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Development of a website and mobile application for guiding the hospital use of antimicrobials in pediatric care

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Abstract

Objective: To develop the website and mobile app PedCuidados, designed to provide accurate and accessible information on the prescription and administration of injectable antimicrobials in pediatric patients. **Methods:** This study is a technological production research project focused on developing a website and mobile app using rapid prototyping for desktop and Android systems in the Brazilian context. The website and mobile app structure followed three key stages: 1) conception, defining the content, assessing related needs, and identifying the target audience; 2) planning and prototype development, establishing the key topics on antimicrobials, designing the website and mobile app pages, and structuring the interface layout; 3) final deployment, configuring tools and technological resources to ensure easy access to the website and facilitate mobile app downloads. **Results:** PedCuidados features 45 screens in Portuguese, gathering information on 38 injectable antimicrobials, reflecting the medication error profile to which the pediatric population is most exposed and vulnerable. In addition, it is a free tool with low storage consumption and a layout designed to enable quick access to essential and reliable information. **Conclusion:** A website and free mobile app were developed to guide the use of antimicrobials in pediatric hospital care. This tool supports healthcare professionals, contributing to the safety and effectiveness of antimicrobial treatments in this population.

Keywords: pediatrics, anti-infective agents, drug utilization, biomedical technology, mobile applications.

Desenvolvimento de um website e aplicativo móvel para orientação do uso hospitalar de antimicrobianos na pediatria

Resumo

Objetivo: Desenvolver o website e aplicativo móvel denominado PedCuidados, elaborado para fornecer informações precisas e acessíveis sobre a prescrição e administração de antimicrobianos injetáveis em pacientes pediátricos. **Métodos:** Trata-se de uma pesquisa de produção tecnológica do tipo prototipagem rápida de software para sistemas desktop e Android no contexto brasileiro. A estrutura do site e do aplicativo móvel seguiu três etapas principais: 1) Concepção – definição do conteúdo, avaliação das necessidades relacionadas e identificação do público-alvo; 2) Planejamento e desenvolvimento do protótipo – estabelecimento dos principais tópicos sobre antimicrobianos, *layout* das páginas do site e do aplicativo móvel e estruturação da interface; 3) Implementação final – configuração de ferramentas e recursos tecnológicos para garantir fácil acesso ao site e facilitar o download do aplicativo móvel. **Resultados:** O PedCuidados conta com 45 telas em português, reunindo informações sobre 38 antimicrobianos injetáveis, refletindo o perfil de erros de medicação aos quais a população pediátrica está mais exposta e é mais vulnerável. Além disso, é uma ferramenta de uso gratuito, com baixo consumo de armazenamento e com layout desenvolvido para possibilitar o acesso rápido a informações essenciais e seguras. **Conclusão:** O PedCuidados constitui uma ferramenta voltada ao suporte de profissionais de saúde, visando aprimorar a segurança e a efetividade da terapêutica antimicrobiana em pacientes pediátricos no ambiente hospitalar.

Palavras-chave: pediatria, anti-infecciosos, uso de medicamentos, tecnologia biomédica, aplicativos móveis.



Introduction

In pediatrics, the understanding that “children are not simply miniature adults” is fundamental to the therapeutic approach for this population.^{1,2} The unique physiological characteristics of this group, combined with the fact that their organs are still developing, result in distinct profiles of drug absorption, distribution, metabolism, and excretion.^{3,4} This makes the selection and monitoring of pharmacological treatments more complex, requiring a careful, individualized, and tailored approach adapted to the specificities of this population.⁴

Thus, the prescription and administration of medications—processes that already demand a high level of responsibility—become even more challenging and prone to risks when applied to the pediatric population.⁵ Among the main factors are, for example, the low percentage of drugs tested specifically in children and the scarcity of pharmaceutical formulations suitable for the pediatric age group, which results in the frequent off-label use of medications.^{6,7} A study conducted in the United States revealed that the rate of medication errors in pediatric patients is significantly higher, reaching 31%, whereas for adults this rate is 13%. This highlights the importance of rigorous protocols and specific tools to minimize the risks associated with the prescription and administration of drugs in this vulnerable population.⁵ A systematic review with meta-analysis showed that the prevalence of medication errors in hospitalized pediatric patients is higher in intensive care units and emergency departments, and more frequent when electronic medical records are not used.⁸

In this context, the use of health technologies, such as websites and mobile applications, can be a great ally in this process, promoting safety in the treatment of children across different age groups and stages of development. These tools optimize diagnosis and treatment by providing accessible and straightforward information. Decision support solutions, for instance, assist physicians with recommendations based on algorithms and protocols, being especially useful in high-demand environments such as hospitals.⁹

The use of mobile applications by healthcare professionals to support decision-making can facilitate care processes, although further studies are needed to ensure the quality and reliability of these tools.¹¹ With regard to antimicrobial stewardship, the use of mobile applications to assist in training and decision-making for healthcare professionals in antimicrobial prescription has become increasingly common.^{11–13}

Therefore, the development of a website and a mobile application to guide antimicrobial use in pediatrics, based on updated and reliable information, emerges as a promising and relevant tool for healthcare professionals. Furthermore, few mobile applications are specifically designed to guide antimicrobial use in the pediatric population, and none are currently available in Portuguese as spoken in Brazil. Thus, the objective of this study was to develop a website and mobile application to provide accurate and accessible information on the prescription and administration of antimicrobials in pediatric patients.

Methods

Study design and research team

This study consisted of a technological production through rapid software prototyping for the development of a website/application.

The research team was composed of a resident student from the Multiprofessional Residency Program in Health at a university hospital in the field of women’s and adolescent health, with expertise in both clinical and technological areas, a pharmacist with clinical experience, and a university professor specializing in hospital and clinical pharmacy.

Development phases

The development of the website and mobile application was carried out according to the method described by Dingsøyr *et al.*¹⁴ and adapted from Almeida, Magalhães, and Lima,¹⁵ following three stages: (1) conception; (2) planning and prototype development; and (3) implementation.

Conception

The first stage included defining the content, assessing needs, and identifying the target audience. The selection of antimicrobials to be included in the application was based on the list of standardized drugs from the university hospital, which are commonly used in the treatment of pediatric patients, as well as considering the operational workflow of the institution’s pharmacy department and new incorporations not yet included in the most recent version of the standardized drug list. Initially, topical and enteral medications were excluded, since the primary focus was on injectable antimicrobials (intravenous and/or intramuscular).

Subsequently, several well-established references on pediatric drug use—such as Micromedex, UpToDate, Sanford Guide to Antimicrobial Therapy¹⁶, and Lexicomp¹⁷—along with professional package inserts from manufacturers, were reviewed and compared to assess technical aspects related to the preparation and administration of medications. Additionally, an analysis was conducted of the main needs of the pediatric population and their specificities compared with the general population, in order to identify relevant information to be included in the website and mobile application.

Finally, a survey of mobile applications related to pediatric drug use was carried out in Google Play (Android), one of the two main app stores, to assess the profile and content of available applications. The language of the application and whether registration or payment was required for access were considered. The topics covered and the types of information provided were also analyzed. For freely accessible applications, the list of registered medications was compared, taking into account both the profile (dosage form and presentation) and the quantity (variety of drugs).

Planning and prototype development

The second stage of the project involved defining and organizing the topics to be addressed for each antimicrobial, designing the different pages of the website and mobile application, and creating the interface layouts.

This process was guided by the analysis of how information is structured in other applications available in app stores that provide guidance to healthcare professionals on medication use.

The initial structure was developed using Google Sites (<https://sites.google.com/>), a platform provided by Google that enables website creation without requiring programming knowledge. The interface layout was designed by the research team with the support of the graphic design platform Canva. The chosen development language was Portuguese as spoken in Brazil.

Additionally, important calculators for pediatric drug use were developed using the HTML programming language with the support of generative artificial intelligence (AI), specifically ChatGPT. To generate the codes, the calculation process and the logic behind each desired calculator had to be described in detail (prompts). The prompts used for generating the base codes are provided in Appendix 1. After the generation of the base code, it was adjusted and refined to create a standardized layout in terms of color, font, and display mode of the information in the calculators embedded in the website, in order to ensure the presentation of information in the desired format.

To convert the website into a mobile application structure that would allow download on mobile devices, the service “Median.co” (<https://median.co/>) was used. This service converts URLs into files compatible with Android and iOS operating systems. In this study, only the Android version was developed, since the iOS version would require an Apple device for file delivery.

Website / web app availability

The final stage consisted of configuring the technological tools and resources to enable easy access to the website and download of the mobile application. The configuration process was carried out by the entire research team with monthly feedback until the completion of the beta version. The website is available at the URL (<https://www.pedcuidados.com.br/>) and the mobile application via the QR code shown in Figure 1.

Results

A total of 55 antimicrobials were identified in the standardized drug list of the university hospital. Of these, 16 exclusively oral medications were excluded. In addition, Ganciclovir was excluded because it is distributed in unit doses, Cefotaxime because it is no longer part of the hospital’s standardized list, and Tigecycline because it is not indicated for pediatric use. On the other hand, two antimicrobials were included that, although not initially listed, were recently incorporated into the hospital’s formulary: Aztreonam and Ceftazidime + Avibactam. Thus, in the end, 38 antimicrobials (Appendix 2) were selected for inclusion in the website and mobile application (Figure 2).

The defined target audience for the website and application was healthcare professionals involved in pediatric care.

During the survey and evaluation of applications available on Google Play, it was observed that most were structured as calculators. However, these tools are aimed at calculating drug doses based on their commercial presentations, with the goal of determining the amount required for administering the dose prescribed by the clinician.

Among similar applications, only six were identified (*UpToDate*, *Micromedex*, *Pediamecum*, *Whitebook*, *Medicamentos via Parenteral*, and *DosisPedia*). However, not all are specifically targeted at the pediatric population, and most are available only in foreign languages (English, Spanish, or French), which may represent a language barrier for users. In addition, most of the identified applications require a subscription or paid account to access the content, representing yet another barrier to widespread use.

PedCuidados consists of 45 screens. Of these, 38 contain the monographs of the selected antimicrobials, two are dedicated to calculators for assessing renal function and calculating the minimum dilution of drugs, and another five comprise the organizational structure of the site, including the “Home” page and the introductory pages for the “Antimicrobials” and “Calculators” sections. In addition, there are screens with information about the website/mobile application and one screen with legends explaining the terms used throughout the content. Finally, the mobile application is free and requires only 14.5 megabytes of storage on the device. The main screens are shown in Figure 3.

The monographs of the 38 antimicrobials include the following topics: available presentations; usual dose, including the maximum recommended doses when defined, or the message “Variable depending on indication!” in cases where no maximum dose is established; dose adjustment; administration; monitoring; adverse reactions; compatibility; solution compatibility; and bibliographic references. Additionally, there is a section titled “Attention,” intended to highlight important safety information for specific drugs.

At the beginning of each monograph, up to three images are used to highlight specific characteristics of the drugs: a drop, indicating that the medication presents volume expansion; a syringe, signaling that the drug can be administered intravenously via rapid infusion; and an exclamation mark, alerting to drugs that require special attention.

In addition, *PedCuidados* offers calculators for assessing renal function based on Creatinine Clearance (CrCl) and determining the Minimum Dilution Volume (IV) for each drug, considering the maximum recommended concentrations for antimicrobial infusion. This information is displayed as soon as the drug is selected. The calculator also includes alert messages when the prescribed medication is for exclusive intramuscular administration or when the drug is already commercially available in a ready-to-use form that does not require dilution. Finally, the calculator page also provides a detailed explanation of the mathematical reasoning used in the dose calculation.

Figure 1. QR code generated by the Median website, enabling the download of the PedCuidados mobile application version.



Figure 2. Flowchart of antimicrobial selection for inclusion in PedCuidados.

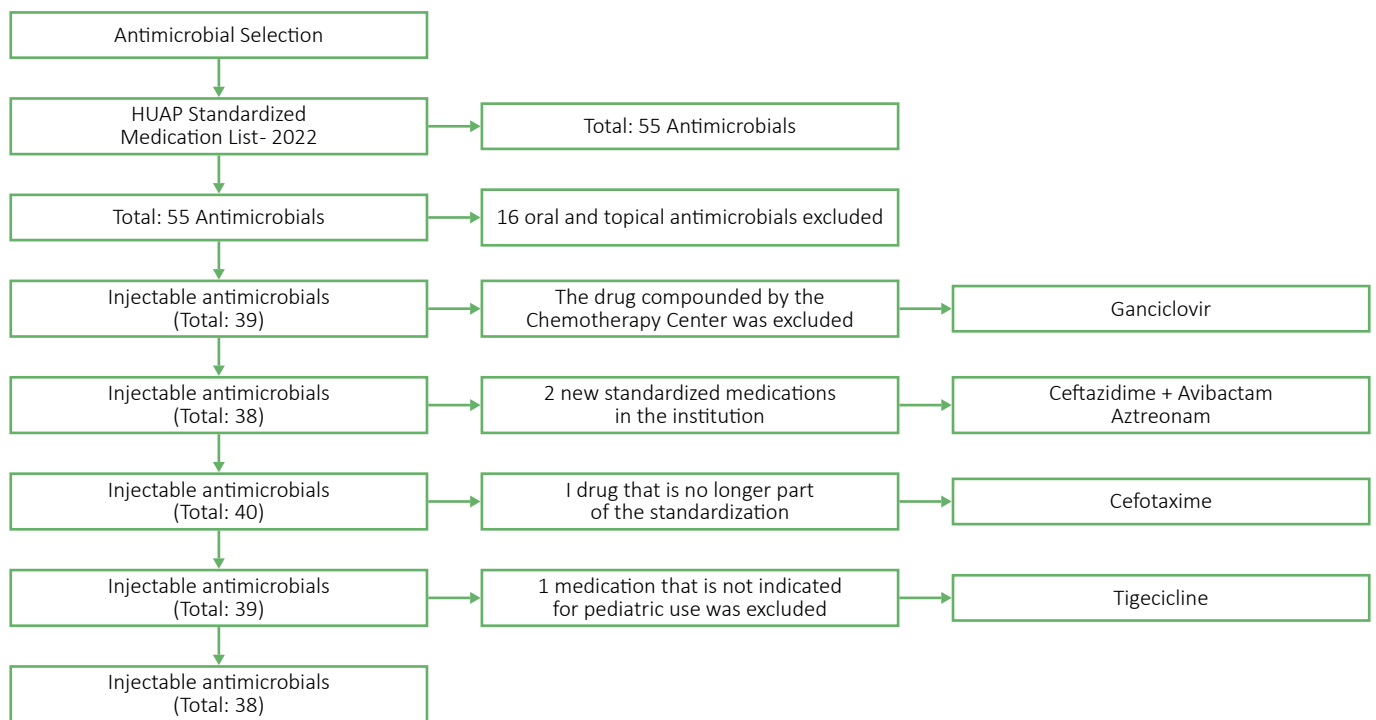
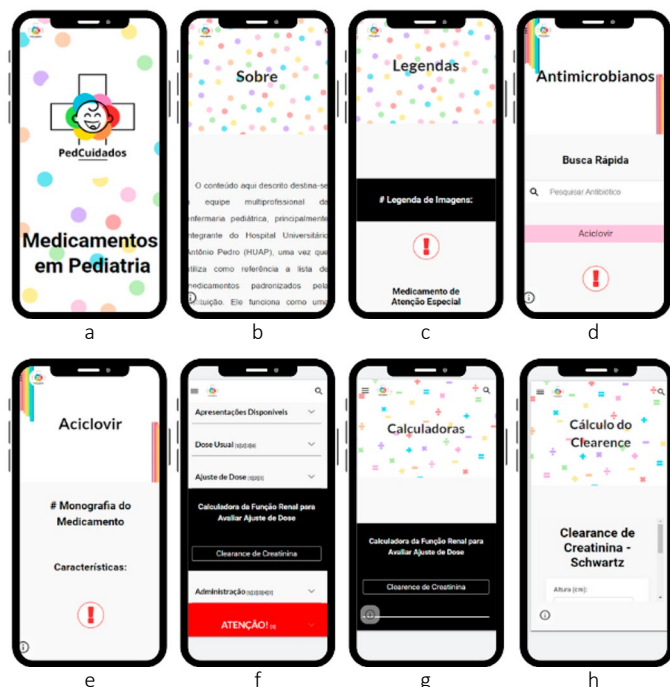


Figure 3. Screens of PedCuidados.



Legend. a: Home screen; b: About the project; c: Legends; d: Main page with monographs organized alphabetically; e: Part 1 of the Acyclovir monograph; f: Part 2 of the Acyclovir monograph; g: Home page for calculators; h: Creatinine Clearance calculator

Discussion

To the best of our knowledge, this is the first free website and mobile application designed to provide reliable and synthesized information in Portuguese on antimicrobials used in pediatrics within the hospital setting. *PedCuidados* offers a broad range of information on injectable antimicrobials, covering aspects from their use to preparation for administration.

The increased use of smartphones has transformed healthcare delivery. These devices offer a wide variety of mobile applications, including those aimed at the health sector. In pediatrics, studies have demonstrated the benefits of these tools in education and learning,¹⁸ child nutrition,¹⁹ mental health,²⁰ disease diagnosis and detection,²¹ and in supporting clinical decision-making, patient education, and self-management in conditions such as cancer, obesity, and asthma.²² In the context of antimicrobial use, a systematic review indicated that such tools can significantly increase adherence to guidelines and protocols, with improvements ranging from 6.5% to 74% for various indications after the implementation of these systems. Mobile applications were also considered easier to use and more useful for prescribers compared with accessing guidelines through booklets.²³ Moreover, institution-specific applications can be developed to address local contexts and institutional protocols, a limitation present in many generic applications.²⁴ This customization is one of the advantages of *PedCuidados*.

The specific selection of injectable antimicrobials for inclusion in the website/application reflects the profile of medication errors to which the pediatric population is most exposed and vulnerable. According to Azar et al. (2021),²⁵ the profile of medication errors in pediatric patients has the following characteristics: the main

drug class involved is systemic antibacterials, representing 15.7% of errors; the most frequent route of administration where errors occur is intravenous, accounting for 65.8%; and the main stages where errors manifest are administration (71%) and prescribing (16.5%). Furthermore, more than half of hospitalized pediatric patients experience problems related to antimicrobial use, such as unnecessary therapy or the need for additional therapy.²⁶ Therefore, investing in the continuing education of healthcare professionals²⁷ and in technological tools²³ that contribute to error prevention may be among the main strategies to reduce risks and minimize errors during the care process.

Six mobile applications providing information on the prescription and administration of pediatric medications were found in the Google Play store for the Android operating system. Most of these applications are not specific to pediatric patients or antimicrobial use and are available only in languages such as English, Spanish, or French, which may represent a language barrier for users in Brazil. Furthermore, many require payment or a subscription to access complete information, potentially limiting access for healthcare professionals who need these tools for free. It is worth noting that *PedCuidados* specifically focuses on antimicrobials, offering detailed information on dilution, stability, and calculators following the recommendations of the Brazilian Society of Pediatrics,²⁸ as well as visual elements to highlight information requiring greater user attention.

The content incorporated into technological tools is essential to ensure that users receive reliable health information. One study evaluated over 5,920 mobile applications, including 215 studies that used the MARS (Mobile App Rating Scale) instrument to measure the quality of these tools. The results revealed that, although many applications performed satisfactorily in terms of functionality, there is a significant gap regarding credibility, highlighting the urgent need for improvements in this aspect.²⁹ *PedCuidados* was developed by experts in the field, following clearly defined steps to ensure the accuracy, updating, and evidence-based foundation of all the information provided.

Among the advantages of *PedCuidados* is the integration between the website and mobile application, allowing any updates to be made quickly and simultaneously. In addition, the mobile application is free, requiring no payment to access its content. It is also worth noting that the mobile application has a small file size, which is relevant as it requires less storage space, contributing to greater speed and performance of the device.³⁰

This study has some limitations. The content of *PedCuidados* includes only monographs of injectable antimicrobials from the standardized drug list of a single university hospital, which may limit its use in other institutions. Another limitation is that the mobile application is available only for the Android operating system. To mitigate this limitation, iOS users can access the content through the web browser.

Additionally, the requirement for the tool to function online is another drawback, particularly in developing countries such as Brazil, where users may face internet connectivity issues. Finally, usability testing of the website and mobile application was not conducted.

Despite these limitations, *PedCuidados* represents a significant advancement for pediatric clinical practice and patient safety. It is an innovative tool adapted to the Brazilian context with the potential to contribute to the safe use of antimicrobials in the hospital setting and may serve as a foundation for future improvements and the development of similar initiatives in the field.

Conclusion

A free website and mobile application were developed in Portuguese, providing reliable information on the prescription and administration of 38 antimicrobials for the pediatric population in the hospital setting. These tools demonstrate high potential for application in clinical practice, potentially contributing significantly to the safety of pediatric treatments. Additionally, they may help reduce errors related to the prescription, preparation, and administration of antimicrobials by providing clear and precise guidance to healthcare professionals.

Future research is needed to assess the usability of these tools, as well as to investigate their acceptability, feasibility, and impact on the safety and effectiveness of antimicrobial use in clinical practice.

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Conflict of interest statement

The authors declare no conflicts of interest regarding this article.

Statement on the use of generative artificial intelligence

AI was used during the preparation of this work to improve the readability and clarity of the manuscript. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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