

Artificial intelligence responses to bronchiectasis patients' questions: the AIR-BE study

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Abstract

Background: The popularity of Generative Artificial Intelligence (AI)-powered chatbots is growing, with more patients using AI to understand respiratory conditions, including bronchiectasis. The quality of AI's responses to bronchiectasis-related questions has not previously been evaluated.

Objectives: To evaluate the reliability, accuracy, comprehensiveness, and understandability of responses generated by different AI-based chatbots to bronchiectasis-related questions formulated by patients.

Design: Cross-sectional international study.

Methods: People living with bronchiectasis from the EMBARC/European Lung Foundation (ELF) patient advisory group formulated 15 bronchiectasis-related questions, categorised into 3 difficulty tiers. These questions were submitted to three AI-based chatbots: ChatGPT, Bard, and Copilot. An international group of 28 experts from the European Respiratory Societies (recruited through Assemblies and the CONNECT clinical research collaboration) and 33 patients evaluated the answers' reliability, accuracy, comprehensiveness, and understandability.

Results: Of 45 outcomes, 37 were deemed reliable. Median accuracy scores ranged from 6.0 to 9.0, with ChatGPT scoring higher than Copilot and Bard [8.0 [7.0–9.0] vs 7.0 [6.0–8.0] vs 7.0 [6.0–8.0], p -value < 0.001]. Median comprehensiveness scores ranged from 6.0 to 9.0, with ChatGPT providing more comprehensive answers compared to Bard and Copilot [8.0 [7.0–9.0] vs 8.0 [6.0–9.0] vs 7.0 [6.0–8.0], p -value < 0.001]. Median understandability scores ranged from 7.0 to 10.0, with ChatGPT and Bard delivering more understandable answers than Copilot [9.0 [8.0–10.0] vs 9.0 [8.0–10.0] vs 9.0 [7.0–10.0], p -value < 0.001]. Differences in understandability were noted in Bard's responses across difficulty tiers (easy 9.0 [8.0–10.0] vs medium 9.0 [7.0–10.0] vs difficult 8.0 [7.0–10.0], p -value = 0.012).

Conclusion: AI software, particularly ChatGPT, provided accurate, comprehensive, and understandable answers to our 15 bronchiectasis-related questions.

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Plain language summary

Can artificial intelligence help answer questions on bronchiectasis formulated by patients?

Artificial intelligence (AI) tools such as chatbots are increasingly used by patients to learn about their health conditions, including bronchiectasis. However, it is not well known whether the information provided by these tools is accurate and reliable. In this study,

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people living with bronchiectasis worked together with patient organisations to develop 15 common questions about their condition, ranging from simple to more complex topics. These questions were asked to three widely used AI chatbots: ChatGPT, Bard, and Copilot. The answers were then evaluated by both medical experts and patients for their reliability, accuracy, completeness, and ease of understanding. Overall, most of the answers provided by AI were considered reliable. ChatGPT generally performed better than the other chatbots, offering more accurate and more complete responses. All three tools provided answers that were easy to understand, although Copilot scored slightly lower in this area. These findings suggest that AI chatbots, especially ChatGPT, can provide helpful and understandable information to people with bronchiectasis. However, while AI can be a useful source of information, it should not replace medical advice from healthcare professionals.

Keywords: artificial intelligence, bronchiectasis, disease awareness, patient education

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Introduction

Bronchiectasis has been considered a neglected disease for many years.¹ Recent data have revealed substantial diagnostic delay, and a considerable misdiagnosis of bronchiectasis, alongside with difficulties for patients in accessing information and care.^{2,3} Despite the recent approval of brensocatib by the U.S. Food and Drug Administration and the European Medicines Agency, most pharmacological treatments currently prescribed for patients suffering from this disease are ‘off-label’ therapies targeting specific phenotypes or endotypes around a ‘treatable trait’ approach.^{4,5} Bronchiectasis awareness is a serious concern, as patients struggle to understand their disease and they constantly look for answers to their clinical needs.³

The rapid evolution of generative Artificial Intelligence (AI) in healthcare has opened new avenues for enhancing patient care, particularly using chatbots and virtual assistants based on Large Language Models (LLMs).⁶ Such generative AI-driven tools can be designed to support clinical decision-making and patient education. AI’s potential to provide personalised, timely, and accurate health information has already been demonstrated across different diseases.^{7–10} However, the accuracy of AI-generated answers in response to patients’ questions remains unexplored in bronchiectasis. Furthermore, multiple generative AI chatbots have been launched on the

market in the last year and a half, built around different LLMs or using the same LLM with different deployments. As they differ in terms of both algorithms and training datasets, such technologies cannot be considered equivalent and the need to assess them both individually and comparatively is urgent.

The AIR-BE (Artificial Intelligence Responses on Bronchiectasis) study was designed to address these gaps by systematically evaluating the performance of AI tools in generating responses to patient-formulated questions about bronchiectasis. Our study aimed to evaluate reliability, accuracy, comprehensiveness, and understandability of generative AI-based chatbots’ and virtual assistants’ answers to questions generated by bronchiectasis patients regarding their disease and its clinical management, and to provide a comparison between different software.

Methods

A cross-sectional study was designed in partnership with the European Lung Foundation (ELF), the ELF/EMBARC Bronchiectasis Patient Advisory Group (PAG) and the European Bronchiectasis Registry EMBARC.¹¹ The reporting of the present study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.¹²

Software

Three LLM-based software selected because they were among the most widely used worldwide and analysed for the purpose of this analysis were ChatGPT by OpenAI, Bard (now Gemini) by Google, and Copilot by Microsoft. Additional features of the software are available in the Supplement Material.

Study procedures

People living with bronchiectasis from the EMBARC/ELF Patient Advisory Group were asked to formulate questions about their condition in November 2023. Questions had to be syntactically simple, they had to contain no more than two short sentences and had to be focused on topics that patients believed to be relevant. Out of a total of 54 questions provided by patients, 15 were selected by investigators to avoid topic overlap. Questions were formulated in English, and no word formatting was performed by investigators. A division into three equal-sized tiers of difficulty according to the judgement of investigators (i.e., easy, medium, and hard) was performed. In a parallel fashion, an international group of experts on the clinical management of bronchiectasis was formed (the AIR-BE Task Force). Experts were recruited sharing the initiative through the EMBARC network, the European Respiratory Society (ERS) Assemblies newsletters and through the ERS CONNECT Clinical Research Collaboration.¹³

Questions were administered to the three AI software on the same day (30 January 2024) on two different devices connected to different Internet lines and through different Internet Protocols (IPs) from the city of Milan (Italy). Questions were administered consecutively within the same session/chat for each AI software. Two investigators (MN and SA) performed an evaluation of the reliability of the three generative AI tools, defined as the proportion of answers containing a consistent core of information when the same question was launched at the same time, on the same software, on different devices. The two investigators independently assessed reliability for each question, with a short discussion in case of disagreements until *consensus* was obtained. After assessment of reliability, a random-generated number sequence was applied to select one of the two answers, which was exported into a spreadsheet and uploaded on

SurveyMonkey.com for evaluations. The following parameters were evaluated:

- Accuracy, defined as the exactitude of the core of the answer evaluated by experts, on a 0–10 scale (where 0 meant ‘not accurate at all’ and 10 meant ‘totally accurate’).
- Comprehensiveness, defined as the completeness of the answer evaluated by experts, on a 0–10 scale (where 0 meant ‘totally incomplete’ and 10 meant ‘totally complete’).
- Understandability, defined as the comprehensibility of the answer evaluated by patients, on a 0–10 scale (where 0 meant ‘not understandable at all’ and 10 meant ‘totally understandable’). ELF patients’ representatives evaluated understandability from the perspective of living with their condition.

All the evaluations performed by both experts and patients were executed without knowing from which of the three generative AI tools they had been extracted. To avoid selection biases, only reviewers (both patients and experts) completing the evaluations for all questions and software were considered for analysis.

Analysis

After evaluations had been completed, results were exported into an Excel spreadsheet and analysed. A comparison among different software in terms of reliability, accuracy, comprehensiveness and understandability was performed. All the analysis and plotting were carried out using GraphPad Prism version 10.2.3 (347). Qualitative and quantitative variables were depicted by relative proportions and median [interquartile range, IQR], respectively. Chi-squared test and Fisher’s exact test were used for comparisons of nominal variables across groups, when appropriate, while Kruskal–Wallis H or Mann–Whitney U test were used for continuous variables, according to data distribution.

Results

The full list of the 15 questions, divided according to the three difficult levels is depicted in Table 1. 28 experts and 33 patients’ representatives from different countries worldwide contributed to the

Table 1. List of questions on bronchiectasis formulated by the patients.

Question list
Easy level
(1) On what evidence will a doctor diagnose bronchiectasis and not another respiratory disease?
(2) I have been diagnosed with bronchiectasis what should I do?
(3) Can bronchiectasis have different causes?
(4) What are the main medications used to treat bronchiectasis?
(5) Do bronchiectasis patients also suffer from emphysema?
Medium level
(6) What is the most effective airway clearance technique for bronchiectasis?
(7) I have been diagnosed with bronchiectasis. How often should I have routine sputum testing?
(8) What are the long-term effects of bronchiectasis?
(9) Can bronchiectasis be cured with the right medications?
(10) I have been diagnosed with bronchiectasis. How do I know if I have an exacerbation?
Difficult level
(11) Is it true or false that excluding dairy products from your diet will reduce mucus production in a patient with bronchiectasis?
(12) I have been diagnosed with bronchiectasis. If I feel drained and my cough is worse because I have a virus, does that count as a bronchiectasis exacerbation?
(13) I have been diagnosed with bronchiectasis. How do I know when I need antibiotics?
(14) What should a person do to avoid contracting bronchiectasis?
(15) Is bronchiectasis a fatal illness?
Questions are numbered with progressive number from 1 to 15 and are divided into three difficulty tiers.

evaluation. The full list of reviewers is displayed in the acknowledgement section.

Reliability

Reliability was assessed for all 15 questions administered to the three analysed software. Among 45 different outcomes evaluated, 37 were considered reliable, while 8 were regarded as unreliable. The total count of reliable answers was 14/15 for Chat-GPT, 10/15 for Bard, and 13/15 for Copilot.

Accuracy

Accuracy was evaluated for all 15 questions administered to the three analysed software. Box

and whisker plots depicting accuracy evaluations for all questions are displayed in Figure 1.

Median accuracy scores ranged between 7.0 (question 1) and 9.0 (questions 1, 8, 10 and 11) for ChatGPT, between 6.0 (questions 5 and 12) and 8.0 (questions 2, 3 and 7) for Bard and between 6.0 (questions 4, 5, 6, 8 and 14) and 8.0 (question 10) for Copilot. Globally, accuracy scores of ChatGPT (median 8.0, IQR [7.0–9.0]) were higher than those of Bard (median 7.0, IQR [6.0–8.0]) and Copilot (median 7.0, IQR [6.0–8.0]) (p -value < 0.001). No differences were detected when accuracy evaluations were compared according to the difficulty tiers of questions (ChatGPT: easy 8.0 [7.0–9.0] vs medium 8.0 [7.0–9.0] vs difficult 8.0 [7.0–9.0], p -value = 0.08;

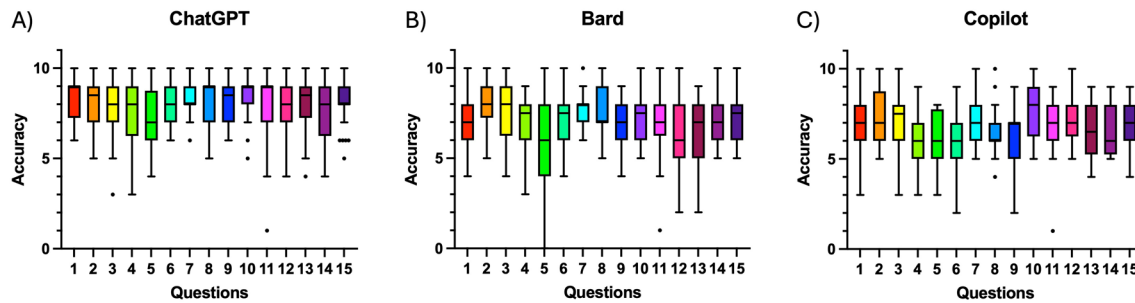


Figure 1. Box and whiskers plot depicting accuracy evaluations for answers provided by: (a) ChatGPT; (b) Bard; (c) Copilot.

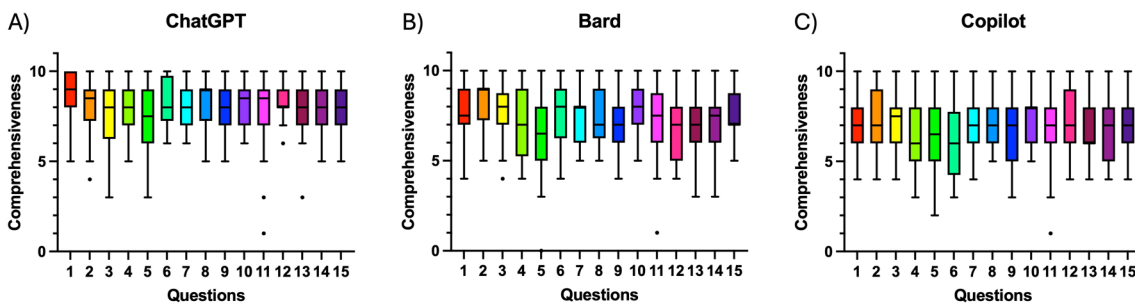


Figure 2. Box and whiskers plot depicting comprehensiveness evaluations for answers provided by: (a) ChatGPT; (b) Bard; (c) Copilot.

Bard: easy 7.5 [6.0–8.8] vs medium 7.0 [6.0–8.0] vs difficult 7.0 [6.0–8.0], p -value = 0.135; Copilot: easy 7.0 [6.0–8.0] vs medium 7.0 [6.0–8.0] vs difficult 7.0 [6.0–8.0], p -value = 0.802). In all three difficulty tiers, ChatGPT's answers were more accurate than those of Bard and Copilot ones (easy: 8.0 [7.0–9.0] vs 7.5 [6.0–8.8] vs 7.0 [6.0–8.0], $p < 0.001$; Medium: 8.0 [7.0–9.0] vs 7.0 [6.0–8.0] vs 7.0 [6.0–8.0], $p < 0.001$; difficult: 8.0 [7.0–9.0] vs 7.0 [6.0–8.0] vs 7.0 [6.0–8.0], p -value < 0.001).

Comprehensiveness

Comprehensiveness was evaluated for all 15 questions administered to the three analysed software. Box and whisker plots showing comprehensiveness evaluations for all questions are displayed in Figure 2.

Median comprehensiveness scores ranged between 7.5 (question 5) and 9.0 (questions 1 and 8) for ChatGPT, between 6.5 (question 5) and 9.0 (question 2) for Bard, and between 6.0 (questions 4, 6, and 13) and 8.0 (question 10) for

Copilot. Comprehensiveness scores for answers provided by ChatGPT (8.0 [7.0–9.0]) were overall higher than the ones provided by both Bard (8.0 [6.0–9.0]) and Copilot (7.0 [6.0–8.0]) (p -value < 0.001). No differences were detected when comprehensiveness evaluations were compared according to the difficulty tiers of questions (ChatGPT: easy 8.0 [7.0–9.0] vs medium 8.0 [7.0–9.0] vs difficult 8.0 [7.0–9.0], p -value = 0.36; Bard: easy 8.0 [6.0–9.0] vs medium 8.0 [6.2–9.0] vs difficult 7.0 [6.0–8.0], p -value = 0.08; Copilot: easy 7.0 [6.0–8.0] vs medium 7.0 [6.0–8.0] vs difficult 7.0 [6.0–8.0], p -value = 0.84). In all three difficulty tiers, ChatGPT answers were more comprehensive than those provided by Bard and Copilot (easy: 8.0 [7.0–9.0] vs 8.0 [6.0–9.0] vs 7.0 [6.0–8.0], p -value < 0.001; medium: 8.0 [7.0–9.0] vs 8.0 [6.3–9.0] vs 7.0 [6.0–8.0], p -value < 0.001; difficult: 8.0 [7.0–9.0] vs 7.0 [6.0–8.0] vs 7.0 [6.0–8.0], p -value < 0.001).

Understandability

Understandability was evaluated for all 15 questions administered to the three analysed software.

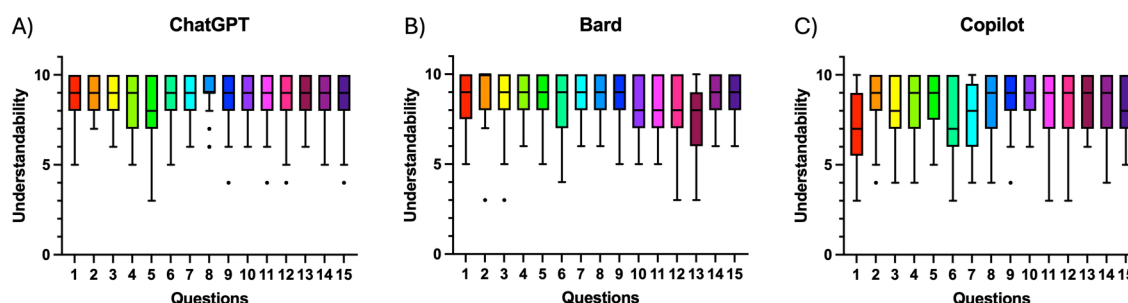


Figure 3. Box and whiskers plot depicting understandability evaluations for answers provided by: (a) ChatGPT; (b) Bard; (c) Copilot.

Box and whisker plots displaying understandability evaluations for all provided questions are depicted in Figure 3.

Median understandability scores ranged between 8.0 (question 5) and 9.0 (all remaining questions) for ChatGPT, between 8.0 (questions 10, 11, 12, and 13) and 10.0 (question 2) for Bard, and between 7.0 (questions 1 and 6) and 9.0 (questions 2, 4, 5, 8, 9, 10, 11, 12, 13, and 14) for Copilot. Understandability scores for answers provided by both ChatGPT (9.0 [8.0–10.0]) and Bard (9.0 [8.0–10.0]) were overall higher than those obtained from Copilot (9.0 [7.0–10.0]) (p -value < 0.001). No differences were detected when understandability evaluations were compared according to the difficulty tiers of questions for both ChatGPT (easy: 9.0 [8.0–10.0] vs medium: 9.0 [8.0–10.0] vs difficult: 9.0 [8.0–10.0], p -value = 0.80) and Copilot (easy: 9.0 [7.0–10.0] vs medium 9.0 [7.0–10.0] vs difficult 9.0 [7.0–10.0], p -value = 0.86). However, Bard's answers to easier questions were more understandable than answers to difficult questions (easy: 9.0 [8.0–10.0] vs medium 9.0 [7.0–10.0] vs difficult 8.0 [7.0–10.0], p -value = 0.012). In all three difficulty tiers, understandability of ChatGPT's answers was higher than those of Bard and Copilot responses (easy: 9.0 [8.0–10.0] vs 9.0 [8.0–10.0] vs 9.0 [7.0–10.0], p -value = 0.005; medium: 9.0 [8.0–10.0] vs 9.0 [7.0–10.0] vs 9.0 [7.0–10.0], p -value = 0.027; difficult: 9.0 [8.0–10.0] vs 8.0 [7.0–10.0] vs 9.0 [7.0–10.0], p -value = 0.045).

Discussion

Our study demonstrates that the three generative AI-driven tools tested in the present experience perform globally well in answering medical

questions on bronchiectasis formulated by people living with the condition. Notably, the reliability of software differs across all the administered questions, hinting at the possibility of finding divergent answers with multiple attempts. Differences in the way in which LLMs have been trained may explain part of the observed unreliability, since source heterogeneity could lead to diverse outcomes, as discussed elsewhere.¹⁴ However, datasets of sources on which each LLM has been trained are not publicly available, and it is therefore difficult to confirm or repudiate this hypothesis.

In our analysis, ChatGPT seemed to perform better than both Bard and Copilot. As described in the Supplemental Material, ChatGPT and Copilot share the same LLM. Microsoft has tried to increase the performance of Copilot through fine tuning and specific training by means of reinforcement learning, but it is expected that those who developed the model, that is, OpenAI, can leverage its potential to the fullest. On the other hand, Bard/Gemini was released a few months after ChatGPT, possibly being the result of Google's rush to reach OpenAI's capability. Gemini was launched later and has been used less than ChatGPT at the beginning of the 'AI boom', even though this is a rapidly evolving landscape with strong competition between the key players. ChatGPT is not inherently multimodal, meaning that it was originally designed to provide responses to text-based prompts, and only recently has become multimodal (i.e. with the possibility to use features such as image prompts and voice commands), while Gemini is inherently multimodal. This is highly promising for Gemini as a general-purpose generative AI chatbot, as it will also be able to count on Google Search's real-time, widely comprehensive data. In the case of

this specific application, however, having access to the Internet indiscriminately is a double-edged sword, as the lack of accuracy and correctness of medical knowledge spread by various unofficial sources, such as websites or forums, can be problematic as training an LLM requires a high-quality dataset.

We were not able to detect any difference analysing AI-driven tools' performance according to different difficulty of questions, with the exception of Bard's understandability. We can speculate that the vast amount of data on which analysed LLM were trained might make the distinction between easy and hard questions irrelevant.

Different disease-related factors make this project relevant for people living with bronchiectasis. Firstly, bronchiectasis patients require continuous education and support to manage their condition effectively and prevent exacerbations, as demonstrated by the role that chest physiotherapy has in this context.¹⁵ Furthermore, self-management programmes have been always advocated as an important option for the management of bronchiectasis patients.^{16,17} However, this kind of approach requires optimal disease awareness, and AI can potentially help in this regard. Finally, a growing number of observational studies and interventional trials on bronchiectasis consider patient-reported outcome measures (PROMs) as relevant endpoints, and AI could potentially help patients in providing a more precise and reliable estimate of their clinical needs.

This is the first experience evaluating AI performance in response to medical questions on bronchiectasis. Similar studies have been conducted on asthma and Chronic Obstructive Pulmonary Disease (COPD) with the same methodology, confirming most of our findings.^{9,10} Overall, our findings are consistent with the growing body of literature suggesting that generative AI models can provide medical information with acceptable levels of accuracy and readability in chronic respiratory diseases and other medical fields.^{7,9,10} Nevertheless, the performance observed across studies remains heterogeneous, with AI-generated responses generally performing better in terms of understandability than in factual precision or completeness. This discrepancy is clinically relevant, as highly understandable but partially inaccurate responses may potentially increase the risk of misinformation among vulnerable patients.

An additional study evaluating AI in answering questions on COPD has been recently conducted.⁸ Important differences between that study and the present project should be highlighted. Firstly, our study is a patient-centred initiative, and not a physician-driven project,⁸ aimed at supporting patients in finding good-quality solutions for their clinical needs, and the collaboration with the ELF has been crucial in this view. Secondly, having questions formulated by the patients, and not by physicians,⁸ is a major strength of our study, as these may differ in terms of topics and syntaxes from the clinician-formulated ones.⁸ Thirdly, both patients and experts recruited for our project come from different countries worldwide, and not from UK alone,⁸ increasing the heterogeneity of the evaluated population and reducing the influence of potential confounding factors related to a single centre or country, although the cohort predominantly represented European and other high-income settings. Fourthly, experts in our study were not arbitrarily selected⁸ but were enrolled through ERS/CONNECT newsletters and did not participate in the formulation of questions. Finally, in all stages of our study, both experts and patients did not know which AI software they were evaluating.⁷

Other additional strengths should be acknowledged, including: (1) The number of AI-driven tools tested in the present study is more than typically tested in similar projects in other diseases; (2) A comparison between questions assigned to different difficulty tiers; (3) the 10-point scales have granted appropriate accuracy in the evaluations.

Our study has also several limitations. Firstly, this is a cross-sectional study evaluating answers collected on a single day; since scientific knowledge increases with time and AI software receives updates, whether AI performance after that date might have improved, worsened, or remained the same is unknown. To address this question, we advocate for a dedicated ELF Task Force that can regularly monitor, with the help of physicians and other healthcare professionals, the performance of generative AI-driven tools in the future. Furthermore, we tested the freeware version of ChatGPT (3.5), since we believed that this would be far more accessible for patients worldwide. However, OpenAI has recently released a premium updated version of ChatGPT (4.0) that could perform better, worse or similarly to the

one we used. Moreover, we only tested English questions, and whether AI performance is similar in other languages should be addressed by further studies directed by and in the interest of national patients' associations. Furthermore, patients involved in the EMBARC/ELF Patient Advisory Group may have greater disease awareness and engagement compared with the general bronchiectasis population. This may have influenced the formulation and complexity of the submitted questions, potentially limiting the generalisability of the findings to less informed patient populations. Besides, there are some countries, listed in the Supplemental Material, in which at least one of the AI-driven tools tested in the present experience is not available. This prevents some patients from having access to tools that might help them to understand their symptoms and disease, establishing a connection between digital divide and health inequities.^{18,19} Finally, the limited sample size of the questions tested did not prevent us from reaching statistical significance for most endpoints.

Conclusion

AI-driven software may serve as supportive educational tools for people living with bronchiectasis. Despite not being a substitute for medical counselling and traditional clinical assessment, the quality of the provided answers in response to patients' formulated questions seems to be adequate. Proper support for patients in the use of such software in a safe, informed and supervised fashion should be identified as a major objective for healthcare providers, primary care doctors and policy makers.

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Declarations

Ethics approval and consent to participate

The AIR-BE study was conducted in accordance with the principles of the Declaration of Helsinki and applicable regulations. Ethical approval was not required for this study because no interventional procedures were performed and no identifiable patient data were collected. Participation in the surveys by both patients and experts was voluntary.

Consent for publication

Not applicable.

Author contributions

Mattia Nigro: Conceptualisation; Data curation; Formal analysis; Investigation; Methodology; Project administration; Software; Validation; Visualisation; Writing – original draft; Writing – review & editing.

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Availability of data and materials

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.*

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Supplemental material

Supplemental material for this article is available online.

Artificial intelligence statement

No Generative Artificial Intelligence tools were used in the writing, analysis, interpretation, or preparation of this manuscript. All content was independently developed and reviewed by the authors, who take full responsibility for the accuracy and integrity of the work.

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