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Expert systems in mental health: innovative approach for personalized treatment

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ABSTRACT

Custom classification of mental illnesses has emerged as a challenge for mental health specialists, often minimized by patients' lack of awareness of symptoms and the importance of early intervention. Therefore, the purpose of this research is to provide a comprehensive understanding of personalized treatment, encompassing both pharmacological and non-pharmacological options, specifically tailored to mental disorders, considering factors such as the patient's age and gender, among other relevant characteristics. In this context, the Buchanan methodology has been chosen as the framework for structuring a web-based expert system. This approach covers everything from problem identification to system implementation and subsequent evaluation. The survey results, with a total of 50 responses, reveal that the category "Good" leads with 70%, closely followed by "Fair" and "Poor," both at 14%. 71.4% of responses reflect a positive evaluation, with 85.7% combining "Good" or "Fair" responses, and all categories reaching 100%. These results support the feasibility and effectiveness of implementing a web-based expert system under the Buchanan methodology. A positive response in the survey suggests that this methodology can significantly contribute to personalizing and recommending appropriate treatments, both pharmacological and non-pharmacological, thereby benefiting a broad spectrum of patients with mental disorders.

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1. INTRODUCTION

The search for effective and personalized therapeutic strategies has become an imperative challenge. With the increasing burden of mental disorders in people's daily lives, the need for tailored and efficient pharmacological treatments has become more pressing than ever. This international context reflects the complexity and diversity of the challenges faced by communities worldwide in terms of mental health [1]. In the pediatric population, disorders such as attention deficit hyperactivity disorder (ADHD), childhood anxiety, and youth depression raise substantial concerns. Early identification and appropriate intervention are crucial to mitigate the long-term impact of these conditions on children's emotional and cognitive development. Adults, on the other hand, face a range of mental challenges spanning from anxiety and depression disorders to more chronic conditions like schizophrenia. The global burden of depression and anxiety has led to a critical review of existing pharmacological strategies and the need for customization to optimize outcomes [2], [3]. In the elderly population, dementia, with Alzheimer's disease at the forefront, poses a significant challenge. As the global population ages, understanding how to adapt pharmacological interventions to address these conditions becomes crucial not only for the quality of life of older individuals but also to alleviate the economic and healthcare burden on societies [4]. Personalizing healthcare, especially in the field of mental health, highlights the need to critically evaluate the effectiveness of current pharmacological treatments. This study, focusing on age and gender adaptation, is part of the global quest for more precise and culturally sensitive therapeutic practices, with the aspiration to enhance mental healthcare internationally. Understanding the peculiarities of these illnesses at different life stages and in diverse cultural contexts is revealed as essential for advancing more inclusive and effective therapeutic strategies worldwide [5], [6].

The study on the effectiveness of pharmacological treatments in managing mental health, with special attention to customization based on age and gender, emerges as indispensable and appropriate in the current global health context. The increasing burden of mental disorders, affecting all life stages, demands more tailored and efficient therapeutic strategies. The need to address specific disorders in the pediatric population, where conditions such as ADHD, anxiety, and youth depression have long-term consequences, underscores the urgency of pharmacological interventions specifically designed for this life stage [7], [8]. In adults, the diversity of mental challenges, from common disorders like anxiety and depression to more complex conditions like schizophrenia, emphasizes the importance of critically reviewing existing pharmacological strategies and exploring more personalized approaches to optimize therapeutic outcomes [9]. The elderly population, with the significant challenge of dementia and Alzheimer's disease, necessitates pharmacological interventions tailored to the complexities of global aging, aiming to elevate well-being and alleviate economic and healthcare burdens. The international trend toward personalizing mental healthcare underscores the importance of critically evaluating the effectiveness of current pharmacological treatments, considering individual differences based on age and gender. This research will not only contribute to filling a knowledge gap but also aims to provide valuable insights for predicting more inclusive and effective therapeutic practices, thus responding to the pressing demands of mental health in contemporary society [10], [11].

The objective of this study is to analyze the effectiveness of pharmacological treatments currently employed in treating mental health problems, personalizing recommendations based on each patient's age and gender by consolidating information into a web-based expert system. A comprehensive analysis of clinical studies and systematic reviews will be conducted to provide a comprehensive overview of available pharmacological options. This examination will include an assessment of therapeutic benefits, possible side effects, and suggestions for optimal patient management, thereby generating added value by considering complementary treatments to the therapeutic approach.

2. LITERATURE REVIEW

Literature review plays a pivotal role in understanding and contextualizing a specific topic, providing a solid foundation for current research. In this section, the consolidation of ten research studies from various information sources, addressing the proposed topic comprehensively, is presented. These selected studies have been meticulously examined to offer an exhaustive view of trends, findings, and key debates in the field. The diversity of perspectives and approaches present in this review aims not only to highlight the breadth of existing knowledge but also to identify possible gaps or areas of controversy that will motivate and guide further research.

Research on mental disorders in children with autistic mental retardation has undergone significant variations over time due to lack of knowledge and specialists in the field. The study aims to develop an expert system for diagnosing early symptoms in children with mental disorders, covering the specialties of pediatrics and psychology. The system's implementation is based on the direct chaining method, which follows rules to predict symptoms and types of disturbances. Usability test findings suggest that the system facilitates community access to treatment information and identification of the type of mental disorder, with an 86% rating in the "very good" category. Initially, tests scored 81% in "very good" and 20% errors, but these were refined over the system's construction time [12], [13]. On the other hand, another case concerning autism detected in children from infancy characterized by abnormal behavior, for this research, a review was conducted on the ability of expert systems to diagnose autism oriented to mobile and web applications. For this purpose, the existing evaluation technique was used using augmented reality; however, most expert systems were designed specially to diagnose the disease in children and very few in adults. The results indicate that these systems have certain limitations, so it is necessary to implement improvements to detect such a diagnosis [14]. In another context, the application of diagnosis of hereditary metabolic diseases was carried out, with special emphasis on mental pathologies. For this purpose, databases were used to collect information from experts in the field, and then determine specific age categories and groups of children applicable to expert systems. The results indicated that the algorithm used in the model managed to diagnose certain hypotheses posed, thus demonstrating an effectiveness of 90% in a control sample composed of 20 randomly selected patients [15], [16]. The combination of tools such as SWI-Prolog and the Java programming language has enabled the consolidation of information into an expert system, focusing on mental disorders such as anxiety. The implementation of an easy-to-use expert system for anxiety diagnosis and treatment has facilitated psychiatric doctors' decision-making in personalized treatments. The application of methods, such as the use of rule-based concept maps, has contributed to diagnosing and treating the disease effectively. In conclusion, the expert system has demonstrated positive aspects suggesting potential for future research in this field [17].

Another relevant case addressed the diagnosis of depression, a condition often mistakenly confused with other mental disorders, which can have catastrophic consequences, even leading to patient suicide. To consolidate this system, the zSlices method was used, which allows extracting fuzzy rules from data collected in hospitals, and the Mendel method to extract business rules previously classified. Test results showed that the system was able to diagnose depression with gradually adjusted accuracy by experts, offering satisfactory performance in its clinical application [18]. The demand for people in e-health service has been affected by the growing influence of people seeking immediate attention. The application of technology has provided optimal short- and long-term solutions to mental health challenges. The research proposes the development of a chatbot based on expert systems to interact with patients and address mental issues. This system is based on the use of an expert system, showing a model accuracy of 98%, with 98% effectiveness in 92 interactions and an optimal response time of 0.016 seconds [19]. Bipolar disorder has generated notable morbidity and mortality in recent years, and the application of technology presents itself as a viable option to address this issue. With the aim of contributing to society, the implementation of an expert system that provides adaptive content and facilitates communication between the expert and the patient was proposed, specifically applied to smartphones for effective disease treatment. The method employed consisted of gathering information about bipolar disorder by consulting experts in the field, using this knowledge to consolidate the system. The results obtained include the application of sleep duration, personalized medication tracking for each patient, and management of specific symptoms and signs during the illness. This approach allows offering personalized treatments according to each patient's individual symptoms [20], [21]. Lifestyle modifications can impact psychological health, manifesting in depressive disorders that some people are unaware of having. To address this issue, the development of a web-based expert system for early diagnosis of depression is proposed. The Delphi methodology and the Java Expert System tool were used to build the knowledge base, considering body weight and key characteristics of the disease.

Additionally, fuzzy logic was adopted to calculate the level of depression. Sensitivity and specificity analyses were performed with the participation of 238 individuals. The proposed system demonstrates usefulness for both the general public and specialists in medical environments, and may be beneficial for psychology students' diagnostic reasoning training [22]. Mental disorder exerts a notable influence on people's lives, significantly affecting their behavior and causing suffering, which significantly impacts the brain. With the aim of addressing this issue, an expert system that employs belief rules through the fuzzy logic algorithm was implemented. The purpose of this system is to detect people's behavior through information provided by the patient. Evidential reasoning functions as the inference engine, and the belief rules base serves as the knowledge representation scheme in this belief rule-based expert system (BRBES). The study demonstrates that the results generated by BRBES are more reliable compared to an expert system based solely on fuzzy rules and decisions of a human expert [23], [24]. In the study focused on the diagnosis of schizophrenia, a complex mental disorder, it was decided to develop an expert system based on artificial intelligence for early detection of the disease. The implementation of this system involved the use of methods to manage knowledge, divided into four stages: acquisition, organization, computer-assisted model development, and system performance evaluation, provided by an expert in the specialty. Performance evaluation compared diagnoses of 38 clinical cases between an expert and the schizophrenia spectrum disorder (SADDESQ). Results revealed a relatively low rate of misclassification (18-34%) and good performance of SADDESQ in diagnosing schizophrenia, with an accuracy of 66-82%. This accuracy was even higher when considering schizophreniform disorder as the presence of schizophrenia. Although these results are preliminary, SADDESQ has demonstrated satisfactory performance, requiring further evaluation in a clinical setting [25].

Upon completion of the comprehensive review of various sources on the diagnosis and treatment of mental disorders, such as autistic mental retardation, anxiety, depression, bipolar disorder, and schizophrenia, valuable insights into the applicability of expert systems in this context have been obtained. However, substantial gaps and limitations are identified in this field. The urgent need for standardization in methods and approaches, the lack of comprehensive approaches to address long-term treatment and follow-up, the lack of solid clinical data, and limitations in research diversity constitute crucial aspects demanding priority attention to improve the effectiveness and applicability of mental disorders. These identified gaps not only underscore the current complexity in research but also provide significant opportunities for future research and improvements in the development of expert systems, with the aim of recommending personalized treatments tailored to each patient's unique symptomatology.

3. METHOD

3.1. Definition of the Buchanan methodology

The Buchanan methodology incorporates elements of the waterfall lifecycle, which implies constant review of the expert web system throughout its development. Additionally, it is distinguished by knowledge acquisition through collaboration between an expert in specific fields of science and the engineer responsible for consolidating and building the expert system model, following the principles of the methodology [26], [27]. This approach favors continuous iteration between development phases, allowing adjustments and improvements as the construction of the expert system progresses [28]. In the consolidation of an expert system through this method as shown in Figure 1, constant review of each developed process is carried out. Its main advantage lies in the ability to easily redefine previously established concepts, facilitating error correction or incorporation of add-ons to the implemented expert system.

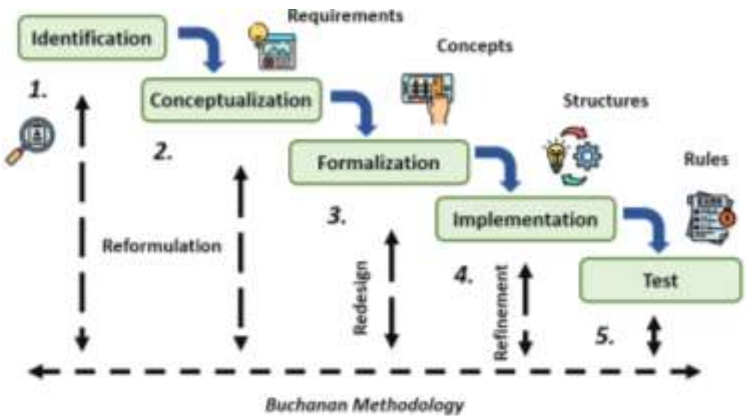

Figure 1. Buchanan methodology process

3.2. Buchanan methodology processes

In this section, the meticulous development of each process was carried out according to the Buchanan methodology for implementing the expert system. Every phase, from identification and conceptualization to knowledge formalization, has been approached with precision and attention to detail. This systematic approach has allowed for the solid and coherent construction of an expert system specifically tailored to the field of mental health.

3.2.1. Identification

This phase, a detailed conceptualization of the problem under study is carried out, addressing key aspects involving various individuals, such as the domain expert, the knowledge engineer, and the future users. The goal is to thoroughly understand their roles, needs, and expectations regarding the project, enabling a clear and comprehensive vision of the human and functional elements that will impact its development [29]. Additionally, the specified characteristics are outlined to determine the direction of the research according to the defined objective.

A. Problem

The central problem lies in the lack of a personalized approach to treatments, leading to the emergence of unwanted side effects. In different geographical regions, the shortage of specialists in mental illnesses exacerbates the situation, creating significant complications in the management of each mental disorder. This lack of specialized attention represents a prevalent risk, with the potential to trigger serious, even fatal, consequences if personalized and adequate treatment is not implemented. The need to address this issue becomes important to ensure the mental health of patients and mitigate the risks associated with the lack of specialized attention.

B. Solution

In response to the presented problem, the implementation of a web-based expert system is proposed. This system will utilize the description of the patient's symptoms as input data, considering specific parameters such as age and gender. The purpose will be to predict the present mental disorder and determine personalized treatment as output data. This solution aims to streamline decision-making, allowing for quick and effective precautions to prevent tragic situations for the patient. The application of this tool will contribute to a more prompt and tailored attention to individual needs, thereby improving the quality of life for patients with mental disorders.

C. Familiarization with the problem

To familiarize ourselves with the problem, we sought the support of experts in psychiatry and neurology through interviews, aiming to extract crucial information for the development of the expert web system. Additionally, we consulted sources such as books and scientific journals. Furthermore, we conducted interviews with patients affected by these disorders to delve deeper and gain a broader understanding of the issue at hand. This approach allowed us to gather valuable and varied data, merging specialized knowledge and direct experiences, to enrich the design and functionality of the system.

D. Structure

The web-based expert system will offer smooth and user-friendly interaction. When a patient experiences symptoms related to mental illnesses, they can provide a detailed description to establish the relationship between the symptoms and the potential illness. As a result, the system will generate output data that will include a specific treatment and additional recommendations, as well as suggest further guidelines beyond the prescribed treatment. This approach aims to provide the patient with comprehensive guidance to address their situation in an informed and personalized manner.

3.2.2. Conceptualization

To achieve knowledge acquisition for the expert system, information provided by the subject matter expert was gathered, leveraging their direct expertise on the topic. Additionally, information from the mental health expert will be collected and stored in a database, taking into account important characteristics to determine the type of illness [30]. Predictions can be made through questionnaires based on the patient's symptoms, facilitating the detection of any mental illness that may be present and providing personalized recommendations and treatments for each patient, as specified in Figure 2.

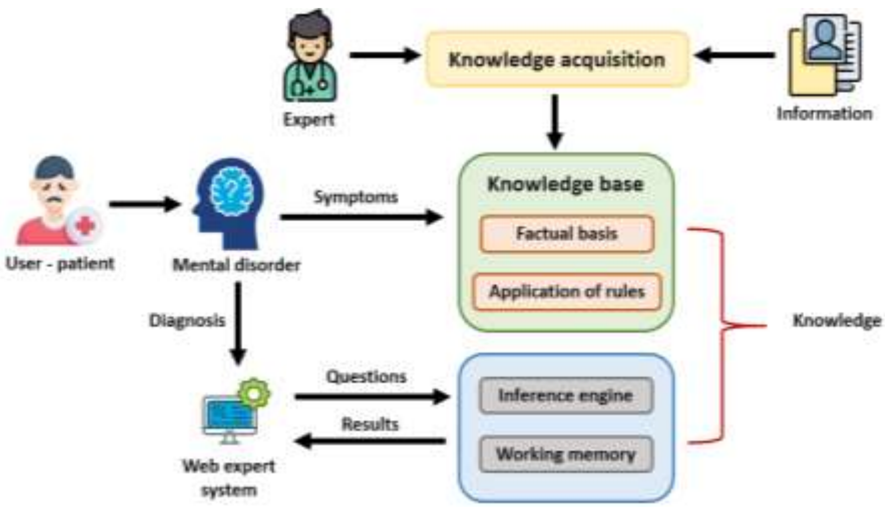

Figure 2. Web expert system operation

3.2.3. Formalization

During the knowledge formalization phase, the task of consolidating the designed database was undertaken, giving rise to a structured set of rules. These rules were meticulously crafted to establish relationships between each mental illness and its associated symptoms. The primary purpose of this formalization was to enable the expert system to process information coherently and, based on the presented symptoms, provide relevant and specific outputs [31], [32]. In this process, not only direct connections between symptoms and illnesses were considered, but also potential interrelationships and variability in the presentation of mental disorders, as mentioned in Figure 3. Additionally, Table 1 presents the description of some mental illnesses, organized according to the aforementioned classification.

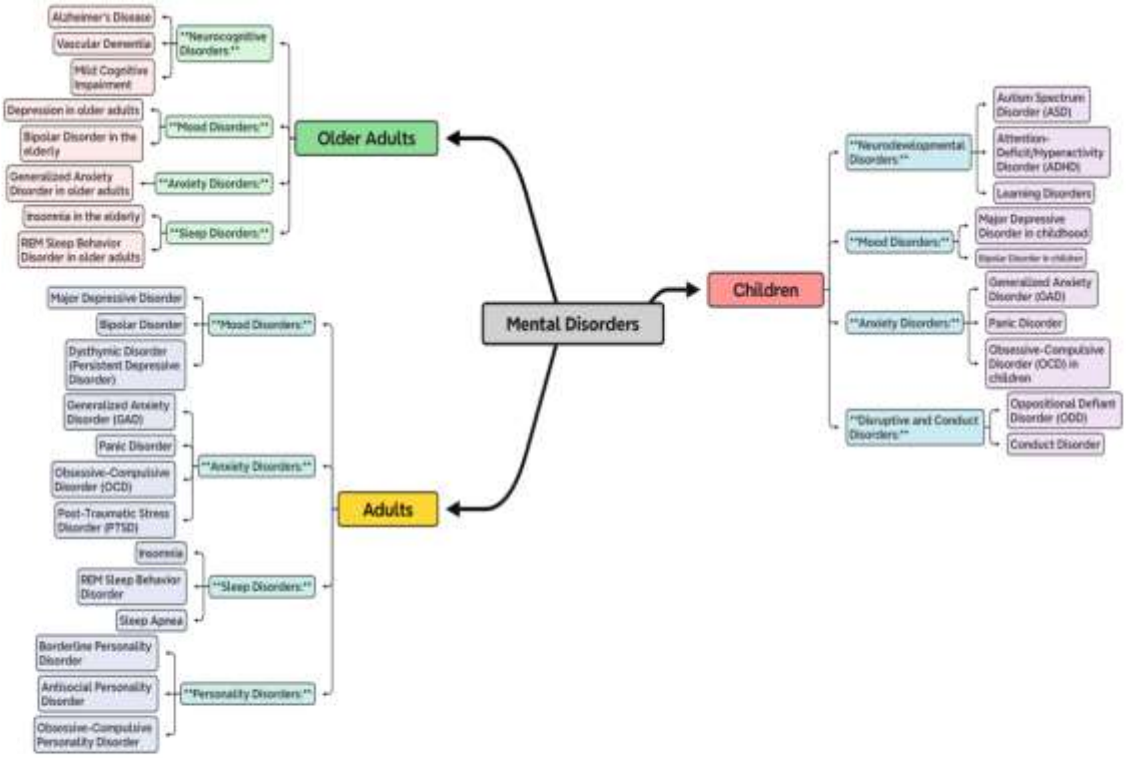

Figure 3. Classification of diseases according to age

Table 1. Description of mental disorders

	Some mental disorders	
Category	Disorder	Description
Neurodevelopmental disorder	Autism spectrum disorder	A condition characterized by challenges in social interaction, communication, and repetitive behaviors.
	ADHD	It involves persistent patterns of inattention, hyperactivity, and impulsivity.
	Learning disorders	Difficulties in acquiring academic skills such as reading, writing or mathematics.
Mood disorders	Major depressive disorder in childhood	Episodes of intense and persistent sadness.
	Bipolar disorder in children	Alternating periods of depression and mania.
		Anxiety disorders.
Anxiety disorders	Persistent anxiety disorder (PAD)	Excessive worry and anxiety about various aspects of life.
	Panic disorder	Sudden and intense episodes of fear.
	Compulsive obesity disorder (OCD) Identified in children	Intrusive thoughts and repetitive behaviors.

A. Rules using SWI-PROLOG

The creation of rules is a fundamental process in the development of an expert system, where features such as symptoms and age are incorporated as input variables. Each variable is associated with a specific illness, allowing the expert system to consider multiple aspects when making inferences. The importance of the inference engine lies in its ability to apply these rules and deduce conclusions. This engine is essential for the effective identification and combination of associated rules, leading to a conclusion that represents the output of the expert system [33]. In Figure 4, the representation of symptoms associated with each illness using SWI-PROLOG code is presented, demonstrating the orientation towards its implementation in a web-based expert system. This approach aims to facilitate interaction with users and provide precise responses based on the combination of key variables, such as symptoms and age, for a more comprehensive and accurate assessment of possible illnesses.

```
% Neurodevelopmental Disorders in Children
has_symptom(autism, lack_of_social_interaction).
has_symptom(autism, communication_difficulties).
has_symptom(autism, repetitive_behaviors).

has_symptom(adhd, attention_difficulties).
has_symptom(adhd, hyperactivity).
has_symptom(adhd, impulsivity).

% Mood Disorders in Adults
has_symptom(depression, deep_sadness).
has_symptom(depression, lack_of_energy).
has_symptom(depression, sleep_changes).
```

Figure 4. Association rules in mental illnesses

3.2.4. Implementation

During the implementation phase, the elaboration of a flowchart following specific business logic is carried out to guide the system's development. To conduct this process, the SWI-PROLOG tool is employed, leveraging its capabilities for creating rules and logical relationships. The construction of questions and answers is an essential part of this process as it contributes to the system's interactivity. SWI-PROLOG is used to model and manage these interactions, defining rules that respond to different situations and queries that patient may have [34], [35].

A. Selective linear defined algorithm

This algorithm fundamentally presents the capacity of logic programming, meaning it allows us to make queries and find solutions through the unification and resolution of clauses. Prolog programming based on the selective linear definite (SLD) algorithm is defined as logic programs performed by Horn clauses according to facts and business rules, where the algorithm is oriented to traverse a search tree top-down, left to right, until a possible solution is found for the given query or until a cutoff condition is reached.

B. A Horn clause

Horn clauses are a type of sophisticated logical rule expression in first-order logic. They are intended for use in inference systems, p being a notable example of a programming language that can benefit from them. They are distinguished by the presence of a single positive literal in the "head" of the sentence, which makes them univalent and lends itself to their application in encoding rules and facts in logic programming environments as mentioned in (1).

$$H \longleftarrow B_1, B_2, \ldots, B_n \quad (1)$$

Where:

- H is the "head" of the clause, which is a positive inico literal (atom).
- $B_1, B_2, \ldots, B_n$ are the "bodies" of the clause, which are literal (atoms), positive and negative.

In practical terms, these clauses are interpreted as "if $B_1, B_2, \ldots, B_n$ then H". It is important to note that in a Horn clause, there can only be one positive literal on the left side (head), which makes it "univalent", an example of how this algorithm works is shown below:

Padre (juan, pedro).
Padre (pedro, maria).
Abuelo (X, Y): - padre (X, Z), padre (Z, Y).

In Figure 5, a diagram detailing the activities the patient performs when accessing the system and undergoing the process of diagnosing mental disorders is presented. This diagram meticulously describes each activity, highlighting the function of each component of the expert web system. The flow starts with the patient's entry into the system and extends to the conclusion of the process, applying conditionals to validate specific constraints throughout the interaction. From the initial phase, which could involve patient registration and data collection, to the final stage that includes generating results and recommendations, conditionals are implemented to ensure the validity and coherence of the diagnostic process.

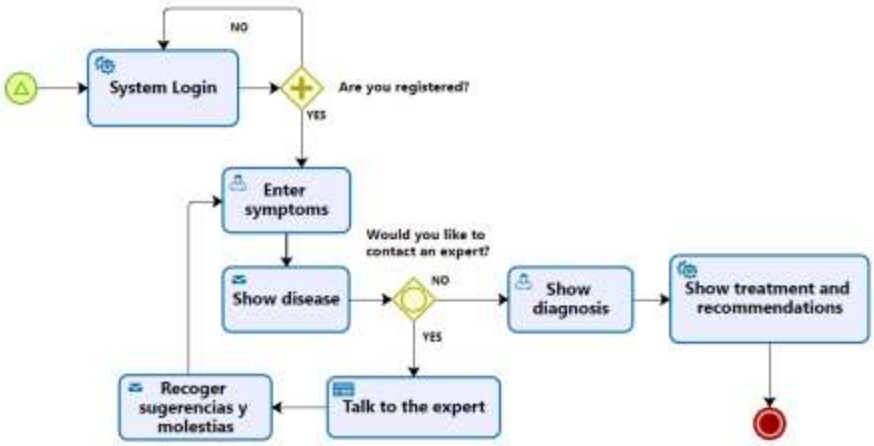

Figure 5. Flowchart for system development

4. RESULTS AND DISCUSSION

4.1. About prototypes

In this section, the prototype of the expert web system is presented. Figure 6 illustrates the login screen, where the patient must enter a username and password or register beforehand. In Figure 7, the collection of patient information and symptoms is carried out. Figure 8 presents the description of the disease predicted by the system. Finally, Figure 9 details the treatment, recommendations, and the added value of a personalized approach, both non-pharmacological and pharmacological.

The final graphical interface, which allows visualization of the personalized treatment from the system, was evaluated by experts in neurological diseases. These specialists considered specific characteristics when evaluating each symptom. Through comparative studies based on the collected information, symptoms are associated with particular diseases, facilitating the establishment of a specific treatment for each patient. The accuracy and reliability of the results will depend on the judgment of the expert physician responsible for the evaluation.

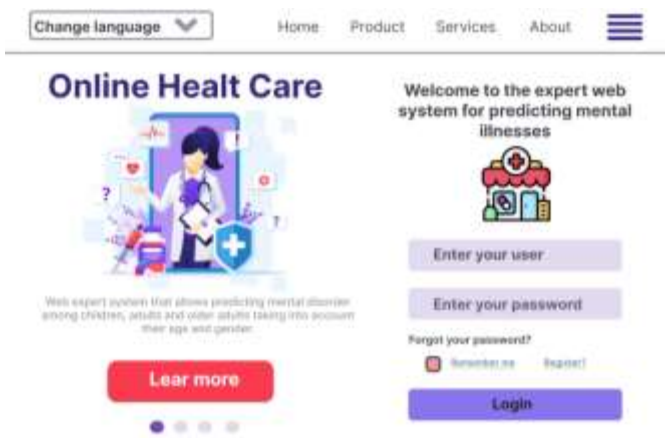

Figure 6. System login

4.2. System tests

In the final phase of this process, a comprehensive evaluation of the system was conducted, considering various characteristics for its validation. This critical analysis was essential to ensure the reliability and effectiveness of the developed expert system [36]. The evaluation focused on key aspects, such as accuracy in identifying mental illnesses, consistency in generating recommendations, and the system's ability to adapt to various clinical scenarios, as shown in Table 2 applying important attributes for validating the system's operation.

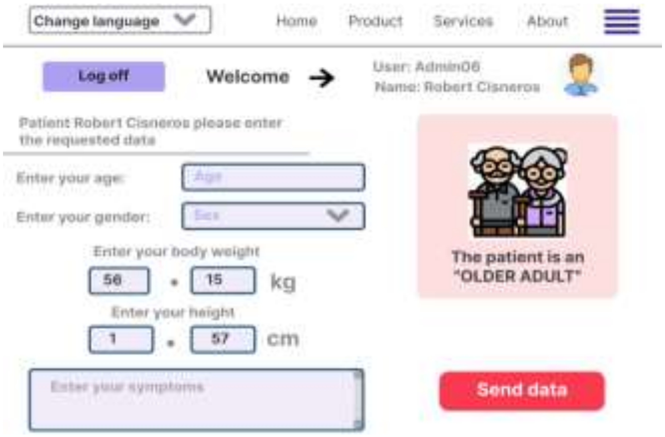

Figure 7. Entry of patient data and symptoms

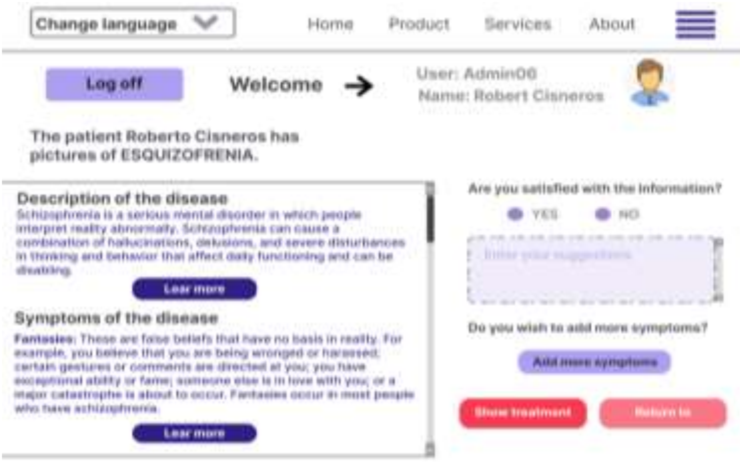

Figure 8. Mental disorder information

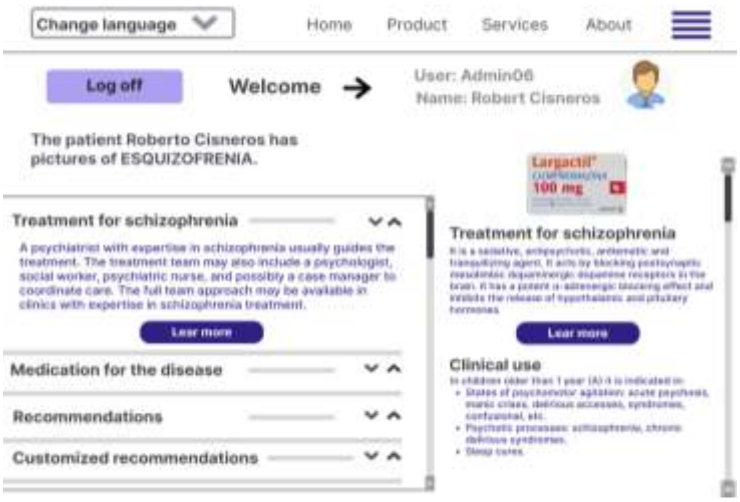

Figure 9. Personalized treatment

4.3. About the survey

Table 3 presents a grid with questions designed to validate the system, distributed across three dimensions, each comprising 5 questions. The first-dimension addresses aspects related to design, the second focuses on functionality, and the third emphasizes security. To carry out the system validation, a survey was conducted following the questions established within each of these dimensions.

Based on the questions formulated in the questionnaire, surveys were conducted with the aim of constructing variables and subsequently carrying out a descriptive analysis of each of them. Table 4 provides a representation of the mean of a dataset overall, offering an interpretation of each measure of central tendency. In Table 5, the mean is presented according to the responses established in the survey, presented in a grouped format detailing the corresponding frequencies and percentages. Finally, Table 6 outlines the calculation of each feature of the mean based on the three dimensions: design, functionality, and security.

Table 2. Description of mental disorders

NRO	Attributes quality	Non-functional requirements
RNF1	Hardware	Client - server architecture.
RNF2	Software	Use of technologies such as React Js, Php, Gith and Githud, Swi Prolog, Sql Server.
RNF3	Security	Queries with bookmarks to safeguard information in PHP, regular expressions and use of security methods in PHP.
RNF4	Security	Defense against possible attacks by malicious programs and detection of possible weak points in security.
RNF5	Confidentiality	Transactions at 95% confidentiality.
RNF6	Confidentiality	Failures are only 5% in transactions.
RNF7	Availability	Operation 24 hours a day.
RNF8	Scalability	Easy to make modifications to various components (version updates)
RNF9	Reusability	Ease of reuse of system components.
RNF10	Integration	It can be easily integrated with other components.

Table 3. Questionnaire for patients

Nro.	Questions
	Design
P-1	Is the user experience of the web expert system pleasant?
P-2	Are the system colors to your liking?
P-3	Is the information displayed adequate and accurate for your diagnosis and information?
P-4	Do you like the interaction of the system to display information?
P-5	Do you have any difficulty interacting with the system?
	Functionality
P-6	Are you having some problems logging into the system?
P-7	In error handling. Do you agree that the system allows error messages to be displayed?
P-8	For the result. Does the system show you the information, treatment and diagnosis correctly?
P-9	According to your opinion. Does the system show errors when adding symptoms to show the disease?
P-10	Do you agree to answer questions about showing the disease?
	Security
P-11	Do you feel safe registering your data in our system?
P-12	Have your registered username and password been the victim of data theft in our system?
P-13	Do you believe that the system meets rigorous security measures to protect your data?
P-14	Do you think the system's security measures should be improved?
P-15	Do you agree that the result of the prediction be supervised by a medical expert in the field?

Table 4. Statistical calculation of the general average

Statisticians General total average		
N	Valid	49
	Lost	1
Half		2.43
Median		2.00
Fashion		2
Dev. Deviation		.736
Variance		.542
Asymmetry		1.401
Skewness standard error		.340
Kurtosis		.393
Kurtosis standard error		.668
Sum		119
	25	2.00
Percentiles	50	2.00
	75	3.00

Table 5. Statistical calculation of the mean according to responses

		Average according to responses (grouped)			
		Frequency	Percentage	Valid percentage	Accumulated percentage
Valid	Well	35	70.0	71.4	71.4
	Regular	7	14.0	14.3	85.7
	Bad	7	14.0	14.3	100.0
	Total	49	98.0	100.0	
Lost	System	1	2.0		
Total		50	100.0		

Table 6. Statistical calculation of the mean by dimensions

		Calculation of the average according to dimensions		
		Design (D1)	Functionality (D2)	Security (D3)
N	Valid	50	49	50
	Lost	0	1	0
Half		1.8400	1.9510	1.9280
Median		1.6000	1.6000	1.6000
Fashion		1.40	1.40	1.60
Dev. deviation		.76772	.81806	.75998
Variance		.589	.669	.578
Asymmetry		1.334	.877	1.055
Skewness standard error		.337	.340	.337
Kurtosis		.636	-.557	-.015
Kurtosis standard error		.662	.668	.662
Sum		92.00	95.60	96.40
Percentiles	25	1.4000	1.4000	1.4000
	50	1.6000	1.6000	1.6000
	75	2.2500	2.6000	2.2000

4.4. Comparison of methodologies

Table 7 outlines the specific characteristics that distinguish the Buchanan methodology, which has been employed in our project. In subsequent stages, we will conduct a comparative evaluation with other widely used methodologies, such as RUP and Scrum. This comparative analysis will enable us to identify similarities, disparities, as well as potential strengths or weaknesses among the various methodologies, providing a comprehensive perspective of their approaches and applications in project development.

Table 7. Comparison of methodologies

Attribute comparison	Methodology Buchanan	Rup methodology	Srcum methodology
Focus	It is an approach that allows constant revisions to the extent that it allows certain concepts to be replaced [37].	RUP is a software development framework that follows an iterative and incremental approach. It is based on use cases and focuses on architecture [38].	Scrum is an agile framework that focuses on delivering software in short, regular increments. It is adaptable and flexible [39].
Lifecycle	It is based on the waterfall life cycle, so it is considered a constant review of the expert system.	RUP has predefined phases that include conception, design, construction and transition. Each phase has iterations.	Scrum has sprints, which are iterations of work that typically last 2 to 4 weeks. It is made up of events such as sprint planning, sprint review, and retrospective.
Functions and responsibilities	This section classifies the expert and the knowledge engineer who work hand in hand to consolidate the information and build the system.	Define clear roles, such as analysts, architects, and designers. Each role has specific responsibilities.	Three key roles: scrum leader, product owner and the development team. Encourages team collaboration and self-regulation.
Documentation	It is documented through stages that make up the methodology to consolidate the information obtained and take it to an expert system that can be an apk, web system, among others.	RUP emphasizes thorough documentation throughout all development phases.	Scrum values working software work over extensive documentation. Documentation is light and focused on the needs of the team.

5. DISCUSSION

The studies by Dairoh *et al.* [12] and Andrade *et al.* [13] differ in terms of research themes, but the implementation of expert systems shows similarities in the results, as both studies achieve percentage approval in specific tests. In contrast, the research by Adamu and Abdullahi [14], focused on a mobile expert system for diagnosing children with autism, differs from ours by focusing more on children and less on adults, unlike our system which covers all ages. Another study suggests the use of a database for diagnosing metabolic diseases, which differs from our focus on algorithm effectiveness, without focusing on patient opinion. Although the implementation of SWI-Prolog and Java tools coincides with the research by author [17] on anxiety, our research is more specific in evaluating statistics and patient satisfaction. Another coincidence is found in the implementation of expert systems for mental illnesses, but our research uses a single methodology compared to others that employ several. The results evaluated by Hsu and Lin [19] also coincide in percentage characteristics, highlighting the importance of patient opinion. The research by [20] and [21] on bipolar disorder relates acceptably, as both consider factors such as sleep duration and personalized medication, although in different contexts. The study by [22] shows similarities in the use of web technologies and expert systems, considering patient involvement in evaluation, albeit with different methodologies. The application of an expert system for diagnosing mental disorders, mentioned by Mulyana *et al.* [23], Putri *et al.* [24], coincides in certain stages with our research but differs in results. Regarding schizophrenia, the research by Afonin *et al.* [25] emphasizes treatment and uses a specific database, unlike our research that covers various diseases and focuses on predicting and recommending personalized treatments. Finally, we consider that the main strength of our research lies in the use of a rigorous methodology to consolidate the information obtained and build the model according to specific requirements. This allowed us to achieve consistency and accuracy in the results, thanks to each process developed in the methodology. In addition, the predictive approach and personalized recommendations for each patient addressing a variety of mental illnesses is a significant advance. However, this approach does not allow us to delve as deeply into other important aspects related to mental illness.

6. CONCLUSION

In conclusion, at the end of our research, it is evident that the stated objective has had a significant impact on the well-being of patients affected by mental disorders. The research not only meets the specifications of the proposed objective, addressing the issues identified at certain points of the study, but also contributes substantially to the awareness of patients, urging them to address early the manifestations of their disorders. The application of the Buchanan methodology has played a crucial role in structuring the implementation of the web expert system, facilitating the consolidation of each stage and ensuring quality information management. This approach has been essential to ensure that the resulting system is appropriate and beneficial to the target patient. The use of specific tools, such as programming languages for web systems and Swi-prolog for expert systems, has been essential to the successful implementation of the system. These components, together with other factors such as the application of robust methodologies, system architecture and expertise in consolidating information, have converged to create a coherent, quality system. The level of patient acceptance in using the system has been remarkable, thanks to the careful attention paid to crucial patient criteria such as design, functionality and safety. The quality of the system has remained strong, backed by extensive testing to ensure that it meets the specifications requested by patients. Our research findings indicate that a significant proportion of patients will benefit from faster care thanks to the expert system. This system compiles all the information experts provide to make accurate and personalized predictions for each patient, revolutionizing care for mental disorders and dramatically improving clinical outcomes. Despite the limitations present in the research, such as the need to reorganize certain stages within the methodology, these difficulties have served as valuable opportunities to refine considerable aspects and achieve a more precise process in the application of each phase. The experiences gathered will not only be fundamental to consolidate future projects but will also serve as a guide for other researchers. The combination of the concepts developed in our research with other technologies, such as the use of tools like Rapid Miner Studio and their adaptation to web or mobile environments to facilitate interaction with the user, and the incursion into the field of big data, offers interesting perspectives for tackling large-scale projects with significant volumes of information.

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