

Pediatricians' perception of factors concerning the clinical application of blockchain technology to pediatric health care: a questionnaire survey

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Background: Interest in digital medical information has increased because it allows doctors to easily access a patient's medical records and provide appropriate medical care. Blockchain technology ensures data safety, reliability, integrity, and transparency by distributing medical data to all users over a peer-to-peer network. This study attempted to assess pediatricians' thoughts and attitudes toward introducing blockchain technology into the medical field.

Methods: This study used a questionnaire survey to examine the thoughts and attitudes of 30- to 60-year-old pediatricians regarding the introduction of blockchain technology into the medical field. Responses to each item were recorded on a scale ranging from 1 (never agree) to 7 (completely agree).

Results: The scores for the intentions and expectations of using blockchain technology were 4.0 to 4.6. Pediatricians from tertiary hospitals responded more positively (4.5–4.9) to the idea of using blockchain technology for hospital work relative to the general population (4.3–4.7). However, pediatricians working in primary and secondary hospitals had a slightly negative view of the application of blockchain technology to hospital work ($p=0.018$).

Conclusion: When introducing the medical records of related pediatric and adolescent patients using blockchain technology in the future, it would be better to conduct a pilot project that prioritizes pediatricians in tertiary hospitals. The cost, policy, and market participants' perceptions are essential factors to consider when introducing technology in the medical field.

Keywords: Blockchain; Pediatricians; Pediatrics; Personal health records; Tertiary care centers

Introduction

Medical technology has facilitated remarkable advances in various fields. With the development of healthcare technology, the quality of life and longevity of humans have improved. Interest in the ex-

change of medical information has also increased [1].

Currently, the medical records of patients are fragmented and stored in different hospitals. Fragmented medical records lead to several problems [2,3]. First, it is difficult for a doctor to check the medical records. Second, because not all medical records are acces-

Received: March 31, 2022 • Revised: May 16, 2022 • Accepted: May 26, 2022

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sible by every doctor, tests performed at another hospital may be duplicated. Third, although medical records can be digitally stored, patients or guardians copy and transport medical records to other hospitals using paper or compact disks (CDs). Fourth, the medical records stored in the hospital may be hacked or lost due to the hospital's closure. Thus, there may be unnecessary damage and a waste of time and human resources.

Blockchain technology ensures data safety, reliability, integrity, and transparency by distributing and documenting data over a peer-to-peer network [4]. This technology is different from traditional methods that store transactions on a central server [5].

Different perspectives on the application of blockchain technology in the healthcare industry are presented in this paper. Currently, the proposed clinical application will help facilitate the exchange of medical records and will be applied to the Internet of Things (IoT) system to manage patients with chronic diseases such as diabetes [6-10].

Pediatrics is also a field with many subfields that can benefit from blockchain technology. This study aims to assess pediatricians' thoughts and attitudes toward introducing blockchain technology into the medical field.

Methods

Ethical statements: This study was conducted according to the guidelines of the Declaration of Helsinki of 1975 and approved by the Institutional Review Board (IRB) of Yeungnam University Hospital (IRB No: YUMC 2019-04-041). At the time of receiving the questionnaire from the study participants, consent was obtained verbally, and a process was approved by the IRB.

1. Survey

Based on widely used theories concerning new technology acceptance, we investigated various factors related to using new technologies, such as blockchain, in our survey. In more detail, our study's factors, such as expected performance and ease of use, theoretically stem from the technology acceptance model [11]. Intention, attitude, and perceived behavioral control of using blockchain for hospital work originate from the theory of planned behavior [12].

We conducted a questionnaire survey among pediatricians aged between 30 and 60 years. A paper questionnaire and Google questionnaire were used. Before the participants responded to the questionnaires (Supplementary material 1), they watched a video about blockchain medical applications. The authors do not have

any associations or relationships with the company that produced the video [13].

The items that were used to measure intentions, attitudes toward using blockchain for hospital work, expected performance, ease of use, and perceived behavioral control were adopted from validated measures that were used in Venkatesh et al. [14]. Responses to each item were recorded on a scale that ranged from 1 (never agree) to 7 (completely agree). Higher scores were indicative of a higher degree of consent, whereas lower scores were indicative of a lower degree of consent.

The attitudes toward using blockchain technology to manage medical information were adapted from Venkatesh et al. [14] and Min and Kim [15]. Replies to these items were gauged on a 7-point scale, ranging from 1 (very negative) to 7 (very positive). Higher scores denoted more positivity, and lower scores indicated more negativity.

Based on Choi [16] and Kim et al. [17], the types of services that could be implemented through blockchain concerning hospital business were classified.

2. Statistical analysis

The collected data were analyzed using IBM SPSS ver. 25.0 (IBM Corp., Armonk, NY, USA). The demographic characteristics and attitudes of the medical doctors, stratified by their characteristics, were compared using the Mann-Whitney *U*-test. Statistical significance was denoted by $p < 0.05$.

Results

1. Study population

A total of 23 pediatricians were enrolled in this study (Table 1). Most of them were in their 30s ($n = 16$, 69.6%), five were in their 40s (21.7%), and two were in their 50s (8.7%). There were 10 men (43.5%) and 13 women (56.5%). The average career duration of the participants was 12 ± 9 years (Table 1). Regarding the hospital type, two were primary hospitals (8.7%), five were secondary hospitals (21.7%), and one was tertiary hospital (65.2%). Regarding job titles, eight of the pediatricians were employed (34.8%), six were residents (26.1%), eight were university professors (34.8%), and one was allocated to the "other" category (4.3%).

2. Thoughts about the use and adoption of blockchain

The participants' perspectives on the use and adoption of blockchain are shown in Table 2 and Fig. 1. The average score for the participants' intentions to use blockchain technology was 4.0 to 4.6. Those working at tertiary hospitals provided slightly more

Table 1. Characteristics of the study population

Variable	Data
No. of participants	23
Age (yr)	
31–40	16 (69.6)
41–50	5 (21.7)
51–60	2 (8.7)
Sex	
Male	10 (43.5)
Female	13 (56.5)
Career year (yr)	12 ± 9
Hospital type	
Primary	2 (8.7)
Secondary	5 (21.7)
Tertiary	15 (65.2)
Others ^{a)}	1 (4.3)
Type of worker	
Employed	8 (34.8)
University professor	8 (34.8)
Resident	6 (26.1)
Others ^{a)}	1 (4.3)

Values are presented as number only or number (%).

^{a)}One is serving as a doctor in the military.

positive answers about their attitudes toward blockchain technology.

Regarding the attitudes toward and perspectives on blockchain technology, the participants expressed only a few positive opinions about the use of blockchain for hospital work (4.3–4.7). Those working at tertiary hospitals provided slightly more positive answers related to the attitudes toward blockchain technology. However, those working in primary and secondary hospitals had slightly negative perspectives on applying blockchain technology to hospital work ($p = 0.018$).

The expectations of the effectiveness of blockchain technology were generally neutral. The participants in tertiary hospitals had positive expectations. Those in tertiary hospitals believed that it would improve productivity, processing speed, quality, and convenience. Participants from primary and secondary hospitals expressed neutral opinions, but these were not statistically significant.

The participants expressed neutral opinions about the ease of using blockchain technology. Participants working in primary and secondary hospitals expressed slightly more negative views regarding the ease of use and learning curve of the technology.

All participants expressed relatively negative opinions of their environment when using blockchain technology. Participants from primary and secondary hospitals expressed more negative views than those from tertiary hospitals. They thought that the informa-

tion technology resources necessary to use blockchain technology were insufficient and believed they lacked knowledge of blockchain technology. They also considered blockchain incompatible with the hospital work support system they were using.

3. Attitudes toward using blockchain technology to manage medical information

Regarding the benefits of blockchain technology, the most preferred was exchanging medical information between hospitals (Table 3, Fig. 2).

With blockchain technology, when a patient visits another hospital, there is no need to print out the chart from the prior hospital or transfer image information to a CD and deliver it to the new hospital, thereby facilitating the exchange of medical information between the hospitals. Blockchain technology can reduce repetitive tests, thus reducing patient treatment costs and shortening treatment time. Blockchain technology makes it possible to use standardized medical big data for precision medical care and customized medical care.

In addition, the participants found that blockchain technology reduced repetitive examinations, medical expenses, and treatment hours, and it facilitated the use of standardized medical big data. However, the participants expressed neutral opinions about the inability to modify medical records without patient consent, patients managing medical information by themselves, the transmission of all patient medical information to medical staff, and patient access to medical records at any time.

4. Necessity and feasibility of blockchain technology related to hospital business

All participants expressed positive opinions about the need for services that could be implemented through blockchain. Regarding the feasibility of the services that could be implemented through blockchain, positive views were expressed for all services other than patient-centered medical data management services, about which the participants expressed a neutral opinion (Table 4). There were no differences according to the hospital type.

Discussion

This study aimed to clarify the opinions and attitudes of pediatricians related to the adoption of blockchain technology in the medical field. The study findings revealed that pediatricians expressed only a few positive opinions about blockchain, and pediatricians working in tertiary medical institutions were found to have more positive attitudes toward this technology. Pediatricians working in primary and secondary hospitals expressed neutral opinions about

Table 2. Perspectives on the application of blockchain technology in the medical field

Domain	Question	Score by hospital type			p-value
		Total	Tertiary hospital	Others	
Intention to use blockchain technology					
	I intend to use blockchain technology for my hospital work	4.6 ± 1.7	4.9 ± 1.4	4.4 ± 1.9	0.283
	I plan to use blockchain technology for my hospital work	4.0 ± 1.8	4.5 ± 1.5	3.8 ± 1.9	0.062
	I expect to use blockchain technology for my hospital work	4.2 ± 1.8	4.8 ± 1.4	3.8 ± 1.8	0.005
	I will try to use blockchain technology in my hospital work	4.2 ± 1.7	4.7 ± 1.5	3.9 ± 1.9	0.036
Attitudes toward blockchain technology					
	It is desirable for me to use blockchain technology to handle hospital work	4.6 ± 1.7	5.0 ± 1.3	4.4 ± 1.8	0.104
	It's a good idea for me to use blockchain technology to do hospital work	4.7 ± 1.7	5.0 ± 1.4	4.5 ± 1.8	0.154
	It is wise for me to use blockchain technology to do hospital work	4.7 ± 1.7	5.0 ± 1.3	4.5 ± 1.8	0.099
	I like to use blockchain technology to do hospital work	4.3 ± 1.7	4.7 ± 1.5	3.9 ± 1.8	0.018
Expected performance from using blockchain					
	The use of blockchain technology will increase the productivity of my hospital business processing	4.8 ± 1.6	5.0 ± 1.2	4.6 ± 1.8	0.328
	The use of blockchain technology will speed up my hospital business processing	4.8 ± 1.6	5.0 ± 1.4	4.6 ± 1.7	0.352
	The use of blockchain technology will improve the quality of my hospital business results	4.8 ± 1.7	5.0 ± 1.4	4.6 ± 1.9	0.054
	Through the use of blockchain technology, my hospital work will be handled more easily	4.7 ± 1.8	5.0 ± 1.5	4.5 ± 1.9	0.166
Ease of use of blockchain technology					
	It will be easy for me to use blockchain technology to handle the hospital work I am currently doing	4.0 ± 1.7	4.3 ± 1.7	3.8 ± 1.7	0.120
	It will be easy for me to learn how to use blockchain technology to handle my hospital business	4.0 ± 1.7	4.2 ± 1.7	4.0 ± 1.7	0.511
	It will be easy for me to use blockchain technology to handle the hospital work I intend to do in the future	4.1 ± 1.7	4.3 ± 1.6	3.9 ± 1.7	0.323
Perceived behavioral control of using blockchain technology					
	I have the information technology (IT) resources (ex: IT devices, experts) needed to use blockchain technology	2.6 ± 1.7	2.9 ± 1.8	2.4 ± 1.7	0.080
	I have the necessary knowledge to use blockchain technology	2.6 ± 1.6	2.7 ± 1.7	2.5 ± 1.6	0.798
	Blockchain technology is well compatible with the hospital work support information system that I am using	2.6 ± 1.7	3.0 ± 1.8	2.3 ± 1.6	0.009

blockchain technology and somewhat negative opinions about its introduction into hospitals.

In our previous study, medical doctors demonstrated significantly more negative attitudes toward blockchain technology than did patients [2]. Furthermore, self-employed doctors demonstrated more negative attitudes than employed doctors and university professors [2]. We attempted to understand these findings using the expectancy theory of psychological motivation [18,19], which suggests that people are motivated to pursue positive outcomes and avoid adverse effects.

Blockchain technology has various applications in pediatrics. Even simple invasive procedures such as obtaining blood samples are often difficult to perform in infants. Using blockchain technology to deliver medical information can lower medical expenses and lessen the inconvenience for children by eliminating redundant examinations.

Children may have to move frequently, sometimes against their will, depending on the circumstances of their parents. Therefore, it is highly possible that finding past records will be difficult. Although a system where the government manages vaccination records has been introduced in Korea, medical records other than vaccination records should be checked by relying on the memory of the guardian.

With blockchain technology, patients do not need to maintain their medical records. Instead of waiting to receive medical information from the guardian of a child, the hospital staff can access the medical history because the technology allows the transmission of the appropriate medical information. Additionally, there is no risk of record loss or distortion. It is essential to share the medical records of patients across different hospitals following their wishes; this is also important for the security of personal data.

In a study of medical record keeping in a summer camp setting

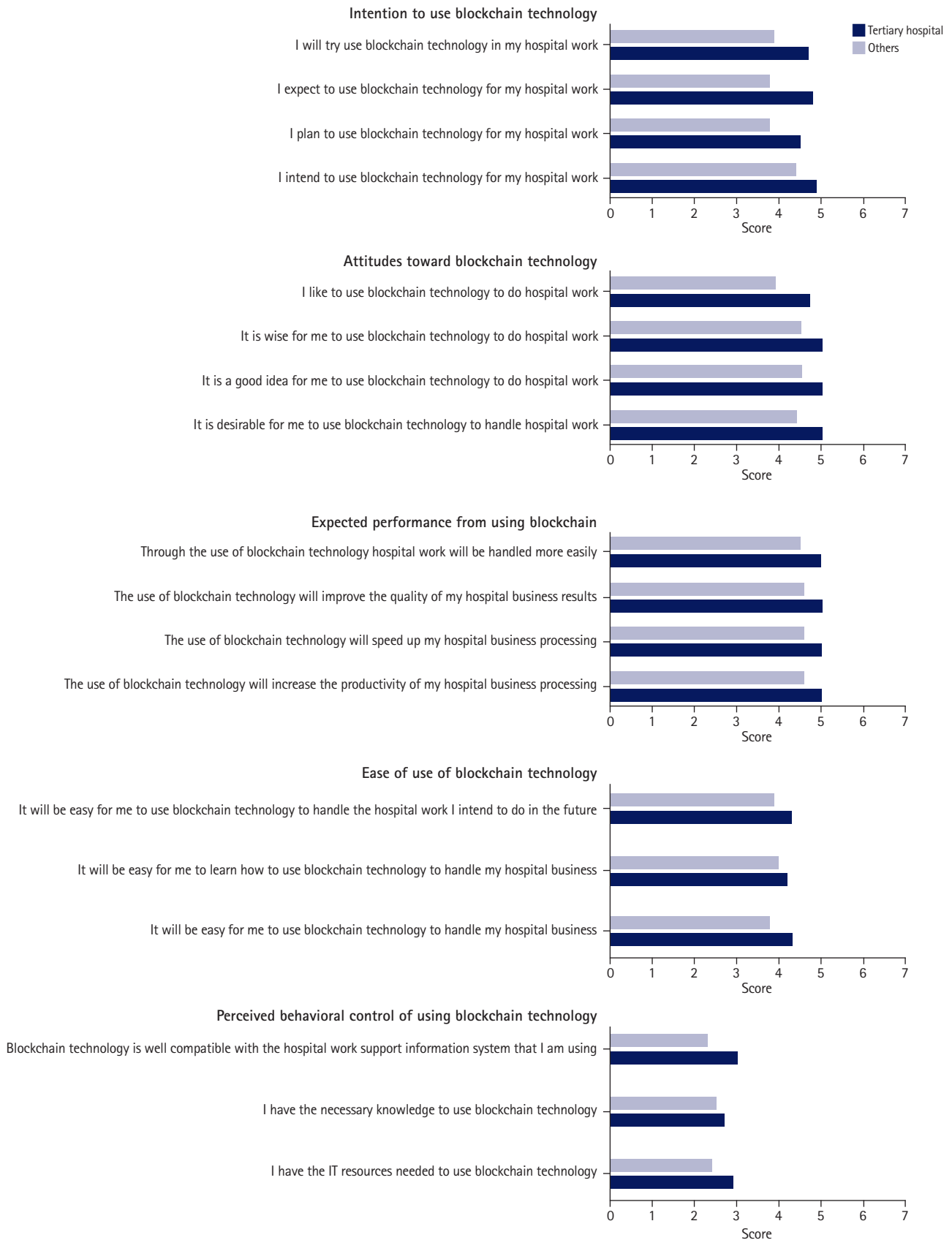


Fig. 1. Perspectives on the application of blockchain technology in the medical field according to hospital type. IT, information technology.

Table 3. Attitudes toward using blockchain technology to manage medical information

Characteristics of blockchain technology	Score by hospital type			p-value
	Total	Tertiary hospital	Others	
Through blockchain technology, all the medical information of a patient can be delivered to the medical staff	4.7 ± 1.8	5.0 ± 1.5	4.5 ± 2.0	0.315
Since hacking is impossible using blockchain technology, the security of the patient's medical information can be strengthened	4.6 ± 1.8	4.8 ± 1.7	4.5 ± 1.9	0.561
Once entered by the doctor, the medical chart cannot be modified without the consent of the patient if blockchain technology is used	4.1 ± 1.9	4.2 ± 1.8	4.0 ± 2.1	0.736
Blockchain technology allows patients to freely access their medical information anytime, anywhere	4.6 ± 1.8	4.9 ± 1.6	4.4 ± 1.9	0.173
With blockchain technology, when a patient goes to another hospital, there is no need to print the chart of an existing hospital on paper or put image information on a compact disc and deliver it to other hospitals, thereby facilitating exchange of medical information between hospitals	5.2 ± 1.8	5.5 ± 1.3	5.0 ± 2.0	0.418
Blockchain technology can reduce repetitive tests, thus reducing patient treatment costs and shortening treatment time	5.1 ± 1.8	5.4 ± 1.5	4.8 ± 2.0	0.179
Blockchain technology makes it possible to use standardized medical big data for precision medical care and customized medical care	5.0 ± 1.9	5.3 ± 1.6	4.7 ± 2.1	0.238

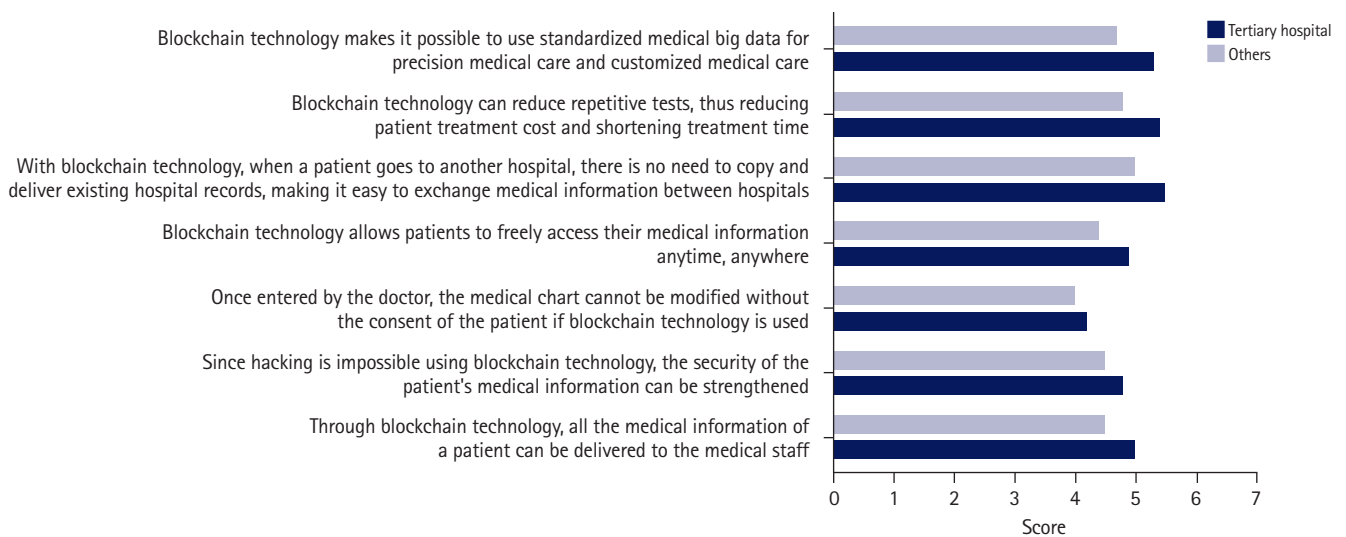


Fig. 2. Attitudes toward using blockchain technology to manage medical information according to hospital type.

Table 4. Necessity and feasibility of services related to hospital business that can be implemented through blockchain technology

Domain	Necessity	Feasibility
Patient-centered medical data management service	4.7 ± 1.6	4.6 ± 1.7
Personal lifelog data integrated management service	4.5 ± 1.7	4.6 ± 1.6
Simplified insurance payment service	4.7 ± 1.8	4.7 ± 1.7
Pharmaceutical safety distribution service	4.8 ± 1.6	4.7 ± 1.6
Integrated medical data management service	5.0 ± 1.7	4.7 ± 1.7
Clinical trial data sharing service	4.9 ± 1.7	4.7 ± 1.7
Genome analysis data safe transaction service	4.6 ± 1.7	4.6 ± 1.7
Integrated management of medical device licensing	4.7 ± 1.8	4.7 ± 1.8
Clinical research data sharing service between countries	4.8 ± 1.6	4.5 ± 1.7

by Kaufman et al. [20], approximately one-fifth of school-aged children were found to spend their time at residential summer camps in the United States. Many of these children had chronic medical conditions. In such a situation, the delivery of medical information for the special pediatric settings of a healthcare provider is said to be necessary. The study noted that standard software for documenting summer camp healthcare practice was needed, along with network and technical support. The delivery of medical records using blockchain technology with the approval of an authorized guardian may be helpful in this field.

The Korea Disease Control and Prevention Agency manages Korea's national immunization program, and vaccinations can be checked online [21,22]. Since a child's vaccination record is maintained from birth, this information is a good starting point for ap-

plying blockchain technology in the medical field. The immunization registration management information system may contain various errors that occurred during data entry. Owing to the nature of blockchain technology, access and modification are possible only with the individual patient's consent, and a potential solution needs to be formulated.

The study findings revealed that pediatricians in tertiary hospitals expressed more positive views about blockchain technology than those in primary and secondary hospitals. A previous study reported similar results for doctors who were not pediatricians [2], which was not related to their direct compensation; there is relatively limited information about individual income levels. The availability of information technology support in tertiary hospitals also could have led to more positive answers.

In the future, the integration of blockchain technology with the medical record systems of pediatric and adolescent patients may be preceded by a pilot project that prioritizes pediatricians in tertiary hospitals. Blockchain technology has various applications in pediatric healthcare management. First, it can be used to deliver medical information securely, transparently, and cost-effectively. For example, it can be used for a national vaccination schedule registry. Blockchain technology can also facilitate a national interoperability framework, eliminate the need to manage different immunization records for each hospital, and lower the overall cost of vaccinations in the country. Second, blockchain technology can be helpful in conducting clinical trials involving children with rare hereditary diseases. Third, blockchain can be used for data sharing without compromising or leaking personal information in big data collected by a monitoring device—a wearable device that continuously monitors medical parameters using the IoT network.

After the coronavirus disease 2019 (COVID-19) outbreak, telemedicine use has increased dramatically in the United States [23]. Telemedicine sessions increased by 683% between March and April 2020. In response to COVID-19, the virtual urgent care system has expanded. Considering the increasing attention given to “untact” technology after COVID-19, the use of blockchain technology for medical record management has garnered interest.

In addition, blockchain technology plays a role as a means of delivering medical information, but digitalization of medical care, telemedicine, and smooth information delivery cannot be fully realized with only blockchain. To use medical blockchain technology, preliminary work such as standardization of medical databases will be required. The standardization of different medical databases for each hospital will facilitate the activation of information sharing between hospitals, which will require policy support from the government.

The limitations of this study are that the survey population was

small, and patient and guardian surveys were not obtained. It seems that additional large-scale surveys are needed in this area.

It appears that there is adequate scope for the application of blockchain technology to pediatric healthcare management. With the introduction of blockchain technology to the medical industry, the technology, cost, policies, and the perception of market participants are important. We hope that the reported perceptions of pediatricians, who are important market participants in the introduction of blockchain to the medical industry, will help stimulate active discussions on the introduction of blockchain technology to the field of pediatrics in the future.

Supplementary materials

Supplementary material 1 can be found via <https://doi.org/10.12701/jyms.2022.00241>.

Notes

Conflicts of interest

Min Cheol Chang has been Associate editor of *Journal of Yeungnam Medical Science (JYMS)* since 2021. Jae Min Lee has been editorial board member of *JYMS* since 2021. They were not involved in the review process of this manuscript. Otherwise, there is no conflict of interest to declare.

Funding

This work was supported by a 2021 Yeungnam University Research Grant.

Author contributions

Conceptualization, Methodology, Data curation, Formal analysis, Project administration: YSH, JCP, MCC, JML; Investigation, Funding acquisition: JML; Supervision: all authors; Writing-original draft: JML; Writing-review & editing: all authors.

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