

Digital transformation of community pharmacies through AI and predictive analytics

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Transformación digital de farmacias comunitarias mediante IA y análisis predictivo

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ABSTRACT

Introduction: the project proposed a comprehensive solution aimed at community pharmacies, seeking to improve customer service, operational management and technological integration. To this end, it combined a mobile application with e-commerce functions and an artificial intelligence chatbot, along with a desktop application for sales management and forecasting. The proposal responded to the growing need for efficient and personalized access to pharmaceutical services, especially in a digitized environment.

Development: building on successful experiences in healthcare and retail, the proposal leveraged tools such as mHealth apps, which were shown to improve treatment adherence and patient autonomy. It also integrated AI-enabled chatbots, useful for medical care, healthcare education and administrative tasks. At the operational level, it incorporated automated inventory systems that optimized processes and reduced errors, strengthening patient safety. In addition, predictive analysis models such as Random Forest or XGBoost were applied, which made it possible to anticipate demand and segment customers with high precision. The use of technologies such as Java, Kotlin, Python and environments such as Android Studio and Electron Forge ensured technical feasibility. The competitive analysis revealed that, although there were pharmacies with shopping applications, none integrated chatbots or reminders, which represented a differential advantage.

Conclusions: the solution proposed offered a substantial improvement in community pharmaceutical care, by integrating efficiency, artificial intelligence and user-centered approach. Its implementation consolidated an innovative, scalable alternative, adapted to current requirements, allowing progress towards a more intelligent and accessible pharmacy model.

Keywords: Pharmacies; Artificial Intelligence; Chatbot; Sales Prediction; MHealth.

RESUMEN

Introducción: el proyecto propuso una solución integral orientada a farmacias comunitarias, buscando mejorar la atención al cliente, la gestión operativa y la integración tecnológica. Para ello, combinó una aplicación móvil con funciones de comercio electrónico y un chatbot de inteligencia artificial, junto con una aplicación de escritorio para la administración y la predicción de ventas. La propuesta respondió a la necesidad creciente de acceso eficiente y personalizado a servicios farmacéuticos, especialmente en un entorno digitalizado.

Desarrollo: basándose en experiencias exitosas en salud y comercio minorista, la propuesta aprovechó herramientas como las aplicaciones mHealth, que demostraron mejorar la adherencia al tratamiento y la autonomía del paciente. También integró chatbots con IA, útiles para atención médica, educación sanitaria y tareas administrativas. A nivel operativo, incorporó sistemas automatizados de inventario que optimizaron procesos y redujeron errores, fortaleciendo la seguridad del paciente. Además, se aplicaron modelos de análisis predictivo como Random Forest o XGBoost, que permitieron anticipar la demanda y segmentar clientes con alta precisión. El uso de tecnologías como Java, Kotlin, Python y entornos como Android Studio y Electron Forge aseguró la viabilidad técnica. El análisis competitivo reveló que, aunque existían farmacias con aplicaciones de compra, ninguna integraba chatbots ni recordatorios, lo que representó una ventaja diferencial.

Conclusiones: la solución planteada ofreció una mejora sustancial en la atención farmacéutica comunitaria, al integrar eficiencia, inteligencia artificial y enfoque centrado en el usuario. Su implementación consolidó una alternativa innovadora, escalable y adaptada a las exigencias actuales, permitiendo avanzar hacia un modelo de farmacia más inteligente y accesible.

Palabras clave: Farmacias; Inteligencia Artificial; Chatbot; Predicción de Ventas; Mhealth.

INTRODUCTION

Today, efficient access to healthcare services and pharmaceutical products is a critical need, especially in contexts where immediacy and personalization are decisive factors in the patient experience. Community pharmacies, as key players in local healthcare systems, face challenges related to operational management, customer service, and technological integration. In response to these issues, a proposal has emerged to develop a comprehensive system that combines a user-oriented mobile application with e-commerce and assistance capabilities through an artificial intelligence chatbot, along with a desktop application for administrative management and sales forecasting.^(1,2)

This approach is based on established trends in information and communication technologies (ICTs), especially in the healthcare sector. On the one hand, mobile health applications (mHealth) have proven effective in improving patient engagement, facilitating access to medical information, and promoting treatment adherence, as evidenced by cases such as Mango Health. On the other hand, artificial intelligence chatbots have gained ground as support tools in healthcare, offering reliable information, personalized follow-up, and reduced administrative burdens.⁽³⁾

In addition, process automation in pharmacies, such as inventory management, has significantly contributed to improving the accuracy of medication dispensing and preventing errors that compromise patient safety. At the same time, predictive analytics has revolutionized business planning in the retail sector, allowing demand to be anticipated through machine learning algorithms and adjusted to market dynamics.⁽¹⁾

The current competitive environment also highlights the opportunity for innovation: while some online pharmacies offer in-app purchasing platforms, none integrate customer service chatbots or medication reminders. This gap represents a strategic opportunity to develop solutions that not only meet commercial needs but also add value in terms of health and well-being for users.

Taken together, this evidence supports the relevance of a comprehensive technology solution for community pharmacies that combines functionality, efficiency, and a user-centric approach. By leveraging modern technologies such as artificial intelligence, predictive analytics, and multi-platform development, it is possible to transform pharmaceutical care at the local and regional levels digitally.

DEVELOPMENT

Problem Domain

The proposal to develop a comprehensive system for community pharmacies combines a mobile application with e-commerce and artificial intelligence chatbot support functions, along with a desktop application for administrative management and sales forecasting. This approach is based on the successful implementation of similar solutions in other contexts, both in healthcare and retail. Analyzing these previous experiences allows us to establish a solid technical and functional framework that justifies the feasibility and relevance of the proposed system.

First, mobile health (mHealth) applications have been widely used to promote patient engagement and improve clinical outcomes. These tools enable users to actively manage their health by facilitating communication with medical professionals and promoting healthy habits. Successful cases, such as Mango Health, have demonstrated the value of incorporating features for

tracking health metrics, managing medications, and accessing personalized information. These approaches have significantly improved the patient experience by offering practical resources that strengthen autonomy in healthcare.⁽⁴⁾

Similarly, artificial intelligence-based chatbots have found a growing niche in healthcare, where they are used to provide patient support, manage care, offer health education, and facilitate administrative tasks. They have been instrumental in the field of Mental health, chronic disease monitoring, and the delivery of reliable medical information. While the use of advanced language models, such as ChatGPT, presents challenges related to misinformation, their ability to analyze large volumes of data and generate coherent responses has sparked great interest in their integration into care systems. Thanks to these capabilities, AI chatbots offer more natural and effective interaction with users.

In the case of automation and inventory management in pharmacies, automated systems have proven to be practical tools for increasing accuracy in medication dispensing, reducing errors, and optimizing logistics processes, which directly contributes to improving patient care.⁽⁵⁾ These systems also allow for more rigorous control of sensitive substances and contribute to more efficient management of available resources. Proper inventory management, through methods such as the perpetual system, has been identified as a key factor in preventing stockouts or the presence of expired products, thereby improving both operational efficiency and patient safety.

Finally, the use of predictive analytics in the retail sector has optimized decision-making by generating valuable insights into consumer behavior, pricing strategies, and sales trends. In particular, sales forecasting has become a critical tool for financial planning and inventory management. Through machine learning models such as Random Forest, XGBoost, LGBM, and CatBoost, high levels of accuracy in sales estimation have been achieved, with coefficients of determination (R^2) of up to 0,98. In addition, predictive analytics, in combination with techniques such as K-Means clustering, allows customers to be segmented according to their consumption patterns, facilitating the implementation of personalized and effective marketing strategies.⁽⁶⁾

ICTs.

The main technologies available to support this type of project are described below:

Programming languages

Java: An object-oriented programming language developed by Sun Microsystems in the early 1990s by James Gosling, Mike Sheridan, and Patrick Naughton. Initially designed for digital devices, Java was later adapted for internet programming, standing out for its portability and robustness.

Kotlin: An open-source, statically typed programming language that supports both object-oriented and functional programming. Designed to interoperate fully with Java, Kotlin offers a concise and modern syntax and is widely used in Android application development.

JavaScript: An interpreted, object-oriented programming language used primarily for web development. It allows the creation of dynamic interfaces and real-time user interaction. Together with HTML and CSS, it forms the basis of modern web development.

Python: A high-level, interpreted, general-purpose programming language. It is characterized by its clear and readable syntax, which facilitates rapid application development. It is widely used in data science, artificial intelligence, and web development.

Development environments

Android Studio: This is the official integrated development environment (IDE) for developing Android applications. It provides tools for code editing, debugging, and testing, facilitating the creation of efficient mobile applications.⁽⁸⁾

Electron Forge: This is a tool that simplifies the process of creating, packaging, and distributing cross-platform desktop applications using web technologies such as JavaScript, HTML, and CSS. It allows you to develop desktop applications with a single code base.⁽⁹⁾

Frameworks and libraries

Express.js: A minimalist and flexible web framework for Node.js that provides a robust set of features for developing web and mobile applications. It facilitates route management, middleware, and database integration.⁽¹⁰⁾

Flask: This is a web microframework written in Python that allows you to develop web applications quickly and easily. It offers flexibility and control over the components used, making it ideal for projects that require a lightweight architecture.

APIs and artificial intelligence services

Gemini API: This is an application programming interface provided by Google that allows artificial intelligence capabilities, such as chatbots and natural language processing, to be integrated into applications. It facilitates the creation of advanced conversational experiences.⁽¹¹⁾

Prophet: This is an open-source library developed by Facebook for time series forecasting. It uses an additive model that handles non-linear trends and seasonality, and is robust against missing data and changes in trends.

Database management systems

PostgreSQL: This is an open-source relational database management system known for its stability, extensibility, and compliance with SQL standards. It supports a wide variety of data types and advanced functions, making it suitable for applications that require integrity and scalability.

Competition

Table 1. Comparison of applications

Competitor	Country	Chatbot	Purchases from the app	Medication reminders
Farmashop	Uruguay	No	Yes	No
PuntoFarma	Paraguay	No	Yes	No
Zentner Pharmacy	Argentina	No	Yes	No

After analyzing competitors in the online pharmacy market, it was found that all of them offer purchases through their mobile app, which makes it easier for customers to access a wide range of products. However, none of the competitors provide customer service through chatbots or offer medication reminder features. This lack of additional services could represent an opportunity

to differentiate themselves in an increasingly competitive market focused on convenience and personalized service.

CONCLUSIONS

Throughout this analysis, it has become clear that the integration of digital technologies in the pharmaceutical sector represents a strategic opportunity to improve service quality, optimize internal management, and offer a more complete user experience. The proposal for a comprehensive system for community pharmacies—consisting of a mobile app with e-commerce and AI-powered support capabilities, along with a desktop app focused on administrative management and sales forecasting—directly addresses specific unmet needs in the current context.

A review of successful experiences in related sectors has demonstrated the effectiveness of tools such as mHealth applications, intelligent chatbots, and automated management and inventory systems. These advances not only facilitate access to healthcare services but also promote more proactive, safe, and personalized care. Similarly, the application of predictive analytics models based on machine learning makes it possible to anticipate demand and adapt commercial strategies, which is essential for maintaining competitiveness in the dynamic retail environment.

On the other hand, the study of the competitive landscape reveals a clear area of opportunity: although some pharmacies already allow purchases to be made from their mobile applications, they do not yet offer value-added tools such as chatbot support or medication reminders. This gap can be exploited as a key differentiator by incorporating features that not only streamline processes but also improve treatment adherence and strengthen the bond between patient and pharmacy.

The proposed project is based on a careful selection of modern development technologies, versatile programming languages, and robust tools for building multi-platform solutions. This ensures the technical viability and scalability of the system, which are fundamental elements for its long-term sustainability.

In summary, the implementation of this comprehensive solution not only represents an innovative technological response but also a significant step towards the digital transformation of the community pharmacy sector. By combining operational efficiency, artificial intelligence, and user focus, the foundations are laid for a more accessible, intelligent pharmacy that is centered on the real needs of its customers. This vision paves the way for a more personalized, agile care model that is adapted to the demands of today's world.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION

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