

# Exploring the Potential of Blockchain Technology to Meet the Needs of 21st Century Japanese Healthcare

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# Exploring the Potential of Blockchain Technology to Meet the Needs of 21st Century Japanese Healthcare

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## Abstract

Japan is undergoing a major population health transition as its society ages and it continues to experience low birth rates. These changes will bring new challenges to its public health system, highlighted as a model for Universal Health Coverage. Specific challenges Japan's healthcare system will face include an increase in national public health expenditures, higher demand for healthcare services, acute need for elder and long-term care, shortage of healthcare workers, and disparities between healthcare access in rural versus urban areas. Blockchain technology has potential to address some of these challenges, but only if a "health" blockchain is conceptualized, designed, and deployed in a way that is compatible with Japan's centralized public health system, national health and innovation policy, and healthcare IT architecture. In this viewpoint we identify major opportunities and potential challenges to blockchain adoption in the future of Japan's healthcare.

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## Original Manuscript

**TITLE: Exploring the Potential of Blockchain Technology to Meet the Needs of 21<sup>st</sup> Century Japanese Healthcare****Hirofumi Bekki, MD, PhD<sup>1,7</sup>, Hiroshi Mizushima, PhD<sup>2,3</sup>, Tokio Matsuzaki, MD, PhD<sup>4</sup>, Tim K. Mackey, MAS, PhD<sup>5,6,7</sup>**<sup>1</sup> Department of Orthopedic Surgery, Graduate School of Medical Sciences, Kyushu University, Fukuoka, Japan<sup>2</sup> Director, Center for Public Health Informatics, National Institute of Public Health, Saitama, Japan<sup>3</sup> President, Japanese Medical Blockchain Association. Tokyo Japan.<sup>4</sup> Innovation Fellow, Department of Cardiac Surgery, Japan Biodesign program, The University of Tokyo, Tokyo, Japan<sup>5</sup> Department of Anesthesiology, University of California, San Diego School of Medicine, San Diego, CA USA<sup>6</sup> Division of Global Public Health, University of California, San Diego School of Medicine, Department of Medicine, San Diego, CA USA<sup>7</sup> Global Health Policy Institute, San Diego, CA USA**Word count (main text):** 2,822**Tables/Figures:** 1 Figure**Address****for****Correspondence:**

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**ABSTRACT**

Japan is undergoing a major population health transition as its society ages and it continues to experience low birth rates. These changes will bring new challenges to its public health system, highlighted as a model for Universal Health Coverage. Specific challenges Japan's healthcare system will face include an increase in national public health expenditures, higher demand for healthcare services, acute need for elder and long-term care, shortage of healthcare workers, and disparities between healthcare access in rural versus urban areas. Blockchain technology has potential to address some of these challenges, but only if a "health" blockchain is conceptualized, designed, and deployed in a way that is compatible with Japan's centralized public health system, national health and innovation policy, and healthcare IT architecture. In this viewpoint we identify major opportunities and potential challenges to blockchain adoption in the future of Japan's healthcare.

## INTRODUCTION

The hype around blockchain technology is spreading akin to the rapid pace of globalization. Fundamentally, blockchain is a form of distributed digital ledger technology used to share and store data in a decentralized manner [1]. “Blocks” of data are secured through cryptography, so that a “chain” of blocks is created that provides the provenance of any given transaction and also makes the records tamper-evident [2]. In the context of healthcare, a “health” blockchain can enable better trust, security, management, and transparency for healthcare data, processes and transactions, and is actively being explored in several countries [3].

Despite growing interest, investment, and ongoing efforts towards commercialization, blockchain technology is still in its early adoption phases, particularly in the healthcare context. With its potential to transform different industry verticals, several proof-of-concepts (POCs), pilots, and projects in transition between development and production are being explored by various companies, communities, and national governments for healthcare [4]. This includes countries such as Japan, which has recently seen increased activity around examining and deploying blockchain applications to address healthcare problems specific to its changing society and populations [5].

In fact, Japan’s 21<sup>st</sup> century healthcare challenges are historically unique, with a demographic shift underway called *kōreikashakai* (高齢化社会) (translated as “population aging society”), which has resulted in Japan becoming the world’s oldest country (with 27.7% of its population over 65 years of age) [6]. The resulting “upside down” demographic pyramid (precipitated by low birth rate and high life expectancy) will bring new economic challenges (e.g., stabilizing national pensions and public services) coupled with increased strain on the national healthcare delivery system. Specific challenges include increased national public health expenditures, higher demand for healthcare services lacking appropriate controls,

acute need for elder and long-term care, lack of availability and shortage of healthcare workers (including nurses and caregivers), and continuing disparities between healthcare access in rural versus urban areas [7-9].

Hence, “health” blockchain approaches need to be tailored to the unique patient and population health challenges of countries like Japan and also aligned with its healthcare system design. Specifically, Japan operates a robust public health system, characterized by universal healthcare coverage (UHC), which has long been touted by the Japanese government as “first -class” in terms of access, quality, and low-cost [10].

However, recent data indicates that medical-related spending is growing, with Japan now ranked third in total health spending out of 35 OECD countries [11]. Further, though it operates a national health insurance system and a centralized social security and tax number system (known as “My Number System”), adoption of health informatics infrastructure for centralized healthcare data management and decision making is lagging [12]. This includes electronic medical records, where in 2017, the adoption rate was reported as only 34.4%, though it is expected that implementation rates will increase [13].

All of these factors give rise to promising prospects for blockchain solutions to address specific needs of Japan’s future healthcare system, but only if they are conceptualized, designed, and deployed to directly address the country’s most unique and localized healthcare and population health challenges. In response, this viewpoint outlines the unique opportunities and challenges faced by Japan’s current and future healthcare system, examines how these challenges can be addressed by blockchain technology, and also discusses emerging Japanese public policy on technology and whether it can encourage future adoption.

## Japan’s Current and Future Healthcare Challenges

In this section, we outline Japan's most pressing current and future healthcare challenges and describe how blockchain solutions need to directly map to solving these problems. To begin, Japan's healthcare system is based on a centralized UHC public insurance system with care provisioned by a network of over 4,000 public and private payers [14]. Residents of Japan are required to have health insurance coverage and receive coverage through Employees' Health Insurance (健康保険 *Kenkō-Hoken*) or the National Health Insurance system (国民健康保険 *Kokumin-Kenkō-Hoken*). Citizens without insurance coverage from employers can participate in the national health insurance program. Depending on the total income and age of the insured, the ratio of medical fees patients pay differs from 0 to 30%, with the government paying the remaining fees [15]. The national health insurance system is based on fiscal resources generated by a combination of employee and employer contributions, cost-sharing by patients, and subsidization by the government, all factors that are impacted by demographic changes.

As previously described, Japan is a rapidly aging society with the number of elderly (over 65 years of age) quadrupling in number in the last 40 years, which will also result in what some projections suggest will be a long period of overall population decline [16]. In fact, the percentage of elderly is expected to reach a staggering 31.2% by 2030 [6]. Conversely, the population of the labor force (15-64 years old) has been decreasing since 1995 when 87 million people were included in this group, but in 2016 only comprised 76 million people [6]. The labor force is further estimated to shrink to 68 million in 2030, also coinciding with an increase in non-working pensioners [6]. This will lead to a decrease in working age individuals and employers who can contribute payroll taxes into the health system to fund public health programs [6]. This will also shift the risk pool of enrollees to more expensive patients who require higher frequency visits, long-term care and more complex health interventions.

All of these demographic trends point to a trifecta of health system shocks, including increased utilization, rising national medical costs, and decreases in healthcare financing relative to population changes [6]. In 2015, Japan's total health spending accounted for 11.2 percent of its GDP equating to 42.3 trillion yen [17]. Currently, this expenditure is lower than the United States (which is ranked #1 in spending among OECD countries), which was \$3.3 trillion or 18% of GDP in 2017 [18]. Japan's elderly care health expenditure is also projected to rapidly increase, projected to peak in the next few decades and then continue increasing until 2065 [19]. Given these characteristics of an "aging of Japan" and its public health system design, it is expected that increased costs related to a growing burden of chronic diseases and expensive medical interventions and technologies will result in a healthcare funding gap of approximately 44 trillion yen by 2035 [14].

These factors are also exacerbated by suboptimal healthcare utilization in Japan. For example, Japanese patients tend to go to outpatient clinics more often than in other OECD countries; Japanese physicians see approximately twice as many patients annually than other countries, and the length of hospital stay is very high [11]. Additionally, the provisioning of unnecessary healthcare services, which includes higher volume or higher costs, is something Japan is struggling to tackle. Japan aggressively introduces and uses advanced medical devices and new technologies, which increase the cost of diagnosis and disease management [18].

Expensive services include radiographic examination procedures, such as x-ray and Computer Tomography (CT), that result in Japanese patients having a higher exposure to radiation compared to other developed countries and concomitantly higher costs due to the frequency of these procedures. Overutilization is incentivized by a fee-for-service model coupled with national pricing that is meant to control costs but not utilization [20,21]. Overutilization may also be related to lack of comprehensive facility accreditation, as

currently, the Japan Council for Quality Health Care (JCQHC) (established in 1995) acts as third-party accreditor to evaluate the functions of medical institutions, but only 26.1% of hospitals nationwide are certified and reviewed by the JCQHC [22].

Additionally, with increasing number of elderly patients, more physicians and other healthcare professionals (including nurses and caregivers) will be needed [7,8]. According to a survey by National Institute of Population and Social Security Research in Japan, the total number of medical doctors is 2.4/1000 people in 2010, which is fewer than the average of other OECD countries [7]. Physician shortages are also impacted by a system where physicians can decide their specialties freely regardless of grades or achievements. In terms of board certification, historically, Japan has not set a limitation on the number of doctors in each department that approves these specialties leading to specialty imbalances. In addition to physicians, the Ministry of Health, Labour and Welfare has also reported a gap of two million nursing personnel as would be required by 2025 to meet healthcare utilization demands [8]. Further, Japan's immigration policies and bilateral trade agreements have also impacted availability to foreign nursing and caregiver workforces [23].

Finally, there exists a growing gap of medical care coverage between rural and urban communities. In 2017, the reporting agency Nikkei Inc. conducted analysis on government data and reported that the mortality rate from acute myocardial infarction differed four to five times depending on whether a patient resided in a rural or urban community [9]. This data suggests that the quality of medical care may experience variation depending on geographic location (including rural versus urban) and that these differences can manifest in different communities in the same prefecture.

### **Blockchain, a Solution for Japan's Future Healthcare?**

Given the unique current and future challenges faced by Japan's health system, what challenge areas are blockchain technology-based solutions uniquely poised to offer real-world solutions? The answer to that question resides both in mapping localized use cases to Japan's healthcare system and also taking into account the national policy and healthcare IT architecture of a centralized public health system (see *Figure 1* for summary). For example, the Japanese government currently prohibits mixed billing, which consists of private and public health insurance for one condition, and patients have no choice but to select the treatment covered by their insurance [24]. This policy decision means blockchains will need to be responsive to centralized financing, though healthcare systems and providers themselves may be decentralized in operating their health IT systems.

Many of the leading use cases for blockchain deployment in healthcare are familiar to other markets, including the United States and Europe. These include management of electronic healthcare records, optimizing the performance of clinical trials, enhancing the health and pharmaceutical supply chain, and interfacing with the Internet of Medical Things (IoMT). Some use cases map directly to Japan's future healthcare challenges as summarized in *Figure 1* including: (1) blockchain-based EHR systems to improve healthcare billing, utilization, and reduce waste to ensure efficiency in national healthcare spending; (2) blockchain-enabled credentialing systems to address workforce shortages by speeding up healthcare worker credentialing (including in the context of immigration); (3) blockchain integration with IoMT to address aging society and support homecare; (4) blockchain patient digital identity tied national social security system records; and (5) blockchain-enabled clinical research.

For example, blockchain technology represents a major opportunity for clinical research that has also been recognized by Japanese biopharma companies and multinational pharmaceutical firms that operate in Japan. Primarily, clinical research

blockchains can help in structuring more verifiable data associated with clinical trial study protocol management and when provided a set of core defined metadata, can help ensure clinical trial integrity, transparency and auditability for regulators [25]. For example, a clinical research blockchain system could have helped with the 2014 arrest of a former Japanese employee of Novartis who was accused of falsifying clinical data for the popular hypertension drug valsartan [26]. This is particularly important as Japan is one of the world's largest markets for clinical trials and pharmaceutical product development.

Other health use cases that are emerging in Japan include integrating blockchain into the Internet of Things (IoT)/IoMT, especially given the rise of connected medical devices and the ubiquitous use of other tools that can enable medical applications (such as mobile phones). In fact, Japan represents the world's third largest market for medical device and is a major export market, largely driven by its aging population which relies on these devices. Blockchains can enable interconnection of smart devices to collect healthcare data (including in the acute care setting, outpatient setting, and for homecare applications) while also verifying the identity and provenance of data that may originate from multiple IoT enabled sources [27].

However, a lack of intrinsic security measures makes IoT vulnerable to privacy and security threats, a challenge blockchain is also well suited to address [28]. Specifically, once recorded, the data in any given block cannot be altered retroactively without alteration of all subsequent blocks, rendering data tamper-evident, and better securing healthcare data for purposes of analysis, insights into patient compliance and treatment, and also potentially enhancing reimbursement processes [29]. Increased utilization in the inpatient setting due to growth in elderly patients may also present opportunities for Japan's burgeoning health robotics industry and connected devices in the homecare setting, which will be critical in order to increase efficiencies, lower costs, and address healthcare

workforce shortages.

Finally, even though Japan is a public health system, electronic records are generally managed by individual institutions and are housed locally on disparate systems operated by private firms, not the government. Hence, patients' data and health identity are scattered across different providers, which impedes access and portability, and also impedes big data analysis for large population health trends. For example, even radiographic examinations performed on the same day can be conducted at different provider locations, with the images residing in different databases.

This problem seems perfectly situated for blockchain adoption, including exploring managing patient digital data and identity through a shared distributed ledger of eligible providers tied to the recently launched "My Number" social security and national tax number ID system. This could provide patients with EHR authenticity (tied to a validated national social security identity), auditability and potential data sharing with other providers to improve continuity of care similar to the MedRec blockchain system. MedRec, is an open-source platform that applies blockchain smart contracts to create a decentralized content-management system for healthcare data and has been piloted with Beth Israel Deaconess Medical Center [30].

Though these use cases hold promise, progress in research and development, financial investment, and deployment will require both national government buy-in (as Japan's health system is largely publicly funded) and adaptive policymaking to ensure blockchain technologies are incentivized and regulated correctly. Leading these efforts in new technology spaces is the Cross-ministerial Strategic Innovation Promotion Program (SIP). The SIP is a national project for science, technology and innovation supported by Japan's Cabinet office. As an example of some of their efforts in emerging technology, the SIP is engaged in projects to establish artificial intelligence (AI) and big data solutions in

hospitals to serve patients with automatic diagnosis and treatment options with a commitment of \$20 million in funding for 2018 [31].

One of the goals of the SIP is to establish a medical database with strong security, which is called “subtheme-A”. Interestingly, according to the draft for subtheme-A, blockchain technology will be explored as a potential solution for this project area. However, the Japanese government also hints at some practical barriers to exploration of these use cases including that costs of blockchain systems are still unknown and that there is a shortage of qualified blockchain developers. Both of these challenges have the potential to increase the costs and prevent future government blockchain adoption in the health sector [32].

## CONCLUSION

Blockchain’s earliest and most popularized use cases have arisen from cryptocurrencies, and more specifically bitcoin. Not surprisingly, Japan’s most mature sector for blockchain adoption has been financial services technology (aka “Fintech”), with several ongoing initiatives by Japanese banks and financial institutions to create cryptocurrencies and decentralized digital currency marketplaces and exchanges [33,34]. For example, Mitsubishi UFJ Financial Group, the largest bank in Japan, is planning on launching a bitcoin and cryptocurrency exchange targeting institutional and retail investors.<sup>34</sup> Additionally, OCBC, a bank in South-east Asia has carried out successful pilots of payment transactions using blockchain technology [35].

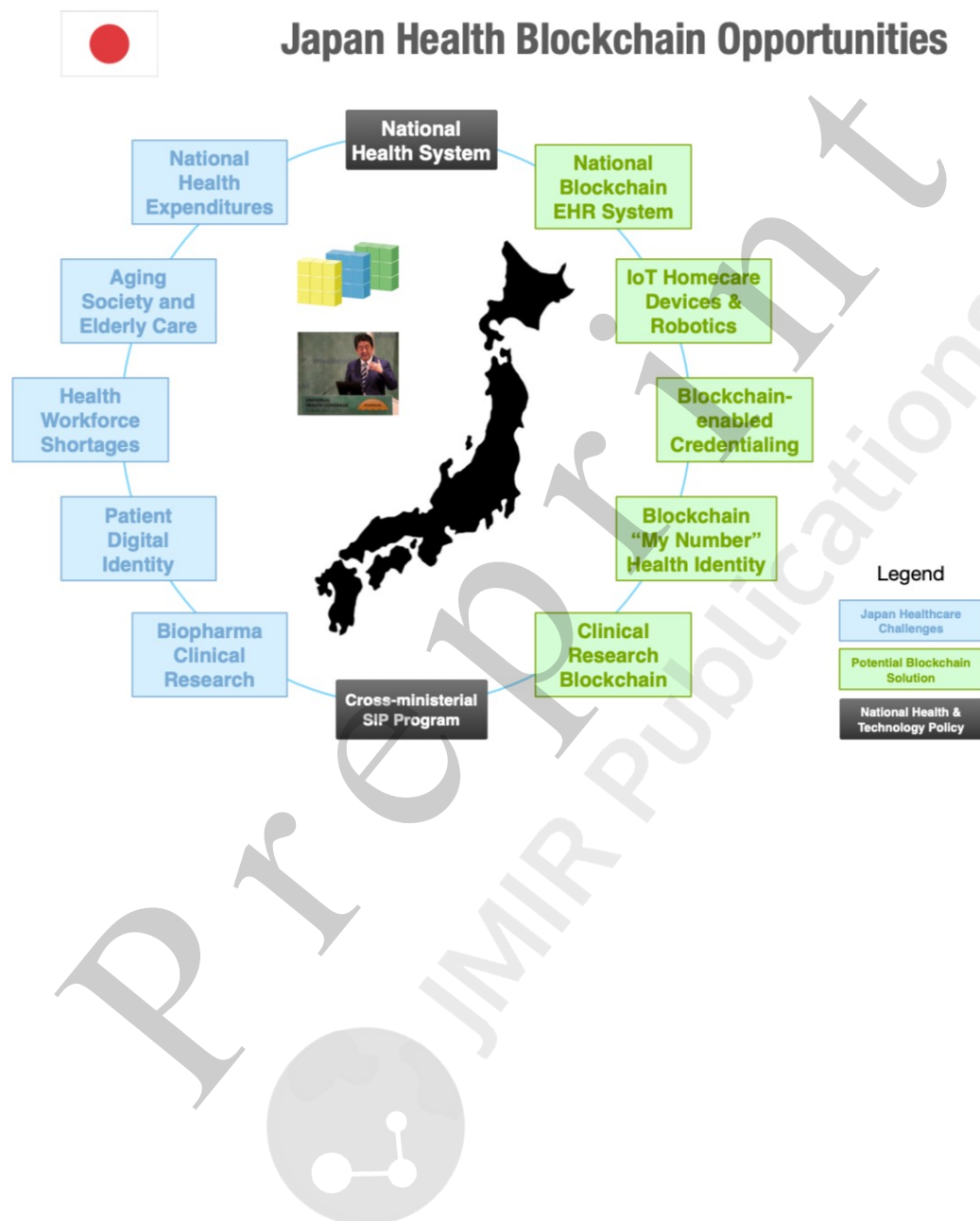
Overall, these fintech blockchains are designed to show that traditional functions of the financial system can be reliably executed by decentralized networks and in doing so speed up financial settlements and also raising the prospect of new financial system design [36]. However, along with growth in blockchain fintech-related activities have been calls for

regulation and taxation, including changes to Japan's Financial Services Agency [37]. These early adoption challenges for fintech in Japan also raise important questions regarding future adoption and regulation of blockchain technologies in other industries such as healthcare.

Importantly, any Japan blockchain in healthcare strategy has to take into account the national and public health characteristics of Japan's health system in addition to the unique challenges it faces with its aging society, concerns of healthcare overutilization, and shortage in its healthcare workforce. One approach may be to design Japan's healthcare blockchains as part of a whole-of-government approach similar to Estonia where a national e-government-backed blockchain is being used in the healthcare sector [38]. Regardless of the approach, Japan's current healthcare problems are acute and its future healthcare challenges are daunting. Blockchain technology has the potential to help, but only if it is "fit-for-purpose" to meet the changing demands of 21<sup>st</sup> century Japanese healthcare.

## FIGURE

Figure 1: Summary of Blockchain Potential for Japanese Healthcare System



**DECLARATIONS:**

**Ethics Approval and Consent to Participate:** Not applicable/Not required for this study.

**Consent to Publish:** Not applicable.

**Availability of Data and Materials:** Data associated with our literature and legal review are available via information in references.

**Competing Interests:** Tim K. Mackey has received speaker fees and reimbursement for travel from Cardinal Health to present on blockchain and healthcare research. He is also the co-Chair of the IEEE Standards Association Supply Chain/Clinical Trials Technology Implementation Industry Connections Program that focuses on stakeholder collaboration around blockchain technology for the pharmaceutical supply chain and has received reimbursement for travel expenses associated with speaking at IEEE-sponsored events. Additionally, he is a non-compensated advisory board member for the blockchain and pharmaceutical company FarmaTrust. All other authors report no conflicts of interest associated with this manuscript.

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## Supplementary Files

## Figures

**Figure 1.** Summary of Blockchain Potential for Japanese Healthcare System.

