



Electronic Health Technologies and Thematic Scopes of the Interventional Studies in Asthma: A Study based on PubMed

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Authors

Shahbodaghi A.^{*1} PhD,
Asadi F.² PhD,
Almasi S.² MSc,
Gavili Kilaneh N.³ MSc

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¹Department of Medical Library and Information Science, School of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran

²Department of Health Information Technology and Management, School of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran

³Department of Medical Library and Information Science, School of Health Management and Information Sciences, Iran University of Medical Sciences, Tehran, Iran

*Correspondence

Address: School of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Darband Street, Qods Squar, Tehran, Iran.

Phone: +98 (21) 26850560

Fax: -

shahbodaghi@sbmu.ac.ir

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ABSTRACT

Aims E-health intervention can be a valuable way to deal with asthma and reduce its global burden of it. This research aimed to determine the type of e-health interventions in the interventional studies in asthma based on PubMed.

Information & Methods The research was carried out from 2000 to 2018 using content analysis and scientometric techniques. To reach the research population, the keywords of two concepts of asthma and e-health were identified, and then the search formula was developed using "Mesh" and "Ti" tags. By examining the 452 articles, the research population was limited to 102 articles that had somehow used e-health technologies to intervene in asthma. The extracted data from the articles were: the publication year, type of e-health technology used in the intervention, thematic scope of the intervention, and the affiliated countries of the articles.

Findings The highest number of articles has published in 2016. Seventeen categories of e-health technology were identified by analyzing the content of 102 articles. The findings indicate that web-based systems, text messaging, and mobile applications were at the forefront of the technologies used in the studies. The highest number of interventions occurred in "asthma control", "medication adherence", and "self-management". The United States has the highest share among the affiliated countries of the articles.

Conclusion Web-based solutions have been the most extensively employed technology. In most studies, the key aim of deploying e-health interventions has been to improve "asthma control". The United States has contributed the most to the studies.

Keywords Asthma; Electronic Health Records; Methodological Study; Scientometric Analysis

CITATION LINKS

[1] eHealth in ... [2] Increasing ... [3] Introducing ... [4] Electronic ... [5] What is ... [6] E-Health ... [7] What is ... [8] What is ... [9] Health ... [10] The economics ... [11] Guidelines ... [12] Asthma [13] Asthma ... [14] Economic ... [15] Economic ... [16] Epidemiology ... [17] Epidemiology ... [18] Electronic ... [19] Novel ... [20] Effect of ... [21] An interactive ... [22] Use of ... [23] The "physician ... [24] Accessibility ... [25] Internet ... [26] Randomised ... [27] A randomized ... [28] Real-world ... [29] A pharmacist-led ... [30] A mobile ... [31] A web-based ... [32] Effectiveness ... [33] Targeted ... [34] Engagement ... [35] Effectiveness ... [36] An Internet-based ... [37] Telehealth ... [38] Evaluation ... [39] A website ... [40] Compliance ... [41] Working ... [42] Evaluating ... [43] The effects ... [44] Using ... [45] Applying ... [46] A randomized ... [47] Long-term ... [48] An in-school ... [49] Parent-reported ... [50] Easy diagnosis ... [51] A virtual ... [52] Developing ... [53] Internet-based ... [54] Patient-perceived ... [55] Accessibility ... [56] Improving ... [57] Web-based ... [58] Improving ... [59] Patient ... [60] Impact ... [61] Clinical ... [62] Computer ... [63] Impact ... [64] A cluster ... [65] Cost-effectiveness ... [66] Internet-enabled ... [67] Media ... [68] A randomized ... [69] Outcomes ... [70] A mobile ... [71] Remote ... [72] Feasibility ... [73] The effectiveness ... [74] A daily ... [75] Results ... [76] Smartphone ... [77] Internet ... [78] Telephone ... [79] Internet ... [80] Internet ... [81] A web-based ... [82] WeChat ... [83] Cost-effectiveness ... [84] Effect ... [85] Findings ... [86] Internet ... [87] Asthma ... [88] The effect ... [89] Validation ... [90] Electronic ... [91] Implementation ... [92] E-Monitoring ... [93] A pilot ... [94] The effectiveness ... [95] Clinical ... [96] The feasibility ... [97] Cost-effectiveness ... [98] Watch ... [99] "Why ... [100] Effect ... [101] Planning ... [102] A text ... [103] Electronic ... [104] A randomized ... [105] Initiating ... [106] Electronic ... [107] Improving ... [108] Evaluation ... [109] Use ... [110] An internet ... [111] Internet ... [112] STAAR ... [113] A randomized ... [114] An evaluation ... [115] Cartoons ... [116] The ... [117] Pilot ... [118] Telemedicine ... [119] Active ... [120] Inhaler ... [121] Internet ... [122] Improvement ... [123] Digital ... [124] E-health ... [125] The ... [126] An ehealth ... [127] American ... [128] Telehealthcare ... [129] Online ... [130] Effectiveness ... [131] Chapter 3 ... [132] Chapter 2 ... [133] Interactive ... [134] The effectiveness ... [135] Patient ... [136] The use ... [137] Positive ... [138] A systematic ... [139] Using ... [140] The effects ... [141] Impact ... [142] Interventions ... [143] The top ... [144] The ten ... [145] Country ...

Introduction

In today's world, information and communication technologies have undeniably affected human life with their increasing changes so that no dimension of individual and social life has been deprived of its effects. One of the essential aspects of human life affected by the growth and development of information and communication technologies is the health area. Information and communication technologies play a vital role in improving the health care of individuals and communities. These technologies facilitate communication between providers and recipients of health care services by providing innovative and effective routes for accessing, exchanging, and storing information. They also help health researchers and consumers with their research results. In addition, information and communication technologies can enhance the efficiency of health systems and reduce medical errors [1]. The influence of information and communication technologies in the health area has led to the formation of an attractive and concise concept, at the same time huge, called Electronic Health [2]. A concept that some consider ambiguous and others as expanding [3]. Organizations and sources have provided several definitions of e-health [4-7], as shown in a review study that up to 2005 had 51 different meanings of e-health in the literature [8]. Despite this multiplicity, the common denominator of all e-health definitions is the emphasis on the safe and cost-effective use of information and communication technologies to support healthcare and related areas.

E-health covers interactions between patients and health care providers, data transfers between healthcare providers, and peer-to-peer communication between patients and health professionals. Besides, health information networks, e-health records, telemedicine services, portable or wearable personal health systems, and other information and communication technology-based tools used in the prevention, diagnosis, treatment, and follow-up of diseases are examples of e-health benefits. Also, providing health information to health professionals and customers through the Internet and telecommunications technologies, harnessing the power of information technology and e-commerce to improve public health services, and using e-commerce and e-business capacity in management information systems are other benefits of e-health. E-health can help shape broader communication networks between healthcare providers, patients, and health researchers by providing innovative and effective ways to store, access, and exchange information. E-health can help shape broader communication networks between healthcare providers, patients, and health researchers by providing innovative and effective ways to store, access, and exchange information. In

addition, organizational changes in health care systems will lead to the formation of new skills to improve citizens' health, improve the efficiency and productivity of health care services, and increase the economic and social value of health [3, 8-10].

Asthma is a chronic lung disease that occurs in all age groups but is usually common in children, and its onset date back to childhood [11]. The disease is difficult to diagnose and treat. Asthma affected an estimated 262 million people in 2019 and caused 461000 deaths [12]. Moreover, asthma was responsible for 21.6 million disability-adjusted life years (DALYs) in 2019 [13]. Although most asthma mortality occurs in low-and lower-income countries, asthma is a public health problem in all countries today, regardless of income and development. Studies indicate an increasing prevalence of asthma and the economic burden of the disease worldwide [14-17]; therefore, the prevention and control of this disease, in addition to promoting global health, will reduce the economic costs of this disease. Researchers' findings confirm that the use of e-health beneficially affects the control and management of this disease [18-20].

By searching the databases, especially PubMed, it can be found that in some interventional studies in the field of asthma, e-health technologies have been used. The present study aimed to determine the type of e-health technologies by quality thematic analysis method, as well as to determine the thematic scope of intervention studies in the field of asthma based on the PubMed database in the period 2000 to 2018. Furthermore, using scientometric techniques, the process of science production in the mentioned field is determined, and the contribution of countries in the production of these articles is examined.

Information and Methods

The present study was carried out using scientometric and thematic analysis techniques.

This scientometric review research used PubMed as the largest database of published biomedical literature. The keywords of the two concepts of "asthma" and "e-health" were first identified to reach the research community using language control tools and referring to texts. Table 1 shows the equivalent terms of each concept along with the tags used. It should be noted that utilizing an asterisk sign following a few words is to cover different derivatives of them.

Then, the above two formulas were combined with the "AND" operator and the original formula was created and searched on 20/10/2019.

Considering that the purpose of this study is to investigate e-health interventions, in terms of the type of study, the retrieved articles were limited to Interventional studies i.e. Clinical trials. Also, the date of publication was limited to the period 2000 to 2018. Because this research required content

analysis and it was necessary to examine some articles in full text, the research team, decided to limit the research population to English language articles.

After the mentioned restrictions were imposed, Four hundred and fifty-two articles were obtained. By examining the title, abstract, and in some cases the full text of the articles, the research population was limited to those articles that had somehow used e-health technologies to intervene in asthma. Eventually, 102 articles [21-123] were identified as eligible for research and reviewed for data extraction.

The extracted data were: the publication year of the articles, type of e-health technology used in the intervention, thematic scope of the intervention, age group of the patients on whom the intervention was performed, and the countries of the corresponding author and the first author of the articles. One

hundred two articles were analyzed and indexed by a 3-member team to determine the thematic scope of the intervention and the type of e-health technology used in the intervention. It should be noted that in some cases, the controlled language of American Medical Subject Headings (MeSH) was used for indexing, but in cases where the MeSH was not responsive, the natural language was used. Then, the keywords extracted from the texts were controlled by a 3-member team. It should be noted that in the classification of electronic health technologies as well as the thematic scopes of asthma, an attempt was made to choose the categories in such a way that no intervention was neglected. For example, although some text messaging technologies belong under the reminder systems category, both technologies were chosen as the major category, and some studies inevitably fell into both categories.

Table 1) The equivalent terms of each concept in the formula

Main concept	Equivalent terms
Asthma	("Asthma"[Mesh] OR asthma*[ti])
e-health	("Telemedicine"[Mesh] OR telemedicine[ti] OR ehealth*[ti] OR e-health*[ti] OR "electronic health*[ti] OR "digital health*[ti] OR mhealth*[ti] OR "Telemedicine"[Mesh] OR "Mobile Applications"[Mesh] OR mobile*[ti] OR m-health*[ti] OR "Mobile Applications"[Mesh] OR smartphone*[ti] OR *phone*[ti] OR "Cell Phone"[Mesh] OR "Cell Phone Use"[Mesh] OR "Smartphone"[Mesh] OR smart[ti] OR telehealth*[ti] OR telepathology[ti] OR teleradiology[ti] OR telerehabilitation[ti] OR telecommunication[ti] OR "Telecommunications"[Mesh] OR "Telemetry"[Mesh] OR telemetr*[ti] OR telemanagement[ti] OR teleconference*[ti] OR televideo*[ti] OR telecare[ti] OR remote[ti] OR "radio frequency"[ti] OR RFID[ti] OR *computer*[ti] OR "Computers, Handheld"[Mesh] OR handheld[ti] OR digital[ti] OR electronic[ti] OR virtual[ti] OR wireless[ti] OR technolog*[ti] OR "Wireless Technology"[Mesh] OR "Internet"[Mesh] OR internet[ti] OR emedicine[ti] OR e-medicine[ti] OR eprescrib*[ti] OR etherapy[ti] OR e-prescrib*[ti] OR e-therapy[ti] OR "cyber space"[ti] OR cyberspace[ti] OR informatic*[ti] OR "Medical Informatics"[Mesh] OR "Reminder Systems"[Mesh] OR "Patient Portals"[Mesh] OR portal*[ti] OR palmtop*[ti] OR message*[ti] OR podcast*[ti] OR online[ti] OR web[ti] OR website*[ti] OR email*[ti] OR e-mail*[ti] OR tablet*[ti] OR "Text Messaging"[Mesh] OR "Answering Services"[Mesh] OR "Electronic Mail"[Mesh] OR "Mass Media"[Mesh] OR "social media"[ti] OR message*[ti] OR texting[ti] OR communication*[ti] OR CPOE[ti] OR "order entry System*[ti] OR PDA[ti] OR CDSS[ti] OR referral*[ti] OR Alert[ti] OR reminder*[ti] OR registr*[ti] OR "Registries"[Mesh] OR "Information Systems"[Mesh] OR "information system*[ti] OR "expert system*[ti] OR "Artificial Intelligence"[Mesh] OR intelligence[ti] OR satellite*[ti] OR radio[ti] OR radar[ti] OR tag[ti] OR barcode*[ti] OR "Computing Methodologies"[Mesh] OR "point of care"[ti] OR "Hospital Information Systems"[Mesh] OR "Information Science"[Mesh])

Findings

The findings are presented in Figure 1 to determine the publication trends of 102 articles. As Figure 1 shows, the highest number of articles is in 2012 and 2016. In order to show which electronic health technologies have been used to intervene in various areas related to asthma in the studies, the findings are set out in Table 2.

Seventeen categories of electronic health technology were identified by analyzing the content of 102 articles, which were used to intervene in various areas related to asthma. The findings indicate that web-based systems (in 40 studies) were at the forefront of the technologies used to intervene in the studies. "Asthma control", "self-management" and "patient monitoring" are the thematic scopes of asthma that account for the largest share of these intervention studies, respectively. The technology of

sending and receiving text messaging (in 15 studies) is ranked second among the technologies used in the examined interventional studies. The findings showed that this technology has been mostly used to perform interventions in the thematic scopes of "medication adherence", "asthma control" and "patient monitoring". The third rank of technologies that have been used in the studies belongs to the mobile application (in 14 studies) that has been mostly used for "Asthma control" and "medication adherence". Voice-call technologies have been used in 12 studies, more for "asthma control" and "patient assessment". Also, Reminder systems have been used in 12 studies. "Medication adherence" is the prominent thematic scope of these studies.

The data are presented in Table 3 to show in which thematic scope of asthma, the most e-health interventions have been performed.

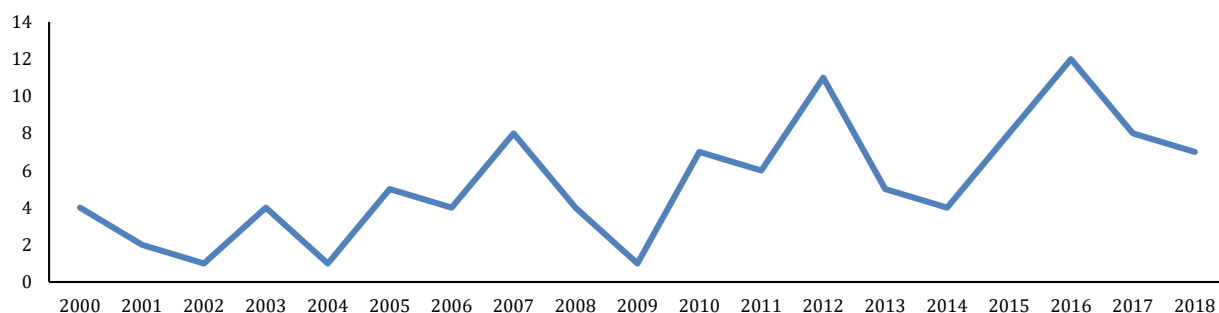


Figure 1) Publication trends of the articles

Table 2) Type of e-health technology used in the intervention

Type of e-health technology	Number of studies	Thematic scope of Asthma	Number of studies
Web-based systems	40	Asthma control	13
		Self-management	11
		Patient monitoring	8
		Medication adherence	6
		Patient Education	5
		Parenting intervention	3
		Outcome assessment	2
		Health Management Information	2
		Asthma management	2
		Medication administration	1
		Physician-Patient Relations	1
		Data collection	1
Text messaging	15	Medication adherence	7
		Asthma control	7
		Patient monitoring	4
		Asthma management	2
		Data collection	1
		Outcome Assessment	1
		Home care services	1
		Health information management	1
		Medication errors	1
		Patient assessment	1
Mobile applications	14	Asthma control	8
		Medication adherence	4
		Patient monitoring	3
		Self-management	2
		Patient assessment	1
		Data collection	1
		Empowering caregivers	1
Voice-call technologies	12	Asthma control	4
		Patient assessment	4
		Self-management	3
		Patient Education	1
		Parent's quality of life	1
		Outcome assessment	1
		parenting intervention	1
		Asthma management	1
Reminder systems	12	Medication adherence	10
		Asthma control	5
		Patient monitoring	2
		Home care services	1
		Outcome Assessment	1
Computer program	11	Patient Education	
		Health literacy	
		Asthma control	
		Medication adherence	
		Healthcare Disparities	
		Diagnosis	
		Game therapy	
CDSS	8	Self-management	
		Asthma control	6
		Clinician performance	1
		Outcome assessment	1
		Asthma management	1
		Community Health Services	1

Continue of Table 2) Type of e-health technology used in the intervention

Type of e-health technology	Number of studies	Thematic scope of Asthma	Number of studies
Tele-monitoring devices & systems	7	Asthma control	5
		Medication adherence	2
		Patient monitoring	2
		Outcome Assessment	1
Web site	7	Self-management	4
		Medication adherence	3
		Asthma control	1
		Patient Education	1
		Parenting intervention	1
		Patient Care Team- Education	1
		Physician-Patient Relations	1
E- game	6	Patient Education	
		Exercise therapy	
		Asthma control	
		Game therapy	
		Self-management	
Tele-consultation devices & systems	6	Asthma control	3
		Self-management	1
		Outcome Assessment	1
		Patient monitoring	1
		Patient assessment	1
		Patient Education	1
		Parent's quality of life	1
Video-Audio Media	5	Patient Education	2
		Asthma control	1
		Medication adherence	1
		Health literacy	1
		Healthcare Disparities	1
Tele-conferencing	3	Patient Education	2
		Patient monitoring	1
Electronic Health Record	3	Asthma control	3
		Outcome assessment	1
Social media	2	Medication adherence	2
		Patient Education	1
Tele-visit devices & systems	2	Patient monitoring	2
		Self-management	1
health information system	2	Health Information management	2
		data collection	1
		Medication error	1

As shown in table 3, the highest number of interventions occurred in the control of asthma (in 37 studies), followed by patient adherence to medication (in 22 studies), self-management (in 18 studies), and patient education (in 17 studies).

Children were studied in 33 studies, Adolescents in 24 studies, and adults in 51 studies, according to the findings of the study on the age range of the study population in the articles.

The researchers' findings on the countries of the corresponding authors or the first authors of the articles are also shown in Figure 2.

As shown in Figure 2, the United States has the highest share (45% of cases) among the countries of the first or the corresponding authors for the articles reviewed, followed by the United Kingdom (14%) and the Netherlands (11%), respectively.

Further studies by researchers have shown that in the list of countries of the authors, regardless of the position of the author, the United States with the production of 50 articles (49%) is ranked first, followed by the United Kingdom with 16 articles (15.69%), the Netherlands with 12 articles (11.76%), and Australia with ten articles (9.8%).

Table 3) Thematic scopes of the interventions in the articles

Thematic scope of the intervention	Number of studies
Asthma control	37
Medication adherence	22
Self-management	18
Patient Education	17
Patient monitoring	13
Patient assessment	5
Outcome assessment	5
Health Management	4
Information	
Asthma management	4
Data collection	3
Parenting intervention	3
Medication errors	2
Medication administration	1
Home care services	1
Empowering caregivers	1
Parent's quality of life	1
Home care services	1
Healthcare Disparities	1
Diagnosis	1
Game therapy	1
Clinician performance	1
Community Health Services	1
Patient Care Team- Education	1
Physician-Patient Relations	1
Exercise therapy	1
Health literacy	1

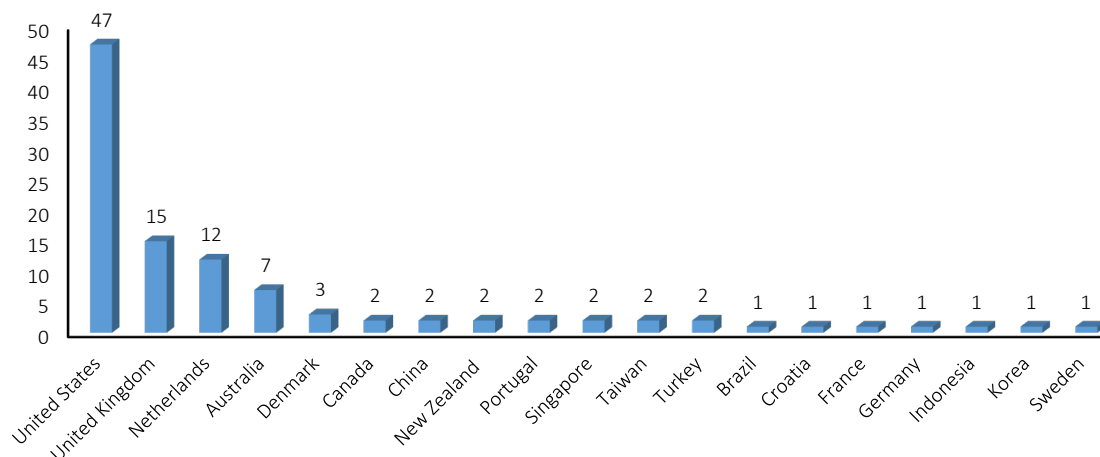


Figure 2) Countries of the first authors and the corresponding authors of the articles

Discussion

Asthma is a chronic respiratory disease whose increasing prevalence has imposed many economic and social burdens on societies around the globe [14-17]. E-health is a set of Internet-based technologies used in healthcare services to improve the quality of life and facilitate providing healthcare services [124]. In addition, it can be a valuable way to prevent, diagnose and treat this disease and reduce the global burden of this disease. In this study, in the period 2000 to 2018, 102 interventional studies were found in the PubMed database, which in a way, used e-health technologies in asthma. In this study, an attempt was made to determine e-health technologies, thematic domains, and some scientometric features of these interventional studies by reviewing these 102 articles.

According to the research results, with slight negligence, it can be said that the trend of publishing 102 articles, despite many ups and downs, has been a growing trend. These results may confirm that asthma researchers have recognized the value of using e-health technology as a valuable intervention tool. Alotaibi *et al.* have shown in their study that e-health technology is an essential tool for improving the quality of health care and patient safety [125]. Talboom-Kamp *et al.* have also shown in their research that e-health solutions can increase the quality of life and reduce the cost of care [126].

Elliott *et al.* have also argued that telemedicine, as a form of e-health, increases access to care, improves health outcomes, reduces medical costs, makes better use of resources, expands educational opportunities, and improves collaboration between patients and physicians [127]. Other studies in the field of asthma have found positive effects on the use of e-health technologies [18, 128-130].

The research findings indicate that web-based applications, technologies related to sending and receiving SMS, mobile applications, voice-call technologies, and reminder systems are at the top of

the technologies used to intervene in trial studies related to asthma, respectively. Web-based applications are mainly used through web browsers [131]. It differs from client-server applications in terms of presentation and application logic pieces [132].

Murray *et al.* [133], as well as Morrison *et al.* [85], have shown in their review studies that the use of web-based interventions positively affects improving and controlling chronic conditions, especially asthma. Also, in the present research, the researchers discovered that the majority of the studies used web-based systems to improve asthma control, self-management, and patient monitoring. Sarabi *et al.* have also argued that the use of SMS shows tremendous potential for drug adherence [134]. In addition, Tran *et al.*'s study stated that they positively evaluated the tools such as SMS and reminder systems in the timely use of drugs and adherence to the treatment plan [135]. The findings of this study also showed that text messaging was used in the studies to improve medication adherence and asthma control. Also, in a systematic review of the use of mobile applications to support asthma patients' self-management, Hui *et al.* found that using these technologies can improve asthma control [136].

Based on the findings of the present study, the voice-call technology was the fourth technology used in the research to perform the intervention in the field of asthma. The finding of a systematic review conducted by Yasmin *et al.* showed evidence of improved adherence, as well as health outcomes in disease management, using mobile Short Message Systems and/or Voice Calls [137]. As mentioned in the findings section, 10 of the 12 interventional studies used reminder systems to intervene in medication adherence. Tran *et al.* [135] and Dong *et al.* [138] in their systematic review studies indicated the effectiveness of this technology on medication adherence. Also, Jones Cooper *et al.* reported

improvement in influenza immunization rates with the implementation of reminder/recall systems [139]. According to the research findings, the highest number of interventions occurred in asthma control, followed by patients' adherence to medication, patient monitoring, and self-management. Chongmelaxme *et al.*, in their study, stated that the use of telemedicine helps to better control asthma and increase the quality of life of these patients [140]. McLean *et al.* have also suggested that the use of distance care interventions has the potential to reduce the risk of hospitalization, especially for patients with severe asthma [128]. Similarly, concerning patients' adherence to drug use, similar review studies have evaluated the use of electronic health tools in adherence to treatment and drug use in patients with asthma as acceptable and effective [141, 142].

Researchers' findings of the authors' countries, both as the corresponding author and the first author of the articles, and as other authors, the United States, the United Kingdom, and the Netherlands, respectively, have the highest share in the production of the articles. According to reports published in the Index Nature, the United States ranked first, and the United Kingdom ranked fourth in science production in 2018 and 2019 [143, 144]. According to the Scimago Institution in 2021, the United States ranked first in article production, the United Kingdom ranked third, and the Netherlands ranked fifteenth [145].

Conclusion

E-health intervention can be a valuable tool for preventing, diagnosing, and treating asthma, as well as reducing the disease's worldwide burden. The review of the publication trends of 102 articles revealed that more researchers in the asthma area used e-health interventions over time. Web-based applications, text messaging technologies, mobile applications, voice call technologies, and reminder systems were at the top of the technologies used by researchers to perform the intervention, respectively. The highest number of interventions occurred in the field of asthma control, followed by patients' adherence to medication, patient monitoring, and self-care. The United States was the country that contributed the most to these intervention studies.

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Authors' Contributions: Shahbodaghi A (First Author), Introduction Writer/Methodologist/Main Researcher/

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Statistical Analyst/Discussion Writer (50%); Asadi F (Second Author), Methodologist/Statistical Analyst/Discussion Writer (25%); Almasi S (Third Author), Assistant Researcher/ Discussion Writer (15%); Gavili Kilane N (Fourth author), Assistant Researcher (10%)

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