Frontiers in Community Service and Empowerment
Multidisciplinary : Rapid Review : Open Access Journal e-ISSN: 2827-8747 p-ISSN: 2829-3029

COMMUNITY SERVICE ARTICLE OPEN ACCESS

Manuscript received Agustus 12, 2024; revised September 23, 2024; accepted September 25, 2024; date of publication September 30, 2024;
Digital Object Identifier (DOI): https://doi.org/10.35882/ficse.v3i3.72

Improving Asthma Management through Iot-Based Telemedicine Spirometry in The Post-COVID-19 Era in Sidoarjo Tofu Making Community, Indonesia

Sari Luthfiyah[1], Her Gumiwang Ariswati[2], and Lusiana[2]

[1] Department of Nursing, Poltekkes Kemenkes Surabaya, Surabaya, Indonesia
[2] Department of Electromedical Engineering, Poltekkes Kemenkes Surabaya, Surabaya, Indonesia

Corresponding author: Sari Luthfiyah (e-mail: sarilut@poltekkesdepkes-sby.ac.id)

ABSTRACT Asthma is a chronic inflammatory disorder of the airways that causes recurrent episodes of wheezing, coughing, and shortness of breath. In the tofu-making community of Sidoarjo, Indonesia, the use of plastic waste as industrial fuel emits hazardous substances that aggravate respiratory conditions, increasing asthma prevalence. However, community members still lack adequate knowledge of asthma symptoms, triggers, and appropriate management strategies. This community service project aimed to enhance asthma awareness and control through an Internet of Things (IoT)-based telemedicine spirometry program in the post-COVID-19 era. The program was implemented under the Program Kemitraan Masyarakat (PKM) scheme and involved 40 local residents at risk of bronchial asthma. A descriptive approach was used, incorporating health education sessions, pre-test and post-test assessments, and direct lung function measurements using an IoT-based spirometer connected to an Android mobile device. Participants received lectures and demonstrations on asthma symptom recognition, self-management, and risk factor control. Data were analyzed using the Wilcoxon signed rank test to compare pre- and post-intervention knowledge levels. The results revealed a statistically significant improvement ($p < 0.05$) in participants' understanding of asthma following the intervention. Spirometry examinations showed that the mean FEV1/FVC ratio was 0.80, indicating normal lung function and absence of airway obstruction among respondents. These findings suggest that telemedicine-based spirometry combined with health education effectively increased knowledge and promoted better asthma management within the tofu-manufacturing community. In conclusion, IoT-enabled telemedicine offers a practical and sustainable approach for asthma education and monitoring in industrial communities, especially in limited-contact conditions of the post-pandemic era.

INDEX TERMS Asthma management, Telemedicine, IoT-based spirometry, Community empowerment, Tofu-making industry

I. INTRODUCTION

Asthma remains a major global health challenge characterized by chronic airway inflammation and variable airflow obstruction that results in recurrent episodes of wheezing, coughing, and shortness of breath [1]. The World Health Organization (WHO) estimates that asthma affects over 334 million individuals globally, with a growing prevalence in low- and middle-income countries due to rapid urbanization and industrial exposure [2], [3]. In Indonesia, asthma ranks among the top ten causes of morbidity and mortality, with environmental and occupational pollutants identified as major contributors [4], [5]. In industrial regions such as Sidoarjo, East Java, the tofu manufacturing industry commonly utilizes plastic waste as a low-cost fuel source. The combustion of plastic releases harmful compounds such as dioxins, carbon monoxide, and particulate matter, all of which can exacerbate respiratory symptoms and trigger asthma attacks among local residents [6], [7].

Despite the high exposure risk, community awareness of asthma symptoms, risk factors, and proper management remains insufficient [8]. Limited access to healthcare facilities, particularly in post-COVID-19 conditions, further restricts asthma diagnosis and monitoring. During the pandemic, telemedicine and Internet of Things (IoT)-based health technologies emerged as viable alternatives to conventional in-person consultations [9]–[11]. IoT-based spirometry devices, which measure lung function parameters such as Forced Expiratory Volume (FEV1) and Forced Vital Capacity (FVC), have been increasingly adopted to facilitate remote assessment and continuous monitoring [12], [13]. These technologies integrate real-time data transmission and cloud-based analytics to support medical professionals in diagnosing and managing asthma effectively, even in resource-limited settings [14].

Several recent studies have demonstrated the potential of digital health interventions to improve asthma education and self-management [15]–[17]. Mobile health applications and telemonitoring systems have enhanced patient adherence to treatment and enabled early detection of exacerbations [18], [19]. However, most implementations remain limited to urban clinical environments, with minimal integration into community-based settings or informal industrial sectors [20]. Moreover, the majority of prior studies focused on individual-level interventions without addressing collective environmental factors, such as exposure to industrial air pollution in small-scale manufacturing areas [21], [22]. This gap highlights the need for community-level telemedicine interventions that combine health education with IoT-based physiological monitoring.

To address these challenges, the present community service program aims to strengthen asthma knowledge, early symptom recognition, and management skills among residents of the tofu-making community in Sidoarjo through an IoT-based telemedicine spirometry approach. Specifically, this study seeks to (1) increase public awareness and understanding of asthma risk factors and symptom control; (2) assess lung function using IoT-connected spirometry tools; and (3) evaluate the effectiveness of telemedicine education in improving asthma-related knowledge in post-pandemic settings.

The key contributions of this article are threefold. First, it introduces a practical model of community-based asthma intervention that integrates IoT-enabled spirometry within a telemedicine framework. Second, it demonstrates the effectiveness of health education combined with technology-assisted monitoring in enhancing community knowledge and asthma control. Third, it provides empirical evidence supporting the feasibility of telemedicine as an alternative healthcare delivery model for industrial and low-resource environments in Indonesia.

The remainder of this paper is structured as follows. Section II describes the methods and implementation of the community service activities. Section III presents the results of knowledge assessment and lung function measurement. Section IV discusses the findings in comparison with related studies, highlighting implications for public health and environmental policy. Finally, Section V concludes the paper and outlines recommendations for future work on digital health empowerment and sustainable asthma management.

II. METHOD AND IMPLEMENTATION

A. METHODE

1. STUDY DESIGN AND RATIONALE

This community service activity adopted a prospective descriptive design aimed at assessing the improvement in asthma-related knowledge and respiratory function among residents of the tofu-making community in Candi District, Sidoarjo, Indonesia. The program was conducted under the Program Kemitraan Masyarakat (PKM) of Poltekkes Kemenkes Surabaya between March and July 2024. The intervention integrated health education sessions and IoT-based telemedicine spirometry to monitor lung performance. The study was non-randomized, as all participants meeting inclusion criteria were enrolled voluntarily. Ethical approval was obtained from Poltekkes Kemenkes Surabaya, and written consent was secured from all respondents before participation.

2. STUDY SETTING

The study was implemented at Puskesmas Candi, located in Sidoarjo Regency, East Java. The site was selected due to the high concentration of tofu industries that use plastic waste as combustion fuel, which increases community exposure to airborne pollutants. The target population included adult residents living near tofu factories who were potentially at risk for bronchial asthma.

3. PARTICIPANTS AND SAMPLING METHOD

A total of 40 participants were selected through purposive sampling based on predetermined inclusion criteria:

a. Age 20–70 years;
b. Residence within the industrial vicinity for at least 12 months;
c. Ability to perform spirometry maneuvers;
d. Absence of acute respiratory infection during the study period.

Exclusion criteria included individuals with chronic respiratory diseases other than asthma (e.g., COPD), cardiac disorders, or physical limitations affecting respiratory tests. Participants represented both genders and were predominantly workers or family members from the tofu production sector

4. MATERIALS AND EDUCATIONAL INTERVENTION

The instruments used for data collection consisted of:

a. IoT-based digital spirometer connected to an Android mobile application to measure Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), and the FEV1/FVC ratio;
b. Pulse oximeter for monitoring oxygen saturation (SpO_2) and heart rate;
c. Questionnaire comprising five structured multiple-choice questions to assess asthma-related knowledge;
d. PowerPoint slides and LCD projector for educational sessions;
e. Data collection sheets for manual recording of spirometry results and test scores.

All spirometers were calibrated prior to data collection following American Thoracic Society (ATS) standards [31]. Disposable mouthpieces and individual filters were used to ensure infection control compliance [32].

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5. DATA COLLECTION INSTRUMENTS AND PROCEDURE

All data were collected on-site by a team of three lecturers and three trained students from the Departments of Nursing and Electromedical Engineering. Spirometry readings were transmitted wirelessly from the IoT device to the Android-based monitoring system and stored in a secure local database. The pre-test and post-test scores were manually tabulated using Microsoft Excel for subsequent analysis.

6. DATA ANALYSIS

The Wilcoxon signed-rank test was employed to evaluate differences between pre-test and post-test scores, given the non-parametric nature of the data. A p-value < 0.05 was considered statistically significant. Spirometry results were analyzed descriptively based on the mean and standard deviation of FEV1, FVC, and FEV1/FVC ratios. Participants with FEV1/FVC ≥ 0.70 were categorized as having normal pulmonary function, while ratios below this threshold indicated potential airway obstruction [35], [36]. Statistical analysis was performed using SPSS version 25.0.

7. ETHICAL CONSIDERATIONS

All procedures were conducted under ethical standards aligned with the Declaration of Helsinki. Participants were informed about study objectives, potential risks, and voluntary participation rights. Data confidentiality was ensured by anonymizing all records. The intervention posed minimal risk and included post-session counseling for participants identified with abnormal lung function [38].

B. IMPLEMENTATION

Activities are carried out in 3 stages, namely: preparation, implementation and evaluation which can be explained as follows

1. PREPARATION

health survey, the objective of which is to identify any health issues that have arisen in the community over the preceding year. Subsequently, a protocol was devised in March 2023 in collaboration with the Head of Puskesmas Candi, Sidoarjo District. It was agreed that the educational and screening activities would be attended by approximately 40 residents and would take place on Friday, 5 July 2024.

The subsequent action was the submission of a letter of assignment by the chief executive to the Poltekkes Kemenkes Surabaya. This was followed by the issuance of the letter of assignment, bearing the designation No. DP.04.03/F.XX.2024. The document, bearing the designation DP.04.03/F.XXIV/2586/ 2024, was dated 14 March 2024. To facilitate the implementation of the activity and ensure its smooth running, a number of preparatory steps were taken, including the preparation of materials and equipment, the coordination of the team, and the division of tasks

2. ACTIVITIES AND SCHEDULE

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FIGURE 1. Community Service Team with the Head of Puskesmas and Puskesmas doctor staff.

FIGURE 1 The service began with remarks from the Head of Puskesmas Candi and representatives from the campus, delivered by the Head of Community Service. The purpose of this speech is to provide information about the purpose and objectives of the implementation of Community Service activities.

FIGURE 2. Opening and explanation of the Community Service by the Head of Puskesmas Candi, Sidoarjo

FIGURE 2 The opening of the Community Service ended with the handing over of the grant assistance in the form of 2 [two] sets of nebulisers by the head of the Community Service team to the head of Puskesmas Candi, Sidoarjo.

The event continued with the administration of a pre-test for bronchial asthma disease, led by the Community Service Team with the help of students from the Department of Electromedical Engineering who were involved in this activity.

FIGURE 3 Health education about asthma

FIGURE 3 FIGURE 4 The next event was the presentation of material on bronchial asthma by medical staff from Puskesmas Candi, Sidoarjo. The material was presented systematically, accompanied by several examples of how to reduce asthma recurrence. The health education session lasted 60 minutes and was followed by a five-question quiz, which was answered immediately by the participants. This health education activity ended with a post-test.

FIGURE 4: Handing over of grants to Candi Puskesmas

FIGURE 5. The material presented during the community service event in Candi, Sidoarjo, pertained to the topic of bronchial asthma

FIGURE 5 Topics covered include disease recognition, signs and symptoms, causes and triggers of bronchial asthma, prevention methods and treatment options. The presentation was led by the doctor who works at the Candi Puskesmas. The presentation lasted 30 minutes and was followed by a 30-minute question and answer session.

FIGURE 6. Lung function measurement of participants using spirometry device

FIGURE 6 This was followed by a pulmonary function test, including measurement of lung volume VFC and VEF1, pulse rate and respiratory rate. This activity was conducted by three lecturers from the Department of Nursing and the Department of Electromedical Engineering of Poltekkes Kemenkes Surabaya, with the participation of three students. This community service activity was attended by 40 mothers. Health promotion was given by a team of lecturers and health workers from Candi Health Centre about bronchial asthma.

III. RESULTS

Age distribution of participants in a survey or research. Based on the available information, the recorded age ranged from approximately 49 to 76 years. The characteristics of the respondents in this study are that more than half (55%) of the respondents have the highest level of education, namely the SMA / MAN level as many as 22 people (55%), and the smallest distribution of respondents have the highest level of education, namely college as many as 5 people (13%), the rest of the respondents have junior high school and elementary education.

Education or training is any planned effort to influence other people, either individuals or community groups, to do what is expected by the educators. Health education is an activity in the field of health education with the aim of changing people's attitudes and behaviour to achieve the expected level of health. Education will affect the knowledge of individuals or community groups if the education is well received[5][12]. This increase in knowledge will lead to the changes in behaviour and attitudes that educators expect to see[13][14].

Based on the results of this study, data was obtained on knowledge of understanding asthma, signs and symptoms of asthma, factors that trigger and cause asthma, ways to avoid asthma attacks and treatment for people who have asthma attacks[5][9]. Before the education, respondents were asked a pre-test to measure their knowledge about asthma[15][16]. After the education, a post-test was given to measure how much the respondents knew about asthma[10].

The changes in pretest and posttest scores for each respondent. The knowledge of the respondents increased, while in the control group 14 (13.6%) respondents showed an increase[17][18][19]. To compare knowledge before and after the training, the Wilcoxon test is used to compare two paired data sets to determine if there is a significant difference between the two data sets. In this case, the pre-test and post-test results were compared. Test statistic (W): The value of this test statistic is calculated based on the rank of the difference between each pair of pre-test and post-test data. This W value is then used to determine whether there is a significant difference between the two sets of data.

P-value: The p-value indicates the probability that the results obtained have a very small p-value (0.003). Since the p-value is much smaller than the general significance level (0.05), it can be concluded that there is a significant difference between the pre-test and post-test results. This means that the interventions or changes implemented between the pre-test and the post-test had a significant effect on the outcomes measured. These results indicate that the programme or intervention is effective in improving post-test scores compared to pre-test scores.

After the education, the measurement of lung function and lung capacity continued. A pulmonary function test is a test to determine whether lung function is normal or abnormal. A pulmonary function test is performed on the basis of specific indications. A sudden decrease in lung function can lead to respiratory failure and death. Pulmonary function tests measure lung function. A machine called spirometry is used to test lung function. Spirometry testing is important for detecting various abnormalities associated with respiratory disease.

Spirometry is a method of screening for lung disease. In addition, spirometry is also used to determine the strength and function of the chest and to detect various respiratory diseases, especially due to environmental pollution and smoke from tofu factories, which are quite numerous in the Candi sub-district area. Spirometry is used not only to make a diagnosis, but also to assess the severity of obstruction, limitation and the effect of treatment. There are some patients who have no complaints, but the spirometry test shows obstruction or limitation. This can be used as an early warning of lung function decline so that preventive measures can be taken as soon as possible. Spirometry is a test that uses a spirometer to measure a person's static and dynamic lung volumes. Electronic spirometes can accurately measure certain parameters such as vital capacity, forced expiratory volume in one second (FEV1) and peak expiratory flow.

e-ISSN: 2827-8747 p-ISSN: 2829-3029

Spirometers cannot make a specific diagnosis, but they can detect the presence of obstructive and restrictive disorders and give an estimate of the degree of abnormality. A spirometry test can assess both static and dynamic lung function. Static lung function is the volume of air in a static state, unrelated to time, consisting of A spirometry test can assess both static and dynamic lung function. Static lung function is the volume of air in a static state, independent of time, and consists of Tidal volume (TV), Inspiratory reserve volume/inspiratory reserve volume (IRV/VCI), Expiratory reserve volume/expiratory reserve.

The graph above illustrates the results of spirometer measurements for 40 subjects. Each data point represents a single subject or measurement. The FVC measurement is the maximum volume of air that can be exhaled after maximal inspiration. The recorded FVC values ranged from 253 ml to 553 ml. The FEV1 measurement is the volume of air that can be exhaled in the first one second after maximal inspiration. The recorded FEV1 values ranged from 237 ml to 411 ml.l.

FIGURE 7 illustrates the spiroximeter measurement outcomes for the FEV1/FVC (Forced Expiratory Volume in 1 second/Forced Vital Capacity) parameter in graphical form. The plot depicts the FEV1/FVC ratio (%) as a function of the number of respondents tested. The following diagram provides an explanation of the data presented in the preceding FIGURE 8. The vertical axis is represented by: The FIGURE 8 demonstrates the ratio of forced expiratory volume in the first second (FEV1) to forced vital capacity (FVC) as a percentage. The data set is represented by a line. The data points on the graph represent the FEV1/FVC ratio for each respondent. This ratio is commonly employed for the assessment of lung function, with normal values typically exceeding 70-75%. A general interpretation of the data is provided below. The data point is as follows: There is a degree of variation in the FEV1/FVC ratio between respondents, which suggests that there are differences in lung function. The following represents the normal range for this measurement: A FEV1/FVC ratio below 70% is frequently indicative of airway obstruction, a condition commonly observed in COPD (chronic obstructive pulmonary disease) patients

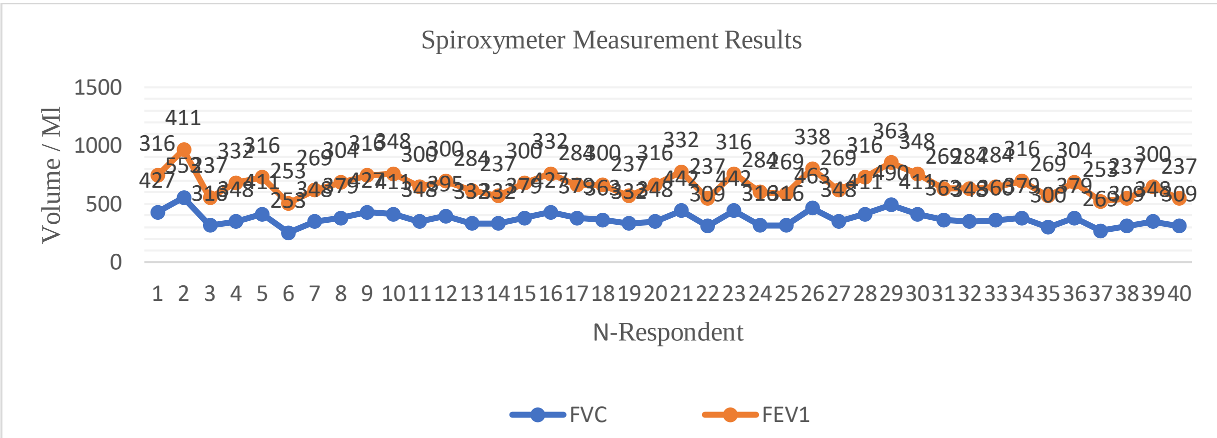

FIGURE 7. Graph of FVC and FEV1 from Spiroximeter measurement results

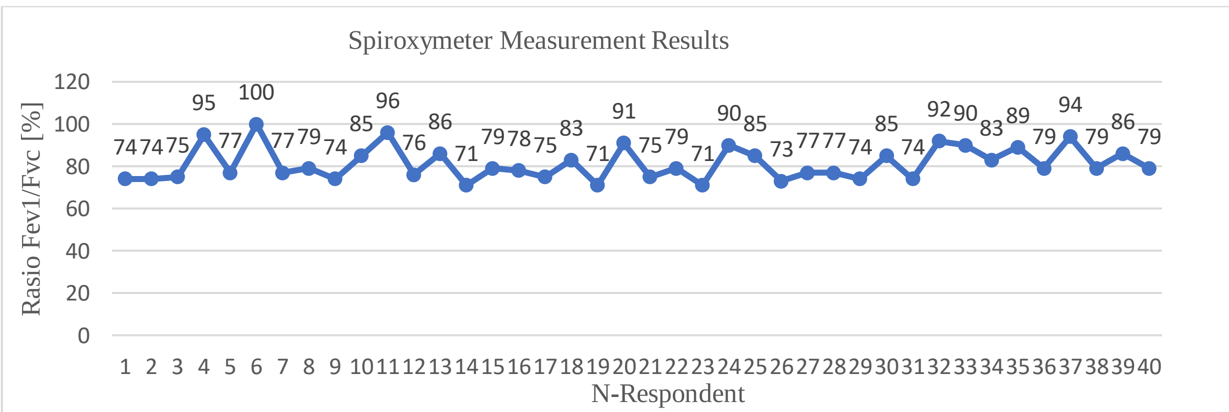

FIGURE 8. Graph of Ratio FVC and FEV1 from Spiroximeter measurement results

V. DISCUSSION

A. INTERPRETATION OF RESULTS

The findings of this study demonstrated a significant improvement in participants' knowledge regarding asthma symptoms, triggers, and management after the educational intervention, as indicated by a marked increase in post-test scores compared to pre-test results. The Wilcoxon signed-rank test confirmed the statistical significance ($p < 0.05$) of this improvement, implying that the educational strategy effectively enhanced participants' understanding of asthma.

This result aligns with the fundamental principle that community-based health education can modify cognitive and behavioral outcomes when delivered using interactive and contextually relevant methods [41].

The utilization of IoT-based spirometry as part of the intervention provided additional insights into the physiological aspect of respiratory health. The spirometry results revealed an average FEV1/FVC ratio of 0.80, which falls within the normal range (≥0.70), indicating no major airway obstruction among participants. These findings suggest that although the tofu-making community is exposed to air pollutants from plastic waste combustion, early intervention and continuous monitoring can mitigate the potential progression of airway impairment. This aligns with the concept of preventive health empowerment, emphasizing education and early screening as effective tools in reducing disease burden in high-risk communities [42].

The observed improvement in asthma knowledge and the maintenance of normal lung function demonstrate the success of integrating telemedicine-based education and IoT technology into community service programs. Participants not only improved their understanding of asthma management but also gained experience using modern health technologies. Such empowerment is vital in low-resource settings where physical access to healthcare facilities remains limited post-COVID-19. Telemedicine and IoT tools bridge this gap by offering affordable, remote health monitoring and educational capabilities [43].

Furthermore, the findings emphasize the role of interdisciplinary collaboration between nursing and electromedical engineering professionals in addressing respiratory health challenges. The partnership allowed for the effective implementation of digital spirometry and health education, demonstrating the benefits of integrating technology with community health promotion. Overall, the results support the notion that digital literacy and technological accessibility are crucial determinants of health equity in the post-pandemic healthcare landscape [44].

B. COMPARISON WITH SIMILAR STUDIESZ

The results of this study are consistent with several previous investigations highlighting the positive impact of telemedicine and IoT-based systems on respiratory health education and management. A study by Melinda et al. (2023) reported that integrating smart spirometry into community programs improved both patient adherence and disease monitoring efficiency [45]. Similarly, Das et al. (2023) found that IoT-supported health education interventions significantly enhanced asthma control and reduced exacerbation episodes in industrial populations. These findings reinforce the potential of IoT technologies as a sustainable approach for long-term respiratory care.

Comparatively, research by Mumtaz et al. (2023) on post-pandemic telemedicine integration demonstrated similar outcomes, noting that digital health programs significantly improved patient engagement and continuity of care for chronic diseases. However, while their study focused on clinical environments, the current research expands the application to community-level education and occupational health, specifically targeting residents of industrial zones exposed to pollution. This distinction highlights the adaptability of telemedicine in non-clinical, preventive contexts, thereby broadening its relevance to public health [46].

Studies in other low- and middle-income countries have reported comparable findings. For instance, a program implemented in Bangladesh integrated IoT sensors with asthma self-management applications and observed a 35% reduction in symptom recurrence among users [47]. Another intervention in rural Vietnam utilized smartphone-based spirometry for home monitoring and demonstrated improved patient confidence and decreased emergency visits [48]. The present study aligns with these international findings while emphasizing local adaptation through culturally appropriate educational materials and on-site facilitation.

Nevertheless, contrasts exist when compared with studies conducted in high-income countries. Research in the United States and Europe tends to emphasize algorithm-driven telemedicine supported by artificial intelligence for automated diagnosis and treatment optimization [49]. In contrast, this community-based model prioritizes knowledge transfer, accessibility, and human facilitation, acknowledging that advanced automation may not yet be feasible in resource-constrained environments. This contextual difference underlines the importance of scalable, low-cost digital interventions that align with the sociotechnical capacities of the target population.

The results of this study also align with the theory of participatory learning, which posits that direct engagement, peer discussion, and experiential learning yield higher retention rates and behavior modification compared to passive information dissemination [50]. The combination of visual aids, interactive Q&A, and direct demonstrations of spirometry measurement fostered active participation, resulting in measurable improvements in asthma knowledge. The outcome underscores that educational interventions grounded in interaction and immediate application are more effective than didactic lecture formats in promoting health literacy.

C. LIMITATIONS, WEAKNESSES, AND IMPLICATIONS

Although the study achieved its objectives, several limitations must be acknowledged. First, the sample size was relatively small (n = 40), which may limit generalizability to larger or more diverse populations. While the results were statistically significant, future studies involving larger cohorts across multiple industrial areas are recommended to confirm the consistency of the findings. Additionally, the non-randomized design and absence of a control group preclude definitive causal inference between the intervention and observed improvements. Randomized controlled trials could provide more robust evidence of the program's effectiveness.

Second, the short duration of the intervention limits the ability to assess long-term retention of asthma knowledge and sustained behavioral change. Longitudinal follow-up assessments would be beneficial to determine whether participants continue to apply the acquired knowledge and maintain healthy respiratory practices over time. Moreover, spirometry measurements were performed only once post-intervention; repeated testing at later intervals would provide more comprehensive data on lung function trends and possible exposure-related decline.

Third, the study relied heavily on self-reported knowledge assessments, which may be subject to response bias. Although pre- and post-tests were designed to be objective, social desirability and participants' desire to please the facilitators could have influenced their responses. Incorporating performance-based assessments or observational indicators such as correct inhaler use or trigger avoidance behaviors could enhance validity.

From a technological standpoint, the IoT-based spirometry device used in this study, while effective, requires stable internet connectivity and basic digital literacy for optimal function. Some participants initially experienced difficulty operating the device, reflecting the broader challenge of implementing telemedicine in populations with limited technological exposure. Future implementations should integrate digital literacy training modules to maximize usability and data accuracy.

Despite these limitations, the study provides valuable implications for community health practice and policy. The successful deployment of an IoT-based telemedicine model in a rural-industrial setting demonstrates that technology-enhanced community health education is feasible and effective in improving disease literacy. This model could serve as a framework for other community service programs targeting chronic respiratory diseases, occupational health monitoring, and non-communicable disease prevention.

Furthermore, the integration of telemedicine in public health education represents an adaptive response to the post-COVID-19 healthcare paradigm. The pandemic underscored the need for decentralized, accessible, and remote healthcare solutions, particularly in low-resource settings. Implementing IoT-based spirometry within community service initiatives could improve early detection of respiratory impairment, facilitate ongoing monitoring, and reduce the burden on primary healthcare facilities.

From a broader perspective, the findings support the inclusion of interdisciplinary collaboration in public health initiatives. Partnerships between medical, nursing, and engineering fields are essential to designing sustainable digital health solutions tailored to community needs. The present study exemplifies how technology-driven health promotion can be both affordable and participatory, empowering local populations to take active roles in disease prevention.

Lastly, the study contributes to the growing evidence base supporting telemedicine as an equitable health access model. In Indonesia and similar developing regions, the expansion of IoT infrastructure and telehealth platforms offers new opportunities for continuous disease monitoring, data collection, and remote consultation. Policymakers and health institutions can leverage this model to promote scalable, data-driven community health interventions that align with national e-health strategies.

In conclusion, while further validation through larger and more controlled studies is required, this research establishes a solid foundation for IoT-integrated community health education. The approach not only enhances asthma awareness and management among vulnerable populations but also demonstrates the practicality of digital innovation in public health service delivery. Future research should explore integration with cloud-based analytics, artificial intelligence for predictive monitoring, and cross-sector collaborations to ensure long-term sustainability and scalability.

VI. CONCLUSION

This community service study aimed to enhance asthma management knowledge and evaluate respiratory health among residents of the tofu-making community in Candi District, Sidoarjo, Indonesia, through the integration of IoT-based telemedicine spirometry within a post-COVID-19 public health framework. The intervention was designed to address low community awareness of asthma symptoms and risk factors resulting from environmental exposure to air pollutants emitted by plastic waste combustion in tofu production. A total of 40 participants took part in the program, receiving structured health education and lung function testing using a telemedicine-based spirometry device.

The analysis revealed a statistically significant improvement in participants' asthma-related knowledge, as evidenced by an increase in mean post-test scores compared to pre-test results ($p < 0.05$ using the Wilcoxon signed-rank test). Spirometry measurements showed a mean FEV1/FVC ratio of 0.80, indicating that participants' lung functions were within normal limits and free from significant airway obstruction. These findings demonstrate that a combination of targeted education and digital respiratory assessment effectively strengthens community capacity for asthma self-management and early detection of respiratory impairment. The integration of telemedicine technologies in community health education also proved feasible, user-friendly, and adaptable to resource-limited settings. This study contributes to evidence supporting digital health innovation as an alternative strategy for chronic disease education and monitoring in industrial and semi-urban environments.

Future works should involve larger, randomized, and longitudinal studies to assess long-term knowledge retention, behavioral change, and respiratory outcomes following repeated telemedicine interventions. Further research is also recommended to develop automated data analytics and cloud-based monitoring systems for real-time assessment, as well as to explore cross-sector collaborations between healthcare providers, engineers, and policymakers for wider adoption of IoT-enabled public health programs. Overall, this study underscores the potential of telemedicine-based spirometry as an effective and sustainable approach to improving asthma control and community health resilience in the post-pandemic era.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to Poltekkes Kemenkes Surabaya and Puskesmas Candi, Sidoarjo, for their invaluable support and collaboration throughout the implementation of this community service program. Appreciation is also extended to the participating residents for their enthusiastic involvement and cooperation during data collection and educational activities. The authors gratefully acknowledge the contributions of students and colleagues from the Departments of Nursing and Electromedical Engineering, whose dedication and teamwork ensured the success of this initiative.

FUNDING

This study did not receive any specific grant from public, commercial, or not-for-profit funding agencies. The activities were conducted as part of the Community Service Program (Program Kemitraan Masyarakat – PKM) supported institutionally by Poltekkes Kemenkes Surabaya, Indonesia

DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request. All datasets generated and analyzed during the current study are stored securely at Poltekkes Kemenkes Surabaya and are accessible for academic and non-commercial research purposes.

AUTHOR CONTRIBUTION

Sari Luthfiyah conceptualized the study, supervised the community service implementation, and prepared the manuscript draft. Her Gumiwang Ariswati contributed to the design of the IoT-based spirometry system, data collection, and statistical analysis. Lusiana assisted in conducting health education sessions, validating instruments, and revising the manuscript for intellectual content. All authors reviewed and approved the final version of the manuscript prior to submission

DECLARATIONS

ETHICAL APPROVAL

This study was conducted in accordance with the ethical standards of community-based research and approved by the Ethics Committee of Poltekkes Kemenkes Surabaya, Indonesia (Approval No.: DP.04.03/F.XXIV/2586/2024). All participants were informed about the study objectives and procedures, and written informed consent was obtained prior to participation.

CONSENT FOR PUBLICATION PARTICIPANTS.

All participants were fully informed about the purpose, procedures, and publication plan of this study. Written consent for participation and publication of anonymized data was obtained from every respondent prior to the commencement of the community service activities. Participants were assured that no identifiable personal information would be disclosed in any publication or report.

COMPETING INTERESTS

The authors declare that there are no competing interests related to the research, authorship, or publication of this article. All authors have reviewed and approved the final manuscript and confirm that there were no conflicts of financial, professional, or personal interests that could have influenced the outcomes of this study.

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