Vol. 3(4), 148-154, 2025

REVIEW

Smart stethoscopes, smart inhalers, and ChatGPT: latest developments of digital health in childhood asthma

Doi
10.56164/PediatrRespirJ.2025.81

David **Drummond** *

* Correspondence to:
david.drummond@aphp.fr. ORCID: https://orcid.org/0000-0002-7324-4992

Department of Paediatric Pulmonology and Allergology, University Hospital Necker-Enfants Malades, AP-HP, Université Paris Cité, Inserm UMR 1346, HeKA team, Pari Santé Campus, Paris, France

ABSTRACT

Asthma is the most common chronic disease in children, yet outcomes remain suboptimal, with high rates of exacerbations, emergency visits, and preventable deaths. Despite well-established treatment guidelines, care delivery continues to be limited by three major structural barriers: incomplete or unreliable symptom assessment, infrequent and reactive follow-up, and insufficient day-to-day support for families. Digital health technologies offer new opportunities to address these challenges by enabling objective data collection, continuous monitoring, and accessible guidance outside clinical settings. This mini-review explores three key innovations that are transforming paediatric asthma care: smart stethoscopes, smart inhalers, and large language models (LLMs). Smart stethoscopes use artificial intelligence to detect wheezing and other abnormal breath sounds at home with high sensitivity. Although evidence in routine clinical practice is still limited, they offer promise in improving symptom recognition, especially in preschool-aged children. Smart inhalers and spacers provide objective data on medication use and inhaler technique, helping clinicians distinguish poor asthma control from non-adherence. Real-time monitoring systems have also been shown to improve asthma control scores, although they may increase healthcare utilisation due to heightened clinical vigilance. Predictive modelling based on inhaler sensor data has demonstrated good accuracy in forecasting exacerbations several days in advance, offering a shift from reactive to preventative care. LLMs such as ChatGPT, Claude, and Gemini provide immediate, comprehensible responses to asthma-related questions from families, filling a critical gap in support between clinic visits. Recent studies show that their responses are generally accurate, clear, and appropriate for parents, particularly when using paid versions. They may also assist healthcare professionals by generating educational materials and synthesising clinical guidance, though concerns around hallucinations, data privacy, and safety in acute settings currently limit their clinical use. Together, these digital tools offer promising avenues to personalise and modernise asthma care for children. However, further validation, integration into care pathways, and attention to safety and equity will be essential to translate this potential into improved outcomes.

IMPACT STATEMENT

Digital health tools can provide objective monitoring, timely interventions, and accessible support, offering new opportunities to improve outcomes in childhood asthma.

KEY WORDS
Digital inhalers; adherence; inhaler technique; digital health; remote monitoring; eHealth; electronic monitoring.

 |

INTRODUCTION

Asthma is the most common chronic disease in children, yet outcomes remain unacceptably poor, with persistently high rates of exacerbations, emergency visits, and preventable deaths (1-3). Despite advances in treatment and management guidelines, three key structural limitations continue to impede the delivery of optimal asthma care for children.

First, clinical assessment is often undermined by incomplete or unreliable data. One of the primary challenges for clinicians is determining whether the respiratory symptoms reported by families genuinely reflect asthma manifestations. Studies have shown that parents frequently describe a range of respiratory noises as “wheezing”, even when these sounds are more consistent with snoring or stridor (4). This misreporting can complicate diagnostic clarity and lead to inappropriate management decisions. A second key limitation is the difficulty in obtaining reliable information about short-acting β_2-agonist (SABA) use at home. SABA use is a critical indicator of asthma control, and excessive reliance on reliever medication has been linked to an increased risk of severe, and even fatal, asthma attacks (3, 5, 6). Equally, clinicians have no reliable way of assessing adherence to maintenance therapy or the correctness of inhaler technique in the home setting - yet these are fundamental considerations when evaluating poor asthma control (7). Without objective insight into these elements, treatment escalation decisions may be made without addressing the true underlying cause, such as poor adherence or incorrect inhaler use. Finally, environmental factors known to influence asthma - such as air pollution, weather conditions, and allergen exposure - are rarely documented in a systematic or meaningful manner (8, 9). The lack of tools to capture these parameters continuously and objectively means they are often overlooked or reduced to simplistic screening questions, despite their recognised clinical relevance.

Second, follow-up remains episodic and reactive, rather than aligned with the continuous and dynamic nature of asthma. While children live with the condition 24 hours a day, clinical assessments are typically limited to brief, scheduled visits occurring every 3 to 12 months (10). In the meantime, day-to-day changes in symptoms, medication use, or environmental exposures may go undetected. This gap in monitoring can delay necessary treatment adjustments and increase the risk of sudden, potentially preventable exacerbations.

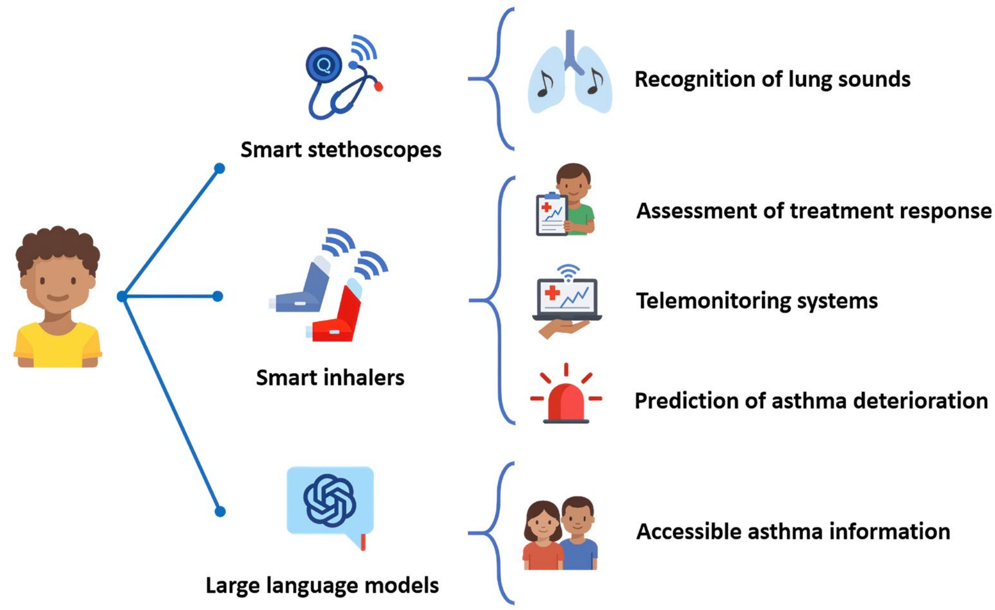

Figure 1*. Overview of emerging digital health tools in paediatric asthma. Smart stethoscopes enable recognition of lung sounds at home. Smart inhalers provide objective data for assessment of treatment response, allow integration into telemonitoring systems, and can contribute to predictive modelling of asthma deterioration. Large language models such as ChatGPT support families with accessible asthma information and education.*

Third, families often lack the day-to-day support needed to manage asthma effectively. Questions, concerns, and uncertainties frequently arise between clinic visits - precisely when professional advice is not readily available. Without timely access to guidance, families may feel isolated in managing the condition, which can lead to anxiety, suboptimal decisions, and inconsistent adherence (11). Addressing this unmet need is essential to empower families, support confident self-management, and ultimately improve outcomes.

Digital health technologies and artificial intelligence (AI) are increasingly being investigated as potential solutions to these structural limitations (12-16). By enabling objective data collection, continuous monitoring, and accessible support outside of clinical settings, these tools may help bridge longstanding gaps in paediatric asthma care. The aim of this mini-review is to explore how emerging innovations - such as smart stethoscopes, digital inhalers, and conversational AI - could contribute to improving asthma care in children (**Figure 1**).

SMART STETHOSCOPES

The aim of smart stethoscopes is to enable reliable assessment of lung sounds in children outside of clinical settings, particularly at home. These devices are designed to detect abnormal respiratory sounds - most notably wheezing - with greater objectivity and consistency than traditional parental reporting (17). These portable devices typically connect via Bluetooth to a smartphone and, once placed on the child's chest, record and analyse breath sounds using artificial intelligence (AI) algorithms.

Validation studies have demonstrated that AI-driven acoustic analysis, particularly neural network–based models, can identify wheezes, rhonchi, and crackles with higher sensitivity and comparable specificity to experienced clinicians (18). Smart stethoscopes may be especially useful in preschool-aged children, where differentiating asthma exacerbations from viral upper respiratory infections remains a common clinical challenge.

To date, no studies have evaluated the role of smart stethoscopes in routine clinical practice for the diagnosis of asthma. The only trial conducted - the WheezeScan study - focused instead on their use for home monitoring (19). This multicentre trial, conducted in Berlin, London, and Istanbul, enrolled 167 children aged 4 months to 7 years with recurrent wheeze. Families in the intervention group used the device at home for 120 days, while those in the control group received usual care. The primary outcome, asthma control assessed by the TRACK questionnaire at day 90, did not differ significantly between groups. However, a major limitation of the study was that families were not given systematic instructions on how to respond when wheeze was detected, likely limiting the clinical impact of the intervention. Secondary outcomes, including parental quality of life and self-efficacy, also showed no significant differences, although improvements were seen in both groups over time. Most parents in the intervention arm found the device easy to use and perceived it as beneficial for their child, despite challenges such as background noise interference and difficulty keeping younger children calm during recordings.

In summary, smart stethoscopes offer a promising opportunity to generate objective data and support the recognition of wheeze in the home environment. However, their effective integration into paediatric asthma management will require structured guidance for families on how to interpret and act upon device outputs.

SMART INHALERS

The latest generation of smart inhalers and smart spacers are equipped with sensors that capture objective data on both inhaler use and technique. These data can be leveraged in various ways: retrospectively, to inform treatment decisions; prospectively, for real-time telemonitoring; and increasingly, as inputs for predictive modelling and personalised care strategies.

Objective and reliable data on adherence and inhalation technique

Poor adherence and incorrect inhaler technique remain two of the most significant barriers to achieving asthma control in children. First-generation smart inhalers, which recorded only the timing of actuations, already provided valuable retrospective insights. A paediatric study demonstrated that electronic monitoring of inhaled corticosteroid (ICS) use was key to distinguishing true severe asthma from uncontrolled disease due to non-adherence (20). Among children with persistently poor control after a three-month monitoring period, two-thirds were found to have suboptimal adherence, while only one-third required treatment escalation, including biologics.

In adults, the INCA Sun trial extended this principle by incorporating a smart inhaler capable of assessing both ICS adherence and inhalation technique, alongside digital peak flow monitoring (21). In this six-month study involving 213 adults with difficult-to-control asthma, participants in the intervention arm were significantly less likely to require escalation to biologics or high-dose ICS, and more likely to have treatment stepped down. Importantly, this was achieved without any deterioration in asthma control, lung function, quality of life, or exacerbation rates. The findings demonstrated that objective digital monitoring can safely reduce unnecessary treatment intensification and associated healthcare costs, while maintaining clinical stability.

Beyond adherence to maintenance therapy, smart inhalers also enable detailed tracking of reliever use – particularly SABA - in everyday life, offering a level of granularity that is unattainable through routine clinical assessment. These devices provide clinicians with accurate data to replace or complement self-reporting by families. In a recent prospective study, smart inhalers used to monitor home salbutamol use revealed frequent deviations from prescribed action plans (22). Such insights enable more individualised action plan reviews, helping to align actual SABA use with intended strategies - particularly important given the well-established association between SABA overuse and severe, or even fatal, asthma exacerbations.

Collecting data in real time for telemonitoring systems

While retrospective analysis of smart inhaler data provides valuable insights during clinical consultations, real-time telemonitoring systems take this approach further by enabling timely responses to concerning usage patterns as they emerge. This proactive model of care allows healthcare teams to intervene before asthma control deteriorates significantly, potentially preventing exacerbations.

The largest paediatric randomised controlled trial to date in this area is the iTRACC study, which enrolled 252 children aged 4-17 years across the United States (23). Participants in the intervention group used sensor-enabled inhalers linked to a digital platform, which triggered automated alerts to a nurse when predefined thresholds were exceeded (*e.g.*, more than four SABA doses in a day or more than four days without ICS use). Over the 12-month follow-up period, children in the intervention group experienced significantly greater improvements in asthma control, with a mean ACT score increase of +2.7 compared to +0.5 in the control group ($p < 0.01$). However, the study also reported a paradoxical increase in emergency visits and hospitalisations in the intervention group. This was attributed to enhanced clinical vigilance and more frequent referrals in response to real-time alerts.

These findings suggest that while smart inhalers with telemonitoring capabilities can improve symptom control and patient-reported outcomes, they may also lead to increased healthcare utilisation due to more proactive identification and management of risk patterns.

Prediction of asthma deterioration

The most advanced application of smart inhaler technology lies in predictive modelling - using sensor data to anticipate asthma exacerbations before they occur. This approach enables a shift from reactive management to a more proactive, preventative model of care.

Lugogo and colleagues developed the first machine learning model based on data from digital reliever inhalers to forecast impending asthma deterioration (24). In their 12-week study involving 360 adults with poorly controlled asthma, participants used the *ProAir® Digihaler®*, which recorded inhaler usage along with inhalation parameters such as peak inspiratory flow, inhalation volume, and duration. A gradient-boosting algorithm was trained on this dataset, combined with baseline patient characteristics, to predict the risk of an exacerbation occurring within five days. The model achieved a strong predictive performance, with an area under the receiver operating characteristic curve (AUC) of 0.83.

The most powerful predictive variable was the mean number of daily inhalations in the four days preceding the prediction window. Patients who experienced an exacerbation averaged 7.3 inhalations in the 24 hours prior to the event. In addition, both peak inspiratory flow and inhalation volume were found to decline in the days leading up to deterioration, offering further early-warning signals.

These findings illustrate the potential of smart inhalers not only to monitor asthma control but also to provide real-time risk stratification, opening the door to earlier and more targeted interventions. However, for such predictive tools to be clinically useful, implementation must carefully balance sensitivity and specificity to minimise false positives while ensuring timely responses to true deterioration.

CHATGPT AND OTHER COMMERCIAL LARGE LANGUAGE MODELS

The third major innovation transforming childhood asthma care stems from large language models (LLMs) such as ChatGPT, Claude, Gemini, Copilot, Deepseek or Mistral. These conversational agents are capable of delivering immediate, comprehensible responses to natural language queries, thereby offering timely support when families have questions outside the context of scheduled consultations.

Supporting families with asthma information

Parents of children with asthma frequently turn to the internet - most commonly via general search engines such as Google - when seeking information about their child's condition (25). LLMs now offer an alternative, allowing parents to pose asthma-related questions and receive rapid, personalised responses. A critical issue, however, is the reliability, clarity, and appropriateness of the information provided.

Recent evaluations of LLM performance in this context have shown encouraging results. Girault *et al.* assessed ten LLMs using the ten most common questions posed by parents of children with asthma attending a tertiary care centre (26). Responses were independently rated by both paediatric pulmonologists and parents. Medical accuracy, as evaluated by paediatric pulmonologists, was rated highly (median 4/5), with 91% of responses scoring ≥4. Paid versions of LLMs consistently outperformed their free counterparts. Comprehensibility was also rated favourably by parents, with 93% of responses scoring ≥4/5. The way information was phrased - specifically its clarity, tone, and suitability for a lay audience - was considered appropriate in 72% of cases by physicians and 90% by parents. Other potential applications of LLMs include helping families better understand complex medical information discussed during consultations, and providing real-time translation of instructions into their native language.

Applications for healthcare professionals

For clinicians, large language models may support a range of tasks, including the rapid summarisation of clinical guidelines, synthesis of relevant literature, and the development of patient education materials tailored to different developmental stages.

Early evidence also suggests potential value in medical education. A randomised trial conducted in China found that brief training in the use of ChatGPT improved doctors' knowledge and management of paediatric asthma (27). This effect was particularly notable in resource-limited settings, where access to specialist training and up-to-date guidelines may be constrained.

Limitations and safety concerns

Despite these promising applications, several limitations restrict the current clinical use of LLMs. Most notably, they can produce plausible - sounding but factually inaccurate responses - a phenomenon known as "hallucination" (28). In addition, commercial LLM platforms do not meet the data protection standards required for use in healthcare settings, raising concerns around confidentiality and regulatory compliance.

To date, no study has assessed the safety or reliability of LLMs in acute clinical situations such as asthma exacerbations, and these tools are not validated for use as clinical decision support systems. As such, while they may offer valuable educational and supportive functions, they should not be relied upon for urgent or high-stakes medical decision-making.

CONCLUSIONS

Digital health technologies offer promising solutions to longstanding challenges in childhood asthma care. Smart stethoscopes, smart inhalers, and LLMs provide new ways to collect objective data, monitor disease in real time, and support families between clinic visits. Together, these tools have the potential to improve symptom recognition, optimise treatment, and promote proactive, personalised care. However, their clinical integration remains limited. Most tools require further validation, particularly in real-world settings, and key concerns persist around data privacy, safety, and appropriate use. Ensuring equitable access and embedding these innovations into care pathways will be essential. If these challenges can be addressed, digital tools will play a key role in transforming paediatric asthma management in the years ahead.

ACKNOWLEDGEMENTS

During the preparation of this work, DD used ChatGPT to proofread and improve grammar and sentence flow.

After using this tool, DD reviewed and edited the content as needed and take full responsibility for the content of the publication.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest

David Drummond is the secretary of the group 1.04 mHealth/eHealth at the European Respiratory Society. He is the principal investigator of several ongoing studies involving electronic monitoring devices (NCT04810169) and social robots (NCT04942639), the latter being funded by the company Ludocare.

Financial support

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

DD is the sole author of the article.

Ethical approval

Human studies and subjects

N/A.

Animal studies

N/A.

Data sharing and data accessibility

The data that support the findings of this study are available from the corresponding author upon reasonable request. Due to the nature of the survey and the anonymized dataset, no individual identifiable information is included. Data sharing will be considered for academic and research purposes in compliance with applicable data protection regulations.

Publication ethics

The author declare that this manuscript is original, has not been previously published, and is not under consideration for publication elsewhere.

REFERENCES

1. Paracha R, Lo DKH, Montgomery U, Ryan L, Varakantam V, Gaillard EA. Asthma medication adherence and exacerbations and lung function in children managed in Leicester primary care. NPJ Prim Care Respir Med 2023;33:12. doi: 10.1038/s41533-022-00323-6.
2. Nwaru BI, Ekström M, Hasvold P, Wiklund F, Telg G, Janson C. Overuse of short-acting β2-agonists in asthma is associated with increased risk of exacerbation and mortality: a nationwide cohort study of the global SABINA programme. Eur Respir J 2020;55:1901872. doi: 10.1183/13993003.01872-2019.
3. Melén E, Nwaru BI, Wiklund F, de Fine Licht S, Telg G, Maslova E, et al. Short-acting β2 -agonist use and asthma exacerbations in Swedish children: A SABINA Junior study. Pediatr Allergy Immunol 2022;33:e13885. doi: 10.1111/pai.13885.
4. Cane RS, Ranganathan SC, McKenzie SA. What do parents of wheezy children understand by "wheeze"? Archives of Disease in Childhood 2000;82:327–32. doi: 10.1136/adc.82.4.327.
5. Morgan A, Maslova E, Kallis C, Sinha I, Roberts G, Tran TN, et al. Short-acting β2-agonists and exacerbations in children with asthma in England: SABINA Junior. ERJ Open Res 2023;9:00571–2022. doi: 10.1183/23120541.00571-2022.
6. Child deaths due to asthma or anaphylaxis (NCMD). HQIP 2024. https://www.hqip.org.uk/resource/ncmd-dec24/ (accessed July 6, 2025).
7. Dhruve H, Jackson DJ. Assessing adherence to inhaled therapies in asthma and the emergence of electronic monitoring devices. European Respiratory Review 2022;31. doi: 10.1183/16000617.0271-2021.
8. Zheng X, Ding H, Jiang L, Chen S, Zheng J, Qiu M, et al. Association between Air Pollutants and Asthma Emergency Room Visits and Hospital Admissions in Time Series Studies: A Systematic Review and Meta-Analysis. PLoS One 2015;10:e0138146. doi: 10.1371/journal.pone.0138146.
9. Erbas B, Jazayeri M, Lambert KA, Katelaris CH, Prendergast LA, Tham R, et al. Outdoor pollen is a trigger of child and adolescent asthma emergency department presentations: A systematic review and meta-analysis. Allergy 2018;73:1632–41. doi: 10.1111/all.13407.
10. Drummond D, Roukema J, Pijnenburg M. Home monitoring in asthma: towards digital twins. Current Opinion in Pulmonary Medicine 2023;29:270–6.
11. Shulhan-Kilroy J, Elliott SA, Scott SD, Hartling L. Parents' self-reported experiences and information needs related to acute pediatric asthma exacerbations: A mixed studies systematic review. PEC Innov 2022;1:100006. doi: 10.1016/j.pecinn.2021.100006.
12. Drummond D, Gonsard A, Robinson PD. Digital respiratory medicine for children and young people. Digital Respiratory Healthcare (ERS Monograph) Sheffield: European Respiratory Society 2023:122–31.
13. Gonsard A, Genet M, Drummond D. Digital twins for chronic lung diseases. European Respiratory Review 2024;33. doi: 10.1183/16000617.0159-2024.

14. Gonsard A, AbouTaam R, Prévost B, Roy C, Hadchouel A, Nathan N, et al. Children's views on artificial intelligence and digital twins for the daily management of their asthma: a mixed-method study. European Journal of Pediatrics 2023;182:877–88.
15. Masrour O, Personnic J, Amat F, Abou Taam R, Prevost B, Lezmi G, et al. Objectives for algorithmic decision-making systems in childhood asthma: Perspectives of children, parents, and physicians. DIGITAL HEALTH 2024;10:20552076241227285. doi: 10.1177/20552076241227285.
16. Abdoul C, Cros P, Coutier L, Hadchouel A, Neuraz A, Burgun A, et al. Parents' views on artificial intelligence for the daily management of childhood asthma: a survey. J Allergy Clin Immunol Pract 2021;9:1728-1730.e3. doi: 10.1016/j.jaip.2020.11.048.
17. Emeryk A, Derom E, Janeczek K, Kuźnar-Kamińska B, Zelent A, Łukaszyk M, et al. Home Monitoring of Asthma Exacerbations in Children and Adults With Use of an AI-Aided Stethoscope. Ann Fam Med 2023;21:517–25. doi: 10.1370/afm.3039.
18. Grzywalski T, Piecuch M, Szajek M, Bręborowicz A, Hafke-Dys H, Kociński J, et al. Practical implementation of artificial intelligence algorithms in pulmonary auscultation examination. European Journal of Pediatrics 2019;178:883. doi: 10.1007/s00431-019-03363-2.
19. Do YH, van Aalderen W, Dellbrügger E, Grenzbach C, Grigg J, Grittner U, et al. Clinical efficacy and satisfaction of a digital wheeze detector in a multicentre randomised controlled trial: the WheezeScan study. ERJ Open Res 2024;10:00518–2023. doi: 10.1183/23120541.00518-2023.
20. Jochmann A, Artusio L, Jamalzadeh A, Nagakumar P, Delgado-Eckert E, Saglani S, et al. Electronic monitoring of adherence to inhaled corticosteroids: an essential tool in identifying severe asthma in children. Eur Respir J 2017;50. doi: 10.1183/13993003.00910-2017.
21. Hale EM, Greene G, Mulvey C, Mokoka MC, van Boven JFM, Cushen B, et al. Use of digital measurement of medication adherence and lung function to guide the management of uncontrolled asthma (INCA Sun): a multicentre, single-blinded, randomised clinical trial. Lancet Respir Med 2023;11:591–601. doi: 10.1016/S2213-2600(22)00534-3.
22. Gonsard A, Giovannini-Chami L, Cros P, Masson A, Menetrey C, Mordacq C, et al. Home use of short-acting beta agonists by children with asthma: a multicentre digital prospective study. Arch Dis Child 2025:archdischild-2024-327447. doi: 10.1136/archdischild-2024-327447.
23. Gupta RS, Fierstein JL, Boon KL, Kanaley MK, Bozen A, Kan K, et al. Sensor-Based Electronic Monitoring for Asthma: A Randomized Controlled Trial. Pediatrics 2021;147:e20201330. doi: 0.1542/peds.2020-1330.
24. Lugogo NL, DePietro M, Reich M, Merchant R, Chrystyn H, Pleasants R, et al. A Predictive Machine Learning Tool for Asthma Exacerbations: Results from a 12-Week, Open-Label Study Using an Electronic Multi-Dose Dry Powder Inhaler with Integrated Sensors. J Asthma Allergy 2022;15:1623–37. doi: 10.2147/JAA.S377631.
25. AlSaadi MM. Evaluation of internet use for health information by parents of asthmatic children attending pediatric clinics in Riyadh, Saudi Arabia. Ann Saudi Med 2012;32:630–6. doi: 10.5144/0256-4947.2012.630.
26. Girault A, Le A, Gonsard A, Abou Taam R, Sarfati E, Lezmi G, et al. ChatGPT and other large language models for parents' questions about childhood asthma: a comparative study. European Respiratory Journal 2025;65:2500254.
27. Zhang L, Yang G, Yuan J, Yuan S, Zhang J, Chen J, et al. Enhancing pediatric asthma management in underdeveloped regions through ChatGPT training for doctors: a randomized controlled trial. Front Pediatr 2025;13:1519751. doi: 10.3389/fped.2025.1519751.
28. Chelli M, Descamps J, Lavoué V, Trojani C, Azar M, Deckert M, et al. Hallucination Rates and Reference Accuracy of ChatGPT and Bard for Systematic Reviews: Comparative Analysis. J Med Internet Res 2024;26:e53164. doi: 10.2196/53164.