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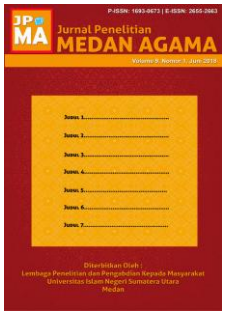

AIRIS Smart Inhaler: An Integrated Health Technology Innovation to Improve Early Detection and Proactive Control of Asthma Attacks

AIRIS Smart Inhaler: Inovasi Teknologi Kesehatan Terintegrasi untuk Meningkatkan Deteksi Dini dan Pengendalian Proaktif Serangan Asma

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Abstract

Asthma is a chronic respiratory disease of the airways characterized by inflammation narrowing of the airways, causing sufferers to experience difficulty breathing. This disease requires long-term management and consistent monitoring of medication use. However, the use of inhalers as asthma therapy is not regularly used due to low awareness and minimal monitoring. This has led to a surge in asthma relapse cases. Therefore, a solution is needed to help increase awareness and monitor inhaler use in real-time, while supporting patient adherence to treatment. The research method used is a Research and Development (R&D) approach, involving prototype design, functional testing, and initial system evaluation. This device is designed to track inhaler usage patterns, detect potential symptoms through manual input and environmental data, and provide real-time notifications via a companion app. Testing results show that the AIRIS Smart Inhaler can automatically detect inhaler usage, record frequency and usage time, and send this data to the companion app in real-time. This system also successfully provides usage reminders to users. With this feature, AIRIS is considered to be able to improve therapy compliance and facilitate monitoring by medical personnel. AIRIS Smart Inhaler is expected to improve therapy compliance, facilitate asthma monitoring, and become an innovative solution in technology-based asthma management.

Keywords: *Asthma, Smart Inhaler, Real-Time Monitoring, Research and Development (R&D)*

Abstrak

Asma merupakan penyakit pernapasan kronis pada saluran napas yang ditandai oleh peradangan dan penyempitan saluran napas sehingga penderitanya mengalami kesulitan bernapas. Penyakit ini memerlukan pengelolaan jangka panjang serta pemantauan penggunaan obat secara konsisten. Namun, penggunaan inhaler sebagai terapi asma sering kali tidak dilakukan secara rutin akibat rendahnya kesadaran dan minimnya pemantauan. Hal ini menyebabkan meningkatnya angka kekambuhan asma. Oleh karena itu, diperlukan suatu solusi yang dapat membantu meningkatkan kesadaran pasien serta memantau penggunaan inhaler secara real-time, sekaligus mendukung kepatuhan pasien terhadap terapi. Metode penelitian yang digunakan adalah metode Research and Development (R&D), yang meliputi perancangan prototipe, pengujian fungsional, dan evaluasi awal sistem. Perangkat ini dirancang untuk melacak pola penggunaan inhaler, mendeteksi potensi gejala melalui input manual dan data lingkungan, serta memberikan notifikasi secara real-time melalui aplikasi pendamping. Hasil pengujian menunjukkan bahwa AIRIS Smart Inhaler mampu mendeteksi penggunaan inhaler secara otomatis, mencatat frekuensi dan waktu penggunaan, serta

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mengirimkan data tersebut ke aplikasi pendamping secara real-time. Sistem ini juga berhasil memberikan pengingat penggunaan kepada pengguna. Dengan fitur tersebut, AIRIS dinilai mampu meningkatkan kepatuhan terapi dan memudahkan pemantauan oleh tenaga medis. AIRIS Smart Inhaler diharapkan dapat meningkatkan kepatuhan terapi, memfasilitasi pemantauan asma, serta menjadi solusi inovatif dalam pengelolaan asma berbasis teknologi.
Kata kunci: *Asma, Smart Inhaler, Pemantauan Real-Time, Research and Development (R&D)*

1. INTRODUCTION

Asthma is a chronic respiratory disease characterized by persistent airway inflammation, bronchial hyperresponsiveness, and reversible airflow obstruction, which manifests clinically as shortness of breath, wheezing, coughing, and chest tightness (Global Initiative for Asthma [GINA], 2023). Asthma can affect individuals of all ages and remains a significant public health concern worldwide due to its chronic nature, recurrent exacerbations, and substantial impact on quality of life. According to the World Health Organization (WHO), asthma affects more than 260 million people globally and contributes to over 450,000 deaths annually, particularly in low- and middle-income countries (WHO, 2023). The global prevalence of asthma continues to increase, driven by rapid urbanization, air pollution, lifestyle changes, and environmental exposure to allergens and irritants (Alwadhahi et al., 2022).

In Indonesia, asthma is also a major health problem. Data from national health surveys indicate that approximately 2.4% of the Indonesian population suffers from asthma, with higher prevalence observed in urban areas and industrial regions (Alqarni et al., 2024).

Despite the availability of effective pharmacological therapies, asthma remains poorly controlled in many patients, leading to frequent exacerbations, emergency department visits, hospitalization, and reduced productivity (Ministry of Health Republic of Indonesia, 2022).

Poor asthma control not only increases the clinical burden on patients but also results in significant economic costs for both individuals and healthcare systems (Bahadori et al., 2019).

Effective asthma management relies heavily on long-term control therapy, primarily through the regular use of inhaled medications such as inhaled corticosteroids (ICS) and bronchodilators. Inhalers are considered the cornerstone of asthma treatment because they deliver medication directly to the lungs, resulting in faster onset of action and fewer systemic side effects compared to oral medications (GINA, 2023). However, despite their proven effectiveness, adherence to inhaler therapy remains a critical challenge in asthma management. Numerous studies report that adherence rates among asthma patients range between 30% and 70%, with many patients failing to use their inhalers as prescribed (Bender, 2020; Mäkelä et al., 2021).

Low adherence to inhaler use is influenced by various factors, including forgetfulness, lack of awareness, misunderstanding of treatment instructions, fear of side effects, improper inhaler technique, and limited monitoring by healthcare providers (Vrijens et al., 2018). In particular, adolescents and young adults demonstrate lower adherence rates due to busy schedules, low perceived disease severity, and limited supervision (BMC Pulmonary Medicine, 2025). This non-adherence significantly increases the risk of asthma exacerbations, accelerates lung function decline, and reduces overall treatment effectiveness (Williams et al., 2019).

Another major challenge in asthma management is exposure to environmental triggers. Air pollution, including particulate matter (PM2.5 and PM10), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and ozone (O_3), has been strongly associated with asthma onset, symptom worsening, and increased hospitalization rates (Guarnieri & Balmes, 2014). In urban environments, traffic-related air pollution and industrial emissions are among the most significant contributors to asthma exacerbations (Nguyen et al., 2020). In Indonesia, air quality issues have become increasingly concerning, particularly in densely populated cities, where pollution levels frequently exceed WHO recommended limits (IQAir, 2023).

Despite the strong influence of environmental factors on asthma control, most asthma management strategies still rely heavily on patient self-awareness and subjective symptom recognition. Many patients are unable to identify early signs of worsening asthma or recognize hazardous environmental conditions that may trigger an attack (Foster et al., 2017). Consequently, asthma exacerbations often occur suddenly, requiring urgent medical

intervention. This highlights the urgent need for innovative solutions that can support patients not only in medication adherence but also in environmental risk awareness and early detection of potential asthma triggers.

Advances in digital health technology have opened new opportunities to address these challenges. Mobile health (mHealth) applications and smart medical devices have demonstrated significant potential in improving chronic disease management by enhancing patient engagement, monitoring treatment adherence, and facilitating real-time data collection (WHO, 2021). In asthma care, smart inhaler technology has emerged as a promising innovation. Smart inhalers are equipped with sensors that can record inhaler usage, track dosing frequency, and transmit data to mobile applications for analysis and feedback (Chan et al., 2022).

Several studies have shown that smart inhaler systems can significantly improve medication adherence and asthma control. A randomized controlled trial by Merchant et al. (2018) reported that patients using smart inhalers with digital reminders demonstrated higher adherence rates and fewer asthma exacerbations compared to those receiving standard care. Additionally, smart inhalers allow healthcare providers to monitor patient behavior remotely, enabling personalized interventions and timely adjustments to treatment plans (Hammond et al., 2020).

Furthermore, the integration of environmental sensors into asthma management systems has gained increasing attention. Air quality sensors capable of detecting particulate matter, temperature, humidity, and gaseous pollutants can provide real-time environmental data relevant to asthma triggers (Nguyen et al., 2020). When integrated with mobile applications, these sensors can generate early warnings, alerting patients when air conditions may increase the risk of asthma exacerbations. This proactive approach empowers patients to take preventive actions, such as avoiding outdoor activities, using protective equipment, or ensuring timely medication use (Patterson et al., 2021).

Based on these considerations, the Airis Smart Inhaler was developed as an integrated mobile app-based smart inhaler platform designed to support comprehensive asthma management. This system combines inhaler usage monitoring, automated medication reminders, and environmental air quality detection into a single digital platform. The Airis Smart Inhaler aims to reduce inhaler usage negligence, improve patient adherence, enhance awareness of environmental triggers, and provide early warnings to prevent asthma attacks. By leveraging digital health technology, this innovation is expected to contribute to more effective, proactive, and patient-centered asthma management, particularly in environments with high pollution exposure.

2. METHODS

2.1. Research Design and Type

This study adopts the Research and Development (R&D) method with the objective of developing, testing the feasibility, and evaluating the effectiveness of the AIRIS Smart Inhaler as a technological innovation in asthma management. The R&D method is selected because this research is not limited to theoretical analysis or hypothesis testing, but emphasizes the systematic process of designing, developing, and validating a health technology product intended for practical application in real-world settings.

The R&D approach enables researchers to translate identified problems in asthma management—such as low adherence to inhaler use and limited awareness of environmental triggers—into a functional technological solution. Through iterative development and evaluation, this method ensures that the resulting product meets technical, functional, and usability requirements, which are essential for digital health innovations (Sugiyono, 2019).

The development process in this study applies the ADDIE model, which consists of five sequential stages: Analysis, Design, Development, Implementation, and Evaluation. This model is chosen because it provides a structured yet flexible framework that is well suited for the development of integrated systems combining hardware and software components, such as smart inhaler devices and mobile health applications. Each stage of the ADDIE model allows

for systematic planning, execution, and refinement, ensuring that the product is developed based on user needs and technological feasibility.

Furthermore, the ADDIE model supports continuous and formative evaluation at each stage of development. This staged evaluation approach allows potential technical issues, design limitations, and usability challenges to be identified and addressed early in the development process. As a result, the AIRIS Smart Inhaler can be optimized progressively, increasing its feasibility and initial effectiveness as a supportive tool for asthma management.

2.2. Research Topics and Sample Selection Methods

The research topic of this study focuses on the development and initial evaluation of the AIRIS Smart Inhaler as a digital health innovation to support asthma management, particularly in improving inhaler adherence and increasing awareness of environmental triggers. The study emphasizes the feasibility, usability, and initial effectiveness of the developed prototype during the early development phase.

This study involved 20 respondents diagnosed with asthma, who were selected using purposive sampling. Purposive sampling was employed because the study required participants with specific characteristics that were relevant to the objectives of prototype testing. This sampling technique allows researchers to select participants who are considered most suitable for providing meaningful data related to the use and evaluation of the developed product.

The inclusion criteria for participants in this study were as follows:

a) Individuals diagnosed with asthma who routinely use inhalers as part of their treatment.

b) Individuals who own and are able to operate a smartphone using the Android operating system, as the AIRIS Smart Inhaler system is integrated with an Android-based mobile application.

c) Individuals who were willing to participate voluntarily and complete the entire testing and evaluation process of the AIRIS Smart Inhaler system.

The sample size of 20 respondents was determined based on the objectives of the initial development and prototype testing stage, which prioritized feasibility and preliminary effectiveness evaluation rather than statistical generalization. In Research and Development studies, particularly in early-stage product testing, a limited sample size is considered adequate to identify functional issues, usability challenges, and initial user responses to the developed system. The findings from this stage serve as a foundation for further refinement of the product and for subsequent studies involving larger and more diverse populations.

2.3. Research Methods

2.3.1. Analysis

The analysis stage was conducted to identify problems related to inhaler usage and to determine user needs in asthma management. This stage aimed to ensure that the development of the AIRIS Smart Inhaler was based on actual user requirements and relevant clinical challenges.

Data were collected through:

1. Literature review, focusing on asthma management, inhaler adherence, smart inhaler technology, and environmental triggers of asthma exacerbations.
2. Needs analysis questionnaires, distributed to potential users to explore difficulties in inhaler use, awareness of asthma triggers, and expectations regarding smart inhaler features.

The results of this analysis stage were used to define functional requirements, determine system specifications, and establish the core features of the AIRIS Smart Inhaler, including usage monitoring, reminder notifications, air quality detection, and educational content. This stage plays a critical role in ensuring the relevance and usability of the developed product (Branch, 2009).

2.3.2. Design

In the design stage, both hardware and software systems of the AIRIS Smart Inhaler were systematically planned based on the findings from the analysis stage. The design process included:

1. Hardware system design, which involved the integration of airflow sensors to detect inhaler actuation, microcontrollers for data processing, Bluetooth modules for wireless data transmission, and rechargeable batteries to ensure portability and continuous usage.
2. Software system design, developed as a mobile application, including features such as inhaler usage reminders, air quality monitoring, usage history recording, and asthma education modules.
3. System architecture and data flow design, outlining the interaction between the inhaler device, environmental sensors, mobile application, and data storage.

The design stage aimed to ensure that the system was user-friendly, reliable, and aligned with asthma management guidelines, while also considering technical feasibility and energy efficiency (Chan et al., 2022).

2.3.3. Development

The development stage involved transforming the design into a functional prototype. This process included:

1. Assembly and programming of the AIRIS Smart Inhaler device components.
2. Development of the mobile application using the Flutter framework with the Dart programming language, chosen for its cross-platform capability and efficient performance.
3. Integration of hardware and software components to enable real-time data transmission from the inhaler device to the mobile application via Bluetooth.
4. After development, functional testing was conducted to ensure that the system could accurately detect inhaler usage, record time and frequency of use, transmit data reliably, and display information correctly within the application. This testing aimed to identify technical errors and ensure system stability before user implementation (Hammond et al., 2020).

2.3.4. Implementation

The implementation stage was conducted by testing the AIRIS Smart Inhaler with respondents during their daily activities in accordance with their prescribed asthma therapy schedules. During this stage, respondents used the smart inhaler over a predetermined period.

Throughout the implementation phase, the system automatically recorded:

1. Frequency and timing of inhaler usage.
2. Environmental conditions around the user, including air quality indicators relevant to asthma triggers.
3. User interaction with reminder notifications and educational features.

This stage aimed to observe real-world system performance, user behavior, and initial responses to the AIRIS Smart Inhaler in everyday asthma management scenarios (Merchant et al., 2018).

2.3.5. Evaluation

The evaluation stage was conducted to assess both the feasibility and effectiveness of the AIRIS Smart Inhaler system. Evaluation was performed through two main approaches:

1. Feasibility testing, conducted through expert validation involving media experts, material experts, and language experts. This validation assessed aspects such as system functionality, content accuracy, interface clarity, and overall suitability of the product for asthma management.
2. Effectiveness testing, conducted using a pretest–posttest design to measure changes in respondents' understanding, awareness, and behavior related to asthma management after using the AIRIS Smart Inhaler. This design allows for comparison of conditions before and after intervention, providing initial evidence of the system's effectiveness (Creswell & Creswell, 2018).

2.4. Data Collection Methods

The data collection methods applied in this study were designed to support the objectives of feasibility and effectiveness evaluation. The methods include:
a) Needs analysis questionnaires, used during the analysis stage to identify user requirements, challenges in inhaler use, and expectations regarding smart inhaler features.
b) Expert assessment sheets, completed by media experts, material experts, and language experts to evaluate the feasibility, clarity, accuracy, and suitability of the AIRIS Smart Inhaler system.
c) Pretest and posttest instruments, administered to respondents before and after the implementation stage to assess changes in understanding, awareness, and attitudes toward asthma management and inhaler usage.
The combination of quantitative and qualitative data collection methods enables a comprehensive evaluation of the AIRIS Smart Inhaler system during the initial development phase.

2.5. Data Analysis Methods

Data analysis in this study was conducted using a quantitative descriptive approach. This method was selected because the objective of the research is to evaluate the feasibility and initial effectiveness of the AIRIS Smart Inhaler during the prototype development stage, rather than to test causal relationships or make statistical generalizations.

Quantitative data obtained from questionnaires, expert validation sheets, and pretest–posttest instruments were analyzed by calculating the mean score and percentage of achievement for each assessed aspect. The percentage score was used to determine the level of feasibility, efficiency, and effectiveness of the developed system. This approach is commonly applied in Research and Development studies to assess product quality and user responses in the early stages of innovation (Sugiyono, 2019).

The pretest and posttest results were analyzed descriptively to identify changes in respondents' understanding, awareness, and behavior related to asthma management before and after using the AIRIS Smart Inhaler. An increase in posttest scores compared to pretest scores was interpreted as an indication of the system's initial effectiveness in supporting asthma management.

To facilitate interpretation, the results of data analysis were classified based on predetermined feasibility and effectiveness criteria, as presented in Table 1.

Table 1. Facilitate Interpretation

Percentage Range	Interpretation
81%-100%	Very feasible / Very efficient
61%-80%	Feasible / Efficient
41%-60%	Moderately feasible / Fairly efficient
21%-40%	Less feasible / Less efficient
0%-20%	Not feasible / Very ineffecient

These criteria were used to categorize the level of feasibility and effectiveness of the AIRIS Smart Inhaler system based on expert validation, user responses, and pretest–posttest outcomes. The use of percentage-based interpretation allows for clear and consistent evaluation of the developed product and supports decision-making regarding further refinement and large-scale implementation.

3. RESULTS AND DISCUSSION

3.1. Analysis Phase

3.2. Performance Analysis

Asthma is one of the chronic noncommunicable diseases whose prevalence continues to increase in various parts of the world, including Indonesia. According to the World Health Organization (WHO, 2021), more than 262 million people worldwide live with asthma, with mortality rates reaching 455,000 deaths per year. In Indonesia, asthma is among the top ten causes of morbidity and mortality, particularly among children and young adults Unfortunately, public understanding of asthma, its triggers, and long-term management remains limited. Inhalers are the primary therapy for asthma management, but their implementation still faces several challenges. Research by shows that there are many challenges in asthma treatment and therapy, and in practice, there are still significant obstacles to overcome.

Patient adherence to inhaler usage schedules tends to be low, resulting in suboptimal treatment effectiveness. Additionally, errors in usage technique or dosage frequently occur, which can reduce therapeutic benefits and even increase the risk of relapse. Another challenge is the absence of a continuous monitoring system, making it difficult for healthcare providers to accurately assess patients' inhaler usage patterns outside of clinic visits. On the other hand, environmental factors such as air pollution, dust, and humidity, which act as triggers for asthma attacks, are often not detected early, leaving patients ill-prepared to manage the risks. sudden attacks.

These various issues highlight the need for innovation in asthma management that focuses not only on therapy, but also on monitoring, education, and detection of risk factors. The development of Internet of Things (IoT)-based technology now offersinnovative solutions through devices like the AIRIS Smart Inhaler. AIRIS is equipped with sensors that can detect air quality to identify potential asthma triggers, while also integrating with an app that provides inhaler usage schedules based on doctor consultations, usage control to prevent dosage errors, and educational features about asthma. The app also includes emergency notifications and relevant health information, making it not only a therapeutic device but also an integrated education and asthma management tool. As such, the AIRIS Smart Inhaler has the potential to enhance treatment effectiveness while strengthening public health literacy in addressing asthma more comprehensively.

3.1.2. Need Analysis

One of the main needs identified is more structured, regular, and preventive asthma management. Many asthma sufferers find it difficult to adhere to their inhaler schedule, resulting in less effective treatment. Current education generally consists of brief consultations with health workers and brochures, which do little to help patients remember their daily inhaler schedule. Therefore, an innovation is needed that can provide automatic reminders and monitor inhaler usage schedules in a more practical and personalized manner. Additionally, another emerging need is the ability to detect environmental conditions that may trigger asthma flare-ups. Environmental factors such as air quality, pollution levels, humidity, and temperature often trigger asthma attacks, but patients are not always aware of them. Currently, most asthma patients rely solely on subjective feelings or general information about air quality, which is

insufficiently accurate for individual needs. The proposed solution is the use of a Smart Inhaler equipped with medication schedule reminders, directly connected to a smartphone app, and featuring sensors for detect the air quality around the patient.

This inhaler will give a warning when the air quality isn't ideal for someone with asthma, so patients can be more vigilant and early prevention. Through the app,patients can also monitor their inhaler usage history and daily air quality in an integrated manner. Thus, this innovation can help improve therapy compliance, reduce the risk of sudden asthma attacks, and provide better control over patients' health condition.

Table 2 Percentage of Respondents' Needs for Smart Inhalers

No.	Statement	Presentation
1.	Regular inhaler usage reminders	**85%**
2.	Monitoring of ambient air quality	**78%**
3.	Connected mobile app to record usage history and patient condition	**74%**
4.	Connected mobile app to record usage history and patient condition	**69%**
5.	Practical, portable, and easy-to-use inhaler for daily use	**72%**
6.	Data integration for consultation with healthcare professionals	**65%**
7.	Education on inhaler use and asthma attack prevention Tips Education on inhaler use and tips for preventing asthma attacks	**70%**
8.	Daily symptom tracking to monitor asthma conditions	**69%**
9.	Automatic reports for families or caregivers of patients	**66%**
10.	Preventive action recommendations based on conditions and air quality	**72%**

Based on the results ofthe questionnaire data analysis, there is a significant need for more structured and interactive asthma management. Respondents stated that they urgently need tools that can help them remember to use their inhalers regularly, while also providing information about air conditions that can trigger asthma attacks. Additionally, respondents acknowledged difficulties in manually monitoring inhaler usage history and environmental conditions, necessitating a platform that can facilitate real-time monitoring. Teenagers and adults with asthma require practical and easily accessible solutions, as evidenced by respondents who stated they do not fully understand the connection between air quality and asthma attacks and lack optimal control over inhaler usage. Therefore, the innovation of the Smart Inhaler, which is connected to a mobile app, features usage schedule reminders, air quality detection sensors, and monitoring history and usage education features, is urgently needed as a more effective and safe asthma management solution.

3.2. Development Phase

3.2.1. Creation of AIRIS Smart Inhaler and AIRIS Smart App

Figure 1 Logo of AIRIS Smart Inhaler and App

3.2.2. Design of the Smart Inhaler

The design of the smart inhaler includes the integration of an airflow sensor to detect inhalation, a microcontroller as the data processing center, a Bluetoothmodule for connectivity with a smartphone, and a rechargeable battery as the power source, all controlled through a mobile-based supporting app.

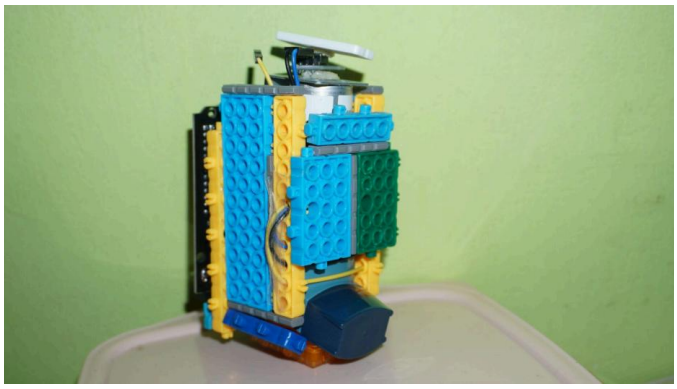

Figure 2 AIRIS Smart Inhaler

3.2.3. Design of the Smart Inhaler App

The design of the AIRIS Smart Inhaler app was carried out through needs analysis, interface design, and development using Flutter in Visual Studio Code with the Dart programminglanguage. The app includes features such as IoT sensor-based asthma trigger detection, inhaler usage control, therapy schedule notifications, and educational information. After the implementation phase, the app was tested, evaluated, and implemented in the form of a distribution file

3.2.4. Use of AIRIS Smart Inhaler and AIRIS Smart Inhaler App

The AIRIS Smart Inhaler is used by patients inhaling medication through a device equipped with sensors to detect dosage, frequency, and inhalation quality. The data is automatically transmitted to the AIRIS Smart Inhaler App, which records and monitors usage, provides therapy schedule reminders, and displays treatmenthistory and effectiveness in real-time on a smartphone.

Figure 3 Schedule Settings in the Application

Figure 3 shows the schedule settings feature in the application, where users can set reminders for their inhaler usage. This feature helps patients stay consistent with their therapy schedule by sending notifications at the appropriate times.

Figure 4. Control usage history and air quality reports on the app

Figure 4 illustrates the feature for controlling usage history and viewing air quality reports in the application. Through this feature, users can monitor their inhaler usage patterns as well as track environmental conditions, such as pollution levels, that may affect their asthma.

Figure 5. Long term inhaler usage report on the app

Figure 5 displays the long-term inhaler usage report available in the application. This feature allows users to review their therapy progress over time, track adherence, and evaluate the effectiveness of their treatment.

3.3. Expert Validation Test

3.3.1. Media Expert Assessment Results

The smart inhaler technology integrated with a mobile application is a revolutionary step in asthma management. Through real-time monitoring, dosage reminders, and automatic data reporting, this deviceprovides a concrete solution to the low adherence problem in inhaler usage. This innovation reflects the synergy between digital technology and healthcare, which is increasingly needed in this era of digital transformation. Media plays an important role in raising this issue so the public can better understand the urgency of utilizing medical technology in daily life.

3.3.2. Language Expert Assessment Results

From a linguistic perspective, the journal on smart inhalers based on mobile applications is written in a communicative and effective manner. Medical and technological terms are clearly explained, making it easier for readers from various disciplines to understand the content. The sentence structure is well-organized and consistent, supporting the logical and sequential delivery of information. The scientific writing style is maintained without sacrificing readability, making this journal suitable as an academic reference as well as a medium for scientific communication with the public.

3.3.3. Content Expert Assessment Results

This journal presents an in-depth and accurate study of the integration of smart inhaler technology with mobile applications in asthma management. From a content perspective, the discussion is highly relevant to developments in digital health innovation and demonstrates a strong understanding of patients' clinical needs. The data used supports the authors' arguments, and the proposed solutions are practical. This shows that the authors not only understand theory but also its practical application in the field.

4. RESULT

4.1. Effectiveness test

The effectiveness test was conducted to determine the extent to which the use of the inhaler improved asthma therapy effectiveness and anticipation ability through trigger detection, inhaler usage control, and education via the AIRIS app. The test was carried out using the pretest and posttest method on respondents who had used the media. Respondents consisted of 20 people. The pretest was given before respondents used the AIRIS Smart Inhaler, while the posttest was given after respondents finished using it. The test instrument consisted of 10 multiple-choice questions, validated by content and media experts. Pretest and posttest scores were compared to see the improvement in knowledge.

4.1.1. Evaluation of Conceptual Understanding of Asthma and Effectiveness

1. Pre-test Evaluation

Table 3. Pre-test Evaluation

Principle	Item	(∑x)	PST Score (%)
Indicator of Conceptual Understanding of Asthma & Inhaler	1,2,3,4,5,6,7,8,9	266	74%
Indicator of Awareness in Asthma Monitoring and Control	10	14	70%
Total PST Score (%)	72%		

2. Post-test Evaluation

Table 4. Post-test Evaluation

Principle	Item	(∑x)	PST Score (%)
Improved Conceptual Understanding of Asthma & Inhaler	1,2,3,4,5,6,7,8,9	340	94%
Improved Awareness in Asthma Monitoring and Control	10	18	90%
Total PST Score (%)	92%		

Based on the questionnaire results before and after using the AIRIS Smart Inhaler educational media, there was a significant improvement in the effectiveness of inhaler use as an asthma therapy. In the pretest stage, participants showed conceptual understanding of the Asthma & Inhaler Indicator with a PST score of 74%, while awareness of Asthma Monitoring & Control was at 70%. Combined, the total PST score before intervention was 72%, which can be considered low.

After using the AIRIS Smart Inhaler, posttest results showed a significant improvement. Participants' conceptual understanding of Asthma and Inhalers increased to 94%, while awareness of asthma monitoring and control also rose to 90%. Overall, the total PST score after intervention increased to 92%. This increase demonstrates the success of enhancing awareness and the importance of asthma management and therapy in a more effective way. Participants not only gained deeper knowledge about asthma but also became more familiar with effective asthma management methods. Therefore, it can be concluded that the AIRIS Smart Inhaler is highly effective in improving participants' understanding and awareness regarding asthma management and therapy.

5. DISCUSSION

The Smart Inhaler is a technology-based healthcare innovation developed to assist asthma management in a more structured,modern, and preventive way. This inhaler is designed not only as atherapeutic tool but also as an interactive and integrated health support system. This innovation addresses major challenges in asthma management, such as low patient adherence to inhaler schedules and lack of awareness of environmental factors that may trigger attacks. With the Smart Inhaler, users not only gain therapeutic benefits but also monitoring support through a mobile app directly connected to the device. The Smart Inhaler is equipped with several key features, including inhaler usage reminders, air quality sensors (pollution,dust,temperature, and humidity),and smartphone app integration.

The app allows users top track inhaler usage history, record daily symptoms, and receive early warnings if air quality is unsuitable for asthma patients. In addition, the app provides practical education on asthma prevention and healthy lifestyle recommendations. Data collected from Smart Inhaler usage can also be shared with healthcare professionals, enabling more data-driven and accurate consultations. The integration of a functional inhaler device with an interactive mobile app makes the Smart Inhaler a comprehensive solution for asthma patients. This approach not only helpspatients maintain adherence to medication but also increases awareness of environmental risk factors. With monitoring and educational features, the Smart Inhaler also serves as a preventive, educational, and medical consultation support tool. Needs analysis conducted in this study shows that respondents require inhaler usage reminders, air quality detection, history monitoring apps, anda user-friendly inhaler.

Additionally, other needs such as early warnings of poor air conditions, education on asthma prevention, and automatic reports for families were also considered important. The Smart Inhaler meets these needs by offering practical, modern, and user-friendly features. The effectiveness of the Smart Inhalerwas evaluated through pretest and posttest experiments on respondents to measure its contribution to asthma management. The results showed significant improvement in adherence to inhaler usage, patients' understanding of asthma triggers, and awareness of air quality monitoring.

This confirms that healthcare technology based on applications and environmental sensors can be an innovative step in supporting better asthma management.Thus, the Smart Inhaler functions not only as a medical therapy tool but also as a monitoring, educational, and preventive medium integrated with digital technology. This innovation is expected to improve the quality of life of asthma patients, reduce the risk of sudden attacks, and strengthen the role of healthcare technology in providing adaptive, modern, and sustainable solutions.

6. CONCLUSION

Asthma is a chronic disease whose prevalence continues to increase globally and poses a serious health challenge, mainly due to low patient compliance with regular

inhaler use. The development of Airis Smart Inhaler, a mobile app-based smart inhaler system equipped with air sensors, can be an innovative solution to improve inhaler compliance and detect potential asthma triggers. This system allows patients to receive timely inhaler usage reminders, track usage history, and receive early warnings about air quality that could potentially trigger attacks. The implementation of this technology has the potential to support more effective asthma management, reduce the risk of attacks, and improve patients' quality of life.

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