JAMIA Open, 5(1), 2022, 1–10
https://doi.org/10.1093/jamiaopen/ooab115
Research and Applications

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Patients', pharmacists', and prescribers' attitude toward using blockchain and machine learning in a proposed ePrescription system: online survey

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Received 16 March 2021; Revised 28 June 2021; Editorial Decision 1 December 2021; Accepted 14 December 2021

ABSTRACT

Objective: To evaluate the attitudes of the parties involved in the system toward the new features and measure the potential benefits of introducing the use of blockchain and machine learning (ML) to strengthen the in-place methods for safely prescribing medication. The proposed blockchain will strengthen the security and privacy of the patient's prescription information shared in the network. Once the ePrescription is submitted, it is only available in read-only mode. This will ensure there is no alteration to the ePrescription information after submission. In addition, the blockchain will provide an improved tracking mechanism to ensure the originality of the ePrescription and that a prescriber can only submit an ePrescription with the patient's authorization. Lastly, before submitting an ePrescription, an ML algorithm will be used to detect any anomalies (eg, missing fields, misplaced information, or wrong dosage) in the ePrescription to ensure the safety of the prescribed medication for the patient.
Methods: The survey contains questions about the features introduced in the proposed ePrescription system to evaluate the security, privacy, reliability, and availability of the ePrescription information in the system. The study population is comprised of 284 respondents in the patient group, 39 respondents in the pharmacist group, and 27 respondents in the prescriber group, all of whom met the inclusion criteria. The response rate was 80% (226/284) in the patient group, 87% (34/39) in the pharmacist group, and 96% (26/27) in the prescriber group.
Key Findings: The vast majority of the respondents in all groups had a positive attitude toward the proposed ePrescription system's security and privacy using blockchain technology, with 72% (163/226) in the patient group, 70.5% (24/34) in the pharmacist group, and 73% (19/26) in the prescriber group. Moreover, the majority of the respondents in the pharmacist (70%, 24/34) and prescriber (85%, 22/26) groups had a positive attitude toward using ML algorithms to generate alerts regarding prescribed medication to enhance the safety of medication prescribing and prevent medication errors.
Conclusion: Our survey showed that a vast majority of respondents in all groups had positive attitudes toward using blockchain and ML algorithms to safely prescribe medications. However, a need for minor improvements regarding the proposed features was identified, and a post-implementation user study is needed to evaluate the proposed ePrescription system in depth.

Key words: community pharmacy, electronic prescribing, health informatics, information technology, blockchain, prescriptions, machine learning

INTRODUCTION

Electronic prescribing is becoming one of the most important emerging information technologies among healthcare organizations. Many healthcare centers and organizations around the world are adopting ePrescription services. The reason for this massive increase in interest is because ePrescription services have the potential to improve the safety, quality, and efficiency of the medication-prescribing process.[1–18] While the focus of ePrescription services is on enhancing the safety of prescribing medications, it can also improve other aspects of the process of prescribing, dispensing, and purchasing medication.[15,19]

Even though ePrescription will help overcome many issues such as the misinterpretation of prescription handwriting, lost or damaged paper prescriptions, and communication issues between prescribers and pharmacists, it may create new problems in different stages that need further investigation and study.[1,4,20] For example, ePrescription systems might affect prescribers and pharmacists' workload by creating new types of prescribing errors such as sending prescriptions with the wrong drug, dose, or medication regimen.[21–27] Thus, ePrescription systems may affect healthcare service quality and safety by requiring more time for checking at the dispensing stage, which might cause fatigue issues. Most of the studies found that the transition to the ePrescription system will impact their experience positively and enhance the patients' safety during the medication-prescribing process.[23,28] However, the overwhelming workload caused by the extra process of verifying during the medication dispensing process might impact the safety of the patients.[28] The ePrescription system also may raise concerns about the patients' information security and privacy when sharing prescription information with the pharmacy. While sharing and storing the patients' prescription information, the security of the data must be ensured to avoid any alteration that could potentially harm the patient's health. Fraud is also a potential threat that could occur if an attacker captured the information and tried to replicate the prescription.[1]

With the patient being more involved in the medical information process, they should also be more involved in evaluating healthcare systems, specifically systems such as ePrescription systems that the patient might deal with more often. Many studies have found that patients that are satisfied with certain services are more likely to continue using those provided healthcare services.[29,30] Therefore, it is important to evaluate the ePrescription system from the point of view of all the parties involved when considering potential improvements.

Many studies have evaluated ePrescription systems to identify their benefits and drawbacks,[6,31,32] the facilitators and limitations of implementing ePrescription systems,[1,33,34] and the effects of ePrescription systems on workflow and medication safety.[2,32,35] These studies evaluated ePrescription systems from the point of view of healthcare experts and professionals. Other studies[36–40] have evaluated ePrescription systems from the perspective of patients in the United States and Sweden.[4] Studies from Australia[41] and Scotland[42] examined patients' attitudes toward ePrescription systems before their implementation. These studies reported that patients' attitudes toward ePrescription were mostly positive. However, these studies had limitations[15] due to being locally focused, having small samples, and involving patients from only one clinic[37,38,41] or one state.[39,40] Lastly, the studies were limited to only certain countries and limited in terms of the ePrescription system's different features regarding the medication prescribing and dispensing process.

Therefore, we conducted this study to evaluate the attitude of the parties involved in the system toward the new features and to measure the potential benefits of introducing the use of blockchain and machine learning (ML) to strengthen the methods in place for safely prescribing medication.

Our study is part of the research on developing a new ePrescription framework that gives the patients an important role in the system by allowing them to control the access to their medication history and ePrescription information, how it is transferred, and whom it is shared with. Moreover, we introduce a new feature to detect any drug interactions in ePrescriptions using ML algorithms and to check ePrescriptions for any anomalies before submitting to the pharmacy.

Through this study, we aim to answer the following research question:

- What benefits and drawbacks exist when using the proposed ePrescription system compared to existing ePrescribing methods (specifically, generating medication-prescribing error alerts, medication histories, and prescription information sharing)?

The proposed ePrescription framework

We are proposing a new ePrescription system that aims to enhance the security and privacy of ePrescription information and improve ePrescription information's availability and reliability in the system. We mainly focus on utilizing blockchain technology to improve the privacy and security of the ePrescription information by designing a blockchain network for the proposed ePrescription system to facilitate the sharing of ePrescription information while maintaining the security and privacy of the patient's ePrescription information in the network. Blockchain is a decentralized network that includes a distributed chain of blocks. The blockchain network is a peer-2-peer network. Each block in the chain includes information about a transaction in the chain. All transactions are recorded in the blocks. These blocks are linked to each other by storing a hash value to the previous block data. The user verifies the block by calculating the hash value and matching it with other blocks' hash in the network. If the verification process is successful, then the new block will be added. One of the well-known examples of blockchain is the Bitcoin network. Bitcoin is a finance network used to organize and monitor the participating peers' financial transactions.[43] The blockchain network in its distributed architecture ensures the privacy of transaction information and the ability to share the blocks in the network securely.[44–46] The blockchain ensures there is no alteration of the submitted ePrescription and verifies the prescriber's identity, since they are the only party who can submit an ePrescription.

We aim to grant patients access to control their information using a unique ID generated by the ePrescription system server. The patient will use this ID to grant access to the other parties in the system (ie, prescribers such as physicians, nurse practitioners, and optometrists as well as pharmacists). The unique ID will be stored in the patients' smartphones and transferred using near-field communication (NFC). The NFC technology allows the user to transfer information an approximate distance (ie, less than 4 cm). The NFC part of the framework was proposed in the usability study.[47] This study mainly focused on surveying the feedback of the involved parties on the other features in the proposed framework (ie, blockchain and ML).

The system will also utilize an ML algorithm to safely prescribe the medication to the patient using their medication history and current health condition. ML algorithms are developed to analyze, un-

derstand, and identify patterns in given data.[48–50] The algorithm will be trained using adverse event reports from the US Food and Drug Administration website.[51] Then, a model of the algorithm will be used in the proposed system to assist the prescribers during the medication-prescribing process. Moreover, another algorithm will check for any misplaced or missing information in the submitted prescription. The input data will be shared from the patient's medication history and prescription information blockchain. Finally, the prescriber will submit the prescription to the patient's blockchain and then share it with the pharmacy. This new proposed system aims to manage the privacy and security of the patient's prescription and medication history using blockchain. Also, ML will be used to assist the prescribers (eg, physicians, nurse practitioners, optometrists) in prescribing the medication safely to the patient. Figure 1 shows an overview of the proposed ePrescription system.

In this survey, we explained the overview of the new proposed ePrescription framework's parts in relation to their role in the framework to each group. The patient group survey included the blockchain part, where we defined the technology first. Then, we explained how we plan to incorporate the blockchain in the framework. However, we did not explain the questions in the survey about the alert generation using ML algorithms due to their limited interaction with this module. As for the other groups, we gave an overview of the proposed system design and what are the features' outcome results. Although we explained and described the system to the participants, we excluded some of the system details because the proposed system implementation and experimental results are yet to be published. However, these excluded details should not prevent participants from providing valuable feedback. Finally, in this paper, we gave an overview of the proposed system only. The proposed system and the features are still under development and the implementation phase has yet to be published. We plan to publish the proposed system's explicit details and implementation results in the near future.

METHODOLOGY

Overview of the study

This study is a survey that evaluates the proposed ePrescription system based on the feedback of the involved parties (ie, patients, pharmacists, and prescribers). The survey focuses on the computer science aspects of the ePrescription system. It involves questions about the features introduced in the proposed ePrescription system to evaluate the security, privacy, reliability and availability of the ePrescription information in the system.[1]

The survey was a web-based questionnaire composed using the Dalhousie University's Opinio survey system[52] in January 2021. The system enables the users to compose a survey question and collect the data in CSV files, and it provides a link to be distributed for participation. The patients' group questionnaire link was distributed using the university emailing list and Amazon Mechanical Turk.[53] Amazon Mechanical Turk has been used in many research to recruit participants, and it is a viable recruiting tool for research.[54,55] For the prescribers and pharmacists groups, we disturbed their questionnaire links using emailing the prescribers' offices and pharmacies, the physicians and pharmacists associations, posting in the prescribers' and pharmacists' LinkedIn groups in Canada, the United States, and the United Kingdom.

Moreover, the survey includes questions that evaluate the features provided by the current ePrescription systems (eg, PrescribeIT in Canada, Surescripts in the United States). Finally, the participants in the patient group were from several countries, including Canada, the United States, the United Kingdom, India, Brazil, and countries in Europe. In contrast, both the pharmacist and the prescriber groups involved Canada, the United States, and the United Kingdom. According to the last reported usage, percent of ePrescription out of total prescriptions in the United States was 84% (2020)[56] and in the United Kingdom was 86% (2020).[57] In Canada, the last

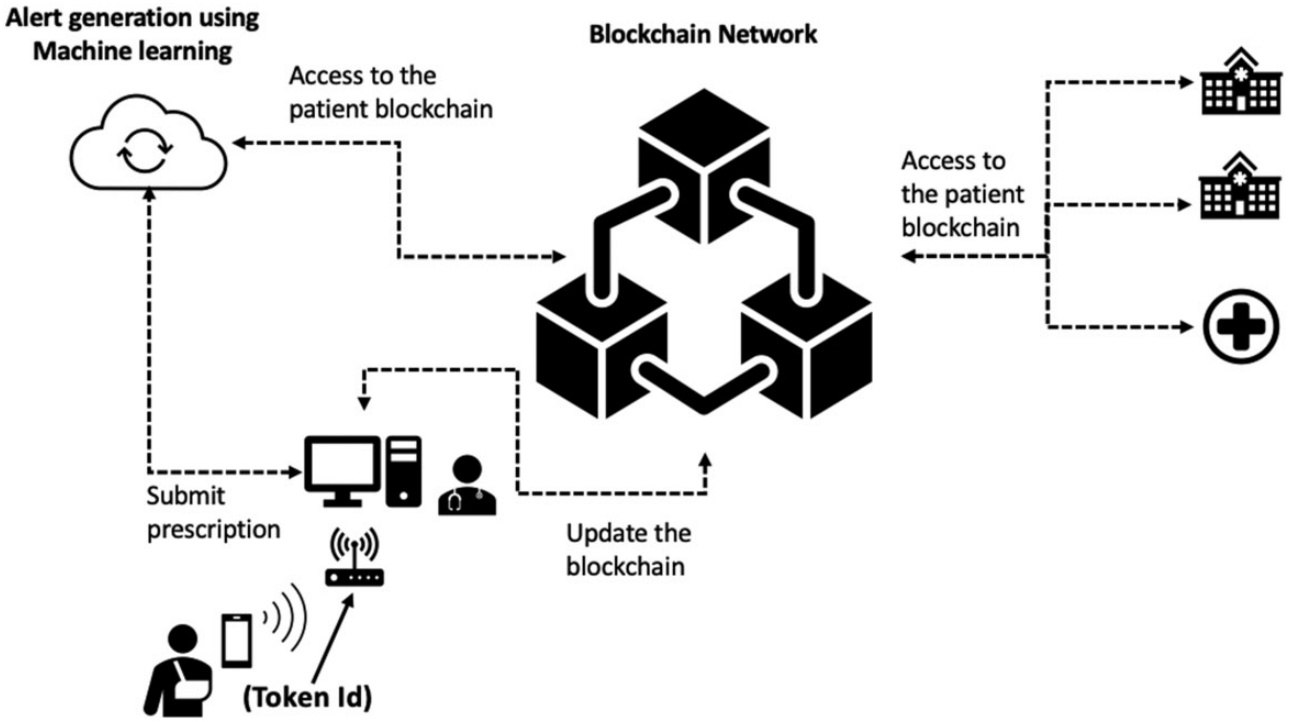

Figure 1. An overview of the proposed ePrescription system. ML: machine learning.

reported information was regarding the number of enrolled prescribers (ie, over 6000) and pharmacists (ie, 4500 pharmacies), who represented more than 9 million patients, in their ePrescription system "PrescribeIT." [58] In Brazil, more than 120 000 doctors using the ePrescription system "Memed."[59] To the best of our knowledge, in India, we did not find any report on the percentage of using ePrescription. However, Indian officials announced plans to implement an ePrescription system in 2018. The Board of Ethics granted ethical approval for this study at Dalhousie University, Halifax, Canada.

Inclusion criteria

In the survey, there were 3 groups of participants: patients, pharmacists, and prescribers. All participants in the 3 groups had to be older than 18 years old. For the patient group, the patient must have had experience with using ePrescription systems or paper prescriptions to pick up prescribed medication in the past year. For the prescriber and pharmacist group participants, we required the prescribers (ie, all prescribers except pharmacists) to have had experience with using any electronic health record (EHR) system and any ePrescribing method (eg, email or an ePrescription system such as PrescribeIT) in the past year. Pharmacists were required to have had experience with using any pharmacy management system and experience with any ePrescribing method (eg, email or an ePrescription system such as PrescribeIT) in the past year. Our targeted samples were at least 150 participants in the patient group and 25 participants in the pharmacist and prescriber groups. We set a low number for the pharmacist and prescriber group samples due to the pandemic's effects on these participant groups' free time and workload.

Even though our sample size is smaller than some of the abovementioned studies, our study explores a larger audience from different backgrounds and different countries. This will help generate better feedback regarding our research objectives. The research objectives focus on researching the security, privacy, and availability of patients' prescription information. In addition, we aim to analyze the reliability of the ePrescription system to improve prescribing and dispensing medication safely. Finally, while conducting the survey, we had to consider the COVID-19 pandemic, which affected the participation, especially for the prescriber and pharmacist groups.

The questionnaires

Each group was presented with a different questionnaire related to their role in the proposed ePrescription system. Each group's questionnaire consisted of 2 sections. The first section evaluated the current ePrescription system in general and its related security and information availability features. The second section evaluated the proposed ePrescription system's new features from their perspective in relation to their role in the system. However, in the second section of the patient group's questionnaire, we did not provide any questions on the alert generation feature using ML. That is because the role of the patients in the proposed system will not involve encountering the ML feature directly.

In each of the groups' questionnaire sections, we explained the overview of the new proposed ePrescription framework parts related to their role in the framework. The patient group survey included the blockchain part, where we defined the technology first. Then, we explained how we plan to incorporate the blockchain in the framework. However, we did not explain questions included in the survey on the alert generation using ML algorithms due to their limited interaction with this module. As for the other groups, we gave an overview of the proposed system design and what are the features' planned outcomes. Although we explained and described the system to the participants, we excluded parts of the system details because the proposed system implementation and experimental results are yet to be published. However, these excluded details should not prevent participants from providing valuable feedback. Finally, in this paper, we gave an overview of the proposed system only. The proposed system and the features are still under development, and the implementation phase has yet to be published. We plan to publish the proposed system's explicit details and implementation results in the near future.

All the questions used a 7-point Likert scale in which the participants responded on a scale from 1 (strongly agree) to 7 (strongly disagree). Also, a final, open-ended question was asked so the participants could provide any suggestions and improvements on the proposed ePrescription framework. The collected answers were analyzed using SPSS (version 26 for macOS; SPSS). Differences between the respondents' answers and their demographic information were tested for significance using a chi-square test.[4,60] Because our sample size is small compared to some of the reviewed studies and to show a strong evidence, we determine the p value ≤ 0.01. All results from the Likert-scale questions were regarded as nominal-level data. The open-ended questions' answers were categorized into the most commonly mentioned opinions.

RESULTS

Once we published the online survey, we had 284 respondents in the patient group, 39 respondents in the pharmacist group, and 27 respondents in the prescriber group. After the exclusion of participants who did not meet our requirements, we analyzed 226 (80%, 226/284) respondents in the patient group, 34 (87%, 34/39) respondents in the pharmacist group, and 26 (96%, 26/27) respondents in the prescriber group. Table 1 shows the statistical description of all the participants groups' demographic information.

Patient group

Using ePrescription

Of the 226 respondents, almost 74% stated that they had used an ePrescription system before. There was no significant difference in the answers to this question between respondents of different ages ($P = .141$) or genders ($P = .309$). However, there was a significant difference ($P = .000$) in the answers to this question between respondents of different education levels. The bachelor's degree group had the highest percentage with 105 participants who had used ePrescription before (105/130 = 81%), and the doctoral degree group had the lowest percentage, as only 1 participant had used ePrescription before out of 4 in total (1/4 = 25%). However, when we look to the graduate degrees combined together (ie, masters and doctoral degrees), the percentage of participants in those groups who had used ePrescription before increased to 73% (45/62).

Patients' feedback on the current ePrescription

The majority of respondents or 88.1% (199/226) agreed that the current ePrescription system transfers ePrescriptions securely and keeps their information private. Only 47.6% of the respondents agreed that the reliability of ePrescriptions and the availability of ePrescription information through the system is what motivates them to use ePrescriptions (Figure S1 in the Supplementary Appendix). There was a significant difference ($P = .000$) in the answers to the questions (ie, about the reliability and the availability of ePre-

Table 1. Demographic of the patients' group ($n = 226$), the pharmacists' group ($n = 34$), and the prescribers' group ($n = 26$)

	Patients' group		Pharmacists' group		Prescribers' group	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Age						
18–34 years old	152	67	11	32	8	31
35–54 years old	55	24	20	59	15	58
Over 55	19	8.4	3	8.8	3	11.5
Gender						
Male	142	62.8	15	44.1	18	69.2
Female	82	36.3	19	55.9	8	30.8
Other	2	0.9	0	0.0	0	0.0
Education						
Undergraduate degree	161	71	23	67.6	6	23.1
Graduate degree	62	27.4	9	26.5	17	65.4
Other	3	1.3	2	5.9	3	11.5
Used any ePrescription system before						
No	58	25.7	0	0.0	0	0.0
Yes	168	74.3	34	100.0	26	100.0

scription information) between respondents of different education levels. The bachelor's degree group had the highest percentage out of the participants who had a positive attitude toward the information availability and reliability in the current ePrescription systems (63/107 = 59%). The participants in the doctoral degree and other education degree groups had lowest percentages at 0.02% and 0.001% respectively. There was no significant difference in the security and privacy question answers between respondents of different ages ($P = .894$), genders ($P = .022$), education levels ($P = .070$), or depending on whether they had used an ePrescription system before or not ($P = .109$).

On the other hand, almost 48% disagreed with the statement that the ePrescription system will improve the process of picking up prescriptions at the pharmacies. There was a significant difference in the answers to the question (ie, Will the ePrescription system improve the process of picking up medication at the pharmacies?) between the respondents of the group who had or had not used an ePrescription system before ($P = .000$). Almost 85% (92/108) of participants who did not agree that the ePrescription system improved the process of picking up prescriptions had used an ePrescription system before. In addition, there was a significant difference in the answers to the same question between the respondents from different ages ($P = .004$). The highest percentage who disagreed with the question was in the age-group of 25–34 years (60/108 = 55%), and the 2 oldest age groups (45–54 and over 55 years) had the lowest percentage with 5.5% (6/108) and 8.3% (9/108), respectively.

Patients' feedback on the new proposed features

When we asked the respondents about the new features of the system, we found the following. Almost 81.4% of the respondents agreed that making the ePrescription in a read-only mode for the other parties after submission will help prevent alterations, and nearly 83% agreed that the read-only mode helps prevent fraud attempts. Additionally, when we asked about introducing a unique ID to control access to the ePrescription information, the respondents agreed that the unique ID would help the pharmacists validate the patients' identity before dispensing the medication. However, only approximately 50% agreed that the unique ID would help keep their information private and only able to be accessed by the authorized parties (ie, authorization is granted by the patient when sharing their unique ID only). Regarding using the blockchain technology and the unique ID to ensure the originality of the ePrescription, almost 87% of respondents agreed with that statement.

However, 67% of respondents believed using blockchain technology to share the ePrescription information would raise security concerns (Figure S2 in the Supplementary Appendix).

We performed a chi-square test to find any significant differences between the question answers across demographic groups. For the question about whether the read-only mode will prevent any alterations (ie, from all parties) to the submitted ePrescription, there was a significant difference in the answers to the questions between participants of different education levels ($P = .001$) and genders ($P = .008$). The highest percentage of participants who had positive feedback regarding whether viewing the information in read-only mode only after submitting will prevent any alterations were in the bachelor's degree group with 58% (106/184), and the lowest 2 groups were the doctoral and other education degree groups with a percentage of 2% (4/184) and 1.6% (3/184), respectively. In the genders group, the group who had the most positive answers to the same question was the male group, 65% (120/184). The lowest 2 groups were the female group with 33% (62/184) and the participants who chose other in the gender specification with 1% (2/184).

There was a significant difference in the answers to the question of whether the read-only mode will prevent fraud between the different education-level groups ($P = .004$). The participants with the highest percentage of a positive attitude toward this question were the bachelor's degree group (107/187 = 57%), and the lowest 2 groups were the doctoral and other education degree groups with a percentage of 2.6% (5/187) and 1.6% (3/187), respectively. For the question about whether using the unique ID will help verify the patient's identity at the pharmacy, there was a significant difference in the answers from the different education-level groups ($P = .001$). The participants with the highest percentage of a positive attitude toward this question were the bachelor's degree group (101/183 = 55%), and the lowest 2 groups were the doctoral and other education degree groups with a percentage of 2.2% (4/183) and 1.6% (3/183), respectively.

On the other hand, there was a significant difference ($P = .007$) in the different age groups' answers to the question about whether using the unique ID will preserve the ePrescription information in the network. The participants with the highest percentage of a positive attitude toward this question were in the age-group of 25–34 years (76/114 = 66%), and the 2 oldest age groups (45–54 and over

55 years) had the lowest percentage with 5.2% (6/114) and 5.2% (6/114), respectively.

Finally, we found a significant difference in the answers of respondents from different education-level ($P = .001$) and age groups ($P = .002$) on the question of whether using blockchain technology to build a private network to share ePrescription information will raise security concerns. The participants with the highest percentage of a positive attitude toward this question were the bachelor's degree group (89/155 = 57%), and the lowest 2 groups were the doctoral and other education degree groups with a percentage of 1.2% (2/155) and 0.6% (1/155), respectively. The participants with the highest percentage of a positive attitude toward this question were in the age-group of 25–34 years (89/155 = 57%), and the 2 oldest age groups (45–54 and over 55 years) were the lowest percentage with 6% (9/155) and 8.3% (13/155), respectively.

Pharmacists group

Pharmacists' attitude toward the ePrescription systems in general

We asked the pharmacists a series of questions about what motivates them to use ePrescription systems in general. Almost 95% of the pharmacists stated that they will use the ePrescription system because it will help transfer ePrescription information securely. Additionally, approximately 91% of the pharmacists stated that they will use the ePrescription system because it will make the process of keeping a record of patients' ePrescription information easier, and 88.2% of the pharmacists think the ePrescription system will help prevent the misinterpretation of paper prescriptions. The majority of pharmacists (73%) believe that the ePrescription system will improve communication with the prescribers, and 82% believe it will reduce the time spent on communicating with prescribers. Nearly 65% of the pharmacists think using the ePrescription system will help verify the originality of the received ePrescription. However, only 29% think the ePrescription system will help verify the prescriber's identity using a digital signature (Figure S3 in the Supplementary Appendix).

Pharmacists' feedback on the new proposed ePrescription alert generation feature

Only 47% of the pharmacists think checking the ePrescription system for any drug interactions in the patient will help reduce their workload. However, 82.4% of the pharmacists think checking the ePrescription system for anomalies (eg, missing fields, misplaced information, or wrong dosage proportions) will help reduce the workload regarding communicating with the prescriber. Nearly 91% of the pharmacists agree that generating alerts for the prescribers to prescribe medication safely to the patient based on their past medication history will help the pharmacists dispense medications safely. Only 62% of them believe that the system checking for drug-to-drug interactions will improve the work efficiency in the pharmacy. Further, 68% of the pharmacists think checking alerts about the patient's drug allergies will improve the work efficiency in the pharmacy. Almost 68% of the pharmacists think checking for prescription anomalies will reduce any dispensing errors. Finally, only 65% of the pharmacists believe that the proposed features for detecting anomalies will help to dispense medication safely (Figure S4 in the Supplementary Appendix).

Pharmacists' feedback on the new proposed ePrescription sharing ePrescription feature

The majority of the pharmacists (94%) think that making the ePrescription in a read-only mode will help prevent alterations, and only 52% believe this will help avoid prescription fraud. Only 56% of the pharmacists think that controlling access to the ePrescription by patients using a unique ID will help verify the patient's identity during the dispensing process. Last, almost 80% of pharmacists think the new proposed ePrescription system will help authenticate the submitted ePrescriptions (Figure S5 in the Supplementary Appendix).

Prescribers group

Prescribers' attitude toward the ePrescription systems in general

We asked the respondent prescribers several questions about the ePrescription system in general and to what extent they agree with the presented statement that they are motivated to use or not to use the ePrescription system in general. Almost 92% of the prescribers believe they will use the ePrescription system because they will be able to use it to transfer ePrescriptions securely. Nearly 88% of the prescribers think the system will allow them to keep a digital record of the patients' prescriptions, and 92% of them will use it because the system will solve most of the issues associated with paper prescriptions.

Only 81% of the prescribers agreed that they will use the system because it will improve communication with pharmacists, and 85% would like to use the system because it helps to track the fulfillment of prescriptions. However, 15% will not use the ePrescription system because it will take more time to type in and submit the prescription, and 23% will not use the system because of the possible security threats associated with the system being online and connected to the internet (Figure S6 in the Supplementary Appendix).

Prescribers' feedback on the new proposed ePrescription alert generation feature

We asked the prescribers to answer if they agree with the provided statements regarding the feature of generating alerts using the ML algorithm (described in detail in "The Proposed ePrescription Framework" section). The majority of prescribers (91%) believe generating alerts about the prescribed medication using one or a combination of previous patient medication history, current health condition, and previous similar cases of drug interactions will help safely prescribe medication. However, only 77% of the prescribers think using the previous health condition of the patient will help prescribe medication safely. Moreover, only 81% of the prescribers think checking for any prescription anomalies will help reduce the time spent to correct the prescription by communicating with the pharmacists. Finally, 77% of the prescribers think integrating the alert-generating feature using ML will help prevent medication errors and enhance the safety of medication prescribing (Figure S7 in the Supplementary Appendix).

Prescribers' feedback on the new proposed ePrescription sharing ePrescription feature

We presented the prescribers with 3 questions about the use of a private ePrescription network using blockchain technology (details described in "The Proposed ePrescription Framework" section). Only 77% of the prescribers think providing the ePrescription in a read-only mode after submission will help avoid any alterations on the original submitted prescription, and only 73% think the read-only mode will help prevent fraud. Finally, almost 65% of the prescribers agree that using a private network to make the ePrescription available to all parties (ie, prescribers, pharmacists, and patients) will enhance the safety of prescribing the medication, while 23% stated their opinion as neutral, and only 12% disagreed with the statement (Figure S8 in the Supplementary Appendix).

Suggested improvements

We asked the 3 groups if they have any suggestions on how to improve or any comments in general about the proposed ePrescription system. Starting with the patient group, almost 39% (89/226) provided answers in free text (see Table 2). The most common comment ($n = 35$) was that the proposed system is sufficient and does not need any further improvements. However, the second most common comment ($n = 18$) was about different security concerns the respondents had toward using the prescription information and sharing it with all parties in the blockchain network. Another common comment ($n = 17$) was on using a simpler design for the mobile application to make it easier to read and navigate for the patient when they browse their ePrescriptions. In addition, the mobile application should use push notifications for any changes made to their ePrescription. Another interesting suggestion is to use a 2-factor authentication scheme ($n = 6$) or a one-time password (OTP) authentication ($n = 4$)[39] to verify the identity of patients and the ePrescriptions.

In the pharmacist group, almost 44% (15/34) of the respondents answered in free text. The answers included 26 comments and suggestions (see Table 3) with a rate of 1.62 comments or suggestions per answer. The most common suggestion ($n = 5$) is to include an indication of the prescribed medication with the prescription to reduce the time spent communicating with the prescriber. Another common suggestion ($n = 3$) is to provide an option for the patient to grant access to the ePrescription online in order to reduce the waiting time for the patient. Sharing the drug interaction alerts sent to the prescriber with pharmacists was another suggestion provided ($n = 2$). It was also suggested ($n = 2$) to provide a digital signature for the prescriber with the ePrescription in order to prevent fraud when prescribing narcotics.

For the prescriber group, almost 50% (13/26) of the respondents answered in free text. The answers included 16 comments and suggestions (see Table 4) with a rate of 1.23 comments or suggestions per answer. The most common suggestion ($n = 5$) is to design the visual alerts in a way that is easy to understand and overcome. Another common suggestion ($n = 4$) was that the proposed system should be easily integrated or utilized by enhancing the currently used EHR systems.

Table 2. The suggestions of the patient group for improvements and comments about the proposed ePrescriptions

Suggestions	*n*	Percentage
The proposed system is sufficient	33	37
Security concerns and improve information privacy	26	29
Simpler design for the mobile application	11	12
2 Factor-authentication	6	7
Pushing notification using the mobile application regarding any prescription's change	5	6
Using password to login into the mobile application	4	4
Use one-time password (OTP)	4	4
Total	89	100

Table 3. Suggestions from the pharmacists' group for improvements and comments about the proposed ePrescriptions

Suggestions	*n*	Percentage
Provide the indication of the medication	5	19
The proposed system is sufficient	3	12
Granting access to the prescription in advance	3	12
Checking for allergies, adherence, and interactions	2	8
Option to share the drug interaction alerts	2	8
Multiple built-in alerts for all parties	2	8
Digital signature for prescribers	2	8
Better integration with the pharmacy system	1	4
Web-based platform of the system to all parties	1	4
Using fingerprint authentication to control access	1	4
Built-in dosage forms for prescribers to select from	1	4
Notification for a new prescription coming in	1	4
Provide an offline mode of the system	1	4
A print option of the prescription	1	4
Total	26	100

Table 4. Suggestions from the prescribers' group for improvements and comments about the proposed ePrescriptions

Suggestions	*n*	Percentage
Visually easy to understand alerts and simple	5	31
Integrated with the current Electronic Health Record (EHR) systems	4	3
List of drugs built-in available to select from	1	6
2 Factor-authentication	1	6
Cross-reference the interactions with official resources	1	6
Option to override dosage restrictions	1	6
The system should not override clinical judgment	1	6
Easy to connect to and access it	1	6
Registration of the patient's preferred pharmacy	1	6
Total	26	100

DISCUSSION

ePrescription in general

We found from the study that the perceptions of the 3 groups toward the ePrescription system are mostly positive. In the patient group, we found that the respondents felt that the security and privacy of their prescription will improve if they use the ePrescription system. The majority of patients believe that the ePrescription system can reliably handle prescription information and will make their information available for them to pick up medication when they are at pharmacies. However, they were not completely sure that the ePrescription system in its current form will improve their experience with picking up medication. This might be because in the ePrescription system's current form, their role is still limited, and they have limited control, or it might be limited to the individual's experiences with different ePrescription systems.

In the other 2 groups (ie, pharmacists and prescribers), we found more enthusiasm about using ePrescription systems since most of the systems were developed to solve most the issues related to paper prescriptions. In the pharmacist group, we found mostly positive responses about how the ePrescription system will improve the security and privacy while transferring prescriptions electronically. We also found both groups' perceptions were positive about whether the ePrescription system will improve communication between them. However, there is some hesitation about whether the system will verify the originality of the ePrescription by only using the prescriber's digital signature.

Using a blockchain network

In the patient group, we found that they are more positive toward the read-only mode proposed, where the prescription cannot be altered once submitted and any changes will be in a new transaction in the blockchain. As we found from the respondents about suggesting any improvements, the patients suggested using other methods to preserve their information privacy (eg, 2-factor authentication or using an OTP). However, the patient group felt positively about using the blockchain network and controlling the access to their information.

In the pharmacist and prescriber groups, we found that they answered positively that the use of the blockchain feature will help verify the originality of the ePrescription and authenticate it. Additionally, we found that the respondents feel positively about using the read-only mode, and they think it will help prevent any alterations to the original ePrescription, whereas we found that they think the read-only mode might prevent fraud. We found that the prescribers think using blockchain to make the medication history of a patient available to all parties will help prescribe medications safely.

The blockchain provides a decentralized network that connects all the parties together, which allows the patients' medication history blocks available to be accessed by authorized parties in the network.

Utilizing the ML algorithms to generate alerts

We asked both the pharmacist and prescriber groups about the new methods for generating alerts. We found that both groups think the new method will help to prescribe and dispense medication safely. The pharmacists think detecting any anomalies in prescriptions to be solved or changed by the prescribers before submitting it will help reduce the time spent clarifying the prescriptions. This will also help increase the patient satisfaction with the service when their prescription is ready in advance. Correspondingly, a prescription checked for any allergies regarding the patients' prescribed medication and for any drug-on-drug interactions will help increase the efficiency in the pharmacy by reducing the workload.

The prescriber group thinks using the current and previous health condition of the patient to check for any drug interactions or allergies with the prescribed medication/s will help prescribe medications safely. In addition, utilizing information from previous similar cases that used the prescribed medication for the same indication will help prevent any prescribing medication errors. However, the prescribers stated in a common comment that fewer alerts should be sent to prevent pop-up fatigue because of the high number of alerts.[61] Therefore, we will be designing the ML algorithm to check for all drug interactions and present the prescribers with only the most important alerts. The importance of the alerts depends heavily on the processed data quality and the accuracy of the ML algorithm. In the future, a usability study will be conducted to evaluate the proposed system further with real-world workload. Most importantly, the generated alerts are intended to be suggestions only to assist the prescribers to make decisions.

LIMITATION AND WEAKNESSES

With the positive findings related to the survey study, some weaknesses and limitations should be considered in future research. One of the limitations is the gender imbalance in the patient group and prescriber group. Finally, another limitation might be that the sample size is lower than some of the similar studies. However, due to the pandemic circumstances and government restrictions, we were limited in the distributing methods we could use, and we used limited venues to contact participants.

CONCLUSION

To summarize, many studies showed that the prescribers and pharmacists appreciate using the ePrescription system to reduce their workflow and solve most of the paper-related issues. Additionally, this study provided information about the prescribers', pharmacists', and patients' evaluation of the security and privacy of the ePrescription system. Moreover, our survey showed that the proposed features are acceptable from the participants' perspective and have the potential to help prevent medication errors and enhance the safe prescribing of medication. Blockchain technology in the proposed ePrescription will be used to build a private network where all the parties in the system can share information about the patients' medication history and ePrescriptions submitted in their blockchain. This network can be accessed by all parties (ie, patients, prescribers, and pharmacists); however, only the authorized parties can access the patients' information blocks. Moreover, using an ML algorithm helps generate personalized alerts about the patient's health condition. The alerts help prevent medication errors and prescribe medication safely. In future research, the ML algorithms will be evaluated in terms of the accuracy of detecting any anomalies in a submitted ePrescription. Then, we will determine which algorithm is suitable for the proposed ePrescription system and serves the objective of this research. In conclusion, we found from the study that the 3 groups had a positive attitude toward our proposed ePrescription system and the proposed features. Further, the participants' feedback shows that using blockchain and ML in the proposed ePrescription system would help prevent medication errors and enhance the safe prescribing of medication.

FUNDING

Jouf University funded the PhD studies of the first author, which has enabled carrying out this research study.

AUTHOR CONTRIBUTIONS

BA is the first author and the primary researcher in this study, and he was responsible for recruitment, administering, and analyzing the study results. This paper is a part of the first author's PhD dissertation, supervised by Dr. SS, the second author. Dr. SS guided administering the study, reviewing the results after analysis, and thoroughly reviewing and editing the paper.

ETHICS APPROVAL

Approval was obtained from the Dalhousie University, Health Sciences Research Ethics Board.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *JAMIA Open* online.

ACKNOWLEDGMENTS

The authors would like to thank Jouf University for supporting this research.

CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflict of interest for this study.

DATA AVAILABILITY

The data underlying this article are available in the Dryad Digital Repository, at https://doi.org/10.5061/dryad.tmpg4f50q

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