English

Applications for asthma management in pediatrics: An integrative review

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Abstract

***Introduction**: Asthma is a respiratory disease that requires control to avoid risks to life, and the use of apps can be an important tool for improving ttreatment adherence. **Objective:** To analyze the use of mobile health applications in the management of pediatric asthma. Methodology: Integrative review based on a guiding question, using the acronym PICo to constitute the search expression, using the descriptors "Asthma", "Mobile Applications" and "Pediatrics" in DeCS, MESH, and Emtree, in the Lilacs, Medline, Embase, and Web of Science databases. Original articles were considered, with full texts and no language restrictions. **Results:** The studies addressed the use of mobile apps for treatment adherence, guidance, and instructional, environmental control management, decision support for healthcare staff, symptom surveillance, and real-time intervention in the urgency of exacerbation. **Conclusion:** Mobile applications for asthma showed low adherence to use, considering the unattractive design, limited instruction, errors during execution, and internet access problems. However, they proved useful in treatment, although the small number of participants meant that statistical tests could not be carried out.*

Keywords: *Asthma; Mobile Applications; Pediatrics..*

Resumen

Aplicaciones para el asma

*El asma es una enfermedad respiratoria que requiere control para evitar riesgos para la vida, y el uso de aplicaciones puede ser una herramienta importante para mejorar la adherencia al tratamiento. **Objetivo:** Analizar el uso de aplicaciones de salud móvil en el manejo del asma pediátrica**. Metodología:** Revisión integradora basada en una pregunta guía, utilizando el acrónimo PICo para constituir la expresión de búsqueda, utilizando los descriptores "Asthma", "Mobile Applications" y "Pediatrics" en DeCS, MESH y Emtree, en las bases de datos Lilacs, Medline, Embase y Web of Science. Se consideraron artículos originales, con textos completos y sin restricciones de idioma. **Resultados:** Los estudios abordaron el uso de aplicaciones móviles para la adherencia al tratamiento, la orientación e instrucción, la gestión del control ambiental, el apoyo a la toma de decisiones del personal sanitario, la vigilancia de síntomas y la intervención en tiempo real en la urgencia de la exacerbación. **Conclusión:** Las aplicaciones móviles para el asma mostraron una baja adherencia al uso, teniendo en cuenta el diseño poco atractivo, la instrucción limitada, los errores durante la ejecución y los problemas con el acceso a Internet. Sin embargo, demostraron ser útiles en el tratamiento, aunque el reducido número de participantes impidió realizar pruebas estadísticas.*

Palabras-clave: *Asma; Aplicaciones móviles; Pediatría.*

Resumo

Aplicativos para asma

Introdução: *A asma é uma doença respiratória que requer controle para evitar riscos à vida, sendo que o uso de aplicativos pode ser uma ferramenta importante para melhorar a adesão ao tratamento. Objetivo: Analisar o uso de aplicativos móveis de saúde no manejo da asma pediátrica.* ***Metodologia:*** *Revisão integrativa realizada a partir da pergunta norteadora elaborada por meio do acrônimo PICo para constituir a expressão de busca, utilizando os descritores "Asma", "Aplicativos Móveis" e "Pediatria" no DeCS, MESH e Emtree, nas bases de dados Lilacs, Medline, Embase e Web of Science. Considerou-se artigos originais, com textos completos e sem restrição de idioma.* ***Resultados:*** *Os estudos abordavam o uso de aplicativos móveis para a adesão ao tratamento, orientação e instrucional, gerenciamento do controle ambiental, suporte de decisão para equipe de saúde, vigilância dos sintomas e intervenção em tempo real na urgência da exacerbação.* ***Conclusão:*** *Aplicativos móveis para asma apresentaram baixa adesão quanto ao uso, considerando o design pouco atrativo, instrução limitada, erros durante a execução e problemas de acesso à internet. Entretanto, mostraram-se úteis no tratamento, ainda que o número restrito de participantes não tenha permitido a realização de testes estatísticos.*

Palavras-chave: *Asma; Aplicativos Móveis; Pediatria.*

INTRODUCTION

Asthma is defined as a chronic disease of the conducting airways, usually caused by an immunological reaction, marked by episodic bronchoconstriction due to increased sensitivity of the airways to a variety of stimuli; inflammation of the bronchial walls, and increased mucous secretion [1].

The Global Initiative for Asthma (GINA) report indicates that 18% of the world's population has this pathology [2]. In Brazil, there is no official data on the prevalence of asthma, since it is not a disease that requires compulsory notification; however, studies with hospitalization data indicate that 403,135 people were hospitalized in the country between 2016 and 2020 because of this disease, approximately 70% were children and adolescents [3].

Correct use of medications reduces exacerbations and improves the patient's quality of life. Therefore, knowing the difficulties faced by asthma sufferers is essential to creating solutions for this problem, including forgetfulness, lack of time, lack of understanding of the pathology, difficulty in obtaining the medication, and difficulty in performing the technique of using inhaler devices, among others [4].

From this perspective, technology emerges as a tool to help improve adherence to treatment since different smartphone applications, with calendar features, reminders for medication use, places to document triggers, and even educational games, are being created to enable better self-care in the treatment of asthma [5].

Thus, this article aims to analyze the use of mobile health applications in the management of pediatric asthma, according to the literature.

METHOD

This is an integrative literature review developed in six stages: formulation of the guiding question, establishment of inclusion and exclusion criteria, location of studies in databases, critical evaluation of the study to select eligible publications, data extraction and analysis, interpretation, and synthesis of knowledge [6].

Based on the guiding question - "What does the literature indicate about mobile health applications for the management of asthma in pediatrics?" - the PICo strategy was developed, in which P (problem) corresponded to asthma, I (the phenomenon of interest) to mobile applications and Co (context) relates to the patients assisted in pediatrics.

The search expression used free and controlled vocabulary indexed in the Health Sciences Descriptors (DeCS), Medical Subject Headings (MESH), and Embase Subject Headings (Emtree), with their respective synonyms in Portuguese, English, and Spanish, combined using the Boolean AND (Table 1).

Table 1. Search expression used in the databases for this literature review, 2023.

	BASES: Lilacs* / Medline / EMBASE/ Web of Science
Problem: Asthma	**Asthma** OR "Bronchial Asthma"
	AND
Phenomenon of Interest: Mobile Applications	**"Mobile Applications"** OR "Mobile App" OR "Portable Software" OR "Portable Software Application" OR "Smartphone App" OR "Portable Electronic App" OR "Portable Electronic Application"
	AND
Context: Pediatrics	**Pediatrics**

The literature search took place on March 6, 2023, carried out by a researcher via the CAPES journal portal, through remote access, in the *Literatura Latino Americana e do Caribe em Ciências da Saúde* (LILACS), Medical Literature Analysis and Retrieval System Online (MEDLINE), EMBASE (Elsevier) and Web Of Science (Elsevier) databases. The search fields considered were the title, abstract, and keywords. The inclusion criteria were original articles with full text and without language restrictions. The exclusion criteria were monographs, theses, dissertations, editorials, manuals, short communications, case studies, and reviews.

Subsequently, the articles were exported to the online reference manager Rayyan QCRI of the Qatar Computing Research Institute [7] to exclude duplicate publications and perform title and abstract analysis by two independent and blinded researchers, whose disagreements were resolved by a third researcher, considering the eligibility criterion — the use of mobile health applications for the management of asthma in pediatrics.

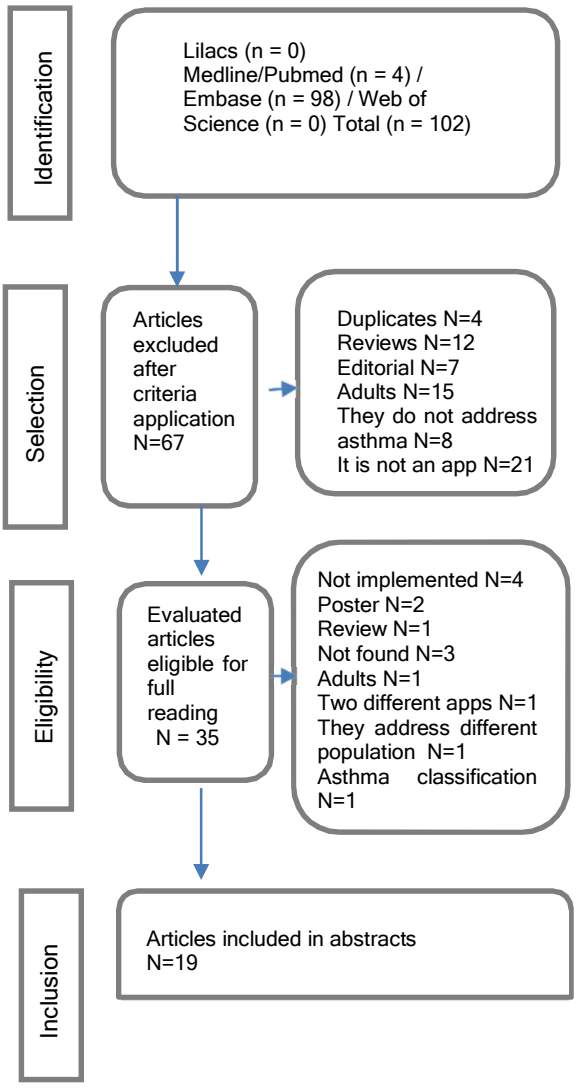
The selected articles went on to the full reading stage and data extraction through the synthesis matrix based on the author(s), year of publication, application name, device type, operating system, objective, main results, and challenges.

RESULTS

A total of 102 publications were found in thedatabases, four of which were excluded because they were duplicates, resulting in 98 articles for reading of titlesand abstracts. Of these, 63 were excluded, of which 12 were literature reviews, seven were editorials, and eight addressed other diseases such as kidney disease, child neurology, pediatric liver transplantation, SARS-CoV-2, type 1 diabetes mellitus, hearing and visual loss, neonatal jaundice, and childhood oncology, among others. In addition, 15 articles were excluded because they addressed asthma in adults and 21 because they did not refer to applications, but only to the use of images or a website for questionnaires.

Then, 35 articles were read in full but we excluded four articles because the application was not implemented, two for being posters, one for being a review article, three that were not found even after contacting the authors, one that included only the adult population, one that addressed two different applications without distinguishing the results of each separately, one for dealing with asthma in children and adults without distinguishing the results, one that classifiedasthma endotypes, one opinion article and one that used pulmonary auscultation for various pathologies withoutseparating the asthma results, totaling 19 articles to compose this review (Figure 1).

Figure 1. Flowchart of the article selection steps for this integrative literature review, 2023.



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The included studies were conducted mainly inthe United States [9-21], followed by Australia [22], Russia [23], China [24-25] and Norway [26]. All of them used mobile devices with iOS [10,11,45,22,26], Android [17,24], or iOS/Android [9,5,12,15,25] operating systems, although in others it was not specified [11,13,16,18-21,23], in addition to the hybrid system (mobile device and website) [5,11,16,18,24] (Table 2).

Most studies´ purposes were monitoring and adherence to treatment [10,11,13-15,17,19-21,23-25], followed by guidance and instruction [12,13,15,22], environmental control management [16,18], decision support tool [5,26], instruction [9], symptom surveillance [11] and real-time intervention in the urgency of exacerbation [24] (Table 2). Some of the challenges presented were the lack of internet [12,22], the unavailability of cell phones that used the applications' operating systems [10,14,17,24,26], lack of time for the user and/or companion to use the application [9,26], dissatisfaction with the appearance and functionalities [9,17,19,20,23,25], low number of participants or low adherence [5,11,13,15,17-19, 23,25], high cost forcreation and implementation [23], financial bonuses [11,14] and reduction of outdoor activities [16] (Table 2).

Regarding the sample size of the studies, there was an application tested by less than 10 participants [14.20], from 11 to 50 [9.10,13,15-17,23,26], from 51 to 100 [23.25] and above 101 [5.11,19, 22.24] (Table 2).

Mobile applications for asthma management have proven to be a crucial tool for improving asthma treatment, contributing to adherence [17,19,21,23,25] through different strategies, such as providing reminders and guidance, educational videos [21], and/or text messages [17,19,23,25], including in remote areas [21,22]. In addition to reducing symptom severity scores [17,24], they provided more effective asthma control. Despite this, there was no significant improvement in lung function in some cases [17].

The applications offered an effective therapeutic plan and asthma control [16], clarified doubts via telemedicine [23], and provided additional support to patients. Other benefits included the integration of the application with medications [10,25], recording of medication administration and feedbackfrom the health professional [9], behavioral changes [17,18], and reduction in emergency room visits [5,11,26] and antibiotic use [24,25].

Table 2. Summary matrix of articles included in thisintegrative literature review, 2023.

Author/ Year	Application Name	Device/ Operating System	Objective	Main results	Challenges
Ramsey et al., 2022[17]	BreatheSmart	Device: Mobile System: Android	Behavioral intervention to improve adherence to asthma treatment	- It improved adherence - Reduction in severity score - No improvement in lung function	- Low acceptability due to the appearance of the application
Rosser et al., 2022[16]	AirNow	Device: mobile and website System: not specified	Environmental control (air quality) Self-monitoring of asthma symptoms.	- Effective therapeutic plan - Asthma control.	- Small sample - High air pollution has reduced outdoor activities
Versteegh et al., 2022[22]	Lung health for kids	Mobile device System: iOS	Guidance/teaching (concept of asthma) Instructional (how to act in a crisis)	- It provided educational videos in multiple languages used inAustralia - It reached people in remote locations - It helped to learn first aid for asthma exacerbations	- Internet access - Difficulty in finding directions due to the lack of non-technical terms in different languages
Arimova et al., 2021[23]	MedQuizBot	Mobile device System: not specified	Adherence to asthma treatment through messages and reminders.	- Medication adherence through reminders, - Automatic algorithm of actions changing medications according to entered symptom data - Clarification of doubts via telemedicine.	-Cost of development and implementation, -Lack of desire or ability of patients to install the application Discontinuation of use after improvement of symptoms.

Kerns et al., 2021[5]	Web site (PIPA) Peds Guide	Mobile device System: iOS and Android	Decision support tool to support the healthcare team.	- Support in the management of hospitalized patients and asthma exacerbations with severity algorithms. - Use of the smoking screening tool, radiography criteria, and triage algorithms. - Reduction in the time of care and hospitalization - Early use of metered-dose inhalers.	- Delay in launching the application - Small sample.
McIntire et al 2021[9]	Emocha	Mobile device System: iOS and Android	Instructional on how to use asthma medication devices.	- Recording of medication administration and feedback from the healthcare professional - It helped in learning the technique of administering inhaled medication, - It provided confidence and autonomy. - Progressive improvement in performing the technique	- Lack of time to send the video - Dissatisfaction due to lack of instructions for recording the video - Dissatisfaction with gamification
Reyes et al., 2021[18]	AirNow	Mobile device and website System: not specified	Environmental control management for asthma sufferers, offering airquality alerts.	- Behavioral changes, - Information about air quality, - It helped to avoid triggers and exacerbation of asthmatic patients.	-Low adherence
Dawson et al., 2020[21]	Asthma MD (AMD-Sp)	Mobile device System: not specified	Self-monitoring and adherence to asthma treatment through messages, email, and alerts.	-Accounting for doses administered by the inhaler -It improved adherence -Bilingual application helped with translation -One-week monitoring by the researcher to adapt to the use of the application -Training of health professionals and parents	-Barriers to communication, accessibility, adherence, and technological interventions -High investment.
Hsia et al., 2020[12]	ASTHMAXcel	Mobile device System: iOS and Android	Guidance with gamification.	-It improved knowledge about the disease, symptoms and exacerbations, -It reduced visits to Emergency Care units -It reduced the use of medication (prednisone) and missed school days.	-Internet access
Kenyon et al., 2019[19]	The name of the app is not mentioned	Mobile device System: not specified	Self-monitoring of adherence to asthma treatment through notification and messages.	-Provision of medication reminders -Acceptability of the application among caregivers -Text message intervention.	-Equipment problems caused a lack of adherence and loss of follow-up, -Small sample -Limited evaluation and short study time
Shaoxia et al, 2019[24]	The name of the app is not mentioned	Mobile device Android systems and computers	Self-monitoring of adherence to maintenance treatment through notification and daily messages, Alert button in cases of exacerbation Real-time treatment recommendations.	-It decreased thefrequency of exacerbations -It increased asthma control test scores. -It decreased the incidence of respiratory tract infection diagnoses. -It reduced days of antibiotic use.	-Limitation of users due to using the Android operating system

Mikalsen; Nassehi, Oymar., 2019[26]	Blowfish	Mobile device System: iOS	Diagnosis and maintenance treatment of asthma through self-management of peak expiratory flow (PEF).	-It allowed the patient to evaluate their PEF measurement. -Perception of triggers responsible for asthma exacerbation. -It contributed to the diagnosis and monitoring of the disease.	-Limitation of users due to using the Android operating system -Forgetting to blow at the expected frequency during the day (twice)
Nkoy et al., 2019[11]	Asthma Tracker	Mobile and web System: not specified	Self-monitoring of adherence to asthma treatment.	-Higher participation during self-monitoring -It reduced school time lost by children and parents at work due to asthma exacerbations. -It reduced the number of hospitalizations in emergency departments.	-Decrease in adherence to the questionnaire -Receipt of financial incentive, based on adherence for four weeks.
Real et al., 2019[13]	CHANGE Asthma	Mobile device smartphone System: not specified	Guidance with gamification, instructional (checks the use of the medication device), and self-monitoring of adherence to asthma treatment.	-Reading the medication using the cell phone camera. -It provided information about the type of inhaler and its typical use. -Access to the name of the medication and how to use it through the game, according to the symptoms presented by the character (Avatar). -Reaching the population with low literacy.	-Small sample -Lack of evaluation of the application's features
Zhow et al., 2019[25]	Nebulizador Omron/ Nebulizador Pari	Mobile Device System: iOS and Android	Monitoring asthma treatment devices for adherence via a smart nebulizer and receiving reminders.	-Smart nebulizers are superior to conventional nebulizers in controlling asthma symptoms. -Greater adherence to inhaled corticosteroidtherapy. -Significant reduction in emergency room visits and antibiotic use. -Improvement in the rate ofadherence to inhaled corticosteroids.	-Problems or failures in devices -Failure to connect to the smartphone application, -High cost -Reduced adherence to the use of the application over time.
Sage et al., 2017[20]	Wireframe	Mobile device System: not specified	Self-monitoring and adherence to asthma treatment with gamification and messages.	-Information about symptoms and factors that contribute to asthma exacerbation. -It detailed record of medication use and treatment.	- Greater efforts by users to use the application's gamification. - Excessive personalization that overloads the user and limits understanding - Limitation of the application in providing data to perform a task.
Cushing et al., 2016[14]	Asthma hero	Mobile device System: iOS	Self-monitoring and adherence to asthma treatment with graphs, gamification, and rewards.	-Change in the routine of medication use. -Reduction in the frequency of symptoms. -Increased confidence in disease control. -All participants expressed interest in continuing to use the application after the study.	-Small sample -Limitation of users due to the use of the iOS operating system -Offer of a monetary prize

Burbank et al., 2015([15])	The name of the app is not mentioned	Mobile devices System: iOS and Android	Self-monitoring of symptoms and adherence to asthma treatment through notification and motivational and alert messages, with guidance/teaching on the use of devices.	-Insertion of expiratory flow and/or symptom data. -Sending reminders to take medication. -Motivational messages are sent when asthma is under control. -Providing instructions on how to dose rescue medication when symptoms are moderate or severe, or when seeking medical assistance. -Feeling of confidence and autonomy in controlling the disease.	- Short research time. - Small sample size

Source: Created by the authors (2023).

DISCUSSION

This study, through a literature review, provided broad knowledge about the applications that are being created and available for controlling asthma in children and adolescents, showing the importance of technology as a tool to help monitor the disease.

Most applications were created to solve the problem of treatment adherence, regardless of whether the patients were children or adolescents [10,11,13-15,17,18-21,23-25]. One of the strategies to eliminate forgetting to take medication was to trigger reminders, alerts, and messages [15,19,20,21,24], which helps to ensure that medications are taken at the correct times, reducing the risk of exacerbations, providing a detailed record of the doses administered and facilitating medical monitoring of the response to treatment. However, this functionality can be performed by the patient without the need for an application exclusively for this purpose on his/her mobile device, which may discourage continued use of the application [5,10,12,14,16-18,22,24]. Perhaps, for this reason, applications that had additional functionalities had greater use continuity.

Monitoring treatment adherence is not a resource aimed solely at assisting the patient; it can also be used by the medical team to classify the severity of the patient's clinical condition, contributing to personalized calculations of maintenance treatment [13,14,15,22]. This aids in management during exacerbations, increasing the patient's confidence and autonomy in controlling the disease [9,14,15], favoring greater independence over time. Also, constant monitoring allows for quick and accurate adjustments in treatment, avoiding complications and unwanted progression of the disease. Accurate monitoring can also facilitate the identification of specific patterns and triggers that lead to exacerbations, allowing for more targeted and effective interventions. All of this consequently results in a reduction in the number of hospitalizations [5,11], unnecessary radiographs [5], diagnostic errors, and excessiveuse of medications [24,25], resulting in a better quality of life for patients and optimization of health resources.

Smart nebulizers have shown greater efficacy in controlling asthma symptoms and greater acceptance in adherence to inhaled corticosteroid therapy [25]. These advanced devices offer more precise and consistently controlled dosages, improving treatment efficacy and reducing side effects. Also, the connectivity of smart nebulizers to applications allows real-time monitoring of medication delivery, providing valuable data for personalized treatment adjustments [10,25]. This isespecially crucial in cases of exacerbation, where time to treatment response is essential to prevent serious complications and ensure faster recovery.

Gamification has been used by several applications to attract the attention of children and adolescents and increase treatment adherence [9,12-14,20]. By incorporating game elements, this strategy makes treatment more engaging and requires significant resources to meet individual patient demands. This includes personalizing games to reflect each user's preferences and needs, as well as using avatars [13], which provide a sense of individualization, although this represents a logistical and financial challenge. However, applications that have used gamification have demonstrated positive reactions among users, increasing engagement and adherence to treatment. This interactive approach not only makes treatment more appealing but also educates patients about asthma management in a fun and accessible way, resulting in a deeper understanding of the disease and its management.

The Asthmacel app [12] used gamification to guide participants, offering support and clarifying doubts about the disease and its attacks. This playful approach significantly increased users' understanding of asthma, resulting in a notable reduction in visits to emergency care units and a decrease in school absences. To instruct people with lower levels of literacy, Chance Asthma [13] demonstrated that the use of gamification helps to indicate theappropriate medication in different situations more objectively and effectively. By transforming medication into a simple and direct process, gamification facilitates treatment adherence, especially in vulnerable populations, promoting more autonomous and reliable management of asthma.

To meet the demands of different languages and different levels of accessibility, including remote locations [21,22], it is crucial to invest in monitoring the process of assimilation and adaptation of applications on devices. This investment not only favors user adherence but also

highlights the need and importance of training health professionals to guide patients [05,22,23]. Places of collective coexistence and routine visits, such as schools, also require the presence of people trained to deal with asthma attacks and knowledge of how to use technological resources to optimize care. This ensures that patients receive continuous and adequate support, regardless of where they are, promoting more effective management of the disease and reducing the risk of exacerbations.

The Emochaapp [9] uses instructional videos and feedback to teach and improve the correct use of medication devices and is a valuable resource in the process of learning and improving patients' techniques. These videos provide clear and practical guidance, helping patients develop appropriate skills for administering their medications, which is essential for effective asthma control.

Similarly, MedQuizBot [23] uses an interactive questionnaire on medication use, symptoms, and inhalation technique, with regular, real-time transmission to the physician, enabling an instant and personalized response with rapid adjustments based on continuous monitoring of the patient's health status. These technological resources not only increase treatment adherence but also promote more proactive and informed management of the disease, benefiting both patients and healthcare professionals.

In circumstances where the number of study participants was less than 10 such as Asthma Hero [14] and Wireframe [20], the evidence found regarding the positive influence on adherence, increased confidence, and interest in maintaining the use of the application on their devices is questioned, especially when there was financial compensation for carrying out and remaining in the study [11,14]. On the other hand, it was possible to observe that socioeconomic difficulties are still a challenge that prevents some individuals from enjoying the benefits that electronic applications can provide, mainly due to the lack of access to the internet and restrictions regarding the operating system [12].

CONCLUSION

Technology has the potential to transform asthma management, meeting several essential needs, from prescribing and correctly using medication to providing guidance, adherence to treatment, organizing care and support during exacerbations, especially with continuous and real-time monitoring, as well as with the use of gamification.

Smart nebulizers connected to the app represent another crucial innovation, as they offer more accurate medication dosage and allow real-time monitoring, which facilitates personalized adjustments that improve treatment efficacy and reduce side effects, allowing for more effective asthma management and helping to maintain control of the disease. It is also important to highlight the importance of the co-responsibility of the patient and their family members in the management of asthma, which is facilitated using technology, especially in more remote areas and/or areas with difficult access to health services.

The limitations of this study are related to the databases chosen, which may restrict the number of articles found on the subject. At the same time, other studies are suggested that address the perception of users of the system in the long term for the improvement of health indicators on asthma, as well as others that allow articulation with environmental aspects, which are also characterized as potential for exacerbating the condition.

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