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EVALUATION OF PATIENTS' PERCEPTION OF A BLOCKCHAIN SYSTEM FOR PRESCRIPTION MANAGEMENT

EVALUACIÓN DE LA PERCEPCIÓN DE LOS PACIENTES SOBRE UN SISTEMA DE BLOCKCHAIN PARA LA GESTIÓN DE RECETAS MÉDICAS

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Evaluation of patients' perception of a blockchain system for prescription management

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ABSTRACT

The management of medical prescriptions without computational system can result in errors and security issues. This study, conducted in Monclova, Coahuila, evaluates the perception and disposition of patients from public and private health services towards implementing a secure computational system to improve prescription and medical record management. A survey of 68 adults, using a mixed research methodology. The results indicate that a secure and low-cost computational system would have positive acceptance among the population, thereby validating the researcher's hypothesis. In conclusion, it was determined that a secure computational system is a feasible solution to improve the management of medical prescriptions, would be accepted by most of the patients, and could serve as a basis for future developments in other areas of the healthcare sector. The literature on blockchain in prescription management supports the system’s benefits. A 10% margin of error was used to maintain validity with a smaller sample size.

Keywords: blockchain, prescription management, medical record management, patient disposition

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Evaluación de la percepción de los pacientes sobre un sistema de blockchain para la gestión de recetas médicas

RESUMEN

La gestión de recetas médicas sin un sistema computacional puede dar lugar a errores y problemas de seguridad. Este estudio, realizado en Monclova, Coahuila, evalúa la percepción y disposición de los pacientes de servicios de salud públicos y privados hacia la implementación de un sistema computacional seguro para mejorar la gestión de recetas y expedientes médicos. Se realizó una encuesta a 68 adultos utilizando una metodología de investigación mixta. Los resultados indican que un sistema computacional seguro y de bajo costo tendría una aceptación positiva entre la población, validando así la hipótesis del investigador. En conclusión, se determinó que un sistema computacional seguro es una solución factible para mejorar la gestión de recetas médicas, sería aceptado por la mayoría de los pacientes, y podría servir como base para futuros desarrollos en otras áreas del sector salud. La literatura sobre blockchain en la gestión de recetas respalda los beneficios del sistema. Se utilizó un margen de error del 10% para mantener la validez con un tamaño de muestra reducido.

Palabras clave: blockchain, gestión de recetas, gestión de expedientes médicos, disposición del paciente

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INTRODUCTION

The management of medical prescriptions includes the issuance, control, and follow-up of treatments prescribed to patients. In Monclova, Coahuila, the lack of an integrated system to manage these prescriptions in both public and private services can cause prescription errors and security issues. This study evaluates how patients perceive and accept a secure computational system that improves efficiency and security in the management of medical records and prescriptions, considering a low or zero cost.

Previous studies have shown that information technologies improve prescription management, but the adoption of blockchain in this field is still limited (Goundrey-Smith, 2008; Joshi et al., 2016; Hölbl et al., 2018). Research on blockchain in prescription management is limited in Mexico (Gupta, 2018; Arroyo et al., 2019). This study contributes to the literature by evaluating the feasibility and effectiveness of blockchain in healthcare systems in Mexico.

Access control, interoperability, provenance, and data integrity are issues that can be improved with blockchain technology in the healthcare sector (Hasselgren et al., 2020). Vera (2020), defines a medical prescription as a written order to dispense medication. Goundrey-Smith (2008), asserts that electronic prescriptions improve communication in medication orders. Reddy and Aggarwal (2015) point out that an electronic prescription facilitates data management in clinical settings. Joshi et al. (2016) found that handwritten prescriptions have more errors, while computerized ones have fewer.

Wager et al. (2017) indicate that healthcare providers face issues with interoperability, usability, and security in information technologies. Gupta (2018) highlights the need for efficient and secure systems to manage medical records. Fernández and Quesada (2017) emphasize that ICTs facilitate the provision of information and communication in healthcare.

Information technology has transformed healthcare services globally, promoting connectivity and rapid information exchange among experts (Kumari, 2022). Blockchain allows for secure and transparent information recording (Álvarez, 2018; Holbrook, 2020). Gupta (2018) mentions that blockchain emerged to create a secure financial system. Arroyo et al. (2019) highlight that blockchain was developed alongside bitcoin to ensure transaction trust.

Blockchain ensures information integrity with cryptographic protocols, using tools such as hashing (Arroyo et al., 2019). A hash is an algorithm that generates a fixed-length output from an input; additionally, blockchain uses asymmetric cryptography with public and private keys (Rojo, 2018). According to Kaur et al. (2023, pp. 216-218), the nature of blockchain, allows for greater security, transparency, and decentralization in transactions.

Blockchain provides a secure and immutable record of medical prescriptions, enhancing information efficiency and security in the healthcare system. Its implementation in prescription management requires detailed planning and analysis. In Monclova, Coahuila, the healthcare system faces challenges in managing medical prescriptions. Blockchain technology is promising but rarely used in this field in Mexico, creating a gap in prescription management.

According to Martos et al. (2006, p. 423), experts from the World Health Organization state that medical records should clearly identify the person, be reliable, concise, logically organized, consistent, resistant to deterioration, uniform in forms, identify those who make entries, and be easily accessible when needed.

Medical history is a data record that facilitates diagnosis and planning of recovery actions (Ornelas, 2013). Currently, in Monclova, there is no computerized system to access prescription histories.

How does the implementation of a blockchain system influence patient willingness to use it and access medical information in Monclova, considering a low or zero cost? Blockchain decentralizes information and ensures transparent record management (Holbrook, 2020). Although its adoption in the healthcare sector in Mexico is in its early stages, this research is relevant for advancing the implementation of emerging technologies and addressing similar issues in the country.

This research aims to generate knowledge about the feasibility and applicability of a blockchain-based computational system for the management of medical prescriptions in Monclova, Coahuila, from the patients' perspective.

METHODS

The research design was a mixed qualitative-quantitative approach, descriptive in nature, with the intention of deeply understanding the problem and its practical solutions. The following shows the formula for calculating sample size for finite populations includes n as the sample size, N as the total population size, Z as the confidence level, p as the expected proportion, q as its complement, an e as the margin of error.

$$n = \frac{Z^2 pqN}{Ne^2 + Z^2 pq} \tag{1}$$

In this research, the population to which the survey was applied consisted of 116,060 adults living in the city of Monclova, Coahuila. The sample consisted of 68 individuals. A margin of error of 10% instead of 5% reduced the sample size to 68 subjects. This decision was justified for several reasons: time and budget constraints prevented a larger sample, the study sought preliminary results to guide future research, and in exploratory studies, a higher margin of error was acceptable. Despite the higher margin of error, the results still provided valuable information to assess the feasibility of implementing blockchain in prescription management in Monclova, Coahuila, and could serve as a basis for more detailed studies.

The sampling was quantitative and simple random. The methodological design was pre-experimental with only a post-test and one group. The technique used was the survey, and the instrument was a questionnaire with a priori categories and a 5-point Likert scale. The results were entered into SPSS software.

The questionnaire was validated through a content validation process, where experts reviewed the questions to ensure their relevance and clarity. Additionally, a pilot test was conducted with 10 participants to identify problems and adjust the questionnaire. The pilot test revealed that some questions needed restructuring to improve comprehension. After the adjustments, the final questionnaire was considered valid and reliable for the main research.

The alternative and null hypotheses were:

H1: If the importance of the medical history was recognized and a system with blockchain technology was implemented in the management of medical prescriptions in the city of Monclova, Coahuila, then patient willingness to use the system would increase and access to medical information would improve, as long as the application cost was low or zero.

H0: If the importance of the medical history was not recognized and a system with blockchain technology was not implemented in the management of medical prescriptions in the city of Monclova, Coahuila, then patient willingness to use the system would not increase nor would access to medical information improve, regardless of the application cost.

The methodological process used in the research included the hypothesis validation method to analyze the empirical data generated during the implementation of blockchain technology in the healthcare system. A mixed approach was adopted, combining qualitative and quantitative methods. In the qualitative part, patients' opinions were analyzed through surveys, while in the quantitative part, variables related to operational efficiency and information security were measured. The surveys, consisting of 10 questions, were designed to capture the perception of patients from health centres about the implementation of a secure computational system for managing medical prescriptions.

The statistical analysis included techniques such as normality analysis, variable correlation, and factor analysis. The researcher's hypothesis was evaluated using a Student's t-test with a 5% significance level. Additionally, frequency and percentage analyses were conducted to interpret the opinions of respondents on the studied variables, along with a descriptive analysis to understand data behavior through measures of central tendency. Data normality was verified using the central limit theorem and graphs to visualize data distribution. The Pearson correlation coefficient was used to examine the relationship between pairs of significant variables, and a multidimensional factor analysis was conducted to explore the underlying structure of the relationships among the analyzed variables.

RESULTS

The variables used in this research are shown in Table 1.

Table 1 Study and measurement variables

No.	ABBREVIATED VARIABLE	IMPORTANCE OF THE RESEARCHER	VARIABLES
1	AMI	1	Access to Medical Information
2	CA	3	Cost of the Application
3	WUS	2	Willingness to Use the System
4	IAPH		Immediate Access to Prescription History
5	IS	5	Information Security
6	PDA		Preference for Digital Access
7	UMI		Update of Medical Information
8	ICPC	4	Importance of Cross-Platform Compatibility
9	IP		Information Privacy
10	SAM		Security Against Modifications

Statistical data processing

Significance level. Denoted as (α) and set at 0.5% equal to 0.05.

Instrument reliability and reliability analysis. The formula to calculate Cronbach's alpha is as follows:

$$\alpha = \left(\frac{k}{k-1}\right) \cdot \left(1 - \frac{\sum Vi}{Vt}\right) \tag{2}$$

The value obtained with Cronbach's alpha is 0.705 (acceptable). The set of variables measured a latent and unidimensional aspect of the individuals surveyed using the measurement instrument applied to ten variables and 68 subjects, based on the application of the questionnaire and the Likert scale (5). These values were determined using SPSS.V25. Statistical tests on the data. Samples from 68 subjects were analysed based on the research instrument.

Hypothesis testing. A parametric test called Student's t-test was performed with a significance level of 5% = 0.05, where all p-values were less than 0.05, thus rejecting the null hypothesis H0 and accepting the research hypothesis H1.

The one-sample Student's t-test was conducted to determine if the means of the evaluated variables are significantly different from the reference value, which in this case is 3. This reference value was chosen because it represents a neutral point on the Likert scale used in the questionnaire.

Table 2 One-Sample Student's T-test

	Test Value = 3					
	t	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
AMI	26.816	67	0	1.60294	1.4836	1.7223
CA	17.263	67	0	1.41176	1.2485	1.575
WUS	15.736	67	0	1.25	1.0914	1.4086
IAPH	9.881	67	0	1.04412	0.8332	1.255
IS	13.014	67	0	1.20588	1.0209	1.3908
PDA	6.726	67	0	0.86765	0.6102	1.1251
UMI	6.669	67	0	0.85294	0.5977	1.1082
ICPC	12.033	67	0	1.10294	0.92	1.2859
IP	5.951	67	0	0.79412	0.5278	1.0605
SAM	20.346	67	0	1.60294	1.4457	1.7602

According to Table 2, all t values are positive and high, indicating that the means of all variables are significantly greater than 3. The p values (Sig. (2-tailed)) are all 0.000, confirming that the observed differences are statistically significant. The confidence intervals do not include the reference value (3) in any case, reinforcing the significance of the differences. Since all p values are less than 0.05, the null hypothesis (H0) is rejected, and the research hypothesis (H1) is accepted for all variables. This suggests that the perceptions and attitudes of the respondents towards the evaluated variables are significantly positive, as the means of all variables are higher than the neutral point of 3 on the Likert scale used.

Frequency and percentage calculation. The conclusions of the analysis of the ten analysed variables were compared with the relevance that each subject assigned to the questionnaire responses to be objectified and measured according to the research purposes, as can be seen in Tables 3, 4 and 5.

Table 3 Frequency analysis

	Access to Medical Information	Cost of the Application	Willingness to Use the System	Immediate Access to Prescription History	Information Security	Preference for Digital Access	Update of Medical Information	Importance of Cross-Platform Compatibility	Information Privacy	Security Against Modifications	Total
1 Irrelevant	0	0	0	0	1	4	2	1	3	0	11
2 Slightly relevant	0	0	0	0	1	2	7	1	7	0	18
3 Moderately relevant	0	7	8	24	5	13	10	7	10	6	90
4 Very relevant	27	26	35	17	37	29	29	40	29	15	284
5 Totally relevant	41	35	25	27	24	20	20	19	19	47	277
Total	68	68	68	68	68	68	68	68	68	68	680

Table 4 Percentage analysis

	Access to Medical Information	Cost of the Application	Willingness to Use the System	Immediate Access to Prescription History	Information Security	Preference for Digital Access	Update of Medical Information	Importance of Cross-Platform Compatibility	Information Privacy	Security Against Modifications
1 Irrelevant	0%	0%	0%	0%	1%	4%	2%	1%	3%	0%
2 Slightly relevant	0%	0%	0%	0%	1%	2%	7%	1%	7%	0%
3 Moderately relevant	0%	7%	8%	25%	5%	14%	10%	7%	10%	6%
4 Very relevant	28%	27%	36%	18%	39%	30%	30%	42%	30%	16%
5 Totally relevant	43%	36%	26%	28%	25%	21%	21%	20%	20%	49%
Total	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%

Table 5 General frequency and percentage

Number on the scale	Description of the scale	Frequency of counted opinions	Total percentage	68 opinions given	10 questions to 68 subjects
1	Irrelevant	11	2%		
2	Slightly relevant	18	3%		
3	Moderately relevant	90	13%		
4	Very relevant	284	42%		
5	Totally relevant	277	41%		
	Total	680	100%		

The frequency and percentage analysis showed how the surveyed subjects expressed their opinions about the analysed variables. The values in the cells indicate how many subjects selected each level of relevance for each variable. The General Frequency and Percentage Table provides an overall summary of how many times each level of relevance was selected across the entire survey. The "Very relevant" level was selected 284 times, representing 42% of the total responses.

Calculation of descriptive statistics

Table 6 Descriptive statistic table and measures of central tendency

Statistics										
	AMI	CA	WUS	IAPH	IS	PDA	UMI	ICPC	IP	SAM
Mean	4.6	4.41	4.25	4.04	4.21	3.87	3.85	4.1	3.79	4.6
Median	5	5	4	4	4	4	4	4	4	5
Mode	5	5	4	5	4	4	4	4	4	5
Std. Deviation	0.49	0.67	0.65	0.87	0.76	1.06	1.05	0.76	1.1	0.65
Range	1	2	2	2	4	4	4	4	4	2
Minimum	4	3	3	3	1	1	1	1	1	3
Maximum	5	5	5	5	5	5	5	5	5	5

The analysis of the ten variables indicated that Access to Medical Information (V1), Cost of the Application (V2), Willingness to Use the System (V3), Immediate Access to Prescription History (V4), Information Security (V5), Importance of Cross-Platform Compatibility (V8), and Security Against Modifications (V10) obtained high average values on the Likert scale (4.60, 4.41, 4.25, 4.04, 4.21, 4.10, and 4.60 respectively), indicating their high relevance. The remaining variables showed average values, at a moderately relevant level. The median also reflected the importance of these variables, with high values indicative of their relevance. The standard deviations suggest moderate dispersion of the data around the mean.

Most opinions were in a mid to high range on the measurement scale, confirming the Access to Medical Information (AMI) in relation to the patients' willingness to use the system as long as the application cost is low or zero. In calculating these data, values ranged from Minimum (Irrelevant) to Maximum (Very relevant).

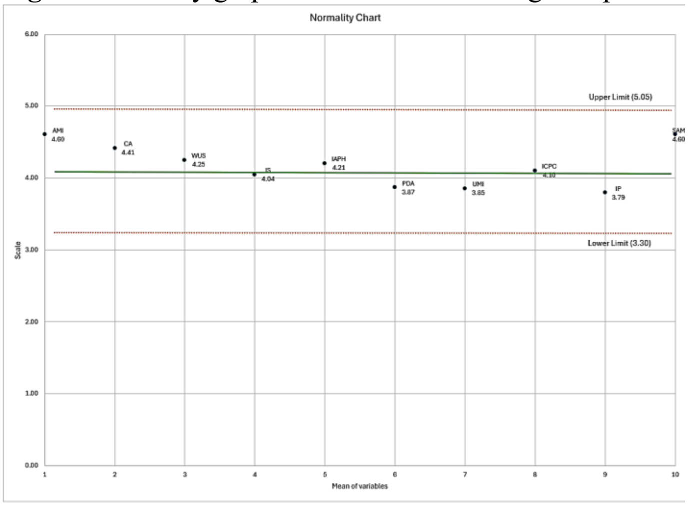
Data normality (Central Limit Theorem). For this statistical test, the averages obtained from the ten variables used in the study were considered.

Table 7 Table of variable averages

VARIABLE	AVERAGE
AMI	4.6
CA	4.41
WUS	4.25
IAPH	4.04
IS	4.21
PDA	3.87
UMI	3.85
ICPC	4.1
IP	3.79
SCS	4.6
Average of averages	4.17

From the above data, the normality graph was obtained, as shown in Fig. 1.

Fig. 1. Normality graph of the variable averages at plus/minus one sigma



According to the distribution of points, all variables were considered "normal." Additionally, variables V1, V2, V3, V5, V8, and V10 were identified as significant in relation to the proposed hypothesis.

Pearson correlation analysis

Table 8 Pearson correlation table

Correlations										
	AMI	CA	WUS	IAPH	IS	PDA	UMI	ICPC	IP	SAM
AMI	1									
CA	-0.219	1								
WUS	0.081	0.169	1							
IAPH	0.007	0.07	-0.15	1						
IS	-0.057	0.268	0.015	0.053	1					
PDA	-0.187	0.452	0.22	0.135	0.273	1				
UMI	-0.171	0.38	0.227	0.202	0.168	0.475	1			
ICPC	0.071	-0.055	0.219	0.152	0.092	0.296	0.15	1		
IP	-0.07	0.518	0.114	0.337	0.175	0.729	0.437	0.116	1	
SAM	-0.127	0.242	0.026	0.401	0.107	0.204	0.306	0.054	0.322	1

Interpretation of values from the correlation table

The Pearson analysis revealed positive correlations between the Cost of the Application (CA) and Patient Preference for Digital Access (PDA) with a correlation of ($r = 0.452$), as well as between the Cost of the Application (CA) and Concern for Information Privacy (IP) with a correlation of ($r = 0.518$). These results show that as the cost of the application decreases, patients are more inclined to adopt digital systems for accessing their prescriptions and medical records. Additionally, a lower cost is associated with a higher value placed on information privacy, indicating that patients seek not only economically accessible solutions but also secure and reliable ones.

The Pearson correlation of ($r = 0.401$) between Immediate Access to Prescription Histories (IAPH) and Security Against Modifications (SAM) indicates a moderate positive relationship. This suggests that improving immediate access to prescription histories also tends to enhance security against modifications.

The Pearson analysis revealed positive correlations between Preference for Digital Access (PDA) and two additional variables. First, a moderate positive correlation ($r = 0.475$) was found between Preference for Digital Access and Update of Medical Information (UMI). This suggests that patients who prefer digital access also value the timely updating of their medical information, indicating an expectation that the digital system will be efficient and keep the information current. Additionally, a strong positive correlation ($r = 0.729$) was observed between Preference for Digital Access (PDA) and Information Privacy (IP). This implies that patients who show a high preference for digital access also have a high concern for the privacy of their medical information. The strong correlation indicates that privacy is a critical factor for patients when considering the use of digital systems to manage their medical data.

The Pearson analysis showed a moderate positive correlation ($r = 0.437$) between Update of Medical Information (UMI) and Information Privacy (IP). This indicates that patients who value the constant updating of their medical information also tend to be concerned about the privacy of their data.

Factor analysis

Table 9 Principal component analysis table

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.064	30.641	30.641	3.064	30.641	30.641
2	1.344	13.439	44.081	1.344	13.439	44.081
3	1.247	12.465	56.546	1.247	12.465	56.546
4	0.946	9.46	66.006			
5	0.883	8.832	74.838			
6	0.794	7.941	82.778			
7	0.577	5.772	88.55			
8	0.498	4.979	93.529			
9	0.457	4.566	98.095			
10	0.19	1.905	100			

The table obtained from the Factor Analysis indicates that three factors with eigenvalues greater than 1 have been generated, according to Kaiser's criterion. These factors explain 56.546% of the total variance of the phenomenon indicated in this study. Despite the identification of three factors, the review suggests that only two can be considered as valid constructs for the final analysis.

Table 10 Factor component matrix of the study phenomenon indicating 3 factors

	Component		
	1	2	3
AMI	-0.253	0.231	0.565
CA	0.678	0.032	-0.423
WUS	0.265	0.712	0.107
IAPH	0.389	-0.592	0.525
IS	0.381	0.067	-0.174
PDA	0.817	0.226	-0.035
UMI	0.702	0.069	-0.013
ICPC	0.274	0.384	0.62
IP	0.822	-0.054	0.029
SAM	0.514	-0.471	0.21

After discrimination in the previous table, considering only factor loadings greater than 0.5, a table is presented that shows the arrangement of the three obtained factors, indicating the variables involved in each factor.

Table 11 Factor component table of the phenomenon using fact loading greater than 0.5.

Variable	Factor	Factor Loading
CA	1	0.678
PDA		0.817
UMI		0.702
IP		0.822
SAM		0.514
WUS	2	0.712
AMI	3	0.565
IS		0.525
ICPC		0.62

The constructs (hypotheses) generated are as follows

Construct 1: Factor 1 reflects the acceptance and positive perception of a digital system for managing medical information, based on five key variables: Cost of the Application (CA), Preference for Digital Access (PDA), Update of Medical Information (UMI), Information Privacy (IP), and Security Against Modifications (SAM). A low or zero cost increases patients' willingness to use the system. The preference for digital access is based on ease of use and convenience. Constant updating of medical information is crucial for effectiveness. Privacy and security against modifications are essential for patient trust. These variables reinforce each other, driving the acceptance of the digital system.

Construct 2: Factor 3 reflects the acceptance of a digital system for managing medical information, based on three key variables: Access to Medical Information (AMI), Information Security (IS), and Cross-Platform Compatibility (ICPC). Access to medical information ensures that patients and professionals obtain relevant data in a timely manner. Information security protects the privacy and integrity of data, preventing unauthorized access and modifications. Cross-platform compatibility ensures that the system works on various devices and operating systems, increasing its accessibility. These variables are interrelated, as a secure and compatible system facilitates access to medical information, reinforcing trust in its use and creating a robust and reliable digital system.

Although the factor analysis suggested a second factor with an eigenvalue greater than 1, only one variable (WUS: Willingness to Use the System) has a significant factor loading (0.712). The second variable (Importance of Cross-Platform Compatibility) has a factor loading (0.384), which does not meet the minimum threshold to be considered in a robust construct. As observed, the underlying constructs obtained (factors) have a consistent relationship and confirm the initial hypothesis of this study.

DISCUSSION

The results of this study provide valuable evidence on the feasibility of implementing a computational system based on blockchain technology in the management of medical prescriptions. The positive perception of patients towards security and access to information reinforces the need to consider this solution in the healthcare sector. The findings are consistent with previous studies that have highlighted the benefits of secure and accessible technologies in terms of efficiency and data protection (Gupta, 2018; Holbrook, 2020).

Factor analysis identified two main constructs, suggesting that patients' perceptions are grouped around technological integration and information security. This indicates that any future implementation of a computational system based on blockchain technology in the healthcare sector should focus on these aspects to maximize acceptance and effectiveness.

The main limitation of the study is the sample size and the 10% margin of error, which, although justified, could have influenced the precision of the results. However, the findings provide a solid basis for future studies that can use larger samples and lower margins of error to validate and expand these results. It is recommended that future research continues to explore this field, considering the limitations and strengths identified in this study.

CONCLUSIONS

The study on the integration of a computational system based on blockchain technology for the management of medical prescriptions in Monclova, Coahuila, from the patients' perspective, generated important information. The implementation of this system is perceived as a viable solution that improves information security and access to prescriptions and medical records, as long as the application cost is low or zero. The empirical data obtained through surveys and analysed with various statistical techniques support the hypothesis that a secure computational system can effectively address the current problems in the management of medical prescriptions. Variables related to security, information updating, and cross-platform compatibility stood out as key factors.

Statistical tests, such as the Student's t-test and Pearson correlation analysis, confirmed that patients' perceptions of the evaluated variables are significantly positive. Additionally, factor analysis identified two main constructs underlying these perceptions: one related to technological integration in medical information management and another with data security and accessibility. These constructs are consistent and confirm the initial hypothesis of the study.

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