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Assessment of mobile applications for drug incompatibility detection: an integrative review

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Abstract

Objective: To evaluate the availability and quality of mobile applications designed for detecting drug incompatibilities. **Methods:** An integrative review was conducted on the Google Play Store and Apple App Selected. Terms in Portuguese, English, and Spanish related to "drug incompatibility" were used. Duplicate applications, applications in languages other than Portuguese, English, and Spanish, or applications that did not directly address drug incompatibilities (i.e., provided only general drug information) were excluded. The apps were assessed using the Portuguese version of the *Mobile App Rating Scale* (MARS) scale by two independent pharmacists. **Results:** Among 244 initially retrieved apps, only three met the inclusion criteria: *Micromedex® IV Compatibility*, *Medscape*, and *Compatibilidad fármacos IV*. *Micromedex®* achieved the highest average MARS score (4.51/5), particularly in information (4.75) and aesthetics (4.6), though it requires institutional subscription. The other two offered limited, monograph-based drug incompatibilities information. None were available in Portuguese, and only one was free. **Conclusion:** The analysis highlighted a lack of free mobile applications, in Portuguese and adapted to the Brazilian context, for drug incompatibilities detection, which reinforces the need to develop accessible digital applications to support clinical practice and patient safety.

Keywords: drug incompatibility, mobile applications, patient safety, medical informatics applications; biomedical technology, medical informatics.

Avaliação de aplicativos móveis para detecção de incompatibilidades medicamentosas: uma revisão integrativa

Resumo

Objetivo: Avaliar a disponibilidade e a qualidade de aplicativos móveis voltados à detecção de incompatibilidades medicamentosas. **Métodos:** Foi conduzida uma revisão integrativa de aplicativos disponíveis nas bibliotecas digitais *Google Play Store* e *Apple App Store*, com busca realizada em junho de 2023. Foram utilizados termos em português, inglês e espanhol relacionados a "incompatibilidade medicamentosa". Aplicativos duplicados, em idiomas diferentes do português, inglês e espanhol ou aplicativos que não abordavam incompatibilidades medicamentosas de forma direta (isto é, traziam apenas informações gerais de medicamentos) foram excluídos. Os aplicativos selecionados foram avaliados com a versão em português do *Mobile App Rating Scale* (MARS) por dois avaliadores independentes. A avaliação de aplicativos pagos ou de acesso restrito foi realizada a partir de acesso institucional. **Resultados:** Dos 244 aplicativos identificados inicialmente, apenas três preencheram os critérios de inclusão: *Micromedex® IV Compatibility*, *Medscape* e *Compatibilidad fármacos IV*. O primeiro obteve a maior média na avaliação MARS (4,51/5), destacando-se em todas as categorias, especialmente informações (4,75) e estética (4,6). No entanto, apresenta acesso restrito a usuários com assinatura institucional. Os demais aplicativos fornecem informações limitadas sobre incompatibilidades medicamentosas e carecem de ferramentas interativas de verificação cruzada. Nenhum dos aplicativos estava disponível em língua portuguesa, e apenas um era gratuito. **Conclusão:** A análise evidenciou uma escassez de aplicativos móveis gratuitos, em português e adaptados ao contexto brasileiro para detecção de incompatibilidades medicamentosas, o que reforça a necessidade de desenvolvimento de ferramentas digitais acessíveis para apoiar a prática clínica e a segurança do paciente.

Palavras-chave: incompatibilidade medicamentosa, aplicativos móveis, aplicações da informática médica, tecnologias em saúde, informática em saúde.

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Introduction

Digital Health (eHealth) refers to the incorporation of information and communication technology resources into the healthcare field, aiming to expand the reach and efficiency of care practices. This approach encompasses a wide range of activities, from health promotion and prevention to diagnosis, treatment, follow-up, and service management, providing direct support to professionals and institutions[1,2]. eHealth not only offers a platform for digital interventions with rapid access to available scientific evidence—thereby optimizing various healthcare processes—but also provides tools that assist in clinical, time management, and economic processes[3].

The safe administration of medications in hospital settings represents one of the greatest contemporary challenges for healthcare systems. Polypharmacy, which is common among hospitalized patients, combined with the complexity of treatments, increases the risk of medication errors that can result in adverse events, prolonged hospital stays, increased costs, and, in extreme cases, death[4,5]. Several studies demonstrate that failures in the medication-use process, such as incorrect prescribing and administration, remain frequent[6,7]. The World Health Organization (WHO) classifies these errors as *active*, when they result from direct human failures, or *latent*, when they stem from deficiencies in systems and organizational processes[8].

In this context, preventive strategies that address both human and systemic factors are crucial. One of the highest-risk clinical situations involves drug interactions and incompatibilities (DI), particularly in intravenous therapies. DI occur when medications administered concurrently through the same infusion system react with each other, leading to precipitation, loss of efficacy, formation of toxic compounds, or increased toxicity[9]. In hospital practice—especially in Intensive Care Units (ICUs)—the use of multi-infusion devices, such as stopcocks and single-lumen catheters, increases the likelihood of DI occurrence. Studies indicate that 10% to 20% of ICU patients may be affected by incompatibilities, which often go unrecognized by healthcare professionals[10,11]. Preventive strategies include the use of multilumen catheters, spacing between infusions, flushing between administrations, and the use of compatibility tables. However, these practices require specific technical knowledge and rapid access to information, which are not always feasible in routine hospital settings[12,13].

The application of digital technologies within the eHealth framework has proven to be a promising ally in promoting the safe use of medications. For example, mobile applications designed to check drug incompatibilities provide real-time clinical support, optimizing therapeutic decisions and reducing risks associated with DI. Nevertheless, no systematic search has yet been conducted specifically to identify and evaluate mobile applications aimed at detecting DI. Moreover, the tools currently available appear to be scarce—especially when considering factors such as cost-free access, availability in Portuguese, and adaptation to the Brazilian healthcare context—which limits their widespread adoption[14,15].

Therefore, this study aimed to conduct an integrative review of mobile applications focused on the detection and prevention of DI in hospital environments, as well as to assess the quality of these applications.

Methods

An integrative review was conducted in mobile app stores to identify solutions designed for the detection of drug incompatibilities (DI), followed by evaluation using the *Mobile App Rating Scale* (MARS), an instrument validated in Portuguese and recommended for the multidimensional assessment of mobile health applications[16].

Literature review and quality assessment

For the integrative literature review, a methodology adapted from the studies by Kim et al.[17], Maciel et al.[18] and Shen et al.[19] was employed to evaluate the availability and quality of digital tools on a specific topic. This methodological adaptation was necessary since mobile applications are not indexed in traditional bibliographic databases, requiring specific strategies for their identification and evaluation[17-20]. The main guiding question was: *"Which software applications are available in Brazil for identifying and preventing drug incompatibilities, and what is their quality?"* To answer this question, a search strategy was developed using a series of topic-specific keywords ("drug incompatibility" or "drug compatibility") in Portuguese, English, and Spanish to select relevant mobile applications. Searches were carried out in the main app libraries—Google Play Store and Apple's App Store—on June 1, 2023.

Mobile applications that explicitly addressed drug incompatibility (DI) within their functional scope were included. After the initial identification, exclusion criteria were applied: a) duplicate applications; b) those available only in languages other than Portuguese, English, or Spanish; and c) applications whose content was limited to the dissemination of events, journals, or materials unrelated to clinical practice.

The quality of the applications was assessed using the *Mobile App Rating Scale* (MARS), a multidimensional instrument developed to evaluate mobile health applications, with a validated version available in Portuguese[16]. MARS consists of 23 main items distributed across four domains, engagement, functionality, aesthetics, and information, plus a section for subjective impact and an overall quality rating, totaling 26 items. In the present study, only items 1 to 19, corresponding to the four main domains, were considered, while items 20 to 26 were excluded, as they pertain to healthy habits and behaviors that applications may promote in users, dimensions not aligned with the objective of this assessment. Each item is rated on a Likert scale from 1 (inadequate) to 5 (excellent), allowing the calculation of mean scores per domain and overall. Evaluation of paid or restricted-access applications was conducted through institutional access.

Two clinical pharmacists, experienced in hospital practice and the use of digital tools, independently performed the evaluations. Discrepancies were discussed until a consensus was reached to ensure consistency in the analyses. No formal statistical analysis of interrater reliability was performed; however, dual evaluation and consensus resolution were used to minimize individual bias.

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Results

Searches conducted in the Google Play Store and Apple's App Store identified a total of 244 applications. After this initial selection, 32 duplicate apps, one app available only in a language other than Portuguese, English, or Spanish, and four apps related to event dissemination were excluded, resulting in 207 applications included at this stage. Following a preliminary screening based on the descriptive titles of the applications, 193 were excluded for addressing unrelated topics. The remaining 16 applications were installed for more detailed evaluation, but 13 were excluded for not presenting specific information on drug incompatibilities (DI)—that is, they contained only general drug information or drug interaction data. The final three applications were included for detailed analysis (as illustrated in Figure 1). Table 1 presents the selection of applications identified according to the search terms used.

Figure 1. Flow diagram of app selection (adapted from PRISMA)

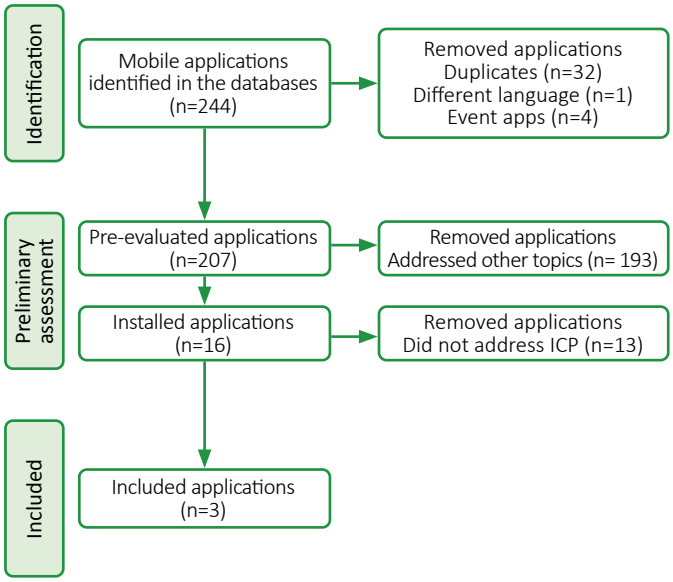

Table 1. Results of the search and selection of applications.

Search term	Applications found	Applications excluded	Applications installed	included
Incompatibilidade medicamentosa	63	57	6	1
Drug incompatibility	38	35	3	1
Incompatibilidad de drogas	33	30	3	1
Compatibilidade medicamentosa	56	55	1	0
Drug compatibility	29	30	1	0
Compatibilidad de fármacos	25	25	0	0
Total	244	232	14	3

The three applications included in the study were Micromedex® IV Compatibility, Medscape, and Compatibilidad fármacos IV. The main characteristics of these applications are presented in Table 2. Among them, only *Micromedex®* offers a specific tool that allows users to enter multiple drug names and cross-check them to identify incompatibilities. Additionally, *Micromedex®* and *Compatibilidad fármacos IV* are paid applications, whereas *Medscape* is freely available.

Table 2. Characteristics of the applications included in the study.

Application	Available platform	Language	Access type	Method of DI assessment
Micromedex®IV compatibility	Android/iOS	English	Paid	Allows simultaneous input of multiple drugs and verification of incompatibilities
Medscape	Android/iOS	English	Free	Presents incompatibilities within individual drug monographs
Drug compatibility IV	Android/iOS	Spanish	Paid	Presents incompatibilities within individual drug monographs

After characterization, the applications were subjected to quality evaluation using the *Mobile App Rating Scale* (MARS), applied by two independent evaluators (pharmacists). Data analysis showed that *Micromedex® IV Compatibility* obtained the highest overall mean score, standing out in all categories, particularly in the information (4.75) and aesthetics (4.6) domains. This application was found to be highly functional and well-rated, although its engagement score (4.2) was slightly lower than that of *Medscape* (4.4) (Table 3).

Table 3. MARS assessment results.

Application	Micromedex®IV compatibility	Medscape	Drug compatibility IV
Engagement	4.20	4.40	3.00
Functionality	4.50	4.00	3.75
Aesthetics	4.60	4.30	3.00
Information	4.75	4.12	3.75
Overall mean score (0 to 5)	4.51	4.20	3.37

Discussion

The integrative review revealed a scarcity of mobile applications specifically designed for detecting drug incompatibilities, with limitations related to language, cost, and available functionalities. This scenario highlights a gap between the needs of hospital clinical practice in Brazil and the digital solutions currently available.

Free access to these technologies is essential, as healthcare systems in low- and middle-income countries often have limited access to digital health tools[21]. Moreover, it is evident that health applications provide valuable resources and tools that can support patient diagnosis, monitoring, treatment safety, and clinical decision-making; however, they frequently require paid subscriptions[21,22]. Unfortunately, the high cost of these subscriptions can be prohibitive for many healthcare professionals in Brazil, particularly those working in resource-limited institutions or those at the beginning of their careers. This restriction may limit their ability to access up-to-date information on drug incompatibilities, potentially resulting in less-informed clinical decisions.

The COVID-19 pandemic further intensified pressure on global infrastructure and demanded the reinvention, reorganization, and transformation of healthcare systems worldwide—particularly the digital health technologies used for management, surveillance, tracing, diagnosis, treatment, and prevention. Modern healthcare requires a proactive and individualized response, combining precision diagnosis with personalized treatment[23,24].

Furthermore, analysis of the quality of currently available applications using the MARS instrument revealed that, although tools for checking drug incompatibilities (DI) do exist, *Micromedex® IV Compatibility* clearly stands out in terms of overall quality. This finding underscores the strong need for improvement in other systems to achieve similar levels of efficiency and usability. In addition, a future solution could incorporate functionalities for exporting and printing results, as well as features for sharing information with the multidisciplinary team or integration with electronic health records. Such resources would enhance the practical utility of these applications and encourage their adoption in hospital settings[24].

One of the most notable findings was the scarcity of applications specifically addressing drug incompatibility information. Although several apps exist for detecting drug interactions—as shown by Kim et al.[17] in a review using the MARS scale and by Villarreal-Portillo et al.[25] in a comparative analysis of ten drug interaction detection applications available in Mexico—there are no studies focusing on mobile applications that specifically address drug incompatibilities[17,25].

A closer evaluation of the apps available in the Google Play and Apple App Stores revealed several critical issues. First, no high-quality applications in this field were found that provided information in Portuguese. This deficiency may lead to comprehension difficulties among professionals who need the information but do not have fluency in English. Several studies on evidence-based practice among healthcare professionals have reported that limited foreign-language proficiency is a major barrier to accessing and applying scientific evidence in clinical care[26,27]. Given the growing globalization and exchange of scientific knowledge, it is common for articles, research studies, and clinical guidelines to be published in foreign languages, especially English. However, many healthcare professionals in Brazil struggle to read and understand this information due to the language barrier, which can result in knowledge gaps, lack of awareness of medical advances, and even the adoption of incorrect practices[28]. In this context, investment in national applications emerges as an effective strategy to overcome this challenge.

Another limitation identified in the evaluated applications was the restricted access to full or partial content requiring payment. Regarding DI, only the *Micromedex®* application provides a tool that allows the input of multiple drugs for comparison; however, access is limited to users affiliated with organizations that have partnered with the developer through service packages, since the incompatibility module license is not commercialized separately.

Other applications, such as *Medscape* and *Compatibilidad de fármacos*, in addition to also lacking support in Portuguese, describe incompatibilities individually within each drug monograph. This method of information presentation tends to be impractical in daily clinical routines.

For instance, for a professional to evaluate a prescription containing ten medications, it would be necessary to access ten separate monographs in order to cross-check data and determine whether any relevant incompatibilities exist among the listed drugs. Performing such tasks is time-consuming, especially given the high volume of prescriptions to be reviewed daily in hospital environments, and therefore becomes inefficient in practice.

In this context, the results of this study indicate that an ideal mobile application should provide support in Portuguese, facilitating comprehension and use by Brazilian healthcare professionals. Moreover, it should be entirely free of charge, thereby removing financial barriers to accessing essential information on drug incompatibilities (DI). The application should also include a tool allowing the simultaneous input of multiple drugs and automatic searches for incompatibilities, making it more efficient and aligned with the realities of hospital pharmacy practice.

This study has several limitations that should be considered when interpreting the results. First, the search was limited to the Google Play Store and Apple App Store digital libraries, which may have excluded institutionally distributed applications or those not listed on these platforms. Furthermore, only three applications met the inclusion criteria, restricting the scope of the analysis. Another important point is that the evaluation was conducted independently by two clinical pharmacists, with disagreements resolved by consensus. While this approach helps minimize individual bias, it may still limit the generalizability of the findings. Finally, the search was conducted in June 2023, meaning that newer applications or updates released afterward were not included. Despite these limitations, the findings provide valuable evidence on the scarcity of digital tools adapted to the Brazilian context for detecting drug incompatibilities and highlight the need for the development of specialized solutions.

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Conclusion

This study investigated the existence and quality of applications for detecting drug incompatibilities (DI) available in virtual stores, assessed using the MARS scale. Of the 244 applications identified, only three met the inclusion criteria, all showing limitations in language, cost, and functionality. We conclude that there is a scarcity of free and Portuguese-language mobile applications, reinforcing the need to develop accessible digital tools to support clinical practice and patient safety.

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Contributors

Santos FP: study conception, data curation, investigation, methodology, original draft preparation, critical manuscript review, and final approval of the version to be published. Santana CR: study conception, formal analysis, validation, writing – review and editing, and final approval of the version to be published. Dos Santos HA: supervision, methodological guidance, writing – critical review of intellectual content, and final approval of the version to be published.

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Conflicts of Interest

The authors declare no conflicts of interest.

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