang Province, VestChain Technology—a tech firm that develops open-source blockchain solutions on Ethereum in support of smart contracts and machine learning—has launched a decentralized application for identity management.[14] Called Access Pass, the app integrates with WeChat to generate QR codes that enable residents only to enter their gated communities.[15] According to VestChain, the app collects, encrypts, and stores users' personal data in VestChain's blockchain-based cloud servers; not even VestChain can access these data, and it has committed to deleting the data when the pandemic has run its course.[16]

The digital crumbs that you leave in daily life create a mirror image that knows more about you than you *do.*

This is important for the future of health, prosperity, and freedom because your medical information is a subset of your digital identity—the "virtual you." The digital crumbs that you leave in daily life create a mirror image that knows more about you than *you* do. You probably can't remember dozens of your personal identifiers: the numbers and other details of your driver's license, passport, credit cards, marriage license, university or corporate ID. But unless your brain works differently from ours, you definitely don't recall your exact location a year ago, what you bought or how much money you spent and received that day, what you said online, and maybe not even which medications you took. Blockchain ledgers *can* remember for you.

That's just the beginning. In the future, the virtual you will contain detailed medical information like your heart rate, blood pressure,

temperature, and myriad other real-time measures of what you do, how you function, where you are, and perhaps even how you feel.

The trouble is that the virtual you is not owned by you. "Imagine if General Motors did not pay for its steel, rubber, or glass—its inputs," economist Robert J. Shapiro once said. "That's what it's like for the big Internet companies. It's a sweet deal."[17] We create the asset, but powerful companies and governments expropriate it.

We create the data asset, but powerful companies and governments expropriate it.

Why should we care about our medical data?

We came up with at least four reasons for caring deeply about our own and our dependents' medical data, especially for those of us with teenagers hugely active on social media or elderly parents unfamiliar with the latest online scams:

- We can't use our own data to plan our lives—our health, our financial planning, our education, and so forth. These data reside in other people's silos, which we can't access—but third parties like Cambridge Analytica can, often without our knowledge.[18]
- We enjoy none of the rewards of this third-party data usage, yet we bear most of the risk and responsibility for its clean up, should they lose or abuse our data.[19]
- Our privacy is at risk. Privacy is not an absolute and sometimes, perhaps in say a pandemic, it may be necessary to trade on this privacy for the social good. The trouble is however that once the crisis is over there is no way to capture our data back.
- We can't monetize these data assets for ourselves, resulting in a bifurcation of wealth and all its discontents.

Person holding test tubes *by Polina Tankilevitch, n.d., used under Pexels license of 4 April 2020.*

Social media companies like Facebook and other big digital conglomerates have suggested ways we could access some of our data. That's a step forward. However, it only partially solves one of four problems listed above—access to our data. We need more than access to some of our data. We need ownership of it.

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Some governments have attempted to help solve this problem by implementing laws such as European Union's General Data Protection Regulation, which is a partial measure at best, and hypocritical in light of the new EU common identity repository.[20] Nor is a heads-will-roll type of policy that calls for the breakup of Amazon, Facebook, and Google for violating anti-monopoly laws.[21]

State-run identity systems are problematic. In the last ten years, at least 48 government databases have been breached, exposing the data of 1.44 billion people—and that number doesn't include hacks to government-managed healthcare and education records.[22] Yet, we're dependent on system administrators who can freeze access, delete our voter registration or other credentials, and use banks, telecoms, and tech firms to surveil us.[23]

Nothing about these institution-centric systems is citizen-friendly. In some countries, these systems discriminate against the poor, the rural, the homeless, the imprisoned, and the overworked in society.[24] Syrian refugees in particular put a spotlight on the crisis of state-based identification.[25]

The reality of a government-sourced and sanctioned identity is untenable—both administratively and philosophically. Why should any government get to rubber-stamp who we are? We should be establishing our own identities and, as Joseph Lubin of ConsenSys wrote, bootstrapping ourselves into economic enfranchisement.[26] We must act now.

The self-sovereign identity in the time of pandemics

What each of us needs is a self-sovereign and inalienable digital identity, one that is neither bestowed nor revocable by any central administrator and is enforceable in any context, in person and online, anywhere in the world.

What each of us needs is a self-sovereign and inalienable digital identity.

What we need is a wholesale shift in how we define and assign ownership of data assets and how we establish, manage, and protect our identities in a digital world. Change *those* rules, and we end up changing *everything*.

As we argued in *Blockchain Revolution*, the means now exist to assert what developer Devon Loffreto calls "sovereign source authority": identity is not simply endowed *at* birth; it is endowed *by* birth.[27] Each identity is in a black box on a blockchain. It sweeps up the exhaust of all our daily transactional and information data—from purchases to our biological data—protecting it and enabling each of us to use it any way we want.

So imagine that each of us owned our digital identity and stored it in a digital wallet on a blockchain. It sweeps up the exhaust of all our daily health and transactional data—from our biological data to purchases or our location at any point in time—protecting it and enabling each of us to use it any way we want.

Our medical records are central to this identity. Our bodies generate medical data. We, not big companies or governments, have a heart rate and a body temperature. When clinicians measure us or take tests of various kinds, that's great, but the data are still data from our bodies. Increasingly with wearables and the IoT, we can capture these data from our insulin levels, blood pressure, body temperature, and the number of steps we take and stairs we climb in a day. By owning our medical and other personal data we could solve the four problems stated above—access, security, privacy, and monetization.

By owning our medical and other personal data we could solve all four problems: access, security, privacy, and monetization.

But how could we help officials in a pandemic? Here's where the blockchain comes in.

- By law, governments could mandate that citizens make available anonymized data about critical health information like, say, body temperature or location for aggregate tracking and predictive analytics.
- Citizens could instruct their digital identities to provide pertinent health information to any registered clinician should they need it, for example, if they were to be hospitalized. Citizens may decide to withhold some information, such as a fracture from an accident a few years ago or a psychiatric problem they have faced. But the smart contract managing their identity would release all other information that may help with their treatment.
- Incentive systems could reward us for making our private data available to appropriate clinicians and government planners, even with identifiers attached. Many citizens would share their data out of sense of a social responsibility and community. Personally, we both would happily reveal medical information about our body temperature or a dry cough or for that matter a positive test of COVID-19 to authorities to help manage the problem in our communities. But there could be extrinsic blockchain-based incentive systems to help as discussed later in this report.

Incentive systems could reward us for making our private data available to appropriate clinicians and government planners, even with identifiers attached.

- All these data would represent the entire population, not some partial and potentially misleading sample of it. Never before have clinicians, epidemiologists, and authorities had such extraordinary access to such a wealth of data. Using next generation data analytics and AI they could understand the possible trajectories of a virus and take steps to crush it in the egg, like never before.
- As individuals recover and develop verifiable immunity, they could receive what MIT's Sandy Pentland calls a "health certification" to attach to their digital identity, to prove that

they're safe to work publicly again.[28] Each citizen could choose which personal information other parties may retain. Some citizens might choose to recall access rights to their released medical information, leaving only the anonymized data.

We can share our health data with third parties and those parties can use it in computations without ever decrypting it.

Research tools such as MIT's Enigma combine the virtues of blockchain's public ledger, the transparency of which "provides strong incentives for honest behavior," with something known as *homomorphic encryption* and *secure multiparty computation*.[29] According to Ann Cavoukian, executive director of the Privacy and Big Data Institute at Ryerson University, "Enigma takes your information—any information—breaks it up, and encrypts it into pieces of data that are randomly distributed to nodes in the network. It doesn't exist in one spot." Designed at MIT Media Lab by Guy Zyskind and Oz Nathan, "Enigma uses blockchain technology to embed the data and track all the pieces of information."[30] We can share our health data with third parties and those parties can use it in computations without ever decrypting it.

Sterilization Equipment Covid 19 Alcohol Sanitizer *by veerasantinithi, 2020, used under Pixabay license of 27 March 2020.*

Blockchain-based identity applications

To bootstrap our identity, we first need a model that is distributed among and maintained by the people whose identities it protects. This means that everyone's incentives align in an identity commons, with clear rights for users to steward their own identity, protect their privacy, access (and allow others to access) and monetize their own data, and participate in rule-making around the preservation and usage of the commons. Several identity projects in the blockchain space are working to deliver such structure and capabilities.

- Blockstack, a public-benefit corporation in Delaware, incorporates the bitcoin blockchain in its open-source identity solution. Blockstack users can set the location of their user profile and application data, and Blockstack has no control over the identity information on the bitcoin blockchain or stored on Blockstack's peer-to-peer (P2P) network.[31]

Civic, a for-profit company based in San Francisco, offers an ID verification solution through an Ethereum-based platform.

- Civic, a for-profit company based in San Francisco, offers an ID verification solution through an Ethereum-based platform. Users collect verifiable claims of attributes from validators—such as banks, governments, and universities—but when a third party wants to learn something about a user, the user can decide whether and how much to reveal. The third party must then pay the validator of the relevant attribute, which is an incentive for validators to take part.[32]

- Sovrin is an identity platform governed by a community-created governance framework and administered by the Utah-based nonprofit Sovrin Foundation.[33] The network runs on a distributed ledger based on Hyperledger Indy.[34] The nodes maintaining the ledger are trusted entities such as banks, colleges, and governments, which are approved by the Sovrin Foundation Board of Trustees. Users download a wallet app like Connect.me for storing their credentials and tokens as well as communicating with other wallets for P2P exchanges of data, which are stored locally in the user's wallet or encrypted cloud backup.[35]

- uPort, a platform built on the Ethereum network and funded by for-profit ConsenSys in New York, enables users to create a decentralized identity (DID) based on the proposed ERC-1056 lightweight Ethereum identity standard for Ethereum wallets.[36] The app manages user identities and credentials, such as keys, identities, and attestations, which are portable across service providers and client applications. The app can authenticate a user and disclose verifiable claims to whomever the user chooses.

The uPort app manages user identities and credentials, such as keys, identities, and attestations, which are portable across service providers and client applications.

- Veres One, a blockchain operating under the guidance of the Veres One W3C Community Group, may be the simplest self-sovereign identity infrastructure.[37] It has no tokens and stores no user data—it only stores only the DIDs used for key management and service endpoints discovery.[38] Through Veres One, anyone with a web browser can generate a DID compatible with other identity services, allowing for portability.

Many of these start-ups are collaborating in the Decentralized Identity Foundation, a consortium consisting of Hyperledger and R3, and incumbents such as Accenture, Microsoft, and IBM.[39] Its working groups are focusing on three big areas—identifiers and discovery, storage and computation of data, and attestation and reputation—with an eye to developing use cases and standards.[40]

Big ideas to combat COVID-19

With this approach to identity, citizens can own and use their own private data, yet at the same time authorities could achieve access in a crisis such as a pandemic. With more precise and more private data, Magierski of Care to Cure believes that we can "identify new cases rapidly and verify those who have immunity." He told us,

> *To ensure the best containment measure, we need a platform for reporting, tracking, and notifying that is global in nature and respects privacy. A COVID-19 digital certificate could be issued that would identify people as being immune, positive, negative, symptomatic, or unknown—that is, no test—by answering those questions without revealing or sacrificing personal, private health information*.[41]

Finding a COVID-19 vaccine is a top priority. To accelerate discovery, the blockchain start-up Shivom is working on a global project to collect and share virus host data.

Magierski has proposed a global collaboration. He hopes to bring his technical teams, resources, and connections from his business Care Chain and team up with others taking similar approaches and with backgrounds in science, epidemiology, and infectious diseases such as NextTrace and TraceTogether.[42]

Finding a COVID-19 vaccine is also a top priority. To accelerate discovery, the blockchain start-up Shivom is working on a global project to collect and share virus host data in response to a call for action from the European Union's Innovative Medicines Initiative (IMI).[43] Shivom scientists formed a global Multi-Omics Data Hub (MODH) Consortium comprised of universities, medical centers, and companies, many of which have expertise in AI and blockchain, all for combatting coronavirus infections. The consortium's data hub will be based on part of Shivom's blockchain-based precision medicine platform. Founded by BRI collaborator Dr. Axel Schumacher, Shivom's platform uses blockchain to share genomic data and data analysis securely and privately with third parties anywhere, without providing access to raw genomic data. Said Dr. Schumacher:

> *Researchers accessing the data in the COVID-19 data hub can run algorithms over the data that provide summary statistics to the data sets. No individual, de-identifying data can be obtained without the explicit consent of the patient. Each such transaction on the platform is regulated by smart contracts on a blockchain*.[44]

Preserving individual rights to healthcare is critical, too. In Honduras, Civitas—an app developed by the start-up Emerge—associates Hondurans' government-issued ID numbers with blockchain records used to track medical appointments and official permits to leave the house. Doctors scan the app to review a patient's symptoms verified and recorded by telemedicine services, and police scan the app to check whether the person holds a government-issued permit to circulate in public at that time. The app shares no personal data with government or the police, and no party can edit or deny the records—meaning that every record asserts the individual's right to healthcare.[45]

Choosing among sources of data is also critical. Dr. Raphael "Rafi" Yahalom of MIT and Oxford-Hainan Research Institute is working on Trustup, a trust-reasoning framework that can systematically highlight the ways in which data recorded on a blockchain ledger is more trustworthy than data stored in conventional databases.[46]

These four initiatives are but a few of the responses from the blockchain ecosystem. Will governments and industry regulators join them in funding and implementing these solutions in time to fight COVID-19, and in response to viral outbreaks of the future?

Person putting a drop on test tube *by Martin Lopez, n.d., used under Pexels license of 4 April 2020. Cropped to fit.*

*Monty C.M. Metzger of LCX encourages everyone to use **#EndCoronavirus** on social media when sharing anything vital to fighting COVID-19.*

Raising awareness

Raising social awareness is another top priority. To coordinate community response and support ongoing efforts, Monty C.M. Metzger—founder of the cryptoasset exchange LCX in Liechtenstein—set up a nonprofit foundation called EndCoronavirus.net "fully dedicated to stop the COVID-19 pandemic."[47] It's working on a transparent fundraising platform "to collect donations in a smart way—empowered by blockchain technology." It's also mobilizing "a network of corporate leaders, entrepreneurs, scientists, data analysts, software engineers, and volunteers."[48] And it's crowdsourcing and aggregating best practices, policies, and guidelines so that individuals and organizations don't need to reinvent the wheel in responding to COVID-19.[49] Metzger encourages everyone reading this report to use #EndCoronavirus on social media when sharing anything vital to fighting COVID-19. According to Metzger, "This is a multistakeholder approach that will address the urgent need to coordinate volunteer activity, source funding, enable traceability of funds, and do so through a platform that would enable shared, trusted, and verifiable information."[50]

The ultimate solution must exist independent of any corporation, government, or other third party.

Transitioning to a new paradigm for identity and personal data

This transition will take time. The ultimate solution must exist independent of any corporation, government, or other third party, and should not be subject to the agency risk of executives or political parties. It must interoperate with these institutions, even as it outlasts them. In fact, it must be built to *outlive* its users and enforce their right to be forgotten.[51] This would mean separating data rights from the actual data, so that the rights holder could delete it. To be inclusive, it must be user-friendly with a low-tech mobile interface and low-cost dispute resolution.

We expect organizations to take at least three actions to rebuild the trust of those whose data they hold.

» The first involves governance. Many large corporations and government agencies have strong governance mechanisms for their hard assets, but really poor governance of information assets.[52] Companies must define decision rights around their data and develop an accountability framework that disciplines how employees use data. Said David Jaffray of the University of Texas MD Anderson Cancer Center, "We need an entire stack of data governance technologies. To me, blockchain is the illustration that makes me believe that it's actually possible."

Figure 2: ConsenSys Health Federated Learning Network

This new operational environment accelerates clinical decisions and scientific discovery for healthcare and life sciences.

- The second involves the discontinuation of practices that collect and store customer data. This could involve either destroying these massive customer databases altogether (after returning files and records to customers) or migrating these data to distributed storage systems, such as the IPFS, and then transferring control to customers.[53]
- The third involves the cultivation of a new core competence: the ability to work with huge anonymized datasets rented from large numbers of people, all handled in a distributed and trust-minimized manner. It will remove data as a toxic asset from the corporate balance sheet and make it a fundamental human asset from birth. It will flip the data-analytics business model on its head and reward corporations for serving as data brokers on behalf of individuals. This will see the end of the large centralized data frackers that scrape, hoard, and rent, but don't protect this data.

"Private, trusted, and safe data is the medicine we need. Now we can analyze data at its source and, with privacy-preserving technologies, create the necessary 'crowd intelligence' to stop and cure COVID-19."

ALEX CAHANA MD
Chief Medical Officer
EMEA Market Lead
ConsenSys Health

These new approaches to privacy and ID management give citizens ownership of their medical information and their identities, the facts of their existence, and the data they create as they live their lives. The self-sovereign identity is one the pillars of a new social contract for the digital economy, and will be critical to the transformation to a more open, inclusive, and private economy.[54]

Of course, such changes are massive, and we can't expect to implement them fully in time to help us with COVID-19. "As the pandemic takes hold, we are making decisions without reliable information," said Dr. Alex Cahana, ConsenSys Health's chief medical officer and market lead for Europe, the Middle East, and Africa.[55] "At ConsenSys Health, we understand that private, trusted, and safe data is the medicine we need. Now we can analyze data at its source and, with privacy-preserving technologies, create the necessary 'crowd intelligence' to stop and cure COVID-19."[56] (See Figure 2, previous page.)

Nicely put! But now is the time to get serious about shifting our paradigm for management of our identity and personal health data to better predict or prevent pandemics from local to global levels and to develop vaccines faster and collaboratively.

Just-in-time supply chain solutions

As elsewhere in the world, hospitals across the United States desperately need medical supplies from ventilators and hand sanitizer to personal protective equipment. The challenges in getting them are several. One is tracking them down. Two is verifying their authenticity and condition as well as the reputation of their supplier. Three is moving them quickly to where they are needed. Four is keeping production up with or ahead of demand—all the while assuring healthcare professionals, hospital administrators, and citizens that they will have what they need, when and where they need it, to stave off hoarding and discourage purchase orders for six months' worth of supplies, as is a common practice in normal times.

List of much-needed supplies

- *Bleach or antimicrobial wipes*
- *Face shields*
- *Foot coverings*
- *Hand sanitizer*
- *N95 particulate respirators*
- *Nasal testing swabs*
- *Non-latex surgical gloves*
- *Powered air purifying respirators and hoods*
- *Safety goggles*
- *Surgical caps*
- *Surgical isolation gowns*
- *Surgical masks*
- *Thermometers*
- *Tyvek coveralls*
- *Ventilator tubing*

At one point, the US president advised state governors, "Try getting it yourselves."[57] Without federal coordination of these critical medical supplies in the United States, states found themselves bidding up prices against each other to win precious quantities or else going through intermediaries to track down stock without revealing their sources.[58] The supply chain we need right now must be transparent and driven by collaboration, not simply competition. By definition, blockchain is a collaborative technology; it is networked and benefits from network effects. The more participants or diverse "nodes" on the network, the more robust it becomes and the more market power it accrues. It is more a value network than a supply chain. It is also the opposite of a large centralized system, which is powerful but fragile: if it crashes, is attacked, or behaves like a monopoly, Big Brother, or Hal 9000, it could jeopardize the rights and well-being of anyone dependent on it.

Tracking and procuring medical supplies

A huge problem is locating inventory. Daniel M. Horn, a physician at Massachusetts General Hospital in Boston, called on the digital technology community to step up and collaborate: "Big tech needs to rapidly build and scale a cloud-based national ventilator surveillance platform [that] will track individual hospital ICU capacity and ventilator supply across the nation in real time."[59] Dr. Horn imagined that "[s]uch a platform—which Silicon Valley could build and FEMA [Federal Emergency Management Agency] could utilize—would allow hospitals nationwide to report their [intensive care unit] bed status and their ventilator supply daily, in an unprecedented data-sharing initiative."[60]

Blockchain technology is already serving as such a platform for tracking a variety of assets for the common good. For example, Everledger helps to prevent conflict diamonds from entering

Limited paper supply *by MJ Pilgrim, 2020, used with permission. All rights reserved.*

legitimate markets, IBM Food Trust helps to identify the source of contaminated foods quickly, and Circulor helps to expose unethical labor practices in cobalt mining.[61] One initiative that's highly relevant to the COVID-19 crisis is RemediChain.[62] One of its co-founders, Dr. Philip Baker, told us, "The power of blockchain is in creating a decentralized, transparent platform that no single entity controls. The most immediate place I see blockchain making an impact is in tracking surplus."[63]

"The most immediate place I see blockchain making an impact is in tracking surplus."

DR. PHILIP BAKER
CEO and Founder
Good Shepherd Pharmacy

Dr. Baker, a practicing pharmacist and the CEO and founder of nonprofit Good Shepherd Pharmacy, has closely studied the supply chain of drugs. Once they reach a facility or a patient, they go "off the grid," and so determining whether they've been properly consumed or discarded, let alone illegally resold, is difficult. He was interested in tracking down and recycling unused but still efficacious medications such as those used for cancer, which are costly. His first challenge was to lobby for the necessary legislative change, which took him two years. His second challenge was to collect and redistribute these drugs lawfully to the vulnerable people who couldn't otherwise afford treatment.

Dr. Baker saw blockchain as means of putting these medications back on the grid and recovering their chain of custody. With the assistance of ConsenSys Health, xCures, and Lipscomb University, he formed RemediChain, a blockchain consortium that has developed a process for parties to log their extra oral chemo medication in a national registry.[64] He told us,

> *By posting the medication and its expiration date, people all over the country can create a decentralized national inventory of surplus medication. When there is sudden run on a previously ubiquitous medication like hydroxychloroquine, healthcare professionals can call on this surplus as a life-saving resource. The same principle applies for ventilators and PPE.*[65]

"We're only at the beginning of the pandemic and, like the pandemic, I believe the pharmaceutical supply chain could get a lot worse before it gets better."

DR. PHILIP BAKER
CEO and Founder
Good Shepherd Pharmacy

In theory, COVID-19 shouldn't stress the pharmaceutical supply chain because we don't have a drug to cure it. But Dr. Baker pointed to sudden runs on medications rumored to be cures, specifically hydroxychloroquine and azithromycin. "These have created shortages for the legitimate use of those meds," he said. He also noted the "extensive rumors of manufacturing delays due to ingredients coming slowly from China."[66]

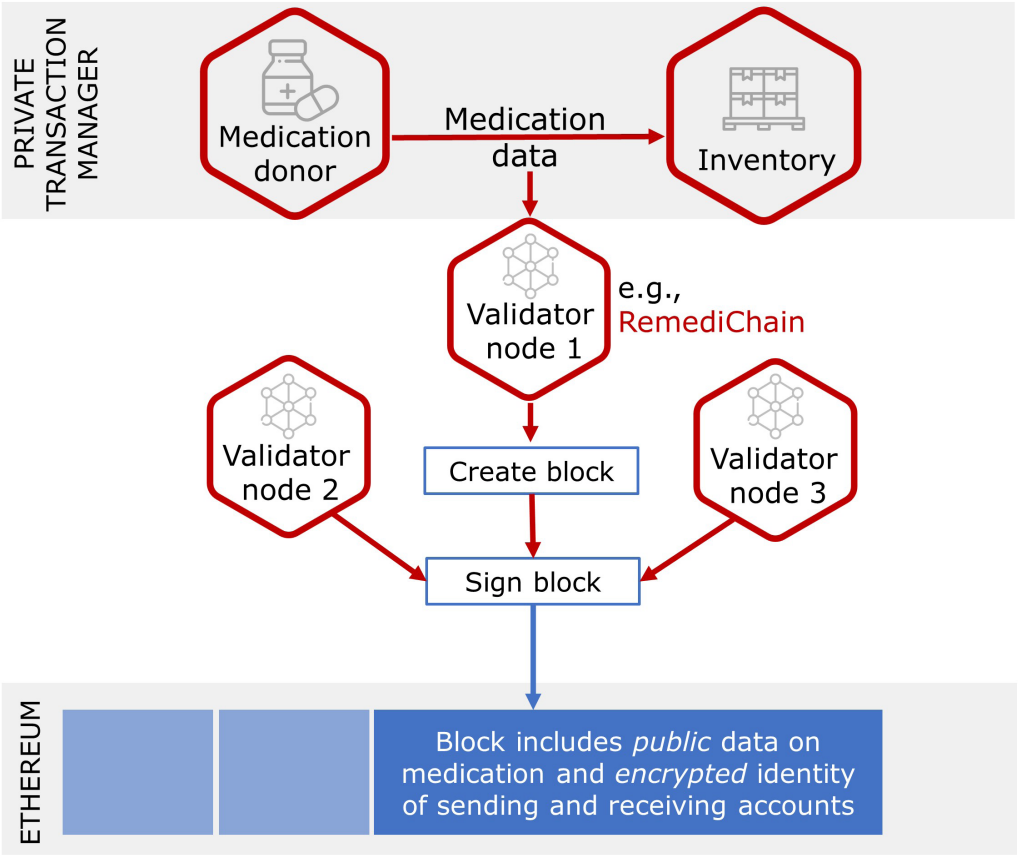
In the absence of supply chain visibility, large healthcare organizations have begun hoarding drugs irrationally, and wholesalers are rationing the volume of drugs that local pharmacies can buy.[67] Dr. Baker underscored his concern: "We're only at the beginning of the pandemic and, like the pandemic, I believe the pharmaceutical supply chain could get a lot worse before it gets better."

Solutions like RemediChain provide visibility into supply, confirm its authenticity, and protect the identities of individuals who donated or requisitioned. From October 2018 to 2019, RemediChain collected

If the donated drug is acceptable, the donor receives mailing instructions and packaging to ship it to Good Shepherd Pharmacy.

$2.2 million worth of oncology drugs from 200 individual donors. So how does it work?[68] Donors use RemediChain's mobile application to scan the labels on their unused medications. For each donation, RemediChain stores on-chain publicly such data as the National Drug Code, lot and serial numbers, expiration date, and number of drugs in the donation.[69] Using Hyperledger Besu's public-permission structure, RemediChain can publicly record and control who may add to and amend those data. If the donated drug is acceptable, the donor receives mailing instructions and packaging to ship it to Good Shepherd Pharmacy. Once the donation arrives, the pharmacy matches it to a patient and sends it directly to the new patient or to a partner pharmacy for distribution—but the transaction between the donor and inventory takes place in a private transaction manager, which restricts the donor's identity to the two parties to the transaction. As one of currently five validator nodes in the network, RemediChain verifies this transaction and creates a block, which needs at least 66 percent of the other validator nodes to approve it. Once the nodes reach consensus, the block is appended to the Ethereum mainnet and the data are available to the public, but donor's identity stays private (Figure 3).[70]

Figure 3: Validating and appending RemediChain inventory to Ethereum



China Xiong'an Group teamed up with blockchain start-up Hyperchain to launch a platform for matching medical supplies with healthcare professionals.

China's blockchain entrepreneurs have risen to their country's supply chain challenge. In Hangzhou, China Xiong'an Group teamed up with blockchain start-up Hyperchain to launch a blockchain-based platform for matching donations of medical supplies with the healthcare professionals who need them. To prevent fraudsters from logging fake or defective equipment onto the chain, the Hangzhou Internet Notary Office stepped in to notarize each donation, and users can see what's available in real time. Like RemediChain, the platform tracks packages in transit and confirms final delivery. Xie Yijun, technical director of the initiative, told *Xinhua News*, "Once information concerning a certain donation is published, it can't be changed or deleted, which greatly increases the cost of counterfeiting." By the end of the platform's first day in operation, donors had registered more 500 items.[71]

Similarly, payment service provider Alipay partnered with both the Health Commission and the Economy and Information Technology Department of Zhejiang Province to launch a similar blockchain-based platform for recording and tracking donated epidemic prevention supplies and sharing the data publicly. Like RemediChain, donors can use a mobile app to upload information about their donations.[72]

Table 1: Blockchain efforts in the pharmaceutical sector

	Year launched	Type of blockchain	Number of partners	Mission
IDLogiq	2017	Private	N/A	Anti-counterfeiting solution that scans pharmaceutical labels to validate product authenticity[73]
KitChain (LedgerDomain)	2017	Private (Fabric)	12	Supply chain for clinical studies to track shipments of packaged drug products to clinical pharmacies[74]
MediLedger (Chronicled)	2019	Private (Parity - Ethereum)	24	Saleable returns directory and verification of chain of custody enable immediate communication between wholesalers and manufacturers[75]
RemediChain	2018	Hybrid (Hyperledger Besu)	5	Tracking, measurement, and donation of pharmaceutical waste
Rymedi	2018	Private	N/A	Interoperability of healthcare data; supply monitoring of medicine between and within state healthcare systems[76]
Information Collaboration Hub for Life Sciences (SAP)	2017	Hybrid (Multichain)	15+	Reduce drug counterfeiting and follow serialization and compliance reporting standards; initial focus on traceability[77]
Trace Histories (TraceLink)	2019	Private	N/A	Distributed ledger integrates into existing compliance and serialization standards; pharmaceutical digital supply network with end-to-end traceability[78]

Source: Anna Hermansen, "Reclaiming Medication on the Blockchain: RemediChain and the Untapped, Untracked Market for Drug Waste," foreword by Don Tapscott, Blockchain Research Institute, 30 March 2020.

With Alipay's brand name and installed base, this initiative could have real impact. Here's a shout out to those who have a popular secure messaging or payments app: maybe there's a blockchain-based supply chain collaboration in your near future?

Authenticity of assets

Here's a shout out to those who have a popular secure messaging or payments app: maybe there's a blockchain-based supply chain collaboration in your near future?

There's nothing like a crisis to bring out the worst in the worst of society. RiskIQ, a threat intelligence consultancy, saw a massive spike in pandemic scams targeting the vulnerable and the desperate for medical supplies and created a "COVID-19 Cybercrime Daily Update" in response.[79] So rampant is the fraud that Electronic Frontier Foundation issued a guide to recognizing malicious phishing scams related to the coronavirus.[80] Criticized in the past for not adequately screening out frauds and defects among third-party sellers, Amazon.com has purged one million products from its site because vendors were price-gouging or falsely advertising the efficacy of their goods against COVID-19.[81]

In addition to engaging notaries in the process as Hyperchain did, blockchain provides at least two types of solutions to these problems. The first is verifying suppliers. Gennaro "Jerry" Cuomo, IBM fellow and vice president of blockchain technologies at IBM, suggested repurposing current blockchain-based supply chain ecosystems, where suppliers have already been vetted and their credentials and competencies verified and recorded.[82] That would help to collapse the approval process for supply chain partners from 45 days to five days, onboard suppliers faster, and manage supplier life cycle more effectively.[83]

The second solution is creating essentially a self-sovereign identity for each physical thing by linking it cryptographically to a unique digital token. Mattereum is a technology start-up dedicated to doing just that. Its founder Vinay Gupta said that there has been interest in digitally twinning physical assets using the Mattereum protocols.[84]

"Anyone who has detailed knowledge of any aspect of an object can attach this information to its asset passport in the form of a guarantee on that information being accurate (called a certification)."

VINAY GUPTA
Founder and CEO
Mattereum

Here's how it works.[85] First, asset owners such as ventilator manufacturers tokenize their assets via what Mattereum calls an *asset passport*, which is "a unique contractual container (legal and smart contracts together) that records and manages the rights and obligations associated with a given asset [and identifies] property in the same way that URLs identify information."[86] Gupta explained, "Anyone who has detailed knowledge of any aspect of an object can attach this information to its asset passport in the form of a guarantee on that information being accurate (called a *certification).*"[87] For example, auxiliary manufacturers of ventilators "could create certifications on a product's asset passport to state that it performs to a certain specification or meets a certain standard and provide the necessary supporting documentation [such as Food and Drug Administration approval] to back up those claims."[88] They could include detailed designs and breakdowns of parts for operation and maintenance. Then manufacturers could automate custodianship, which Mattereum calls "the perfect legal counterparty to a smart contract, … [becoming] an asset's legal owner and registrar, maintaining the authoritative register of interests in the asset."[89]

If certifiers of an asset falsified data, then they would be legally bound to pay damages directly under internationally accepted rules.

Finally, so that hospital procurement officers could discover this new inventory, the automated custodians could publish each asset's availability and terms of use or sale on a distributed smart medical supply registry "without requiring any changes to the current legal framework in any jurisdiction."[90] Here's the kicker: if certifiers of an asset falsified data (as vendors have allegedly done on Amazon.com), then they would be legally bound to pay damages directly under internationally accepted rules.[91]

Gupta was cautious. He and his colleagues aren't sure whether this type of identity technology solves exactly the right problem that auxiliary manufacturers will face. He wrote:

> *We're acutely aware that hasty action can be dangerous in times like this, so we don't want to move until we're better acquainted with the terrain. That said, while rushing in is bad, hanging back is also bad, in fact all options are bad, because the situation is bad. Whatever you do, you're gonna wish you had done something different in the long run.*[92]

Logistics, transport, and custody

How do we move medical supplies quickly from one country to another? Not easily in today's global supply chains. Most still rely heavily on opaque, time-consuming, and costly processes. Documentation is largely paper-based and handled manually. Approvals from multiple parties at each checkpoint often cause delays and are susceptible to fraud on cross-border orders. Catching mistakes in compliance and quality control is difficult. According to

Surgeon wearing mask *by Liquidlibrary, n.d., used under Picspree license of November 2019.*

Blockchain Research Institute research contributors from Deloitte Canada, "Parties throughout the supply chain—banks, freight forwarders, importers, exporters, customs and port authorities, and regulators—lean on pre-existing relationships to avoid such complications. This environment of distrust, however, is what makes global trade suitable for blockchain use cases."[93]

Removing friction within supply chains alone could result in a potential increase in global trade of 15 percent, which would be a hugely welcome boost to a decimated global economy.

To address these issues and expedite cargo, shipping giant Maersk established a joint venture with IBM to launch TradeLens, a blockchain platform that would help to streamline activities in freight forwarding.[94] First, they decided on Hyperledger Fabric 1.0 combined with IBM Blockchain technology and delivered through the IBM Cloud. Next, they developed a pipeline of shipping data to monitor shipments. Then they automated paperwork to reduce the time and costs associated with clearing and moving cargo.[95] Already collaborating on this platform are Mediterranean Shipping Company, CMA CGM SA, Hapag-Lloyd AG, and Ocean Network Express.[96]

Removing friction within supply chains alone could result in a potential increase in global trade of 15 percent, which would be a hugely welcome boost to a decimated global economy.[97] Members are looking to leverage TradeLens in streamlining their complex supply chains, providing customs clearance brokerage and other services on the platform, and facilitating trade flows at international ports and border crossings.[98]

Any medical supplier or equipment manufacturer not using this platform should look into it and others like it in China (e.g., WG Technology Development's Tianjin Port project) as soon as possible.[99] They provide end-to-end visibility in the supply chain, and we could exchange information related to shipment events in near real time, redirecting precious medical supplies wherever possible.

Additive manufacturing and digital distribution

To meet demand, automakers, vacuum cleaner brands, and others are having conversations with ventilator manufacturers. GE Healthcare has spoken with Ford, Medtronic with Tesla and others, and Ventec Life Systems with General Motors to explore how they might boost production.[100] But concerns over intellectual property rights have given ventilator patent holders pause.

How can we best mobilize manufacturing and distribution resources—including intellectual property—to deliver supplies to fighters on the front line in a secure and efficient manner? James Regenor has been studying this question for much of his career. As the business unit director of transformative technologies at Moog—an aircraft precision part manufacturer in a highly regulated industry—Regenor was among the first to explore how blockchain could help Moog identify counterfeits in its supply chain and prove its compliance with aerospace regulations, Federal Aviation Authority audit protocols, and US Department of Defense (DOD) standards.[101]

The real breakthrough came when Moog combined these capabilities with additive manufacturing.[102] In Moog's case, deploying three-dimensional printers was less a hardware-associated production challenge and more a data-management one, as more of Moog's components were exchanged directly on the blockchain in the form of secured design files sent to 3D printers.[103] The key was to shift from the mindset of shipping parts to one of exchanging data and licensing patented designs. Regenor realized that, with a network of highly specialized designers, an enterprise like Moog could adopt a software-as-a-service model and license its designs to other companies' assembly lines, depending on the location of customers and raw materials in the supply chain.[104]

The Rapid Medical Parts team can reverse-engineer a part and manufacture it much faster and at a lower cost than getting it from the original manufacturer or replacing the equipment.

To make this idea a reality, Regenor co-founded and now presides over VeriTX, a virtual marketplace for these digital assets. When COVID-19 hit, he pivoted to medical supplies and launched Rapid Medical Parts, so that medical facilities could essentially print the parts they needed to maintain or repair existing equipment at one of 180 3D printing facilities in Rapid Medical Parts' network.[105] Regenor's design team can reverse-engineer a part, and then his manufacturing team can build it much faster and at a lower cost than getting it from the original manufacturer or replacing the equipment.[106] According to Blockchain Research Institute research contributors Vineet Narula and Prema Shrikrishna,

> *Additive manufacturing also decreases the cost variance between manufacturing locally and offshoring to inexpensive labor. If manufacturing costs for printing an item locally or overseas are the same, then a locally printed item will be cheaper because of lower transportation costs from printer to end customer or assembly factory.*[107]

Like Ford and GM, Regenor applied for DOD Defense Protection Act Title 3 funding for a ventilation solution to help treat COVID-19 patients with acute respiratory distress syndrome. Since our roundtable, he received word that the DOD had approved and is funding this invention. Now Regenor's company will be making organic ventilation systems. The next step is to gain Food and Drug Administration approval.[108]

Blockchain preserves personal privacy and the integrity of data, protects intellectual property rights, and provides maximum flexibility in the medical supply chain.

Blockchain preserves personal privacy and the integrity of data, protects intellectual property rights, and provides maximum flexibility in the medical supply chain. Through VeriTX's platform, manufacturers that have maxed out their production capacity could license the rights to produce their devices to auxiliary manufacturers. Consider Respironics, a subsidiary of Royal Philips. Respironics received $13.8 million from the US Department of Health and Human Services to design and produce an affordable ventilator.[109] With this taxpayer funding, Respironics created the Trilogy Evo Universal, a low-cost ventilator that is portable and easy to use.[110] The Food and Drug Administration approved the device, and Philips appears to have trademarked it and patented four parts relating to it.[111] But Respironics has dedicated its production facilities to its high-end models instead, and Philips is talking with the White House about manufacturing over 40,000 big-ticket ventilators for hospitals.[112]

We need large quantities of low-cost, portable, and easy-to-use ventilators for pop-up hospitals now. Licensing the production rights to technology like the Trilogy Evo Universal is the right thing to do. If patent holders are concerned about the lack of manufacturing experience with these devices, then let's partner with engineering schools at top universities to develop and deliver online training with blockchain-based credentials such as BlockCerts and aimed at any manufacturing, mechanical, or industrial engineer now out of a job.[113] All hands on deck!

Sustaining the economy

Why we need digital cash

Could your cash be contagious? The World Health Organization recently declared that hard currency could be carrying COVID-19 and encouraged people to use contactless payments when possible. This comes on the heels of China's drastic move literally to launder its money by taking cash out of circulation and either cleaning or destroying it.[114]

For decades, cash has been increasingly marginalized as we make more transactions using credit and debit cards. Plus, a valid criticism of cash is that large denominations make money-laundering easier.

For decades, cash has been increasingly marginalized as we make more transactions using credit and debit cards.

Cold Headaches Health Influence Disease Virus *by Luisella Planeta Leoni (sweetlouise), 2018, used under Pixabay license of 27 March 2020. Cropped to fit.*

So with the drumbeat of credit card payments and Apple Pay growing louder and with cash both a carrier of COVID-19 and an accessory to crime, should we eliminate it altogether? Perhaps, but first we must introduce a truly digital alternative to cash.

Some might ask, "Well, what about credit cards, or Venmo, or the CashApp, for that matter. Aren't they digital cash?" No. Applications like Venmo, a popular payment application that handled around $12 billion in payments in 2018, are more like digital wallpaper on the

old edifice of banking. For example, when Mrs. Smith in Seattle uses Venmo to send money to her son at university in Los Angeles to cover his expenses while under quarantine, Venmo is merely moving money between two accounts at Venmo's bank. In a pandemic, this works fine for the Smiths as well as certain merchants and other select American consumers with traditional bank accounts, but it fails for everyone else. Founded more than a decade ago, Venmo is still not available to the billions of unbanked in huge untapped markets like remittances.[115] What's more, Venmo captures valuable data about its users that it can monetize but users can't.

If we are to eliminate cold hard cash, then we must develop a digital alternative that will be foundational to our privacy and independence in the economy.

Digital cash will be critical to our freedom for four reasons. First, like traditional cash, it must be resilient; it should not rely on private banks and payment networks to function. Second, we should not need permission, birth certificates, or other pieces of technology to use it. Third, we must be able to use it anonymously to purchase goods and services. Finally, lower income people sometimes struggle to get a bank account or a credit card, and so digital cash must be easily attainable and easy to use, not requiring a traditional bank account.

If we are to eliminate cold hard (and potentially coronavirus-coated) cash, then we must develop a digital alternative that will be foundational to our privacy and independence in the economy. Traditional cash is freedom enabling: it protects the identities of women who want to buy contraceptives in communities that condemn birth control or sex outside marriage, and it allows us to buy goods and services without turning over our personal data to non-transparent organizations. Jerry Brito, executive director of Coin Center, a US-based think tank focused on issues related to cryptocurrencies, has it right: "A cashless economy is a surveillance economy."[116]

Currently there are three kinds of digital *money* (but not necessarily digital "cash" per se) in use or under development, each with its own benefits and limitations. The first are community driven currencies like bitcoin, which was designed from the outset to be a "peer-to-peer electronic cash system"—in other words, *digital cash*.[117] The second are corporate currencies developed by private companies that holders can use inside and outside the corporate network, such as Facebook's Libra.[118] The third are central bank digital currencies, created by governments and central banks.

Bitcoin already acts as a type of digital cash but is not a panacea.

While initiatives such as Libra, Facebook's digital currency project, could make payments easier, especially for the world's unbanked, they are not substitutes for cash: they'll ultimately be governed by the private corporations that back them. Payments may not be anonymous, and users may be beholden to companies that can change the terms of use at any moment. Bitcoin, the biggest and most consequential community currency, is a better place to start. Bitcoin already acts as a type of digital cash: it's a distributed or P2P system open to anyone with Internet access. Just as cellular technology allowed billions of people to leapfrog landlines, bitcoin could leapfrog legacy financial institutions.

Mark Carney suggested replacing the US dollar as the world's reserve currency with a synthetic global currency backed by a basket of government-issued digital currencies.

However, bitcoin is not a panacea. It's not yet widely held; it's still not all that intuitive to use; and it's volatile. While we can encourage bitcoin where it is accepted, we must explore other options as well.

So let's look at option three: central bank digital currencies that replicate the anonymous, P2P attributes of cash are an emerging alternative. But they also have problems. First, governments will likely be reluctant to build something they can't control and oversee. Indeed, the Bank of Canada highlighted government surveillance as a key reason for exploring its own digital loonie last year. Second, for a central bank digital currency to work like cash and be fully anonymous, private and irreversible, it must also be decentralized, which seems an unlikely venture for a centralized bank.

Perhaps the answer is a global alternative that combines attributes of bitcoin with those of traditional government currencies. Last year, Mark Carney, governor of the Bank of England, suggested replacing the US dollar as the world's reserve currency with a synthetic global currency backed by a basket of government-issued digital currencies.[119] Carney's speech was aspirational in tone and vague on details but provided an intriguing starting point. In theory, "decentralizing" the governance of such a supranational currency across different nation–states would prevent any single government from controlling it or any single authority from surveilling how it's used.

There are at least two implementation challenges to this idea, however. First, we must balance the need for governments to fight organized crime against the need for individuals to exercise economic privacy through a digital cash equivalent. Second, central banks must co-ordinate to develop a system that is resilient and easy to use, even for those without identity cards or digital devices.

Another obvious use case for digital cash is in the quick and efficient disbursement of relief checks to individuals affected by COVID-19. The US Congress just passed a $2.2 trillion stimulus bill, which included expansions to unemployment insurance as well as payments to individuals once living paycheck to paycheck and now getting no paycheck because of COVID-19. Despite passing on March 27, the bill doesn't immediately advance payments to individuals; they may wait weeks for checks. Right now, the government is relying on mailing physical checks to individuals or using their tax filing information to deposit money into their bank accounts.

There are obvious limitations to this approach. For one, mailing checks is slow, time consuming, and problematic for those without a fixed address. Second, using tax filing information may cause the government to overlook individuals who don't pay taxes, such as students or babies born since the last filing. Some have floated using fintech applications to leapfrog this antiquated government infrastructure. That's not a bad idea. But private applications like Venmo or the Cash App may be overwhelmed by such large dollar volumes, and these companies are nowhere near to universal usage.

Coronavirus Militares Venezuela Rafaelurdanetaphoto *by modovisible, 2020, used under Pixabay license of 27 March 2020.*

Instead, imagine that individuals had an account with the Federal Reserve or the equivalent in another country. Every person could have such an account by simply being a citizen or applying for a social security number. When the government wanted to send out a stimulus payment, it would simply deposit it in the individual's account, and the individual would then access it by mobile phone. Recipients could then redeem it for hard cash if they wanted their payments to be anonymous or use the money digitally to avoid potentially spreading the coronavirus.

If cash becomes increasingly marginalized or stigmatized in our economy, then these are challenges we must overcome. The alternative is a world in which powerful private companies and governments know how we earn and spend every dollar. This would be disastrous for human rights. Privacy and economic inclusion are foundational to freedom.

Supply chain finance

What role could blockchain play to keep our global supply chain well lubricated with a seamless flow of money?

Earlier, you read about how supply chains have been significantly strained by COVID-19 and why we need to move to a view of supply chains as "asset networks," state machines that can allow individual companies and other stakeholders to have real-time, true, and transparent information about the state of assets moving around the world. But how do we finance these supply chains in an economic crisis? If all stakeholders start shoring up their balance sheets and bracing for a recession, how do we mitigate a seizure of bank credit and maintain liquidity? What role could blockchain play to keep our global supply chain well lubricated with a seamless flow of money?

Blockchain has several benefits here. Patara Panuparb of the MIT Center for Transportation and Logistics argued that blockchain can enable "more efficient invoice processing, real-time validation

of invoices, irreversible transactions, and easy and fast supplier onboarding."[120] He continued, "Among these benefits, the efficiency of invoice processing is considered to be the most important, since it directly determines how fast suppliers receive the working capital they need. The faster the process, the more working capital can be unlocked."[121]

Smart contracts for trade finance and supply chain financing could ensure that only counterparties with funds, assets, or collateral to satisfy agreements get access to capital.

Speeding the clearance and settlement of payments reduces counterparty risk for financial firms in the supply chain. Nobody wants to wake up on Monday to find out that the trade financing provided to a counterparty last Friday is now due and the counterparty can't pay it.

Similarly to the opaque and convoluted world of credit derivatives—the tinderbox that blew up the mortgage market and destabilized financial markets in 2008—supply chain finance today is based on antiquated and complicated bills of lading, notes, and other financial instruments that are decades, if not centuries, old. The only thing that has changed is e-mail.

Smart contracts for trade finance and supply chain financing could ensure that only counterparties with funds, assets, or collateral to satisfy agreements get access to capital. Greater speed and transparency should give lenders more confidence ensuring that funds flow even during times of crisis.

For example, the Foxconn Technology Group's fintech subsidiary FnConn Financial partnered with Dianrong, China's leader in online lending to small and medium-sized enterprises (SMEs).[122] Most of us know Foxconn as the manufacturer of our beloved mobile and gaming devices.[123] Ranked 24th on the *Fortune Global 500,* it anchors a sprawling global supply chain in garment, electronic, and automobile industries across emerging markets, where falsified invoicing and shoddy bookkeeping make bank loans hard to come by.[124]

Together, they launched Chained Finance, the first blockchain-based platform for supply chain management, combining procurement, financing, and logistics into a single shared ledger system. Using Chained Finance's permissioned ledger, members of all sizes can track order status and the flow of assets and money. To create liquidity, Chained Finance tokenizes the unfinanced accounts payable of Foxconn and those of its Tier 1 suppliers, converting them into digital assets referred to as "eAPs." Tier 1s can then use their own eAPs as they'd like, to get cash from Chained Finance or to pay back or issue credit to their Tier 2+ suppliers.[125]

Using Chained Finance's permissioned ledger, members of all sizes can track order status and the flow of assets and money.

An SME that finds itself short of the capital needed to complete an order can get a short-term loan from other members much faster and at a much lower cost because the other members can see the small business' accounts receivable and its other collateral assets within the supply chain.[126] Dianrong CEO Soul Htite reported that, in its six-month pilot with FnConn, Chained Finance "originated $6.5 million in high-quality loans for supply chain operators, many of whom were unable to secure needed financing in the past."[127]

See Table 2 (below) for a comparison of Chained Finance and traditional bank-based financing.

Insurance and risk management

"There are risks and costs to a program of action. But they are far less than the long-range risks and costs of comfortable inaction."

JOHN F. KENNEDY
US President
1917–1963

COVID-19, in the words of Nicholas Taleb, is not a black swan event but a white swan event, one that happens at fairly regular intervals and was thus predictable.[128] Yet governments, businesses, and individuals have proven ill-equipped to deal with these challenges. They say people in glass houses should take out insurance. Well, the human race has been sitting inside its glass house on a cliff facing erosion in an active fault zone for decades but has not prepared for the seismic risk of a pandemic.

How do we take action to insure ourselves and prevent the failures so obvious in our response in the future? For starters, individuals should have access to universal healthcare during a crisis and should have a minimum viable form of health insurance all the time. Nobody should avoid the doctor's office or not seek testing or treatment during a pandemic because they're worried about the cost. Earlier we discussed blockchain based medical records and identity. Imprinted in that self-sovereign identity should be information that automatically triggers health insurance in times of crisis. In countries which lack basic universal healthcare like the United States, that insurance can be customized to work during pandemics and ensure the government subsidizes co-pays, deductibles, and other costs of private insurance.

Table 2: Comparison of bank-based and blockchain-based supply chain finance

	Traditional supply chain finance	Chained finance
Control	Centralized, anchor dependent	Decentralized but permissioned; nodes have visibility and can record and verify transactions
Process	Manual, with documents to complete	Automated, based on transactional data stored on blockchain
Data transparency	Low; greater risk of tampering	High; low risk of tampering
Risk premium	High	Low
Handling fees	High	Minimal
Average cost of financing	25% for Tier 2+ suppliers (85% if supply chain)	~0% for Tier 1 suppliers <10% for Tier 2+ suppliers
Time to approval	7-10 working days	Same day, if not immediate
Time to approval	7-10 working days	Same day, if not immediate

Source of data: "High Tech, Low Cost: The Easiest Way to Supply Chain Finance," Chained Finance*, FnConn Financial, n.d., accessed 19 Jan. 2019.*

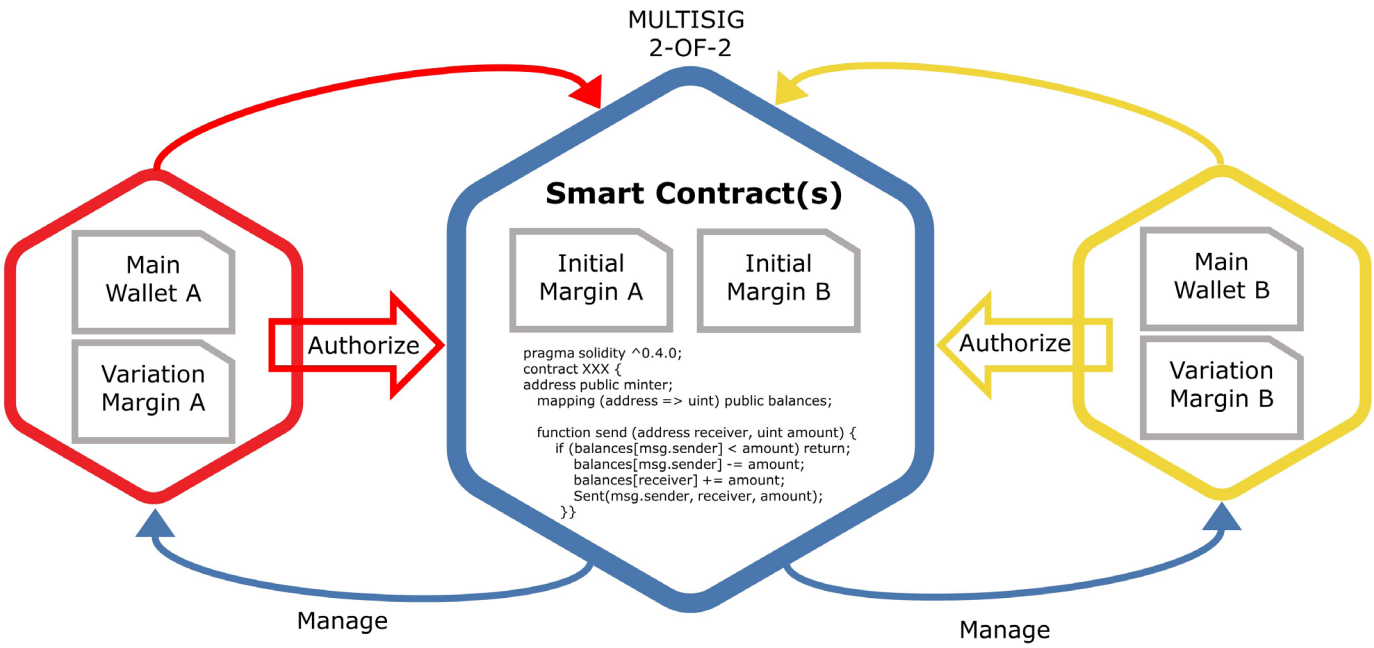
Instead of a buzz saw, we could use a scalpel, isolating only those at-risk populations while allowing others to return to work, patronize open businesses, and revive the economy.

In *Blockchain Revolution*, we argued that "using reputational systems based on a person's social and economic capital, their actions, and other reputational attributes, insurers will have a much clearer picture of the actuarial risk and can make more informed decisions." Let's apply that concept to the current crisis. If insurance was based on these attributes in the future, then individuals would know whether they were higher risk based on the premiums they paid on private insurance, and they could self-quarantine or, under extraordinary circumstances, governments could order a lockdown as China did. Better data would mean better health and economic outcomes. Instead of a buzz saw, we could use a scalpel, isolating only those at-risk populations while allowing others to return to work, patronize open businesses, and revive the economy.

Corporations could also benefit. Most companies hedge against exogenous risk, such as fluctuating currencies or oil prices by buying derivatives. (Think airlines.) But derivatives are traded and cleared in an opaque over-the-counter marketplace dominated by big banks. If derivatives were digital assets—cleared and settled in real time on blockchains (Figure 4)—then companies could price risk more accurately and buy insurance more quickly. And investors, regulators, and taxpayers would have a clearer picture of the risks inherent in a business and the steps they've taken to ameliorate them.

We can manage the whole lifecycle of derivatives on the blockchain. Once parties sign the smart contract, it can auto-execute collateral updates atomically with derivative cash flows and monitor payments.

Figure 4: Smart contract for derivatives collateral



If Party A misses more than a fixed amount of payments, then the contract terminates and Party B gets the collateral as compensation for the lost payments.

Blockchain alone is not a solution to this problem, by any means. Well-functioning institutions should have had a long-term plan and should have been better resourced to deal with the economic and public health shocks of COVID-19. Individuals should have been better informed and prepared and should have taken precautions to fend for themselves when things get very dire. Businesses needed to be better capitalized to absorb shocks so as to avoid the inevitable moral hazard of government bailouts. We collectively did none of these things in advance of COVID-19 and we are suffering the consequences.

Well-functioning institutions should have had a long-term plan and should have been better resourced to deal with the economic and public health shocks of COVID-19.

Decentralized models of governance, organization, and problem-solving

Before this crisis, increased demand for elder care was already straining the healthcare infrastructures of developed economies with aging populations. Data silos and red tape have added to the burden, with nonsensical steps and redundant processes accounting for as much as 30 percent of medical bills.[129] Healthcare industry veteran Pradeep Goel decided to launch Solve.Care to confront this waste head on. He selected blockchain technology because it could help not only to cut costs through P2P transactions but also to minimize fraud and duplication of documents and data. The Solve.Care platform uses the Ethereum protocols and features a native ERC-20 token (SOLVE).[130] Dr. David Hanekom, chief medical officer, told Thrive Global, "Solve.Care has created an ecosystem, not a standalone app ... . Our platform helps direct money away from covering administrative costs and toward directly helping patients through preventative care, which leads to lower premiums and better benefits."[131] It is one to watch.

Blockchain can fundamentally transform how we contribute money and other resources to the fight against COVID-19.

Not only can blockchain help to strip costs from our global healthcare system, but it can also fundamentally transform how nongovernmental organizations (NGOs), governments, and individual donors contribute money and other resources to the fight against COVID-19. Hundreds of billions of dollars flow into aid organizations annually, but the outcome is not always clear, especially in the developing world. For example, there is ample evidence suggesting that corrupt officials, local strongmen, and other intermediaries pocket much of the aid before it reaches its intended target. According to the *Journal of International Economics,* an "increase in government revenues may lower the provision of pubic goods," adding "Large disbursements of aid, or windfalls, do not necessarily lead to increased welfare."[132] Organizational bloat and leadership corruption combine for waste and greater disparity between the haves and the have-nots in the world's poorest countries. As COVID-19 begins to ravage the global south, where governance and infrastructure are less reliable, this waste, rent seeking, and graft will become a big problem.

As of 20 March 2020, Binance had delivered

- *366,000 pairs of gloves*
- *56,800 masks*
- *20,000 pairs of goggles*
- *20,000 testing kits*
- *7,850 protective suits*
- *5,280 bottles of hand sanitizers*
- *1,000 germicidal lamps*
- *388 oxygen concentrators*
- *173 barrels of disinfectant*
- *9 sterilizers*

Blockchain can improve the delivery of aid in two ways. First, by disintermediating the middlemen who act as conduits for large aid transfers, it can reduce the chronic problem of outright misappropriation and theft. Second, as an immutable record of how funds flow, it compels large institutions, from aid groups to governments, to act with integrity and abide by their commitments. If they do not, individuals will be able to see their malfeasance and hold them accountable.

Certain kinds of aid need no middleman. With digital cash, we can and should send money directly to individuals who need it the most.[133] For example, in December 2019, Binance launched its "Binance for Wuhan" project to raise funds for supplies for the city's overwhelmed healthcare workers and facilities. Said Helen Hai, head of Binance Charity, "The most important element of human life is to show compassion and help others as we can, without the limitation or restriction of borders. Blockchain technology enables this in greater capacities than ever before and Binance Charity wishes to bring this to the masses."[134] In that spirit, the Binance Charity Foundation announced its Crypto Against COVID fundraising campaign last month; users of cryptocurrencies can donate to this important cause.

However, not all aid can be peer to peer. Oftentimes, institutions are not only desirable but essential, and blockchain can help improve the transparency of how those institutions function. How might this work in practice? Blockchain is enabling a new form of organization, radically different from anything we've seen in human history. A DAO, short for *distributed autonomous organization*. A DAO is simply software that runs on a blockchain in a trust-minimized manner.[135] DAOs raise the intriguing possibility that software could ameliorate or even eliminate some of the most vexing problems of management and mass collaboration.

On the blockchain, any changes to a DAO require broad stakeholder discussion and consent, usually by consensus. That's huge.

Consider the impact of software that automates important aspects of governance and decision-making in a firm, NGO, or government. DAOs have no executive team, board of directors, or assets other than code, potentially eliminating the possibility of managerial wrongdoing and incompetence. Such an organization will do what it's coded to do, which is to act in the interests of its stakeholders. For example, we could organize a DAO by giving each stakeholder tokens that convey voting rights.

With such an organization, there is no information asymmetry between management and stakeholders, because there are no managers. Nor is there room for moral hazard, where managers may behave contrary to the interests of their customers or clients, taking outsized risks for personal gain because they know they won't suffer the consequences.

Could a DAO really match the efficiency and productivity of traditional organizations such as centralized companies or governments? Right now, there are a few successful DAOs, such as MakerDAO, but it is a nascent industry overall. Still, using smart contracts—agreements written in code that self-enforce—a DAO could do pretty much what any organization could do, with one important exception. On

the blockchain, any changes to agreements, mission statements, corporate values, or operating principles require broad stakeholder discussion and consent, usually by consensus. That's huge.

A DAO also offers superior financial transparency. The company's or organization's finances are visible on the blockchain to anyone, not just its accounting department. (Of course, there is no accounting department.) Its corporate charter or mission statement or constitution is enshrined in code for all to see. Those two qualities—minimized agency problems and public transparency—could make DAOs useful in emergencies. For example, blockchain start-ups Abridged and Aragon have partnered to create a robust DAO that would assist communities affected by COVID-19.[136] Such a DAO would "systematize the management of DAO functions and reduce human coordination costs associated with resource allocation, decision-making processes, and membership administration."[137] While DAOs are quite difficult to create, Abridged is known for its DAO software development kits: anyone who wants to whip up a DAO can do so more easily on Ethereum.[138]

The software could be used as a platform for integrity, a trust protocol of sorts, within traditional organizations.

That's only the beginning. The software could also be used as a platform for integrity, a trust protocol of sorts, within traditional organizations. Stakeholders could participate in organizational governance directly and regularly, rather than by proxy or once a year at shareholder meetings.

Creating a rapid response registry for the workforce

Another supply chain experiencing dire distortion because of the pandemic is the supply of medical talent around the world. Hospitals and clinics are finding doctors and nurses themselves in short supply, exacerbated by the shortage of personal protective equipment.

Surgical team in operating room *by Jupiterimages, n.d., used under Picspree license of November 2019. Cropped to fit.*

Indeed, healthcare workers make up an estimated 10 to 20 percent of COVID-19 cases in each territory of service, and CDC Director Dr. Robert Redfield said it could be as high as 25 percent.[139]

In the best of times, there exists what Andy Spence calls a "talent management paradox," where organizations continuously struggle to tap into the talent supply chain despite the abundance of talented people looking for work.[140] During a pandemic, the ability for the healthcare industry to source medical professionals becomes even more challenging.

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Countries and organizations around the world have been implementing creative solutions to address this gap in human resources. In Canada, most provinces are expediting (re)licensing for nurses through their provincial nursing associations. In Ontario, nurses who are not currently practicing can apply for an expedited license through the College of Nurses of Ontario; those who are registered in the United States or in other provinces can apply for an emergency class license; and nursing students who have finished coursework but have not yet written their licensing exam (NCLEX) can apply for Temporary Class to be deployed as a part of their training.[141] Similarly, respiratory therapist (RT) students at Fanshawe College in London, Ontario, are being fast-tracked as licensed RTs and sent into hospitals to support doctors and nurses before finishing their final exams.[142]

As news sources have reported, provinces and states have received a flood of sign-ups from retired nurses willing to re-certify to help during this crisis.[143] This undoubtedly puts incredible pressure on the systems in charge of recertifying, no matter how well they prioritize. The British Columbia College of Nursing Professionals (BCCNP), for example, has a notice at the top of its temporary emergency registration webpage indicating a high volume of applicants.[144] Similarly, the New York State Education Department's Occupation Professionals' Nurse Licensing webpage asks those applying for licensing to be patient for up to six weeks as the department of education processes applications.[145] What's more, the department is actively reviewing licensing applications from individuals educated in New York, but according to its website, has not reviewed applicants from out-of-state educational institutions since early January.

National responses require a level of coordination that can be challenging to implement under the current system.

National responses require a level of coordination that can be challenging to implement under the current system. In the United States, the National Council of State Boards of Nursing's Nurse Licensure Compact (NLC) is a collection of states that allows nurses to practice in any NLC state without having to obtain additional licenses to practice out of their home state. This national compact, which was enacted before this current crisis, provides a framework for emergency responses by quickly distributing human resources where they are needed most. However, not all states are NLC states; at the time of publication, there are 32 states in the Compact. Crucially, the states most impacted by COVID-19—New York, New Jersey, California, Washington, and Illinois—are not (yet) NLC states.[146]

These creative, national solutions are incredibly important in this time of need. However, as institutions scramble to build their registries of emergency medical professionals, the lack of coordination and transparency makes it difficult to transition professionals from one department, geography, or certification to another temporarily. Convoluted criteria checks, redundancies in the certification process, and the processing of documents and proofs of identity all slow down (re)licensing.

Licensing and staffing challenges

The red tape and redundancies of licensing are not new to the medical industry. In a June 2019 report, the Federation of State Medical Boards (FSMB) discussed the extensive chains of custody and information sources involved in medical certification in the United States that make the licensing process relatively difficult and lengthy.

As Andy Spence argued, typical human resources operations have to deal with opaque talent supply chains, candidate fraud, and rapidly shifting talent pools as they face the challenge of finding the right candidate with the right skills for the job.[147] COVID-19 highlights this problem. Vetting the licenses of medical professionals slows down the deployment of this crucial talent, as staffing agencies are forced to review a mishmash of identities and certifications from a number of institutions.[148]

Typical human resources operations have to deal with opaque talent supply chains, candidate fraud, and rapidly shifting talent pools as they face the challenge of finding the right candidate with the right skills for the job.

Although the current system of certification provides a level of trust essential to the healthcare industry, we could eliminate redundancies while maintaining trust by using cutting-edge technologies such as blockchain. Applying blockchain to this problem—and its values of decentralization, transparency, and trust—would create the kind of system we need to match certified medical professionals quickly and efficiently to the hospitals and clinics desperate for help. Using a technology like blockchain, the FSMB argued, would allow us to "meet the needs of the healthcare market of the future."[149] What about the healthcare needs of COVID-19?

Issuing medical certifications on the blockchain

The creation of self-sovereign digital identities managed through a digital wallet system opens up opportunities here. An individual's digital identity could include government-licensed ID and healthcare records as well as certificates of achievement in education and professional development, all verified and recorded to a blockchain. A network of identities managed through a blockchain platform like Sovrin would create a transparent and trusted skills marketplace, where supply and demand of labor could interact seamlessly without recruiters.[150]

Delay in (re)certification relates to redundant activities of applicants and staffing agencies: all go through multiple institutions to verify each person's certification and identity. For example, the BCCNP is currently requiring emergency nurses to first check whether they

meet the criteria before setting up a BCCNP account, consenting to a criminal record check, sending a copy of their government ID, and completing a form that asks for personal identity information, nursing registration history, and professional experience—all of which BCCNP then verifies.[151]

In a blockchain-based medical talent marketplace, certifying bodies would record these distinct pieces of identity and skills to the individual's digital identity wallet.

In a blockchain-based medical talent marketplace, certifying bodies would record these distinct pieces of identity and skills to the individual's digital identity wallet. Instead of the applicant's sending data from varied sources, and the association's having to verify each piece of identity data against their issuers, all parties could use a rapid response registry. It could be as simple as a smart contract that automatically checked whether a candidate met the criteria, held valid malpractice insurance, and had the experience and certification necessary for (re)licensing. If these conditions weren't met, that system could send an automated message to that wallet holder with feedback on what the individual had to change in order to be licensed.

Office Work Studying Office Working Computer *by Free-Photos, 2016, used under Pixabay license of 27 March 2020. Cropped to fit.*

Candidates can also update their knowledge and profile on the blockchain. For example, an organization called Odem provides education opportunities that are staked to a blockchain network. Once the student completes the course, the digital credential is recorded as a transaction to the blockchain.[152] Online education platforms such as Nurse.com and IntelyCare are providing COVID-19 specific training to nurses; if these courses were run on this kind of blockchain-based system, COVID-19 training certification could be added automatically to a nurse's digital wallet once they completed training.[153]

ProCredEx is an example of a system using blockchain to update the cumbersome process of licensing. The platform connects existing credentialing systems together in a networked database for the secure exchange of relevant information, instead of each

credentialing system acting independently. This kind of solution dramatically reduces the redundancies of verifying candidate identity and certification so that candidates can be licensed within days, not months.[154]

Deploying the global medical talent marketplace

Once medical professionals' credentials are verified and they have received licenses to work, the blockchain-based registry can automatically match skills and talent to job openings. Newly licensed individuals can make themselves searchable in the marketplace, and the authenticity of their digital identity provides a layer of trust for those looking to fill their talent gaps. Instead of completing background checks, insurance checks, and clearances, the staffing unit already knows that this individual meets the organization's requirements. The self-sovereignty of the license also means that it is not administered centrally and can therefore be enforced anywhere in the world.[155]

In the context of the COVID-19 crisis, the healthcare ecosystem could use a blockchain-based rapid response registry for automated deployment of personnel to hotspots around the world. The platform would match each available medical professional with sites within a jurisdiction, according to licenses and skills in need. This match would be then recorded to the blockchain, and the medical professional's deployment would automatically become a badge or certificate of professional experience.

This talent marketplace is also adaptable to changes in regulation. As governments relax restrictions on the jurisdiction of professional licenses, the system can immediately respond to regulatory change by updating the criteria for nurses in the respective jurisdiction. Deploying medical professionals across state and country lines, dependent on regulation changes, becomes much faster and more transparent.

A health credential for workers and job seekers

The goal is to help individuals make the safest decisions about where they go, whom they interact with, and whether to return to work.

Redeploying workers who have contracted and recovered from the disease should be a priority. If we could certify them as "virus-resistant" and add that credential to their identity, then they could more quickly return to work in hospitals, grocery stores, and other essential services with greater certainty that they were no longer contagious or susceptible. They could support those tending to the most vulnerable in, for example, a long-term care facility.[156] This return to work could crank up the economy safely while others recuperate.

Sandy Pentland's team at MIT is studying how to implement this kind of system, potentially calling on platforms such as MIT's Open Algorithms and using secure multiparty computation, which "provably maintains privacy and auditability of fairness and fraud."[157] The goal is help individuals make the safest decisions about where they go, whom they interact with, and whether to return to work.[158]

Reports of delays in licenses and staff shortages signal loudly that something is not right with this market for talent.

This credential depends on a country's ability to mass-test and confirm the presence of antibodies that mark a person's immunity—at least, for a certain period of time. It also requires the implementation of a self-sovereign digital identity system at scale. Singapore and Taiwan have implemented a type of health credential for their workforce; but without a data governance technology like blockchain, this type of credentialing looks too much like Big Brother to citizens of countries like Canada and the United States.[159]

What's possible now for the talent market?

Reports of delays in licenses and staff shortages signal loudly that something is not right with this market for talent—and those problems stem from an outdated, centralized, cumbersome, redundant licensing system. The pandemic has spotlighted the cracks in this system that were already visible to those in the credentialing industry.

Table 3: Initiatives using blockchain in talent marketplace

Startup	What it does	Status as of 2020
APPII appii.io	Blockchain career verification platform uses verified credentials and an "intelligent profile" to record details permanently on a distributed ledger.	System live, currently onboarding candidates and verifying partners
BlockCerts blockcerts.org	BlockCerts is an open standard for creating, issuing, and verifying blockchain-based certificates that are tamperproof, and shareable.	System live, community active
Credly info.credly.com	Credly empowers organizations to issue digital credentials to employees who have demonstrated competencies and skills.	System live, community active
Degreed degreed.com	A platform for skills development and certification; users who complete online courses receive digital credentials.	System live, community active
Dock.io dock.io	This Ethereum-based protocol for managing professional data, reputation, and networking uses W3C's verifiable credentials data model.	Launching Dock test net shortly; partnership with Verifiable
Indorse indorse.io	Powered by Ethereum, this venture rewards developers for assessing and attesting to the skills of other developers looking for work.	System live and onboarding individuals
ODEM odem.io	Ethereum-based ODEM (On-Demand Education Marketplace) allows students to interact with professors and academic partners without intermediaries and earn certificates	System live and onboarding individuals
ProCredEx procredex.com	Validation engine and distributed ledger technology securely presents immutable verifications that fulfill a healthcare organization's skill requirements.	System live and onboarding institutions
Zinc.work zinc.work	Formerly R_Block, this decentralized anonymous network pivoted to redefine the reference checking process.	Onboarding clients

The complexity of self-sovereign identity, on which the implementation of a blockchain-based rapid response registry hinges, is not a novel concept. Nor is it a near-term solution to the COVID-19 crisis. What we can do right now is advocate for change to this system. Existing blockchain credentialing and education systems such as ProCredEx and Odem could pivot in this direction and demonstrate the potential impact of this technology on a larger scale.

Long term, a global talent marketplace based on a blockchain would make another crisis like this one less frustrating to handle from a human resources perspective. Furthermore, as education shifts to a more digital model, the concept of borderless education further amplifies a readily accessible global talent pool. How will universal access to education affect the jurisdiction-specific testing and accreditation of medical professionals? And how will this crisis in turn influence the long-term regulation around the jurisdiction of medical licenses? We must push for clarity and change on both fronts—education and regulation.

Incentive models for change

If ever there were a time for individuals to act in a way that serves the greater good, it is during a pandemic. Public health has always been a collective responsibility, and as such, the steps to getting there are not always easy or agreeable. Being simultaneously "for the people" and "by the people," achieving a functional, public health commons is made more complex because on one hand, not all people have equal access to care, and on the other hand, the thoughtless actions of a few can undermine the concerted efforts of many. As we are discovering during COVID-19, rallying together to self-isolate and engaging in other public health measures to try to save the lives of our elders and prevent our front-line healthcare workers and hospitals from becoming overwhelmed, is more easily said than done. We need a new blueprint.

There are two issues at play. The first pertains to individual accountability in a healthcare crisis. How do we get people to conduct themselves appropriately so that public health need not be an elusive goal? How do we balance individual liberties in the pursuit of the collective good? What kinds of incentives do we need to have in place so that humans manifest the behaviors that will both prevent viral outbreaks from becoming pandemics in the first place, or to behave in such a way as to mitigate the damage they cause? And how can we protect individual privacy in the process of understanding viral transmission from one person to another?

How do we get people to conduct themselves appropriately so that public health need not be an elusive goal?

The second issue is that the responsibility for public health does not solely rest on the shoulders of the individual but with the many organizations and governments the world over. Institutions are responsible for public health policy, border control, reliable delivery of public health services, infrastructure, crisis responsiveness, and the allocation of budgets. What incentives are needed to improve the current public healthcare infrastructure and provide adequate budgets, stockpiles of supplies, and preparations for outbreaks of the future?

It is in this context that we see a profound role for blockchain technology to drive much-needed behavior change by both individuals and entities alike. As Hilary Carter described in her BRI report on the role of blockchain as a tool to encourage governments to engage in the preservation of aquatic life in our oceans, "Blockchain technology is particularly effective because it provides a mechanism to align the incentives of different stakeholder groups around issues and activities, changing patterns of behavior in the process."[160] Blockchain is the platform that facilitates a secure and transparent digital exchange of assets of all kinds, while simultaneously rewarding favorable activities, preserving privacy, and doing so in a secure fashion, all with the potential to be as ubiquitous as the mobile phone. Never before has there been a technology that holds such promise.

In a pandemic, data are highly sought-after assets, specifically data around virus properties, transmission rates, fatalities, and carrier travel histories.

In a pandemic scenario, data are highly sought-after assets, specifically data around virus properties, transmission rates, fatalities, carrier travel histories, and so on. But data are not the only assets that matter. Good old-fashioned money—which enables access to resources such as food, rents, medicine, personal protective equipment, and in some jurisdictions, healthcare itself—is just as important during a time of crisis as it is in our pre-pandemic lives. It is not only possible but probable that blockchain can be the driver of change by aligning our individual need for survival through resource accumulation with our collective need for behaving in a socially responsible way. Through blockchain the twain shall meet.

Incentives to change individual behavior

Spike Lee's 1989 film *Do the Right Thing* gave the world a window into the challenges of a Brooklyn community as it navigates its way through racial tensions. As the story unfolds around a pizzeria and the interplay of individuals—restaurant owners, staff, and customers—we witness varying degrees of failure in basic, community-level accountability. Some characters did the "right thing" much of the time, some made no effort to do the right thing any of the time, but no one did the right thing all of the time, and these failures culminated in a community meltdown.[161]

Controlling a pandemic depends on all of us doing the right thing, all the time. So how do we get there?

Herein lies the challenge for public health in a time of crisis. Controlling a pandemic depends on all of us doing the right thing, all the time. So how do we get there? What kind of incentives will work best?

Incentives for individuals are indeed a powerful tool to create a new kind of order in the world. Stimulus–reward was the foundation of Pavlov's experiments. He tapped into core instincts that have enabled life forms to survive throughout the ages. Rewards produce reinforcing behaviors. When rewards accumulate, we find ourselves better off.

The beauty of blockchain technology is that it is programmable money. Depending on the application in question, an economic reward in the form of digital currency or a loyalty token can be

issued to a given party when certain conditions are met. Blockchain-based rewards, delivered to individuals through an application on their phone, can make the "right" behavior more feasible than if those rewards were nonexistent.

Rewards delivered to individuals through an application on their phone can make the "right" behavior more feasible than if those rewards were non-existent.

For example, "green friendly" products are typically more costly than their noncarbon-neutral alternatives. To incentivize purchases of environmentally friendly products, a carbon credit can be issued to the consumer on a blockchain platform, which in turn, could be spent by the same consumer on other green-friendly solutions such as taking public transit or offsetting the cost of buying other green products. As *CoinDesk* advisory board chair and MIT Digital Currency Initiative senior advisor Michael Casey wrote, "Hope lies in what some people call *crypto-impact economics*, an effort to hard-code into tokens the objectives of fighting environment degradation."[162]

So now imagine this programmable money in action, rewarding citizens for their individual efforts in staving off a virus. Sharing data. Staying home. And receiving digital money for doing so. We are already seeing examples of blockchain-based incentive mechanisms in play in a healthcare setting. The Heart and Stroke Foundation of Canada teamed up with Interac, Canada's largest digital payments company, to create an incentive platform that promoted healthy lifestyle choices. By simply enrolling in the program, people over age 40 who had elevated blood pressure and were not on hypertension medication were given a combination of cash, reward points at a national grocery and pharmacy retailer, a two-month gym membership, personal health coaching, and a platform to track success metrics such as diet, exercise, and blood pressure.[163] How's that for encouragement to get off the couch?

Washing hands wash your hands *by Iva (ivabalk), 2020, used under Pixabay license of 27 March 2020.*

In Switzerland, Care Chain is creating a portable, blockchain-based platform that will allow patients to share their information with any care provider or cure developer in the world.

Individuals are generally motivated to work toward their economic and personal self-interest. Patients with rare diseases, for example, often form well-coordinated interest groups. They have a strong incentive to collaborate and advocate for the advancement of research where the economics of that research are otherwise non-existent. Blockchain is playing an important role to further these efforts. In 2017, we published a case study on the blockchain-based application YouBase, which enabled patients to receive compensation for their health information.[164] In Switzerland, Care Chain is creating a similar portable, blockchain-based platform that will allow patients to share their information with any care provider or cure developer in the world "for the purposes of receiving increasingly personalized care, medicines, and cures."[165]

Now, imagine a scenario where an interoperable network of blockchain platforms were to harness patient data from all around the world for every person who tested positive or negative for COVID-19. What if this cohort were to share data concerning their individual lab results, their recovery, and perhaps even their bloodwork results or blood samples? What if they could do so securely, anonymously, and potentially for economic reward by the very research laboratory or pharmaceutical company working toward bringing a vaccine to market? Imagine this information's feeding AI programs to fuel predictive forecasting so that scientists could predict outbreaks before they gained a foothold on a given community. TCS is working in these areas. Preeti Gandhi and Hanu Rao reported:

> *In societies with a strong tradition of privacy like North America, some of our research partners are working on privacy-preserving and incentivized solutions for people to share data for common good—for example, persons who test positive for coronavirus can share their travel itineraries in an anonymous manner so as to alert others.*[166]

One of TCS' focuses is on the "integration of digital identity, self-sovereignty, medical records, and incentive systems so that individuals who own their data are encouraged and incentivized to share their data for research, drug discovery, public health, and other common good purposes."[167]

People change behavior for one of two reasons: they are either intrinsically motivated to do so, or they've been given a sufficient economic reward for their actions.

While programmable money can't solve centuries' old problems overnight, it can certainly help. People change behavior for one of two reasons: they are either intrinsically motivated to do so, or they've been given a sufficient economic reward for their actions. Economic relief packages have been foundational to global peace treaties now for decades. When there's less hunger, there's generally more peace. Let's use blockchain to give individuals the world over appropriate incentives to work together.

Incentives for transforming institutions

We have long made the case that blockchain is far more than a P2P payments technology. Useful for its ability to reduce inefficiencies,

it has the potential to be an open collaborative platform for all stakeholders in the healthcare community. When we wrote *Blockchain Revolution*, we envisioned a world where blockchain-enabled IoT would use emerging applications to link medical records, keep inventory, preserve patient privacy, reduce waste, enhance precision medicine, and lead to better care.[168] As BRI research collaborator and blockchain and genomics innovator Axel Schumacher wrote,

We envision a world where blockchain-enabled IoT would use emerging applications to link medical records, keep inventory, preserve patient privacy, reduce waste, enhance precision medicine, and lead to better care.

> *This distributed ledger instantiates a set of principles—collaboration, openness, and integrity—whereby healthcare providers, hospitals, laboratories and imaging facilities, insurance companies, pharmaceutical firms, pharmacies, medical supply outfits, local public health agencies, national food and drug regulators, global centers for disease control, government lobbyists, medical schools, and professional healthcare associations come together and co-create data with full transparency, public access, and shared control, all for the benefit of the communities they serve.*[169]

So why aren't we any closer to realizing the potential of this new technology, where infinite data from infinite sources could have potentially staved off a pandemic?

Healthcare is a complex industry. It is either underfunded, publicly funded, governed differently depending on jurisdiction, siloed, and constrained by regulations, limited budgets, and rising costs. Almost universally, health data is controlled by everyone but the patient. In this environment, the obstacles to innovation are great, and instances of novel tools in patient data management are more the exception rather than the rule. Many hospitals find it challenging to innovate when they are prioritizing simply keeping the lights running.

A few organizations, however, such as Canada's University Health Network (UHN), have led the way. In 2018, following a series of design workshops of different stakeholder groups, UHN launched a patient control-and-consent platform to enhance the patient experience and to facilitate clinical research using patient data.[170] Developed in partnership with IBM, the platform leverages blockchain technology not simply to secure and consolidate patient data but also to obtain and record patient consent before any patient information is shared for research purposes. The platform also records which parties subsequently accessed the data, at what time, and for what purpose.

Many hospitals find it challenging to innovate when they are prioritizing simply keeping the lights running.

Applying this capability to a pandemic, imagine a scenario where the UHN solution is virus-specific and interconnected to healthcare facilities all across Canada, so that every Canadian patient had an opportunity to share personal data—perhaps to advance research on a vaccine and contribute to a more accurate incident map of the virus's prevalence. Now take this concept to a global scale, for a single version of the truth of global incidence rates and outcomes, verified and secured by blockchain-powered, decentralized computing. This kind of value creation—transmissions reduced,

lives saved, and economies continuing to function—is the gigantic incentive needed to rally numerous institutions together.

We know where this could go, but how do we get there? What are the incentives needed for governments and healthcare stakeholders first to create robust healthcare data portals that put patients at their core, and then collaborate on a global scale? It has never been clearer that it is incumbent upon organizations and governments to understand better how new technologies can be applied, and which ones are powered by incentive mechanisms and simultaneously lower transaction costs and create economic value.

Quarantine Isolation Empty Supermarket Mall *by Eugen Visan (eugeniu), 2020, used under Pixabay license of 27 March 2020. Cropped to fit.*

According to Drs. Cathy Barrera and Stephanie Hurder, there are three levers that enable blockchain to drive value creation: coordination, commitment, and control.[171] Coordination creates value by reducing the costs associated with sharing and reconciliation of data. Commitment—through blockchain tools such as smart contracts—creates value by reducing uncertainties and lowering the costs of enforcing rules. Control—of patient incidence rates for example—creates value by improving our ability to measure and prevent problems from escalating. While value creation is important, the threat of economic losses is a powerful, though negative incentive. Stakeholders have never had a better reason not just to participate, but to cooperate in creating new governance frameworks, interoperable tools, and standards.

We believe that blockchain applications can be designed in any context to align the behavior of both individuals and institutions around a common goal.

We believe that blockchain applications can be designed in any context—not just a pandemic—to align the behavior of both individuals and institutions around a common goal. We have the technology to reward social distancing and hand washing, and we will soon have the benefit of hindsight to more fully grasp the costs of siloed systems during a health crisis. It’s time to ramp-up capacity,

get buy-in from regulators, budgets from governments and big pharma, and implement blockchain on a global scale for the benefit of public health, everywhere.

Implementation challenges

Crises create opportunities for change. Just as the rising costs of climate-related incidents have moved insurance companies to consider the impact of adverse climate events on a given policy, we could witness a similar reckoning in healthcare as we come to terms with the high costs of this pandemic on society. Now is the time to lead the rapid deployment of blockchain technology. Yet so much can get in the way of progress: the absence of leadership, the lack of shared values and governance, competing standards, and inertia.

Leadership

So much can get in the way of progress: the absence of leadership, the lack of shared values and governance, competing standards, and inertia.

This crisis has revealed the need for a coordinated, multistakeholder approach to problem-solving. That means motivating different governments, industry participants, and civil society to work together. Unfortunately, this pandemic could not have come at a worse time: rising populism has led to an every-country-for-itself attitude that is undermining our global response. In one galling and shameful example, the Trump administration tried to ban the company 3M from exporting N95 masks to Canada, its closest ally and second largest trading partner. 3M warned of significant "humanitarian implications" from the decision.[172]

We must take this same multistakeholder approach to leadership of blockchain innovation if it is to scale and succeed. "Blockchain is a team sport," said Dale Chrystie, blockchain fellow and busienss strategist at FedEx. He added:

> *This moment is the definition of* coopetition*. We need to move this technology and these efforts forward based on the greatest need and applicability of the technology itself. I think we must not focus necessarily on where we traditionally compete, but on where we can agree. I would challenge the great thinkers in this ecosystem to ponder how we can scale this technology quickly, starting with key areas to help our fellow global citizens fight this common enemy.*[173]

Jason Kelley of IBM borrowed from Gen. Stanley McChrystal: we need a "team of teams" approach, where we all run together. We could just as easily use Doris Kearns Goodwin's expression, "team of rivals," to describe how competitors or countries with conflicting interests can rally around a common cause.

Bob Wolpert, chief strategy and information officer of Golden State Foods, a global food service company with more than $5 billion in revenue, said that we should use the momentum for global visibility

generated from COVID-19 to demonstrate the "disaster value" of ongoing collaboration.[174] A crisis is a terrible thing to waste.

Shared values and governance

How will we govern this new technology? Heather Flannery, founder and chief executive officer of ConsenSys Health, said, "We are living in the polarizing tension between freedom and security. Right now, the threat to our security is a pandemic, and the threat to our freedom is current and future corporate and governmental surveillance." She argued that now is the time to prioritize both self-sovereignty in health data and the dialogue around bioethics. She also outlined an approach for embedding bioethics into industry architecture: incorporate stakeholders who aren't parties to our respective agreements into the design process and iteratively consult different stakeholder groups to surface and address unintended consequences.[175] Data is a critical resource for governments fighting a pandemic, but we must ensure that its use doesn't compromise individual liberty permanently and irrecoverably as a result.

Brian Behlendorf said that we must "anticipate a world where this virus and yearly mutations will be endemic."[176] Vaccinated or immune people might have special privileges but those must be bestowed in a privacy-protecting way. Centralized systems, which is all we really have today to fight these problems, "are efficient and scale easily but are very, very fragile." He said that we must "double down on anti-fragility." Behlendorf advocated for these five principles of governance:

- Shared code and shared standards, which are critical to interoperability and integration
- Self-sovereign identities, which are key to speedy and consent-based data sharing
- Confidential computing, which protects civil liberties through secure enclaves, zero-knowledge proofs, and other methods
- Openable networks, meaning that networks can move from private usage to public utilities, which puts pressure on governance and business model viability
- Driving digital processes for business formation and incorporation, especially in times of simultaneous public health and economic crises, to bend bureaucracy

"Innovation is an idea that people, business, or government will pay for."

BOB WOLPERT
Chief Strategy and Information Officer
Golden State Foods

Business models matter. "Ideas are free. Innovation is all about creating value. Innovation is an idea that people, business, or government will pay for," said Wolpert.[177] "Supply chain visibility gets enhanced when it's not owned by one player but visibility is shared by all players."[178] He pointed to Walmart as an example: when the global retail giant mandated the trace of leafy greens, it not only took a position championing public health but also saw a business case for mitigating costs and enhancing brand trust. It didn't get behind an idea; it backed a blockchain ecosystem innovation called Food Trust, powered by IBM.[179]

If multistakeholder governance of blockchain is to work, we need a common set of standards for interoperability.

How we govern the Internet of information as a global resource serves as a model for how to govern this new resource: through what we call "global governance networks."[180] There are seven types that govern the Internet: standards networks such as the Internet Engineering Task Force; knowledge networks such as the Internet Research Task Force; delivery networks such as the International Corporation for Assigned Names and Numbers; policy networks such as the Internet Policy Research Initiative at MIT; advocacy networks such as the Alliance for Affordable Internet; watchdog networks such as the Electronic Frontier Foundation; and networked institutions such as the World Economic Forum. We need something similar for blockchain.

Standards and interoperability

If multistakeholder governance of blockchain is to work, we need a common set of standards for interoperability. If different blockchains operate in siloes, don't talk to each other and are incompatible they will be forever limited in what they can do. Said Chrystie of FedEx, "We've got lots of silos out there in almost every area. What I think we need to do is break through that thinking and realize that we're actually all in this together."[181] Whether to go the open standards route or the patent-and-licensing route is a key decision around the ownership of a collaboration's or a consortium's intellectual property.

Jerry Cuomo of IBM said that the biggest inhibitor for many industries and in use cases where data integrity is critical—is trust. "Can you use a database for this? How is that data attested?" he asked. He advocated for removing, when possible, a single administrator and instead allowing participants to "consent automatically with smart contracts on the validity of data." But to achieve this, we need

Blue Hospital Sheets and Scrubs on Stainless Steel Shelves *by Dynamic Graphics Group, n.d., used under Picspree license of November 2019. Cropped to fit.*

common standards for smart contracts, tokens and other assets, and blockchain interoperability.

The Enterprise Ethereum Alliance pioneered a token taxonomy to get industry buy-in for a set of principles for what is and is not a standard. We view this as critical to scaling and overcoming challenges. Perhaps what is required is an Internet Engineering Task Force for blockchain? Call it the Blockchain Engineering Task Force and bring different technology stakeholders together.

Pandemics happen regularly, if infrequently, and we have no excuse for our unpreparedness.

Sense of urgency

COVID-19 may well be the wake-up call to governments, hospitals, and other stakeholders in the healthcare space, and there's no time to waste in implementing solutions that drive positive global health outcomes. Now, when the need is greatest, is the time for organizations and governments to overcome their inertia and their unwillingness or inability to implement new technologies, business models, and roles for people. Otherwise, once the crisis has passed, this sense of urgency will subside with every normal day, and time will dull the sharp memories of suffering and pain.

Pandemics are a white swans, not black swans—they happen regularly, if infrequently—and thus we have no excuse for our unpreparedness. Blockchain is not a panacea for pandemics. We need functioning governments and institutions, global collaboration, a conscientious, healthy, and engaged populace, and businesses that plan for the long term and the unexpected. But we can and should harness this technology straightaway to address these many challenges.

Recommendations: A coordinated plan

We all have a role to play. Leaders around the world are looking for ways to mitigate the effects of this crisis—and, when the dust settles, they should be implementing changes so that a pandemic does not grip our world in the same way ever again.

It's time to get serious about blockchain and the more secure, transparent, high-performance, distributed, and data-rich systems and institutions that we can build.

It's time to get serious about blockchain and the more secure, transparent, high-performance, distributed, and data-rich systems and institutions that we can build with this technology. Again, there is *nothing so powerful as an idea that has become a necessity.* All three pillars of society—government, the private sector, and the civil society all have a role to play in this crisis. For each, immediate action is possible. For each, we should get cracking on implementing new approaches to achieving long-term goals.

What governments can do

The crisis has shown to everyone that governments, strong and effective, are in fact critical to our society. So much for the

Ronald Reagan/Margaret Thatcher theory that "government is not the solution to our problem; government is the problem."[182] Libertarianism as an ideology is in deep trouble. In the United States, for example, people are looking to the Centers for Disease Control and Prevention (CDC) for up-to-date and accurate information and guidance, to the Food and Drug Administration for a vaccine, to the Army Corps of Engineers to set up much-needed hospital facilities, to Congress for financial relief, and to the Federal Reserve to lessen the inevitable recession.

We need governance of not just the demand side of data (how it is used) but also the supply side (where it originates). Blockchain can deal with both.

However, when it comes to the importance of blockchain in government and our economy, only a handful of government leaders have a clue. Jaffray of the University of Texas MD Anderson Cancer Center spoke passionately at the roundtable:

> *Governments need to wake up to the blockchain opportunity. AI, quantum computing, and other technologies that* consume *data are important. But we also need to think about the* supply *of data. Ultimately, this is about the governance of data, transactions, and trust—all of which are provided by data governance technologies like blockchain.*[183]

In some countries like China or Dubai, there is strong leadership to use this technology in transforming government and building an innovation economy. Governments should act now to help manage the crisis and create the conditions for controlling pandemics more effectively in the future.

First, every national government should create an emergency task force on medical data to start planning and implementing blockchain initiatives. Governments should lead but they must engage private sector and civil society leaders. To implement pilots now, we need new laws in many areas: our current legislative parameters use outdated frameworks that limit the ability to access and use data while protecting citizens' rights. Governments must set the policies to ensure that the second era of the digital age actually serves people. As we discussed at length in the roundtable, the COVID-19 crisis has emphasized the tension between our civil liberties and our health and security. By creating sensible legislation around privacy, security, and identity, policymakers can open up opportunities for blockchain innovation in self-sovereign identities and data governance.[184]

To implement pilots now, we need new laws in many areas: our current legislative parameters use outdated frameworks that limit the ability to access and use data while protecting citizens' rights.

Second, governments can *stimulate* the development of technology companies working on the solutions outlined in the report. Many of these are early stage companies that are critical but most vulnerable. This can be achieved not just through financial investments, but there are numerous other tax changes that can encourage investment in these companies, such as implementing flow through shares for investments in technology.[185] Securities legislation in most countries hampers the development of blockchain fundraising activities like token generation events, and entrepreneurs must deal with regulatory unclarity or outright regulatory hostility toward this technology and its leaders. Further, governments can act as model users of the important platforms and applications coming out of this crisis.

Third, governments must pass legislation to mobilize stakeholders to create the self-sovereign health record and citizen identity. We *can* have our cake and eat it too; that is, real-time, granular data about the health of every citizen in a country, while at the same time protecting their identity, its privacy and security, its accessibility, and its monetization. We need dedicated, speedy work on consent frameworks and legislation that confers ownership of data on the individual. Consent and data governance are key to unlocking this potential of blockchain and how the technology can better serve society's needs. Policy makers, legislators and technologists must engage immediately both for better crisis/pandemic management and to deliver the much-needed emergency dollars to save the economy.

Fourth, they should pilot blockchain incentive systems to mobilize populations to self-isolate and behave responsibly as described in this report Yes, governments must require citizens to do certain things in time of crisis, such as during a war. Government mandated behavior is necessary in this crisis, but this can be supplemented, and the negative effects ameliorated through blockchain based incentive systems.

Fifth, governments have the biggest supply chains in the world, many of which are now involved in producing critical medical supplies and delivering services. The opportunities presented in this report for more proactive, flexible, and trustworthy supply chains should be thought-provoking for officials who must manage not only shortages but the public's faith in their systems.

Finally, governments should move rapidly to implement national fiat digital currencies. The International Monetary Fund can take important leadership in rolling this global basket of currencies into a synthetic hegemonic digital currency, as described by Mark Carney, the head of the Bank of England.

What the private sector can do

"We don't want to build a system that is waiting for the next disaster. We want to build a system that is being used day-to-day."

BOB WOLPERT
Chief Strategy and Information Officer
Golden State Foods

Blockchain is already beginning to change many industries, including parts of the financial services industry, shipping and global transportation logistics, upstream oil and gas, natural resource tracking and consumption, manufacturing, and segments of our global supply chain including food and electronics—many of which have been drastically hit by this crisis.

That said, we are still in the very early days of this second era of the Internet, and deployment is still immature, pretty much across the board. Companies can act now, and benefit in the long term through understanding how blockchain can transform their businesses.

First, large players in these industries affected by COVID-19 must still lead the way, starting today, by incorporating blockchain into their infrastructures. Building systems using blockchain will create a wider, more thorough data environment to mitigate future crises like this one. "We don't want to build a system that is waiting for the next disaster. We want to build a system that is being used day-to-day,

that then enhances our ability to respond in a disaster," said Wolpert of Golden State Foods.[186]

Second, firms must build blockchain consortia in the industries affected by the crisis. By pivoting toward COVID-19, working groups can provide useful solutions to help mitigate the crisis, as well as demonstrate the value of blockchain in the face of distorted supply chains and data opacity, planning an important role as we "return to a state of normal."[187] We need coopetition among even the biggest competitors—especially in this time of crisis, as we all fight a common enemy. Tanya Woods, managing director of the Chamber of Digital Commerce Canada, suggested that we bring our best systems thinking to bear as we look to catalyze ecosystems: "We need to challenge ourselves to move beyond our corporate boxes. We need to think about how we stitch together our solutions. We need to set aside our egos."[188]

"We need to challenge ourselves to move beyond our corporate boxes. ... We need to set aside our egos."

TANYA WOODS
Managing Director
Chamber of Digital Commerce Canada

Third, the private sector needs to continue its work to create pilots framed around all these opportunities: pilots on medical records, credentialing systems, incentive structures, and other sovereign identity solutions. Implementing a sovereign digital citizen identity that includes these aspects of identity will require cooperation with government. "We need to ask, 'Who are we serving? How are we going to do it? And how can government help us?'" said Woods.[189]

Fourth, when architecting these pilots, companies would do well to consider embedding incentive systems to mobilize their consumers to behave in a socially responsible way—whether that be sharing their data for health research and infection tracking or following government-mandated pandemic protocols. To achieve effective incentive systems, they will have to partner with government.

Much of the innovation on public health will come from entrepreneurs; it is our hope that this report will wake up entrepreneurs around the world to seize the day. Heather Flannery of ConsenSys Health was optimistic:

> *Our community of technologists and domain experts from healthcare and life sciences can contribute to a future state where we dissolve that polarity between freedom and security, because our body of technologies allows us to achieve public health objectives while preserving the privacy of individuals.*[190]

"Our body of technologies allows us to achieve public health objectives while preserving the privacy of individuals."

HEATHER FLANNERY
Founder and CEO
ConsenSys Health

What civil society can do

First, we recommend that privacy advocates turn away from focusing purely on laws and governmental regulation to protect privacy. Rather, it is time to advocate for a self-sovereign medical record and citizen identity to protect data privacy while also making it more easily accessible. As we have seen throughout this report, this crisis stems from a crisis in data accessibility. Without transparent data records, politicians, healthcare providers, researchers and citizens are not prepared to build proactive solutions. Citizens—the creators of this data—have a vital role to play in moving this dial forward.

As the UHN pilot in Toronto shows, blockchain can enable patients to provide rights easily to their medical data to scientists and clinicians for critical research and planning.

Second, professional associations like the American Medical Association, nurses' associations and others would benefit from exploring the sovereign patient record and becoming its strongest advocates. As the UHN pilot in Toronto shows, blockchain can enable patients to provide rights easily to their medical data to scientists and clinicians for critical research and planning.

Third, these associations, along with schools, colleges, and universities should consider blockchain-based platforms for medical licensing and accreditation. We need the right clinicians and practitioners at the right places in the right times and blockchain is the new platform for credentials and trust.

Conclusion

This pandemic has showed us the extent to which our current systems are not ready for the next age of our global economy and society. We weren't even ready for a highly predictable global calamity such as COVID-19. What makes anyone think we're prepared for the next global crisis, the next transformation to our economy, or the next shift in our way of life? A new era of transformative digital technologies is arriving, an era that the Blockchain Research Institute is working to understand and interpret in actionable terms for enterprise executives, government officials, heads of nonprofit organizations, and their teams at the top in key economic sectors.

Yet, we haven't realized the promise of the first era—the promise of a P2P empowered world. Instead, the economic and political benefits have accrued asymmetrically, with power and prosperity funneled to those who already have it. In pandemics, those hardest hit are the most vulnerable among us, in the poorest neighborhoods with the worst sanitation systems. How can they hope for medical supplies when they can't easily get clean water?

Let's commit to working toward the common good within our operations and through our relationships with customers, employees, and supply chain partners.

As we've written before, technology doesn't create prosperity—and the quality of healthcare that comes with it—any more than it destroys privacy, property rights, and peace of mind. However, in this digital age, technology is at the heart of just about everything—good and bad. Let's commit to working toward the *common* good within our operations and through our relationships with customers, employees, and supply chain partners. *Primum non nocere.* The opportunities described throughout this report ought not be taken as one-time feel-good initiatives. Rather, they are integral to ongoing business and governmental concerns, opportunities that should pull us out of this crisis and prepare us for the next.

As we wrote at the beginning of *Blockchain Revolution*, "It appears that once again the technological genie has been unleashed from its bottle … now at our service for another kick at the can—to transform the economic power grid and the old order of human affairs. If we will it." That is, if we lead.

Emergencies turbocharge the pace of historical progress. Laws that would have taken months, if not years, to clear congress are passed in days. Businesses like Zoom, once used mostly by technology companies, have become ubiquitous tools of daily life for grandparents in nursing homes and for students now learning at home. Meanwhile, former titans of the Industrial Age like Boeing are asking for bailouts. By necessity, human behavior—from where we work and when to how we socialize or shop—changes overnight. Add to this mix the exponential properties of technologies like blockchain, and we're setting ourselves up for a cataclysm of some kind.

We anticipate a real crisis of leadership as the new digital-first and digital-only models of this next era conflict with the old industrial tried-and-true.[191] Maybe this awful crisis will call forth a new generation of leaders who can help us finally get the digital age on track for promise fulfilled? Who among us will step up?

Appendices

A. Recommended readings

Cathy Barrera and Stephanie Hurder, "Cryptoeconomics: Designing Effective Incentives and Governance Models for Blockchain Networks Using Insights from Economics," foreword by Don Tapscott, Blockchain Research Institute, 13 Jan. 2020.

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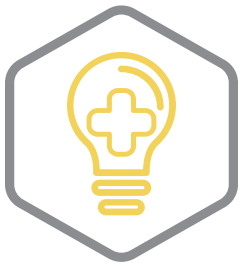
B. Roundtable participants

Organization	Name	Title
Abridged	James Duncan	Co-founder
Binance	Jarred Winn	Senior Vice President of Charity
Binance Charity Foundation	Helen Hai	Head
Block Theory	Caitlin Connors	CEO
Blockchain Research Institute	Don Tapscott	Co-Founder and Executive Chairman
Blockchain Research Institute	Alex Tapscott (Moderator)	Co-Founder
Blockchain Research Institute	Carl Amorim	Executive Representative for Brazil
Blockchain Research Institute	Hilary Carter	Managing Director
Blockchain Research Institute	Kirsten D. Sandberg	Editor-in-Chief
Blockchain Research Institute	Luke Bradley	Director of Communications
Canada Health Infoway	Michael Green	President and CEO
Care to Cure	Brian Magierski	CEO and Founder
Chamber of Digital Commerce Canada	Tanya Woods	Managing Director
ConsenSys Health	Heather Flannery	Founder and CEO
Federal Advisory Council on the Implementation of National Pharmacare	Eric Hoskins	Former Chair
FedEx	Dale Chrystie	Business Fellow, Blockchain Strategist
Golden State Foods	Bob Wolpert	Corporate Senior Vice President and Chief Strategy and Innovation Officer
Good Shepherd Pharmacy, RemediChain	Philip Baker	Founder
Healthcare Information and Management Systems Society	Katie Crenshaw	Senior Manager, Informatics
Healthcare Information and Management Systems Society	Mari Greenberger	Senior Director, Informatics
Hyperledger	Brian Behlendorf	Executive Director
IBM	Jason Kelley	General Manager, Blockchain Services
IBM Blockchain	Gennaro "Jerry" Cuomo	IBM Fellow, Vice President, Blockchain Technologies
Innovation, Science and Economic Development Canada	James Tennant	Policy Advisor, Digital Ecosystems
Mattereum	Vinay Gupta	CEO
MD Anderson Cancer Center	David Jaffray	Chief Technology and Digital Officer
Microsoft	David Houlding	Director of Healthcare Experiences
MIT and Oxford-Hainan Research Institute	Raphael Yahalom	Research Affiliate
MIT Sloan School of Management	Irving Wladawsky-Berger	Research Affiliate
Optum	Mike Jacobs	Technology Fellow and Senior Vice President of Engineering
Shivom	Axel Schumacher	Founder and CEO
Solve.care Global	David Hanekom	Chief Medical Officer and Regional President (North America)
Standard Bank	Ian Putter	Executive Distributed Ledger Technology/Blockchain and CA(SA) training
Tata Consultancy Services	Hanumanthu Rao	Global Head of Technology and Partnerships, Blockchain Services
Tata Consultancy Services	Preeti Gandhi	Manager, Corporate Strategic Initiatives
VeriTX	James Regenor	Founder and President
World Economic Forum	Nadia Hewett	Blockchain and Distributed Ledger Technology Projects Lead



About the Blockchain Research Institute

Co-founded in 2017 by Don and Alex Tapscott, the Blockchain Research Institute is an independent, global think tank established to help realize the new promise of the digital economy. For several years now, we have been investigating the transformative and disruptive potential of blockchain technology on business, government, and society.

Our syndicated research program, which is funded by major corporations and government agencies, aims to fill a large gap in the global understanding of blockchain protocols, applications, and ecosystems and their strategic implications for enterprise leaders, supply chains, and industries.

Our global team of blockchain experts is dedicated to exploring, understanding, documenting, and informing leaders of the market opportunities and implementation challenges of this nascent technology. Research areas include financial services, manufacturing, retail, energy and resources, technology, media, telecommunications, healthcare, and government as well as the management of organizations, the transformation of the corporation, and the regulation of innovation. We also explore blockchain's potential role in the Internet of Things, robotics and autonomous machines, artificial intelligence, and other emerging technologies.

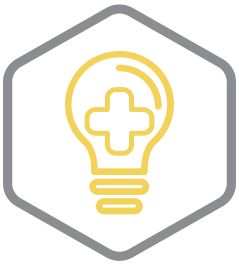
Our findings are initially proprietary to our members and are ultimately released under a Creative Commons license to help achieve our mission. To find out more, please visit www.blockchainresearchinstitute.org.

Research management

Don Tapscott – Co-Founder and Executive Chairman
Kirsten Sandberg – Editor-in-Chief
Hilary Carter – Managing Director

Others in the BRI leadership team

Alisa Acosta – Director of Education
Luke Bradley – Director of Communications
Wayne Chen – Director of Business Development
Maryantonett Flumian – Director of Client Experience
Roya Hussaini – Director of Administration
Jody Stevens – Director of Finance
Alex Tapscott – Co-Founder



About the contributors

Don Tapscott is CEO of the Tapscott Group and executive director of the Blockchain Research Institute and one of the world's leading authorities on the impact of technology on business and society. He has authored more than 16 books, including *Wikinomics: How Mass Collaboration Changes Everything* (with Anthony Williams), which has been translated into more than 25 languages. Don's most recent and ambitious book—*Blockchain Revolution: How the Technology Underlying Bitcoin is Changing Money, Business, and the World*—was co-authored with his son, Alex Tapscott, a globally recognized investor, advisor, and speaker on blockchain technology and cryptocurrencies. According to the late Harvard Business School Professor Clay Christensen, *Blockchain Revolution* is "*the* book, literally, on how to survive and thrive in this next wave of technology-driven disruption." Don is a member of the Order of Canada and is ranked the second most influential management thinker in the world by *Thinkers50.* He is an adjunct professor at INSEAD and former two-term chancellor of Trent University in Ontario.

Alex Tapscott is a globally recognized writer, speaker, investor, and advisor focused on the impact of emerging technologies, such as blockchain and cryptocurrencies, on business, society and government. He is the co-author (with Don Tapscott) of the critically acclaimed nonfiction best seller, *Blockchain Revolution: How the Technology Behind Bitcoin and Other Cryptocurrencies Is Changing the World*, which has been translated into more than 15 languages. His TedX San Francisco talk, "Blockchain is Eating Wall Street," has been viewed over 681,000 times. In 2017, Alex co-founded the Blockchain Research Institute, a multimillion-dollar think tank that is investigating blockchain strategies, opportunities, and use cases. He also received (with Don Tapscott) the Digital Thinking Award, one of Thinkers50's Distinguished Achievement Awards. Previously, Alex was an executive at Canaccord Genuity, Canada's largest independent investment bank. Alex is a graduate of Amherst College (cum laude). He lives in Toronto, Canada.

Hilary Carter is managing director at the Blockchain Research Institute where she works closely with more than 50 blockchain thought leaders to conduct the definitive investigation into blockchain transformations in enterprise, government, and society. She is the author and co-author of a number of Blockchain Research Institute projects including "Social Media on the Blockchain: AKASHA Ushers in a New Era of Censorship-Resistant Communications," and "Networked Hotbeds of Blockchain: Creating Global Hubs for the Internet's Second Era" with Don Tapscott and Jill Rundle. Her recent focus is on blockchain and sustainability, in particular how the technology can be used to help advance the United Nations Sustainable Development Goals. Hilary is a speaker and a management graduate of the London School of Economics and holds the Certified Bitcoin Professional designation.

Anna Hermansen is digital projects manager at the Blockchain Research Institute where she works across departments to support the creation and maintenance of the Institute's web-based assets. She is driven to use technology and data for social good and is particularly interested in studying the decentralization of healthcare data through blockchain to provide greater insight for patients and physicians in clinical chemotherapy trials. Outside of blockchain, she is a co-founder and board member of a youth-led nonprofit, and she volunteers as an instructor at Canada Learning Code. She received her undergraduate degree in international development from the University of British Columbia.

Kirsten Sandberg is currently editor-in-chief of the Blockchain Research Institute, where she is responsible for publishing the practical insights of blockchain pioneers and thought leaders. She is also an adjunct faculty member of the graduate publishing program at Pace University, where she teaches several courses and regularly conducts executive training for China's largest publishers. Kirsten is a huge reader of history and science fiction. She focuses on emerging markets, disruptive technologies, and the management of digital transformation, and has provided change management and communications consulting services to the UN Development Programme and the UN International Computing Centre. For over a decade, she was an executive editor specializing in finance, marketing, and strategy at Harvard Business School Publishing.

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