REVIEW ARTICLE

Chatbot Intervention in Asthma and Obstructive Sleep Apnea: A Systematic Review

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Objective: Asthma and obstructive sleep apnea (OSA) are two common diseases in clinical practice. Both diseases are treated with devices which may require an intervention by an artificial intelligence such as chatbot. The present study aimed to evaluate if chatbot can be used to improve asthma and OSA management by using a systematic review.

Materials and Methods: The present study was a systematic review conducted on five databases. The inclusion criteria were articles conducted in children or adults, used any types of chatbot regardless of outcomes or study types in asthma and OSA management. Eligible studies were reviewed for study characteristics, outcomes, and biases.

Results: There were 275 articles searched from five databases. Of those, two articles met the inclusion criteria. Both eligible articles were conducted in children with asthma with an age of lower than 15 years. The first study used the kBot, a knowledge-enabled personalized chatbot system. This system monitor medication adherence and track asthma status of children asthmatic patients. The average system usability scale scores by physicians and researchers were 83.13 and 82.81/100, respectively. The second study used the MAX in children with asthma age of 10 and 15 years. Almost all conversations were occurred between patients and the MAX agent (99.5%). The asthma knowledge was significantly increased from 7.73 at baseline to 8.79 at the end of study ($p<0.001$).

Conclusion: There is limited data of chatbot on asthma and OSA. However, chatbot may be feasible for pediatric asthmatic patients. Further studies on OSA and objective outcomes such as asthma control or CPAP adhere are needed.

Keywords: Management; Artificial intelligence; Knowledge; Control

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Asthma and obstructive sleep apnea (OSA) are two common diseases in clinical practice. It has been estimated that there are 357.4 and 936 million people with asthma and OSA, respectively[1,2]. Both diseases can be co-existing and called overlap syndrome with a prevalence of 19 to 60% of OSA in patients with asthma[3]. OSA can cause asthmatic attack and worsen asthma, while treatment with a continuous positive airway pressure (CPAP) machine may improve asthma control. Both diseases also related to other cardiovascular consequences such as hypertension[4-8]. As both diseases are treated with device, an intervention such as education may be needed[9-12]. One possible intervention is an artificial intelligence.

Chatbot, an artificial intelligence-based conversational agent, has been used in marketing and businesses. It is also beneficial in health care systems as it is convenient and accessible to deliver behavioral interventions or knowledge[13]. A scoping review on 23 studies for weight loss in adults from nine countries: Ireland, Italy, Lebanon, Spain, Switzerland, Taiwan, The Netherlands, United Kingdom, and United States[14]. The chatbot-delivered program had better outcomes in terms of exercise, diet, and weight loss in three out of four studies. However, there are limited data on chatbot on patients

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with asthma or OSA. The present study aimed to evaluate if chatbot can be used to improve asthma or OSA management by using a systematic review.

Materials and Methods

The present study was a systematic review conducted on five databases. The inclusion criteria were articles conducted in children or adults, used any types of chatbot regardless of outcomes or study types. The authors excluded studies with any of the following: conference paper, study protocol, case report, case series, or commentary. Those studies conducted in pregnant women were also excluded.

The authors searched articles in the following databases: Pubmed, Central database, Scopus, CINAHL Plus, and Web of Science. Search terms included chatbot in English language (Figure 1 to 5). The final search was performed on March 6, 2021. After duplication removal, initial screening was carried out for non-relevant articles. Of these, any articles met the present study criteria were included in the final analysis. Data extraction and the fulltext reviewed were performed by two independent authors (PT, BS). A prima flow chart of article searching and included studies was shown in Figure 6.

Meta-analysis did not conduct to combine results from included studies due to various of outcomes. Included studies were described about study design, population, chatbot model and outcomes. Biases of included studies were evaluated based on Cochrane risk of bias tool for randomized controlled trials that were evaluated six domains including sequence generation, allocation concealment, blinding of participants/personnel and outcome assessors, incomplete outcome data, selective outcome reporting, and other potential sources of bias. Risk of biases categorized as low, unclear, or high risk[15]. Biases or study quality were evaluated by two authors independently (PT, TS). Disagreements were reviewed and reported by a third reviewer (SK). All analyses were performed by Review Manager 5.4[16].

Search number	Search terms
1	Chatbot[Title/Abstract]
2	English[Language]
3	Journal Article[Publication Type]
4	(#1 AND #3) AND #2

Figure 1. Searching strategy for PubMed on 6 March 2021.

TITLE-ABS-KEY (chatbot) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))

Figure 2. Searching strategy for Scopus on 6 March 2021.

Search number	Search terms
1	(TITLE-ABS-KEY (chatbot)) AND (TITLE-ABS-KEY (medic* OR health* OR nurs*)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))
2	TITLE: (medic* OR health* OR nurs*)
3	(AB= (medic* OR health* OR nurs*)) AND LANGUAGE: (English) AND DOCUMENT TYPES: (Article)
4	(AK= (medic* OR health* OR nurs*)) AND LANGUAGE: (English) AND DOCUMENT TYPES: (Article)
5	#4 OR #3 OR #2
6	#5 AND #1

Figure 3. Searching strategy for ISI Web of science on 6 March 2021.

Search number	Search Terms
1	Chatbot

Figure 4. Searching strategy for Central on 6 March 2021.

Search ID	Search Terms
S1	TI Chatbot OR AB Chatbot OR KW Chatbot Limiters - Document Type: Article; Language: English Expanders - Apply equivalent subjects Search modes - Find all my search terms
S2	TI (medicine or medical or health or healthcare or nursing) OR AB (medicine or medical or health or healthcare or nursing) OR KW (medicine or medical or health or healthcare or nursing) Expanders - Apply equivalent subjects Search modes - Find all my search terms
S3	S1 AND S2 Limiters - Document Type: Article; Language: English Expanders - Apply equivalent subjects Search modes - Find all my search terms

Figure 5. Searching strategy for EBSCO on 6 March 2021.

Results

There were 275 articles searched from five databases (Figure 6). Of those, 272 articles were excluded due to non-relevance. Among three articles[13,17,18], one was excluded due to non-intervention study. This excluded study was a commentary on obesity but not OSA. Both eligible articles were conducted in children with asthma with an age of lower

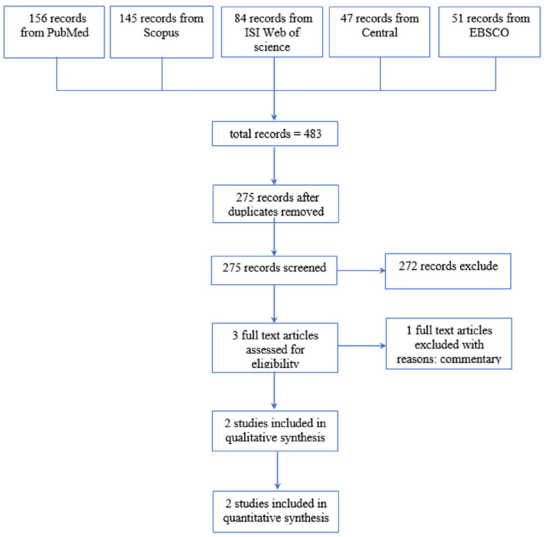

Figure 6. Prisma study flow chart for article searching in five databases to evaluate effects of chatbot in asthma and obstructive sleep apnea.

Table 1. Study characteristics of eligible studies for chatbot intervention in asthma and obstructive sleep apnea.

Authors	Year	Country	Study design	Study population	Chatbot model	Outcomes
Kadariya et al	2019	USA	Single arm, intervention	Children with asthma, age 8 to 15 years	kBot	System usability scale by clinicians and researchers
Kowatsch et al	2021	Switzerland	Single arm, intervention	Children with asthma, age 10 to 15 years	MAX	Knowledge score, health care professional comments

than 15 years[17,18]. One study conducted in Switzerland, while another study was conducted in the US. Details and outcomes of both studies were as follows (Table 1).

The first study (Kadariya et al., 2019) used the kBot, a knowledge-enabled personalized chatbot system[18]. This system monitor medication adherence and track asthma status of children asthmatic patients with age of 8 and 15 years in Dayton, USA. The chatbot had both text and voice on Android application with a cloud-based server. There were eight physicians and eight researchers to evaluate the kBot system. For clinicians, the average scores for kBot in terms of naturalness, information delivery, interpretability, and technology acceptance were 8.25, 8.56, 8.25, and 8.54 from 11 total score. While these scores for researchers were 8.63, 8.44, 8.69, and 8.63, respectively. The average system usability scale scores by both groups were 83.13 and 82.81 score (total score was 100 score), respectively.

The second study (Kowatsch et al., 2021) used the MAX in children with asthma age of 10 and 15 years in Switzerland[17]. The MAX was created based on asthma management, information systems, working alliance, behavior change techniques, and experiential learning theory. MAX was used in two home care setting and four secondary care hospitals. The patients can chat with MAX, chat with family members face-to-face, or chat with asthma expert by app chat or face-to-face. There were 49 children with asthma participated in the present study. The average age of participants was 12 years with the male proportion of 67%. The completion rate of the intervention was 75.5% (37/49 children). Almost all conversation were occurred between patients and the MAX agent (99.5%). The asthma knowledge was significantly increased from 7.73 at baseline to 8.79 at the end of study ($p<0.001$). Health care professionals were able to evaluate the inhalation techniques of the patients and give feedback to the patients by 3 days.

Regarding study biases, both studies had high risk on four items of bias assessment for intervention studies including randomization, allocation concealment, blinding of participants, and blinding of outcome assessment (Figure 7).

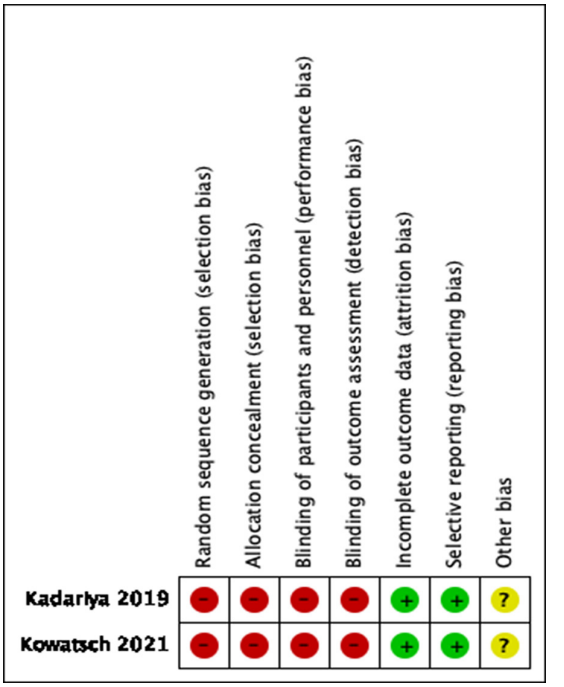

Figure 7. Risk of bias of eligible studies for chatbot intervention in asthma and obstructive sleep apnea.

Note: ? indicated unclear; - indicated high risk; and + indicated low risk.

Discussion

The present study found that there is limited article of chatbot on asthma and OSA. There is no study evaluated the effectiveness of chatbot in patients with OSA. Two studies assessed the feasibility of chatbot in only children with asthma. Both studies were intervention study but not a randomized controlled trial resulting in high risk of biases in selection bias, performance bias, and detection bias (Figure 7). Another issue is that no objective measurement on asthma control was reported. Finally, there is no study of chatbot in adult patients with asthma.

Even though there is limited data of chatbot in asthma and OSA, these two studies showed feasibility of chatbot involving management of pediatric asthmatic patients. The MAX study found that pediatric asthmatic children communicated with the MAX agent very well[18]. The intervention showed beneficial in knowledge improvement. Finally, clinicians were able to detect incorrect use of inhalation device in these children. Note that feedback was provided by 3 days which may be late compared to

emergency room visit but may be faster for the outpatient visit. The kBot study also showed feasibility of chatbot but it was not conducted in patients[18].

There are some limitations in the present study. First, there are very few included studies with no randomized controlled trials or other observational studies[19]. Second, no studies related to associated diseases or conditions of both diseases as well as treatment of asthma and OSA[20,21]. Finally, no objective outcome assessment was made in the included studies. The results of the present study may indicate that chatbot is feasible for asthma management in children with asthma. Further studies are required to show the implications of chatbot in adult patients with asthma and patients with OSA.

In conclusion, there is limited data of chatbot on asthma and OSA. However, chatbot may be feasible for pediatric asthmatic patients. Further studies on OSA and objective outcomes such as asthma control or CPAP adhere are needed.

What is already known on this topic?

Chatbot is one effective intervention to improve several medical conditions such as weight reduction.

What this study adds?

There is limited data of chatbot on asthma and obstructive sleep apnea management. Chatbot may improve asthma knowledge in children with asthma.

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Conflicts of interest

The authors declare no conflict of interests.

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