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The Use of Mobile Applications for Medication Tracking: Implications for Nursing and Pharmacy Practice

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Abstract

Background: Asthma affects approximately 262 million individuals globally, leading to significant morbidity and mortality. Effective management relies on improved patient monitoring and adherence to treatment regimens. This study explores the role of mobile applications and telemedicine in enhancing asthma management through better self-monitoring and communication between healthcare providers and patients.

Methods: A systematic literature review was conducted using databases including PubMed, Web of Science, Scopus, and Cochrane Library, focusing on studies published between 2014 and 2023. The review assessed the effectiveness of home monitoring devices, mobile spirometry, and telemedicine interventions in improving asthma control and patient engagement.

Results: The findings indicate that mobile applications and telemedicine significantly enhance self-monitoring capabilities, leading to improved asthma management outcomes. Studies revealed high patient satisfaction with mobile spirometry and telehealth interventions, with many participants reporting increased adherence to treatment plans. Notably, home spirometry demonstrated comparable results to traditional clinic-based assessments, reinforcing its viability as a monitoring tool.

Conclusion: The integration of mobile health technologies and telemedicine into asthma management presents a promising strategy for enhancing patient outcomes. These tools facilitate better self-regulation, improve adherence to treatment, and reduce the need for in-person consultations. Future research should focus on optimizing these technologies and addressing the barriers to their widespread adoption to maximize their potential benefits.

Keywords: Asthma management, mobile applications, telemedicine, self-monitoring, healthcare technology.

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1. Introduction

The 2019 assessment from the Global Burden of condition collaboration indicates that asthma affects around 262 million persons globally, highlighting its status as a widespread chronic condition. It substantially exacerbates the illness load, resulting in early death and a worse quality of life across diverse age demographics and geographical areas worldwide. Globally, asthma is the 24th leading cause of years lived with disability and the 34th major contributor to disease burden, measured by disability-adjusted life years [1-3].

The economic ramifications of asthma constitute a considerable worldwide issue, as shown by both direct and indirect expenditures. Strategies designed to improve access to and adherence to evidence-based therapies have effectively reduced the economic burden of asthma in both developed and developing countries. Although age-specific asthma mortality rates have decreased in several nations over the last decade, around 1000 persons die from asthma each day, highlighting a serious concern due to the avoidable nature of many of these fatalities. Despite a reduction in mortality rates, the total number of asthma-related deaths has remained relatively stable owing to the aging population. Preventable fatalities from asthma continue owing to insufficient illness treatment, often ascribed to an overdependence on reliever drugs instead of preventative strategies. It is essential to address this problem to decrease preventable asthma-related fatalities [1,2,4].

Asthma is a complex and diverse condition, often characterized by persistent airway inflammation induced by several stimuli. It is clinically diagnosed with a thorough evaluation of respiratory symptoms, including wheezing, dyspnea, chest tightness, and cough, which exhibit variability in both duration and severity, accompanied by intermittent expiratory airflow restriction. Asthma is often associated with airway hyperresponsiveness and inflammation; however, these elements are not essential nor enough for diagnosis. Commonly referred to as asthma phenotypes, discernible clusters of demographics, clinical, and/or pathophysiological traits do not demonstrate a robust association with particular pathogenic mechanisms or therapeutic responses. Spirometry is an effective diagnostic method for monitoring persons with identified respiratory conditions and for ascertaining the cause of unexplained respiratory symptoms. The gold standard test for diagnosing obstructive airway diseases, including asthma and chronic obstructive pulmonary disease (COPD), remains unchanged [1,5,6].

2. Telemedicine

Telemedicine enhances healthcare accessibility and is characterized by the use of information and communication technologies. It may improve healthcare accessibility in urban and rural regions, facilitating remote monitoring and medical education possibilities [7-9]. Global focus is directed towards the potential of telehealth to improve the accessibility, quality, safety, and cost-effectiveness of healthcare services. In respiratory disorders, telemedicine equipment for home monitoring enables doctors to assess the real-time progression of the condition, evaluate treatment compliance, verify inhalation procedures, and give consultations as necessary [10,11].

Prior to the emergence of the COVID-19 epidemic, clinicians used a hybrid paradigm that integrated telemedicine with in-person consultations. During the pandemic, telemedicine emerged as the favored method of treatment delivery when the physical presence of a medical expert was not essential. This strategy reduced interaction with healthcare institutions, emphasizing the safeguarding of both medical personnel and patients. Following the pandemic, several healthcare systems, in partnership with commercial organizations, are contemplating the use of telemedicine as a standard of treatment [12,13].

Health mobile apps are usually intended to track behaviors related to certain diseases, offering users pertinent information about their overall health and well-being or facilitating the independent management of particular medication regimens. These programs are designed to record and assess pertinent medical indicators, including condition-specific symptoms, metabolic levels, blood pressure, and heart activity. They enable the observation of the user's clinical advancement, supplying valuable information for personalized health management. Besides medical monitoring, these apps seek to educate

users on many health-related topics. They may provide pertinent advice on dietary plans, suggested physical activities, or stress management techniques, so aiding in the promotion of a healthy lifestyle. Furthermore, mobile health apps are intended to enhance the management of self-administered pharmaceutical therapies. They provide features such regular alerts for drug intake, accurate monitoring of dose schedules, and reminders for prescription renewal, thereby assuring patient adherence to the prescribed treatment regimen. The utilization of these applications must occur under the oversight and direction of a medical professional to guarantee accurate data interpretation and to ensure that therapeutic interventions are suitable and effective for each patient's specific context [14,15].

Telemedicine has developed as an effective option for providing pulmonary rehabilitation programs remotely, thereby addressing accessibility hurdles for patients unable to attend respiratory rehabilitation sessions in person owing to other commitments or dwelling in distant locations [16]. Telemonitoring of bioparameters enhances proactive management, hence lowering hospitalizations and, consequently, healthcare-related expenses. This innovation in telemedicine offers a practical and effective alternative for managing patients with respiratory diseases, while concurrently tackling issues of geographic distance and access to pulmonary rehabilitation programs [17,18].

This is a novel medical approach designed to enhance the quality of treatment and accessibility of medical services in rural areas. Nonetheless, there exists a paucity of research about the impact of telemedicine on the relationship dynamics between healthcare organizations and local populations. Recent studies have shown a deficiency of data about the precise influence of telemedicine on the hospital-community relationship, highlighting the need for more study in this domain. Assessing this dynamic may provide critical insights for enhancing the deployment of telemedicine to assist rural people in obtaining and benefitting from excellent medical care [19-21].

The implementation of telemedicine may face several challenges and hazards. Legal obstacles in telemedicine include the risk that teleconsultations may not meet the requisite standard of care. There exists the possibility for equipment or systems to encounter failures. Electronic data are prone to manipulation, and electronic records are subject to exploitation. Furthermore, telemedicine networks may lack sufficient data protection, hence jeopardizing confidentiality, authenticity, data reporting, process certification, and overall security and privacy. A further problem is ascertaining the roles and possible obligations of healthcare providers inside the network [22].

Besides these legal barriers, further challenges to telemedicine exist. A significant problem is the inadequate familiarity with eHealth among patients, citizens, and healthcare practitioners. There is insufficient compatibility across various telemedicine solutions. The justification for the cost-effectiveness of telemedicine is limited, and legal challenges and concerns continue to exist. There is a lack of openness over data use, insufficient reimbursement structures, and significant initial installation costs [22].

Healthcare practitioners must evaluate 10 factors to guide the deployment of telemedicine for asthma patients. Initially, they must comprehend the many forms of telemedicine and use the suitable ones for managing asthma patients [23-26]. Staying educated on the most recent telemedicine rules at both local and federal levels is crucial. Choosing an appropriate platform and developing the requisite infrastructure are essential tasks. Healthcare practitioners must conduct telemedicine consultations, get informed permission, and undertake requisite preparations prior to each appointment. During the consultation, they must engage with the patient and provide a physical examination if necessary. Ultimately, they ought to provide an invoice for the telemedicine consultation [27].

This study aimed to evaluate the effects of home monitoring devices on asthma treatment results and their long-term viability. This paper seeks to examine the effectiveness and acceptability of home spirometry and telemedicine in enhancing self-monitoring and patient participation in asthma treatment.

3. Methods

The publications chosen for this literature review conformed to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards. The literature search was conducted in 2023 using the

PubMed database, Web of Science, Scopus, and Cochrane Library, concentrating on papers published between 2014 and 2023.

4. The use of mobile spirometers in adult patients

Asthmatic patients often postpone seeing a physician until they need medicine, since they perceive an improvement in their condition. An analysis of much research on the use of mobile spirometers in adult patients was undertaken. While the majority of study has been on children, there are pertinent studies concerning the adult population as well. As per the single-arm, open-cohort, multicenter study [28-30]. In the study by Kupczyk et al. [31], which assessed the feasibility and safety of a portable respirometry device, it was determined that 67 persons (86%) out of 78 with complete data achieved the primary target. In the three-week follow-up, 75 participants (96%) used the device properly at least once, while 10 patients (13%) attained success daily. Data for three patients were absent due to Wi-Fi connectivity problems, while five patients withdrew their permission. A statistically significant difference in the good respirometry examination rate ($p = 0.013$) was observed between the locations. Out of 62 eligible patients, 20 (32%) needed retraining, and 8 (40%) achieved success. Ninety percent of responders rated the AioCareVR system as practical and user-friendly, indicating a high level of contentment [32-35].

In the research undertaken by Potonos [36], adults with challenging or severe asthma were progressively educated on the use of the AirNext spirometer (NuvoAir US Inc., Boston, USA) and were required to do daily spirometry at home for the first month, then transitioning to weekly sessions or when symptoms exacerbated. Geolocation data were used to differentiate between patients' first spirometry sessions performed in the hospital (designated as 'supervised') and those completed at home (designated as 'unsupervised'). All patients provided informed consent. A total of 10 asthma patients were enrolled, including four persons with uncontrolled asthma and six with moderately managed asthma, according to the GINA 2018 standards. Of these patients, 90% were female, with a mean age of 42.0 ± 10.7 years, and a FEV1 of 69.6 ± 26.2% (range from 27.3 to 101.0) anticipated during the supervised session. During the research period, these patients jointly engaged in 1235 unsupervised sessions, averaging a length of 181.5 ± 153.9 days, with a high of 382 days. Out of these sessions, 877 (71.0%) satisfied the acceptable quality requirements (rated A–C, comprising a minimum of two maneuvers with <200 mL fluctuation in FEV1 and FVC), with the majority (556 sessions) rated as A. Conversely, just 50.0% of the 10 monitored sessions were deemed satisfactory. The evaluation of spirometry session quality was conducted in accordance with the parameters specified in the American Thoracic Society Technical Statement. Analysis of the spirometry findings revealed that the supervised tests done in the hospital had outcomes comparable to those of the original unsupervised testing carried out at home. The FEV1 and FVC readings were 2.1 ± 0.3 L and 2.9 ± 0.3 L, respectively, during supervised assessments, in contrast to 2.2 ± 0.2 L and 2.9 ± 0.2 L, respectively, during the first unsupervised home evaluations. The average expected FEV1 values were 69.6 ± 26.2% and 72.0 ± 24.0%, respectively [36].

Bindler et al. [35] undertook research to determine if frequent monitoring of young persons with asthma improved airway function, as evaluated by FEV1, and to investigate the practicality of self-administered spirometry. A total of 67 individuals (ages 18–26) used a portable spirometer linked to a smartphone application, with data gathered at baseline, week 4, and week 8. Compliance was high, with 100% completing spirometry at baseline, declining to 94% at week 4 and 86.6% at week 8. FEV1 values were consistent throughout the research, and more than two-thirds of individuals used the app to record their symptoms and triggers. The research indicated that self-administered spirometry is a viable and acceptable approach for young individuals [35].

5. Clinic versus Home Spirometry

In this research, Huang et al. [32] aimed to determine if mobile spirometry may provide more statistical power than its clinical counterparts. The average subject compliance for mSpirometry was 70% for twice-daily usage and 85% for at least once-daily use. The FEV1 measurements from mSpirometry exhibited a robust correlation and concordance with those obtained from the clinic on the same morning ($r = 0.993$) and afternoon ($r = 0.988$). The interclass correlation coefficient (ICC) was used to assess the test–retest

reliability of mSpirometry and clinic spirometry. The average difference between the afternoon (0.0019 L) and morning (0.0126 L) measurements was smaller. Both mobile (ICC = 0.932) and clinic (ICC = 0.942) spirometry exhibited comparable test–retest reliability. This simulation analysis demonstrated that dense mSpirometry exhibited more power than sparse clinic measurements. They provide enhanced statistical power, robust agreement, and similar test–retest reliability with clinical counterparts for repeated at-home mSpirometry, potentially benefiting asthma clinical research [37].

Oppenheimer et al. [38] executed the most extensive asthma investigation to date by comparing spirometry completed at home with that performed in a clinic in this post hoc analysis. The randomized double-anonymized parallel-group phase 3A CAPTAIN and phase 2B 205832 investigations, including patients with uncontrolled asthma, supplied the trough FEV1 data used in this retrospective analysis. The 205832 research examined the effects of incorporating umeclidinium with fluticasone furoate vs a placebo, whilst the CAPTAIN trial investigated the effects of adding umeclidinium to fluticasone furoate/vilanterol via a single inhaler. Both home-based and supervised in-person spirometry were used to ascertain trough FEV1. The measurements were conducted at the research clinic. The authors generated post hoc Bland–Altman plots to test the concordance between the two methodologies and the temporal evaluations of FEV1 conducted at home and in the clinic. An analysis was performed on data from 421 participants and 2436 patients. Both trials observed treatment-related improvements in FEV1 by clinic and home spirometry. In comparison to clinical assessments, the increases identified using home spirometry were, however, less substantial and less dependable. Poor concordance was shown by Bland–Altman plots between FEV1 at baseline and week 24 in both home and clinic settings. The results indicate that unsupervised home spirometry readings cannot serve as a direct substitute for clinic measurements due to their lower reliability and diminished concordance with clinic spirometry outcomes. These findings, however, may be limited to home spirometry using the particular apparatus and coaching methodologies used in these studies. Further research is essential to optimize the use of home spirometry post-pandemic [38].

6. Self-Regulation

It is essential for the patient to be aware of their condition, comprehend it, and treat it autonomously. Guarnieri et al. developed a bespoke questionnaire that was sent via email to 180 individuals suffering from severe asthma. Most of these patients, 82%, felt at ease with the idea of self-monitoring and treating their illness. Furthermore, 77% of the participants supported the implementation of virtual consultations and the use of telemedicine. Ninety-three percent regarded self-injection therapy to be uncomplicated, ninety-four percent felt safe, and ninety-three percent had no apprehensions regarding self-administration of the treatment. A mere 22% reported minimal side effects after self-administration. The research indicated agreement among healthcare professionals and patients on the viability of illness treatment and monitoring via telehealth, with biologics demonstrating safety and simplicity of self-administration at home [33].

This observational research, orchestrated by Kuipers et al., included 21 community pharmacies in the Netherlands. The objective was to assess the precision of electronic inhalation monitoring device (EIMD) records by juxtaposing them with patient-reported inhalations. A total of 32 patients from 18 pharmacies participated, validating 932 drug dosages. The research identified a false-positive rate of 3.5% (erroneous device registrations), a true-positive rate of 85.4% (correct registrations), and a positive predictive value of 96.0%. Although several patients were initially reluctant to use the EIMD, the majority deemed it acceptable and user-friendly, although expressing a need for further personalization within the application. Enhancing accuracy and user-specific features was emphasized to improve device use and acceptance [28].

7. Remote Digital Coaching - Follow-Up

In a 12-week remote digital coaching program conducted by Rasulnia et al., 51 persons with uncontrolled asthma participated. The program included several tools and tactics to promote self-management of the condition. Of the original participants, 40 successfully finished the trial. Notable enhancements were noted in mental condition, body mass, and incidence of outpatient exacerbations. The alterations in Asthma Control Test scores were statistically significant; nevertheless, they did not achieve the minimal clinically meaningful difference. Nonetheless, the Asthma Symptom Utility Index scores demonstrated both

statistical significance and clinical relevance. No alterations were seen in pulmonary function and the use of rescue albuterol [25].

Prabhakaran et al. executed a multicenter randomized controlled study in Singapore, focusing on emergency department patients diagnosed with asthma from March 2013 to February 2015. Patients were randomly allocated to the eCARE intervention group (n = 212), which received SMS messages, or to a control group (n = 212), which received standard care. After five weeks, there was no notable difference in attaining well-controlled asthma between the groups who started had poorly controlled asthma. Logistic regression after three months indicated a tendency towards improved asthma control in the usual care group; however, this finding was not statistically significant. Although eCARE participants exhibited a high satisfaction rate (95%) with the SMS service, the intervention did not result in improved asthma control relative to normal treatment [30].

8. Supplementary Telemedicine Instruments

The use of technology by some patients may provide challenges. A smart smartphone with Bluetooth Smart connection and internet access is required to download the application and consistently transmit spirometry findings to the expert. The advancements in technology, especially in personal health monitoring, are really extraordinary. Devices such as smartwatches and other devices are increasingly outfitted with specialized sensors that can monitor various physiological indicators. This provides consumers with a comprehensive picture of their health. These gadgets may record heart rate, monitor sleep quality, and measure physical activity, becoming more sophisticated and beneficial in maintaining and improving our health. It is essential to be cognizant of data privacy and comprehend the methods of data storage and use employed by device makers. Numerous lung monitoring devices are available for home use, intended to assess lung function and monitor elements of respiratory disorders including asthma and COPD. Below are few examples:

Mobile spirometer: This functions as a diagnostic and monitoring instrument for pulmonary disorders. It enables the assessment of the patient's lung volumes to evaluate the efficacy of the management of the ailment [39].

Peak flow meter: This device provides a rapid assessment of the peak expiratory flow rate, facilitating self-monitoring at home for disease management and evaluating patient response to therapy [39].

Pulse oximeter: This compact instrument affixes to an individual's fingertip to assess oxygen saturation levels. It is often used to observe persons with respiratory conditions [39].

Portable capnograph: This device quantifies the quantity of carbon dioxide in exhaled air. Monitoring end-tidal carbon dioxide is essential for assessing patients on mechanical ventilation to ensure adequate ventilation. While mostly used in hospitals for monitoring respiration during anesthesia or critical care, portable variants are accessible for domestic usage [40].

Smart inhalers: These electronic monitoring devices interface with a smartphone application to record medicine consumption, inhalation strategies, and more pertinent data. They assist persons with asthma or COPD in managing their therapy, monitoring symptoms, and receiving prescription reminders. In today's technology context, it is feasible to combine patients' inhaler use geographical data with environmental indicators. This integration enables the detection of areas with increased vulnerability to asthma episodes. Numerous studies have shown that the use of reminders via electronic inhalers substantially enhances adherence to prescription regimens, showing a considerable advantage over conventional therapy methods [41-44].

ADAMM (Automated Device for Asthma Monitoring and Management): This cutting-edge pulmonary monitoring apparatus employs artificial intelligence (AI) to assist patients with asthma in effectively managing their symptoms. ADAMM is a wearable apparatus that tracks respiratory patterns, heart rate, and physical activity. Equipped with sensors that monitor alterations in respiration, like snoring or dyspnea, it

employs artificial intelligence to evaluate the data and provide tailored feedback and suggestions for controlling asthma symptoms [39,45,46].

Portable FeNo: This technique is quantitative, noninvasive, direct, and secure for assessing airway inflammation. It functions as a supplementary resource to other methodologies used for assessing airway illnesses and is advised for the diagnosis of eosinophilic airway inflammation [47-49].

9. Guaranteeing Privacy and Data Security in Telemedicine

Telemedicine presents significant privacy concerns due to its use of electronic medical records (EMRs) for documenting follow-up information, diagnosis, prescriptions, and medical histories. The safeguarding of patient data is inconsistent owing to discrepancies in federal legislation. Patient autonomy, safety, cultural diversity, and informed consent exemplify ethical challenges. Research highlights the need of informed consent while noting the discrepancies in its execution. It is recommended that data protection be regulated by standardized laws, such as the General Data Protection Regulation (GDPR), emphasizing the safeguarding of children's and families' data. Despite persistent concerns over malpractice, telemedicine is mostly more beneficial than detrimental. Proposals for uniform law exist because of the dispersion of legal norms. The advantages of telemedicine, including cost reduction and improved treatment, are well acknowledged; yet cultural awareness remains crucial. The incorporation of AI is expected to enhance the scope and efficacy of telemedicine.

Informed consent: Confidentiality is paramount in telemedicine. Providers must get express permission and provide an explanation for data access and use. Identity verification, perhaps via photographic identification, should be prioritized in sessions. Alongside guaranteeing safe data transfer and storage, suppliers must also educate patients on the need of secure networks. These standards also include emergency care [51].

The General Data Protection Regulation (GDPR), the most stringent privacy and security legislation globally, was adopted on 25 May 2018. Although designed by the European Union (EU), it is relevant to any organization worldwide that targets or collects personal data about persons inside the EU. The GDPR's explicit definition of data points has enhanced the safeguarding of medical information. Experts recommend the adoption of uniform worldwide norms to provide optimum data security and protection [52,53].

The need for cohesive regulation is shown by the fragmented approach to telehealth legislation. European studies focus on the implementation and standardization of directives, while North American studies emphasize interstate legislation and licensing. Comprehensive and consistent rules are essential for the effective operation of telehealth [54].

10. Conclusions

Initially used mostly in distant or rural regions, telemedicine has increasingly expanded to address global health needs. Factors like as ease, efficiency, communication, and privacy are essential for the acceptability of telemedicine, facilitating interactions between patients and healthcare practitioners. However, there are persistent difficulties and problems in the implementation of telemedicine that must be addressed, including technical issues and the assurance of quality and safety in remotely delivered medical services. Addressing these challenges, telemedicine has the potential to emerge as a considerable asset in healthcare, providing major benefits to both patients and healthcare practitioners.

Home spirometry and telemedicine are intriguing approaches for enhancing self-monitoring and patient participation in asthma therapy, thereby decreasing the need for clinic visits. Research demonstrates that with enough training, home spirometry may provide valid results similar to clinic-based assessments. Moreover, patients often exhibit a positive attitude towards telemedicine and self-management tools; nonetheless, enhancements in technology and training are essential to optimize their efficacy and

dependability. These innovations, together with machine learning and digital health platforms, possess considerable promise to improve asthma management and patient quality of life.

References

1. Global Initiative for Asthma—GINA. GINA Main Report. 2023. Available online: https://ginasthma.org/2023-gina-main-report/.
2. Nurmagambetov, T.; Kuwahara, R.; Garbe, P. The Economic Burden of Asthma in the United States, 2008–2013. Ann. ATS 2018, 15, 348–356.
3. Gupta, A.; Bhat, G.; Pianosi, P. What is New in the Management of Childhood Asthma? Indian J. Pediatr. 2018, 85, 773–781.
4. Papi, A.; Brightling, C.; Pedersen, S.E.; Reddel, H.K. Asthma. Lancet 2018, 391, 783–800.
5. Bernstein, J.A. Editorial: Advancements in asthma diagnosis and management: What's new? Curr. Opin. Pulm. Med. 2022, 28, 232–233.
6. Wheatley, J.R. Spirometry: Key to the diagnosis of respiratory disorders. Med. J. Aust. 2017, 207, 422–423. [Google Scholar] [CrossRef] [PubMed]
7. Brown, W.; Odenthal, D. The uses of telemedicine to improve asthma control. J. Allergy Clin. Immunol. Pract. 2015, 3, 300–301.
8. Kew, K.M.; Cates, C.J. Remote versus face-to-face check-ups for asthma. Cochrane Database Syst. Rev. 2016, 4, CD011715.
9. Nelson, R. Telemedicine and Telehealth: The Potential to Improve Rural Access to Care. Am. J. Nurs. 2017, 117, 17–18.
10. McLean, S.; Sheikh, A.; Cresswell, K.; Nurmatov, U.; Mukherjee, M.; Hemmi, A.; Pagliari, C. The Impact of Telehealthcare on the Quality and Safety of Care: A Systematic Overview. PLoS ONE 2013, 8, e71238.
11. Pinnock, H.; Hui, C.Y.; Van Boven, J.F.M. Implementation of digital home monitoring and management of respiratory disease. Curr. Opin. Pulm. Med. 2023, 29, 302–312.
12. Persaud, Y.K. Using Telemedicine to Care for the Asthma Patient. Curr. Allergy Asthma Rep. 2022, 22, 43–52.
13. Persaud, Y.K.; Portnoy, J.M. Ten Rules for Implementation of a Telemedicine Program to Care for Patients with Asthma. J. Allergy Clin. Immunol. Pract. 2021, 9, 13–21.
14. Ventola, C.L. Mobile devices and apps for health care professionals: Uses and benefits. Pharm. Ther. 2014, 39, 356–364.
15. Misra, S.; Lewis, T.L.; Aungst, T.D. Medical Application Use and the Need for Further Research and Assessment for Clinical Practice: Creation and Integration of Standards for Best Practice to Alleviate Poor Application Design. JAMA Dermatol. 2013, 149, 661.
16. Rochester, C.L.; Vogiatzis, I.; Holland, A.E.; Lareau, S.C.; Marciniuk, D.D.; Puhan, M.A.; Spruit, M.A.; Masefield, S.; Casaburi, R.; Clini, E.M.; et al. An Official American Thoracic Society/European Respiratory Society Policy Statement: Enhancing Implementation, Use, and Delivery of Pulmonary Rehabilitation. Am. J. Respir. Crit. Care Med. 2015, 192, 1373–1386.
17. Turner, A.P.; Wallin, M.T.; Sloan, A.; Maloni, H.; Kane, R.; Martz, L.; Haselkorn, J.K. Clinical Management of Multiple Sclerosis Through Home Telehealth Monitoring. Int. J. MS Care 2013, 15, 8–14.
18. Jaglal, S.B.; Haroun, V.A.; Salbach, N.M.; Hawker, G.; Voth, J.; Lou, W.; Kontos, P.; Cameron, J.E.; Cockerill, R.; Bereket, T. Increasing Access to Chronic Disease Self-Management Programs in Rural and Remote Communities Using Telehealth. Telemed. E-Health 2013, 19, 467–473.
19. Bond, C.S. Telehealth as a tool for independent self-management by people living with long term conditions. Stud. Health Technol. Inf. 2014, 206, 1–6.
20. Rixon, L.; Hirani, S.P.; Cartwright, M.; Beynon, M.; Doll, H.; Steventon, A.; Henderson, C.; Newman, S.P. A RCT of telehealth for COPD patient's quality of life: The whole system demonstrator evaluation. Clin. Respir. J. 2017, 11, 459–469.
21. Potter, A.J.; Ward, M.M.; Natafgi, N.; Ullrich, F.; Clinton, A.; Bell, A.L.; Mueller, K.J. Perceptions of the Benefits of Telemedicine in Rural Communities. 2016. Available online:

https://www.proquest.com/openview/a1bec3f367e3222b4b6e3b07a71177c1/1?pq-origsite=gscholar&cbl=51400.
22. Ambrosino, N.; Vitacca, M.; Dreher, M.; Isetta, V.; Montserrat, J.M.; Tonia, T.; Turchetti, G.; Winck, J.C.; Burgos, F.; Kampelmacher, M.; et al. Tele-monitoring of ventilator-dependent patients: A European Respiratory Society Statement. Eur. Respir. J. 2016, 48, 648–663.
23. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ 2021, n71, 372.
24. Honkoop, P.J.; Simpson, A.; Bonini, M.; Snoeck-Stroband, J.B.; Meah, S.; Fan Chung, K.; Usmani, O.S.; Fowler, S.; Sont, J.K. MyAirCoach: The use of home-monitoring and mHealth systems to predict deterioration in asthma control and the occurrence of asthma exacerbations; study protocol of an observational study. BMJ Open 2017, 7, e013935.
25. Rasulnia, M.; Burton, B.S.; Ginter, R.P.; Wang, T.Y.; Pleasants, R.A.; Green, C.L.; Lugogo, N. Assessing the impact of a remote digital coaching engagement program on patient-reported outcomes in asthma. J. Asthma 2018, 55, 795–800.
26. Chan, Y.-F.Y.; Wang, P.; Rogers, L.; Tignor, N.; Zweig, M.; Hershman, S.G.; Genes, N.; Scott, E.R.; Krock, E.; Badgeley, M.; et al. The Asthma Mobile Health Study, a large-scale clinical observational study using ResearchKit. Nat. Biotechnol. 2017, 35, 354–362.
27. Nemanic, T.; Sarc, I.; Skrgat, S.; Flezar, M.; Cukjati, I.; Marc Malovrh, M. Telemonitoring in asthma control: A randomized controlled trial. J. Asthma 2019, 56, 782–790.
28. Kuipers, E.; Poot, C.C.; Wensing, M.; Chavannes, N.H.; De Smet, P.A.; Teichert, M. Self-Management Maintenance Inhalation Therapy With eHealth (SELFIE): Observational Study on the Use of an Electronic Monitoring Device in Respiratory Patient Care and Research. J. Med. Internet Res. 2019, 21, e13551.
29. Rudin, R.S.; Fanta, C.H.; Qureshi, N.; Duffy, E.; Edelen, M.O.; Dalal, A.K.; Bates, D.W. A Clinically Integrated mHealth App and Practice Model for Collecting Patient-Reported Outcomes between Visits for Asthma Patients: Implementation and Feasibility. Appl. Clin. Inf. 2019, 10, 783–793.
30. Prabhakaran, L.; Chun Wei, Y. Effectiveness of the eCARE programme: A short message service for asthma monitoring. BMJ Health Care Inf. 2019, 26, e100007.
31. Kupczyk, M.; Hofman, A.; Kołtowski, Ł.; Kuna, P.; Łukaszyk, M.; Buczyłko, K.; Bodzenta-Łukaszyk, A.; Nastałek, P.; Soliński, M.; Dąbrowiecki, P. Home self-monitoring in patients with asthma using a mobile spirometry system. J. Asthma 2021, 58, 505–511.
32. Huang, C.; Izmailova, E.S.; Jackson, N.; Ellis, R.; Bhatia, G.; Ruddy, M.; Singh, D. Remote FEV1 Monitoring in Asthma Patients: A Pilot Study. Clin. Transl. Sci. 2021, 14, 529–535.
33. Guarnieri, G.; Caminati, M.; Achille, A.; Vaia, R.; Chieco Bianchi, F.; Senna, G.; Vianello, A. Severe Asthma, Telemedicine, and Self-Administered Therapy: Listening First to the Patient. J. Clin. Med. 2022, 11, 960.
34. Furci, F.; Caminati, M.; Genovese, S.; Gangemi, S.; Senna, G. Upsides and downsides of a telecounselling model of integrated asthma management between general practitioners and specialists. Clin. Transl. Allergy 2022, 12, e12088.
35. Bindler, R.; Haverkamp, H.C.; O'Flanagan, H.; Whicker, J.; Rappold, A.G.; Walden, V.; Postma, J. Feasibility and acceptability of home monitoring with portable spirometry in young adults with asthma. J. Asthma 2023, 60, 1474–1479.
36. Potonos, D.; Exarchos, K.; Assioura, A.; Sioutkou, A.; Tatsis, K.; Kyriakopoulos, C.; Gogali, A.; Kostikas, K. Achievement of high-quality home spirometry inpatients with asthma: The NuvoAir platform. Pneumon 2023, 36, A4536.
37. Izmailova, E.S.; Kilian, R.; Bakker, J.P.; Evans, S.; Scotina, A.D.; Reiss, T.F.; Singh, D.; Wagner, J.A. Study protocol: A comparison of mobile and clinic-based spirometry for capturing the treatment effect in moderate asthma. Clin. Transl. Sci. 2023, 16, 2112–2122.

38. Oppenheimer, J.; Hanania, N.A.; Chaudhuri, R.; Sagara, H.; Bailes, Z.; Fowler, A.; Peachey, G.; Pizzichini, E.; Slade, D. Clinic vs Home Spirometry for Monitoring Lung Function in Patients With Asthma. Chest 2023, 164, 1087–1096.
39. Jacox, C.; A Guide to At-Home Lung Monitoring Devices. Health Care Originals. 2022. Available online: https://healthcareoriginals.com/a-guide-to-at-home-lung-monitoring-devices/.
40. Vrijdag, X.C.; Van Waart, H.; Sames, C.; Sleigh, J.W.; Mitchell, S.J. Comparing the EMMA capnograph with sidestream capnography and arterial carbon dioxide pressure at 284 kPa. Diving Hyperb. Med. 2023, 53, 327–332.
41. Van De Hei, S.J.; Stoker, N.; Flokstra-de Blok, B.M.J.; Poot, C.C.; Meijer, E.; Postma, M.J.; Chavannes, N.H.; Kocks, J.W.H.; Van Boven, J.F.M. Anticipated barriers and facilitators for implementing smart inhalers in asthma medication adherence management. npj Prim. Care Respir. Med. 2023, 33, 22.
42. Su, J.G.; Barrett, M.A.; Combs, V.; Henderson, K.; Van Sickle, D.; Hogg, C.; Simrall, G.; Moyer, S.S.; Tarini, P.; Wojcik, O.; et al. Identifying impacts of air pollution on subacute asthma symptoms using digital medication sensors. Int. J. Epidemiol. 2022, 51, 213–224.
43. Kuipers, E.; Wensing, M.; De Smet, P.; Teichert, M. Self-management research of asthma and good drug use (SMARAGD study): A pilot trial. Int. J. Clin. Pharm. 2017, 39, 888–896.
44. Sulaiman, I.; Greene, G.; MacHale, E.; Seheult, J.; Mokoka, M.; D'Arcy, S.; Taylor, T.; Murphy, D.M.; Hunt, E.; Lane, S.J.; et al. A randomised clinical trial of feedback on inhaler adherence and technique in patients with severe uncontrolled asthma. Eur. Respir. J. 2018, 51, 1701126.
45. Broască, L.; Truşculescu, A.A.; Ancuşa, V.M.; Ciocârlie, H.; Oancea, C.-I.; Stoicescu, E.-R.; Manolescu, D.L. A Novel Method for Lung Image Processing Using Complex Networks. Tomography 2022, 8, 1928–1946.
46. Rhee, H.; Miner, S.; Sterling, M.; Halterman, J.S.; Fairbanks, E. The Development of an Automated Device for Asthma Monitoring for Adolescents: Methodologic Approach and User Acceptability. JMIR Mhealth Uhealth 2014, 2, e27.
47. Dweik, R.A.; Boggs, P.B.; Erzurum, S.C.; Irvin, C.G.; Leigh, M.W.; Lundberg, J.O.; Olin, A.-C.; Plummer, A.L.; Taylor, D.R.; on behalf of the American Thoracic Society Committee on Interpretation of Exhaled Nitric Oxide Levels (Fe) for Clinical Applications. An Official ATS Clinical Practice Guideline: Interpretation of Exhaled Nitric Oxide Levels (F E NO) for Clinical Applications. Am. J. Respir. Crit. Care Med. 2011, 184, 602–615.
48. Bjermer, L.; Alving, K.; Diamant, Z.; Magnussen, H.; Pavord, I.; Piacentini, G.; Price, D.; Roche, N.; Sastre, J.; Thomas, M.; et al. Current evidence and future research needs for FeNO measurement in respiratory diseases. Respir. Med. 2014, 108, 830–841.
49. Li, Y.; Huang, K.; Li, W.; Peng, Y.; Tang, X.; Yang, T. Validation of a new portable system containing both FeNO analysis and spirometry measurement. Front. Med. 2023, 10, 1210329.
50. Nittari, G.; Khuman, R.; Baldoni, S.; Pallotta, G.; Battineni, G.; Sirignano, A.; Amenta, F.; Ricci, G. Telemedicine Practice: Review of the Current Ethical and Legal Challenges. Telemed. E-Health 2020, 26, 1427–1437.
51. Kahn, E.N.; La Marca, F.; Mazzola, C.A. Neurosurgery and Telemedicine in the United States: Assessment of the Risks and Opportunities. World Neurosurg. 2016, 89, 133–138.
52. GDPR.eu. What is GDPR, the EU's New Data Protection Law? 2018. Available online: https://gdpr.eu/what-is-gdpr/.
53. Botrugno, C. Telemedicine in daily practice: Addressing legal challenges while waiting for an EU regulatory framework. Health Policy Technol. 2018, 7, 131–136.
54. Parimbelli, E.; Bottalico, B.; Losiouk, E.; Tomasi, M.; Santosuosso, A.; Lanzola, G.; Quaglini, S.; Bellazzi, R. Trusting telemedicine: A discussion on risks, safety, legal implications and liability of involved stakeholders. Int. J. Med. Inform. 2018, 112, 90–98.

الملخص

الخلفية :يؤثر مرض الربو على حوالي 262 مليون شخص عالميًا، مما يؤدي إلى معدلات مرتفعة من المراضة والوفيات. يعتمد العلاج الفعّال على تحسين مراقبة المرضى والالتزام بخطط العلاج. تستكشف هذه الدراسة دور التطبيقات المحمولة والطب عن بُعد في تعزيز إدارة الربو من خلال تحسين المراقبة الذاتية والتواصل بين مقدمي الرعاية الصحية والمرضى.

المنهجيات :أُجريت مراجعة منهجية للأدبيات باستخدام قواعد بيانات مثل PubMed و Web of Scienceو ScopusومكتبةCochrane ، مع التركيز على الدراسات المنشورة بين عامي 2014 و2023. قُيّمت فعالية أجهزة المراقبة المنزلية، ومقياس التنفس المحمول، والتدخلات الطبية عن بُعد في تحسين السيطرة على الربو وزيادة مشاركة المرضى.

النتائج :أظهرت النتائج أن التطبيقات المحمولة والطب عن بُعد يُحسّنان بشكل كبير من قدرات المراقبة الذاتية، مما يؤدي إلى تحسين نتائج إدارة الربو. أشارت الدراسات إلى رضا مرتفع لدى المرضى عن مقياس التنفس المحمول والتدخلات الطبية عن بُعد، حيث أفاد العديد من المشاركين بزيادة الالتزام بخطط العلاج. والجدير بالذكر أن قياس التنفس المنزلي أظهر نتائج مماثلة للتقييمات التي تُجرى في العيادات التقليدية، مما يعزز جدواه كأداة مراقبة.

الخلاصة :يُظهر دمج تقنيات الصحة المحمولة والطب عن بُعد في إدارة الربو استراتيجية واعدة لتحسين نتائج المرضى. تُسهّل هذه الأدوات التنظيم الذاتي الأفضل، وتحسّن الالتزام بالعلاج، وتقلّل الحاجة إلى الاستشارات الشخصية. ينبغي أن تركز الأبحاث المستقبلية على تحسين هذه التقنيات ومعالجة العوائق التي تواجه تبنيها على نطاق واسع لتحقيق أقصى فائدة منها.

الكلمات المفتاحية :إدارة الربو، التطبيقات المحمولة، الطب عن بُعد، المراقبة الذاتية، تكنولوجيا الرعاية الصحية.