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PAPER

Artificial Intelligence for Detection, Control and Monitoring of Monkeypox Outbreaks Using a Mobile Application

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ABSTRACT

Monkeypox is a disease of zoonotic origin that reflects the connection between human, animal, and environmental health. It is transmitted primarily through direct contact with body fluids, skin lesions, or contaminated surfaces. Being of interest after the global outbreak of 2022, which recorded nearly 70,000 cases in more than 100 countries. This study presents a prototype mobile application that incorporates tools such as artificial intelligence (AI) for early detection and monitoring of the disease. The mobile-D methodology was used. The results were validated by experts and users, reaching an average of 85% in user satisfaction and 81% in expert evaluation, indicating a high level of acceptance. This application facilitates real-time data collection, improving communication between health authorities and the population, which is crucial for disease control. With the use of AI and data analysis, the application seeks to optimize case management and support health systems in at-risk areas, representing a significant advance in the response to monkeypox.

KEYWORDS

artificial intelligence (AI), chatbot, monkeypox, mobile applications

1 INTRODUCTION

Globally, public health is constantly challenged by the emergence and re-emergence of infectious diseases [1]. Largely zoonotic in origin, involving the interrelationship between human, animal, and environmental health [2]. In the context of diseases, we have COVID-19 as a clear example, and recent outbreaks, such as monkeypox, which have increased their incidence and exposed the weaknesses of epidemiological surveillance systems and rapid response to health emergencies, affecting both developed and developing countries [3]. According to the World Health Organization (WHO), monkeypox was first identified in 1958 in primate colonies, but it's spread in humans has been relatively rare until its recent global outbreak in 2022, with

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more than 70,000 cases reported in more than 100 countries [4]. This disease is transmitted mainly through direct contact with body fluids, skin lesions, or contaminated surfaces [5]. Early detection is crucial to control the spread of monkeypox. In a situation analysis, the Centers for Disease Control and Prevention (CDC) noted that effective monitoring and rapid identification of cases can significantly reduce transmission in affected communities [6]. However, many countries still face challenges in implementing efficient surveillance systems. In this context, mobile and artificial intelligence (AI)-enabled applications emerge as a viable solution to strengthen early detection systems for disease outbreaks such as monkeypox. These technologies enable real-time data collection, improve communication between health authorities and the population, and facilitate the use of tools such as telemedicine and AI for more agile diagnosis [7]. A WHO study (2021) indicated that countries that integrated real-time monitoring technologies from COVID-19 were able to reduce emergency response times by up to 40% [8]. Thus, the implementation of mobile applications can be an essential component in the overall strategy to mitigate the impact of future epidemics of monkeypox and other infectious diseases. As evidenced by the research work [9], which developed a mobile application to optimize diagnosis and interaction with specialists using platforms such as Azure Machine Learning Studio. The research adopted the RUP methodology, implementing various techniques, and was validated through expert surveys, obtaining 83.3% acceptance. In conclusion, the application was successfully developed, contributing significantly to the prevention of serious diseases and improving public health. Another example is the research [10], which developed the mobile application "BotCovid" in response to the misinformation about COVID-19 in Brazil, where the health crisis generated a growing need for accurate information. Its objective was to create a chatbot that will provide reliable answers, using a database of 600 questions selected from reputable sources. An evaluation was conducted with 52 users, and 20 of them were randomly selected to measure usability using the system usability scale, achieving an average score of 83.25%, indicating excellent usability. The results showed high satisfaction among users, improving their understanding of COVID-19. However, the article [11] describes "StopTheSpread," a mobile application created to increase public awareness of seasonal influenza transmission using CDC and WHO recommendations. This application employs a combination of network science and epidemiology principles, offering interactive games of increasing difficulty. Applied during quarantine by COVID-19 with volunteers recruited through social networks, the result revealed a 20% increase in knowledge about flu transmission among users. The findings support the effectiveness of the app as an awareness tool. Similarly, during the COVID-19 pandemic, the study [12] developed the "Corona Check" mobile application for early detection of infections, assessing symptoms and providing recommendations on possible infections. The application uses self-completed questionnaires to provide immediate feedback to users. Between April 2020 and October 2021, 51,323 evaluations were recorded from 35,118 users, with 70.6% sharing their geolocation. Although no significant variations in symptoms by country, age, or gender were observed, the tool helped ease the burden on care services and control the spread of the virus. In summary, the application proved to be effective in accessing vital information and collecting health data over time, improving the response to the health crisis. Following those models that helped to confront the global pandemic of COVID-19, the research [13] created an Android mobile application that uses deep learning to identify simian pox from images of skin lesions. Developed with Java and the Android 12 SDK, the application uses the Camera2 API for image capture. The convolutional neural network was trained using a publicly available dataset, achieving a classification accuracy of 91.11% in tests performed. This tool makes it easy for users to perform preliminary diagnostics. However, it does not allow a personalized interaction with the user; therefore, the purpose of this study is to develop a prototype mobile application with a chatbot using AI for the detection, control and monitoring of monkeypox outbreaks, called "ViroScan." It is being evaluated by both experts and users to improve the user experience. It also seeks to analyze the impact of this emerging technology to co-connect to the current disease outbreak situation, as well as its potential to complement or replace traditional methods in epidemiological surveillance. This paper is organized into four main sections: Section 1 is the introduction, followed by a detailed explanation of the methodology employed, covering key concepts, software design, and the definition of the target population in Section 2. Section 3 focuses on the application development process, highlighting its architecture and functionality. Finally, the results obtained are presented along with the conclusions of the study in Section 4.

2 METHODOLOGY

The mobile-D methodology is an agile framework oriented to the development of mobile applications that seeks to optimize the software creation process through fast and flexible cycles. This methodology is organized in five fundamental stages: exploration, initialization, production, stabilization, and system testing [14]. Each of these phases is designed to match user requirements and project objectives, ensuring an efficient and functional mobile product [15]. Being iterative, it allows changes to be made at any stage, which facilitates continuous feedback and improves the final product [16]. Figure 1 shows the phases described.

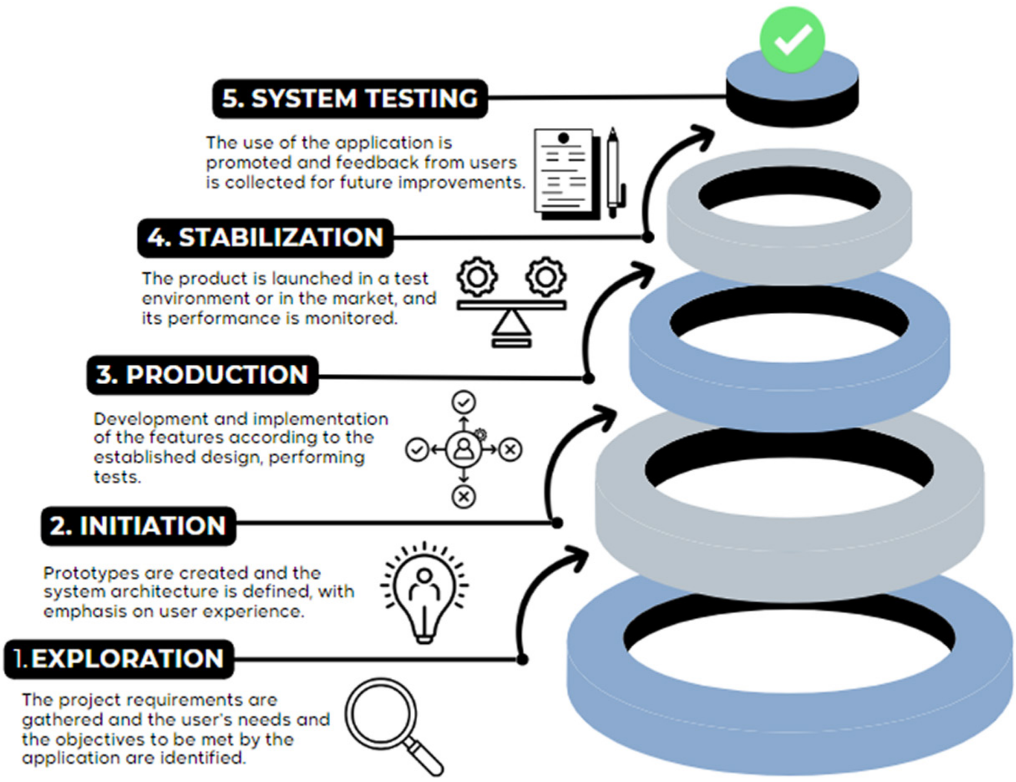

Fig. 1. Phases of the mobile-D methodology

2.1 Exploration

During this phase of the project, the overall plan and fundamental concepts are defined. Although this stage is somewhat distinct from the main production process and can be considered separate, it is essential not to overlook it. Stakeholder involvement is crucial in this phase.

Literature review: This is focused on the topic of interest, such as: What is monkeypox and how is it spread? [17], symptoms [18], and prevention [19].

Interview: Based on a survey of legal persons exposed to the virus. The list of questions related to epidemiological surveillance is shown in Table 1. Consequently, Figure 2 shows the Atlas as a tool for data analysis [20] of the functional requirements that the mobile application must have based on the answers to the survey conducted.

Table 1. Evaluation criteria

Thematic	Questions
1. Connectivity	How important is it for you to have a tool that allows you to access real-time information about your health status?
2. Alerta	How helpful would it be to receive immediate notifications about your health status?
3. Monitoreo	How relevant do you find it to have a tool that continuously records, analyzes, and tracks your symptoms?
4. Prevention	How important do you consider it to receive personalized recommendations to prevent health problems based on your medical history and habits?

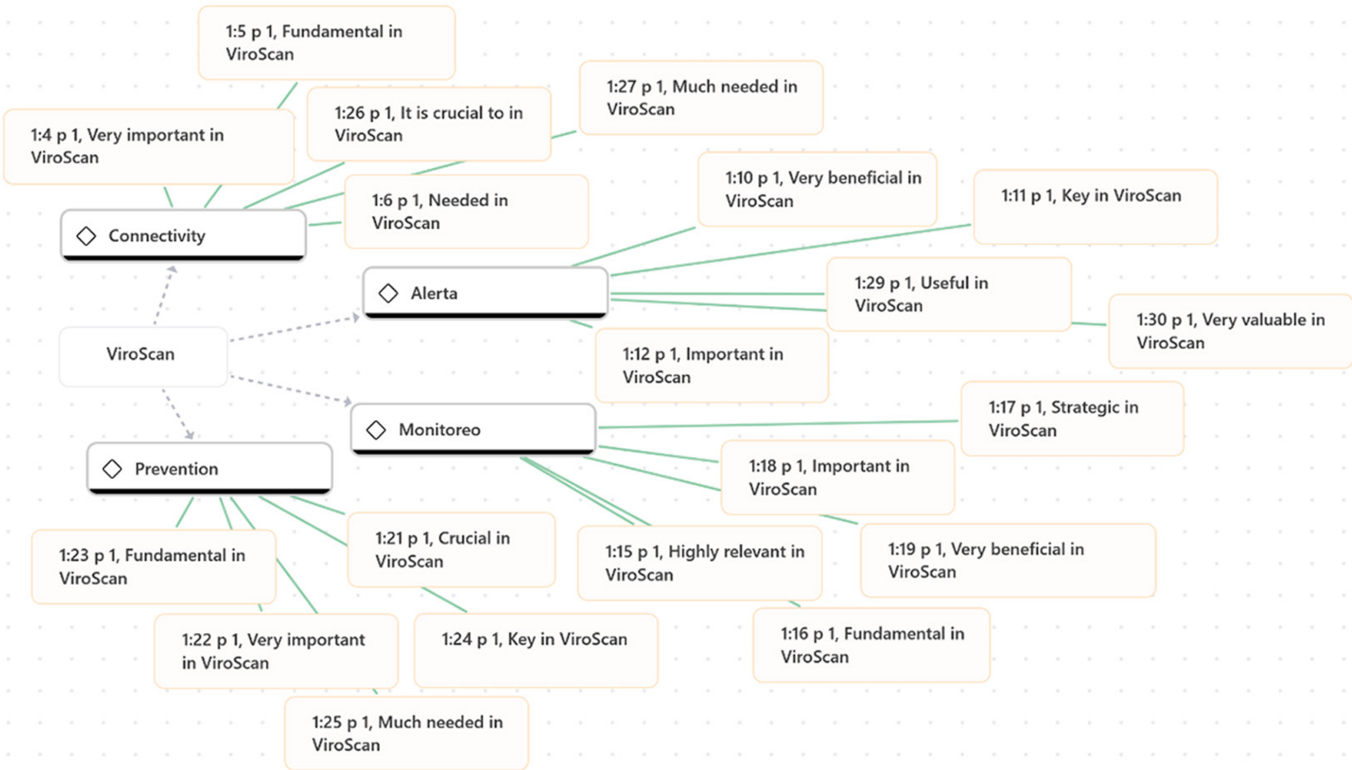

Fig. 2. Functional requirements to be met by the mobile application in Atlas ti

Finally, the results of the survey made it possible to define the needs. It was identified that people need continuous accompaniment by an assistant to provide immediate answers about the monkeypox disease situation. Considering that the target group will be:

Public health companies: Responsible for epidemiological surveillance.
Application users: People vulnerable to contracting the disease.
Developers: Researchers who collaborate in the creation of the project.

2.2 Initialization

In this initial phase, key technological resources, both hardware and software, are secured to ensure the viability of the project. The main aspects addressed are the following:

Hardware: Android and iOS operating systems will be used. Devices must meet the following minimum requirements, described in Table 2.

Table 2. Operating system requirements

Requirements	Features
Processor	More than 2 GHz capacity to run artificial intelligence algorithms without delays.
Memoria RAM	Minimum of 4 GB, allowing simultaneous execution of chatbot and other applications
Camera	High definition (minimum 12 MP) to capture clear images of skin lesions, facilitating preliminary analysis.
Cloud Servers	Scalable servers to ensure real-time processing, which is crucial for securely handling large volumes of data.
Connectivity	Low latency and high-speed network to enable fast chatbot responses, especially in areas with high epidemiological risk.

Software: An intelligent chatbot will be used to interact with users in a natural way and provide personalized recommendations. Key functionalities include: ability to maintain fluid dialogues, answering questions about symptoms, prevention recommendations, and real-time monitoring. The development platforms to be employed are listed in Table 3.

Table 3. Platforms to be used in the operating system

Platforms	Functionality
PostgreSQL	Database to manage complex and scalable data related to monkeypox monitoring.
Google Maps	Integrates maps and real-time location.
Meta	Focused on the creation of virtual and augmented reality.
JavaScript	Programming language for the development of web and mobile applications. It allows interaction with APIs and interactive functions.
Wasapi	Enables advanced audio processing and synthesis in web browsers.
ChatGpt	Language based on open AI.

2.3 Initialization

In this phase, the ideas and functions of the application are organized. An architectural scheme has been developed as shown in Figure 3, which illustrates how the different hardware and software components interact, ensuring an effective integration for the fulfillment of the application's objectives.

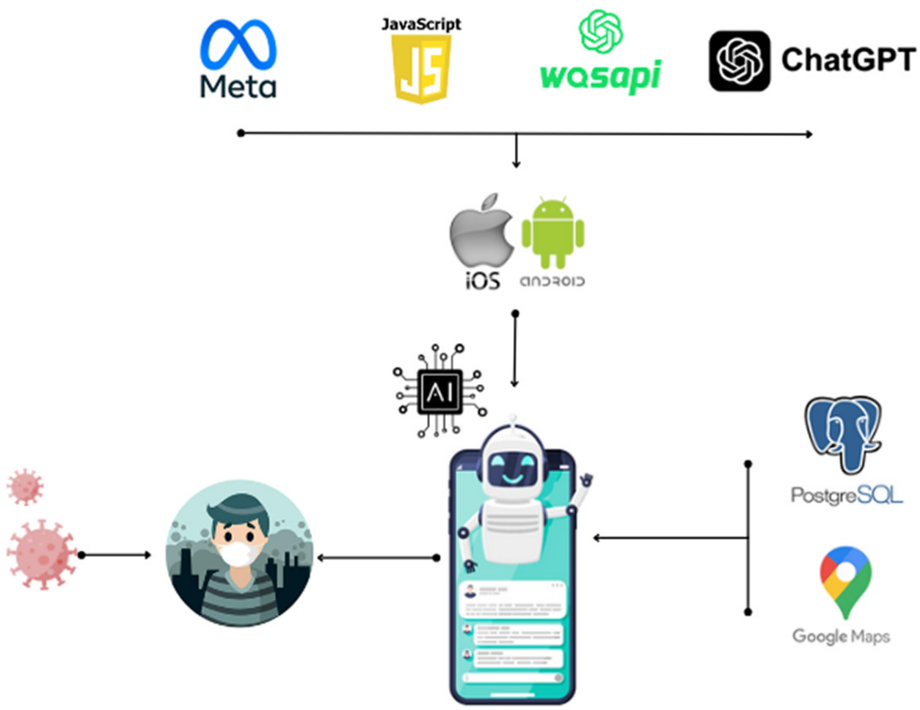

Fig. 3. Project architecture

The project focuses on the creation of a mobile application for the detection, control, and monitoring of monkeypox outbreaks, with a focus on optimizing user interaction and efficient information management. The application is compatible with Android and iOS systems, ensuring accessibility for a broad user base. For optimal operation, devices with processors of at least 2 GHz and 4 GB of RAM are required, which guarantees the correct performance of the AI and chatbot functions. The camera of the devices must have a minimum resolution of 12 MP to allow detailed analysis of skin lesions. The system relies on scalable cloud servers for real-time processing, providing fast, low-latency connectivity. The software features an advanced chatbot, which facilitates smooth and efficient interactions using technologies such as Meta, PostgreSQL, Google Maps, JavaScript, WhatsApp, and ChatGPT, ensuring a robust infrastructure that is adaptable to future enhancements.

2.4 Stabilization

During this stage, the prototypes of the application were developed. Figure 4 shows the initial phase, highlighting both the home screen and the front page of the mobile application. Figure 4a shows the home screen, from where users can access the system. Upon entering, they are directed to the login screen, where they must enter their e-mail and password to access the main home page if they already have an account; otherwise, they must create one, as shown in Figure 4b. Once this process is completed, they are taken to the main screen, shown in Figure 4c, which provides access to key menu functions, such as the map to view nearby contagion cases, news, search, chatbot, and user profile.

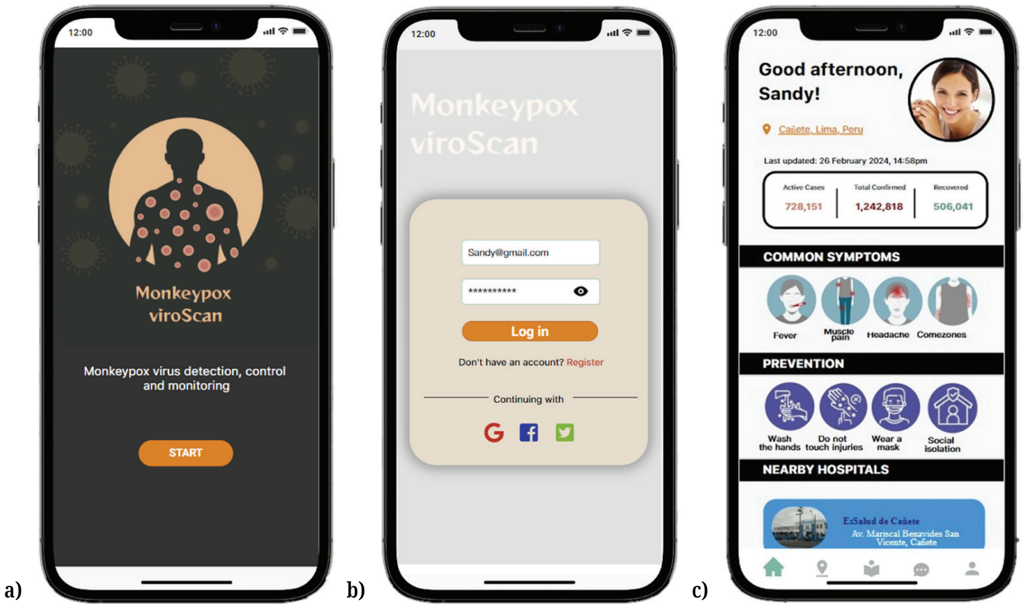

Fig. 4. Logon interfaces: (a) Home; (b) Logon; (c) Main home page

Figure 5 shows various interfaces of the platform, designed to provide the user with quick and efficient access to key data and information. In Figure 5a, the Google Maps screen is displayed, which includes statistical graphs on cases detected in the user's vicinity. Figure 5b provides detailed and updated information on the virus situation, providing relevant data for monitoring the outbreak. Finally, Figure 5c presents the information search screen, allowing the user to quickly access content related to the evolution of the virus and preventive measures.

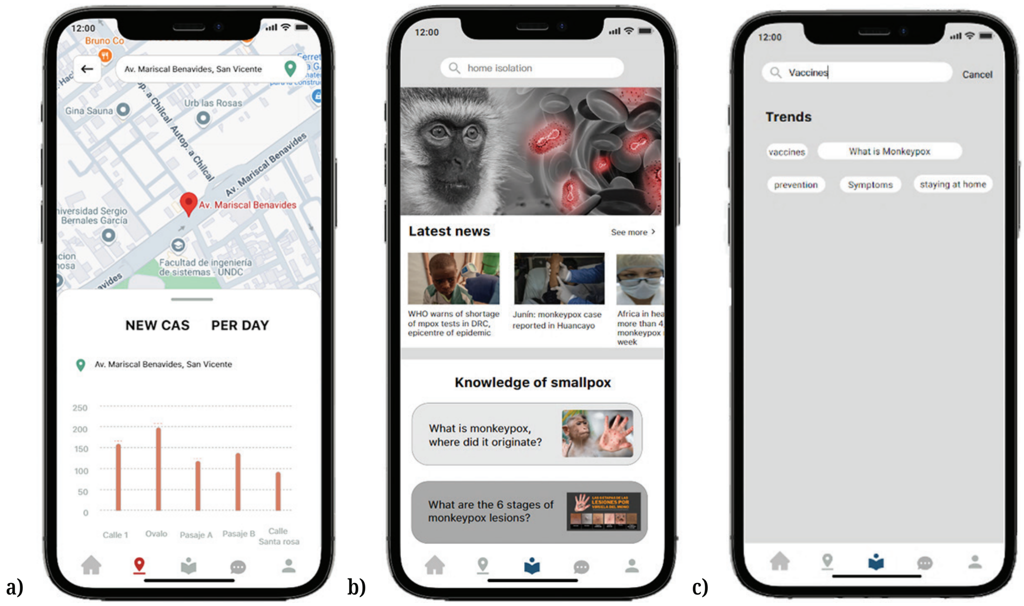

Fig. 5. Platform interfaces to provide the user with access to data and information, (a) Google maps and statistics; (b) Information and news; (c) Search engine for information

Figure 6 shows the screens of the viroscan monkeypox chatbot. Figure 6a shows the interface where the chatbot provides a diagnosis from an image submitted by the user and gives personalized recommendations for monkeypox cases. Figure 6b shows how the chatbot presents statistical graphs on monkeypox cases in the area near the user. Finally, Figure 6c highlights the chatbot's role in providing preventive measures, helping the user to make proactive decisions to decrease the risk of contagion.

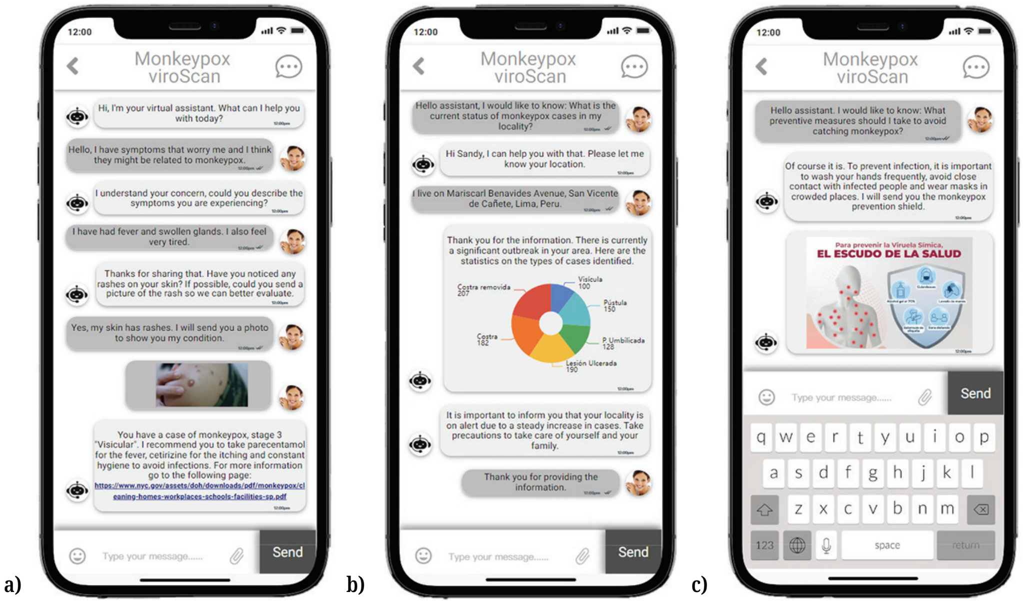

Fig. 6. Vinscan monkeypox chatbot interfaces, (a) Chatbot diagnosis of monkeypox cases; (b) Chatbot environment statistics; (c) Preventive measures chatbot

2.5 System test

The evaluation of the system was carried out with the participation of 20 experts from various universities in Peru, together with 25 legal entities, all residents of Lima, Peru, between the ages of 25 and 30. The evaluation was carried out through questionnaires using the Likert scale. The evaluation criteria are detailed in Tables 4 and 5.

Table 4. Expert evaluation criteria

Criteria	Aspects
Functionality	Do you consider that the chatbot's capabilities meet the monkeypox's monitoring needs?
	Does the chatbot facilitate access to the necessary tools?
	Do you think the chatbot incorporates innovative features for the benefit of public health?
Effectiveness	Do you think the chatbot is efficient in providing an accurate diagnosis of monkeypox?
	Are the suggestions provided by the chatbot useful and applicable in real situations?
	Do you find the chatbot helpful in making informed decisions about disease follow-up?
Security	Are the chatbot's privacy policies adequate and easy for users to understand?
	Are you confident that the chatbot is properly safeguarding users' personal information?
	Do you think the chatbot design helps reduce the risk of sensitive data leaks?
Impact	Can this chatbot improve responsiveness to monkeypox outbreaks in the community?
	Do you consider that the implementation of this chatbot could increase the population's trust in healthcare institutions?
	Does the chatbot contribute to the effective dissemination of relevant information about monkeypox?

Table 5. Evaluation criteria by users

Criteria	Aspects
Usability	Do you find it easy to navigate the chatbot and locate the information you are looking for?
	Is the way information is presented in the chatbot clear and easy to understand?
	Has your experience using the chatbot been pleasant and hassle-free?
Interaction	Does the chatbot answer your queries accurately and helpfully?
	Do you feel that the conversation with the chatbot is smooth and pleasant?
	Are you satisfied with the speed of the answers provided by the chatbot?
Sastifaction	Are you satisfied with the quality of the information provided by the chatbot?
	Have you found the chatbot's assistance helpful in better understanding monkeypox?
	Are you willing to use this chatbot again in the future?
Accessibility	Were you able to access the chatbot easily from your mobile device or computer?
	Is the chatbot available on platforms you use regularly (such as mobile or web)?
	Is the chatbot interface suitable for users with different levels of technological expertise?

3 RESULTS

Design validation with experts: This section presents the results obtained during the validation of the design, carried out with the participation of 20 experts from various universities in Peru. Several key criteria were considered in this evaluation, such as functionality, effectiveness, safety, and impact. Based on these, questions were formulated using a Likert scale to measure the degree of acceptance of the design by the specialists. Table 6 details the criteria evaluated, the questions corresponding to each one, and the results, expressed in terms of average and standard deviation (S.D.). The overall average score was 4.05, which is equivalent to 81%, indicating that the quality of the design is considered very good. According to the previously defined quality range, which varies from "Very Low" (0.00 to 1.00) to "Very High" (4.01 to 5.00), the value obtained suggests that the quality of both the model and the prototype of the mobile application is very high, since it is in the highest range of the rating scale.

Table 6. Expert validation

Criteria	Aspects	Media	SD	Quality
Functionality	Do you consider that the chatbot capabilities meet the monitoring needs of monkeypox?	4.20	0.52	Very high
	Does the chatbot facilitate access to the necessary tools?	4.00	0.46	High
	Do you think the chatbot incorporates innovative functions for the benefit of public health?	3.80	0.41	High
Effectiveness	Do you think the chatbot is efficient in providing an accurate diagnosis of monkeypox?	4.10	0.45	Very high
	Are the suggestions provided by the chatbot useful and applicable in real situations?	4.00	0.56	High
	Do you find the chatbot helpful in making informed decisions about disease follow-up?	3.95	0.51	High

(Continued)

Table 6. Expert validation *(Continued)*

Criteria	Aspects	Media	SD	Quality
Security	Are the chatbot's privacy policies adequate and easy for users to understand?	3.90	0.55	High
	Are you confident that the chatbot is properly safeguarding users' personal information?	3.85	0.59	High
	Do you think the chatbot design helps reduce the risk of sensitive data leaks?	4.05	0.39	Very High
Impact	Can this chatbot improve responsiveness to monkeypox outbreaks in the community?	4.45	0.51	Very High
	Do you consider that the implementation of this chatbot could increase the population's trust in healthcare institutions?	4.10	0.45	Very High
	Does the chatbot contribute to the effective dissemination of relevant information about monkeypox?	4.20	0.52	Very High
Total		4.05	0.49	Very High
		81%		

The graphical summary, shown in Figure 7, reveals that effectiveness is the most highly rated criterion, with 86.1% of the evaluations rated as "Very Good." This is followed by impact at 78.3%, while functionality and safety score 76.7% and 73.3%, respectively, in the "High" category. These percentages clearly highlight the strengths of the prototype in each of the criteria evaluated and indicate the areas with the greatest room for improvement.

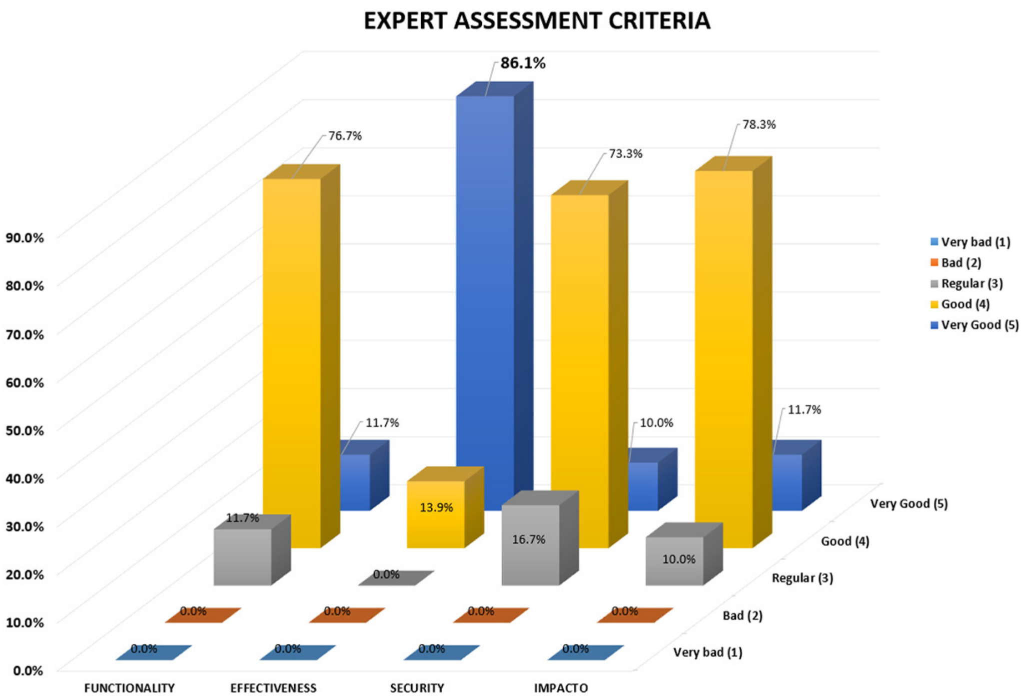

Fig. 7. Summary of criteria

Design validation with users: In addition to the validation performed by experts in the field, a usability study (SUS) was conducted to evaluate the user experience, as shown in Table 7. This study made it possible to detect and correct possible failures related to the operation of the system, as well as to measure the general acceptance of the application. Twenty-five legal entities participated in the study, and both performance and acceptance were evaluated in each aspect. A Likert scale was used to rate performance with the following options: 1 = very low, 2 = low, 3 = fair, 4 = good, and 5 = very Good. The overall average obtained was 4.25, which corresponds to a "Very High" level of acceptance, equivalent to 85% in percentage terms.

Table 7. Validation by users

Criteria	Aspects	Media	SD	Quality
Usability	Do you find it easy to navigate the chatbot and locate the information you are looking for?	4.04	0.73	Very high
	Is the way information is presented in the chatbot clear and easy to understand?	4.24	0.52	High
	Has your experience using the chatbot been pleasant and hassle-free?	4.16	0.55	High
Interaction	Does the chatbot answer your queries accurately and helpfully?	4.12	0.53	Very high
	Do you feel that the conversation with the chatbot is smooth and pleasant?	4.08	0.49	High
	Are you satisfied with the speed of the answers provided by the chatbot?	4.24	0.60	High
Sastifaction	Are you satisfied with the quality of the information provided by the chatbot?	4.32	0.48	High
	Have you found the chatbot's assistance helpful in better understanding monkeypox?	4.32	0.56	High
	Are you willing to use this chatbot again in the future?	4.44	0.51	Very high
Accessibility	Were you able to access the chatbot easily from your mobile device or computer?	4.40	0.50	Very high
	Is the chatbot available on platforms you use regularly (such as mobile or web)?	4.24	0.60	Very high
	Is the chatbot interface suitable for users with different levels of technological expertise?	4.40	0.50	Very high
Total		4.05 85%	0.49	Very high

The quality of the prototype was evaluated by calculating the averages of the criteria considered. As shown in Figure 8, the average scores for each criterion are as follows: Accessibility (4.35), with a percentage value of 86.9%; Satisfaction (4.36), with a percentage value of 87.2%; Integration (4.15), representing 83%; and Usability (4.15), which stands at 82.9%. These results suggest that the quality of the mobile application is satisfactory, with an overall average of 4.05, equivalent to 85%. It is important to highlight that, for the application to be considered viable, its total average score must exceed the value of 4, which corresponds to more than 80%.

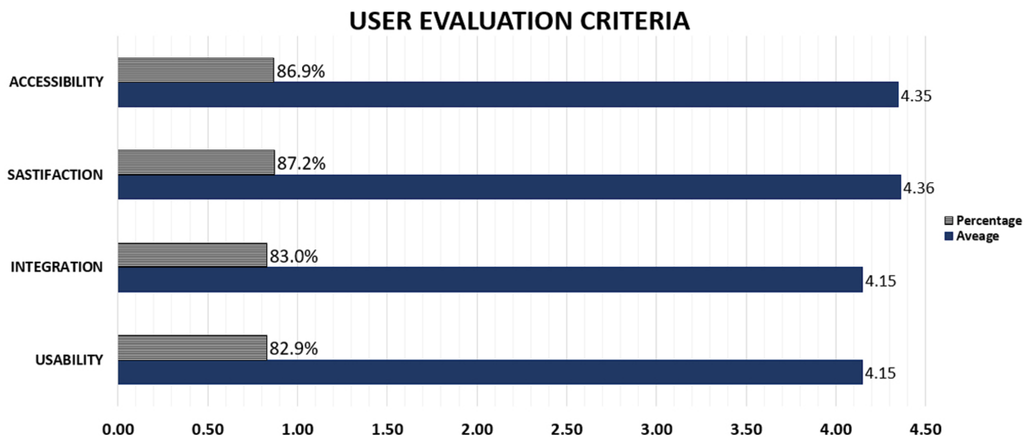

Fig. 8. Summary of criteria

4 DISCUSSION

The creation of the "ViroScan" application, designed for the control of monkeypox, was carried out using the mobile-D agile methodology, achieving 81% compliance by the experts and 85% satisfaction. Compared to the study [10], which developed the mobile application "BotCovid" in Brazil to combat misinformation about COVID-19, which showed great success, with a usability of 83.25% thanks to its chatbot based on reliable information, significantly improving users' understanding of the virus and research work [9], which developed a mobile application to optimize diagnosis and interaction with specialists using platforms such as Azure Machine Learning Studio, obtaining an 83.3% acceptance rate, contributing significantly to the prevention of serious diseases and improving public health. Likewise, the research [11], which developed a mobile application called "StopTheSpread" focused on seasonal flu transmission, increased user awareness by 20% through interactive games, highlighting the value of playful education in public health. Similarly, the study [12] describes the development of the mobile application "Corona Check" for the early detection of COVID-19, relieving pressure on health services by collecting data and assessing symptoms in real time. These applications confirm the positive impact of mobile technologies in public health management, complementing traditional methods.

5 CONCLUSION

This study culminates with the creation of a prototype mobile application, "Viro Scan," for the control, follow-up, and monitoring of monkeypox, standing out for its usability, security, integration, and functionality. This tool enables users to obtain a preliminary diagnosis, access information from reliable sources, receive recommendations for recovery, and prevent the spread of the virus through chatbot interaction with AI. Its implementation contributes to optimizing monkeypox cases, supporting epidemiological surveillance, and preventing catastrophic situations such as the COVID-19 pandemic. To achieve these objectives, the mobile-D methodology was applied, providing an essential structure and approach to offer rapid solutions. However, limitations are identified, such as the difficulty of lesion image recognition to obtain clear diagnostic reports, restricting the ability for more efficient monitoring. Therefore, it is suggested that future studies complement this project with the development of integration interfaces compatible with various devices and technologies.

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