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

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ABSTRACT Asthma is a chronic inflammatory disease of the airways that causes recurrent episodes of wheezing, shortness of breath, chest tightness and coughing. The partners in this study face the problem that tofu factories in their area use plastic waste as fuel, which can aggravate respiratory conditions. In addition, the partners need more knowledge about the clear signs of asthma attacks, asthma symptom control and risk factors for asthma patients. The solution provided through the Community Service Programme with the PKM (Student Creativity Programme) scheme is to measure lung volumes using an IoT-based telemedicine device, specifically a spirometry tool that can be used with an Android mobile phone. In addition, partners will receive support to improve their knowledge, skills and attitudes in the management of asthma exacerbations. The implementation method includes providing health education on asthma, clear signs of asthma attacks, asthma symptom control and risk factors for asthma patients, as well as self-management skills for asthma patients and efforts to monitor asthma signs and symptoms. Lung capacity is measured using a spirometry device connected to an Android mobile phone for direct measurement by health workers. The results of the community service show an increase in respondents' knowledge about asthma after a lecture intervention. This was tested using the Wilcoxon signed rank test, which showed a statistically significant increase in scores from pre-test to post-test. All changes were positive, indicating the effectiveness of the learning methods used. Spirometry measurements showed that the respondents' lungs were functioning well without significant airway obstruction, indicating that the intervention was successful in increasing knowledge about asthma and asthma control.

INDEX TERMS Asthma, Spirometry, Telemedicine, Tofu-Making Community, Indonesia.

I. INTRODUCTION

Asthma is a heterogeneous disease characterized by chronic airway inflammation, leading to symptoms such as shortness of breath, wheezing, chest tightness, and coughing. It can affect individuals of all ages and currently impacts approximately 334 million people worldwide, with a rising prevalence in lower-middle-income countries. In Indonesia, asthma ranks among the top ten diseases contributing to morbidity and mortality.

In Sidoarjo, an industrial city, the use of plastic waste as fuel in many tofu factories to reduce production costs is common. This practice, however, results in the release of toxic substances like dioxins, which are known to cause respiratory problems, including asthma. Vulnerable populations such as children, pregnant women, the elderly, and those with a history of respiratory disease are particularly at risk.

Furthermore, the lack of awareness regarding asthma symptoms and management, along with the inappropriate use of over-the-counter medications without medical guidance, often worsens patient outcomes. In East Java, the incidence of asthma varies, with the highest prevalence reported in Situbondo at 4.8%.

Asthma conditions can be assessed through lung function tests using spirometry and Peak Expiratory Flow (PEF) meters. The COVID-19 pandemic has disrupted access to

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healthcare services, yet telemedicine has emerged as a viable solution, offering online consultations and education on asthma management. These services are expected to enhance asthma control and reduce the risk of exacerbations.

Lung function tests are crucial in assessing the severity of asthma, typically involving spirometry to measure parameters such as Forced Expiratory Volume in the first second (FEV1) and Forced Vital Capacity (FVC)[1][2][3]. Airway obstruction is indicated when the FEV1/FVC ratio is less than 75% or when FEV1 is less than 80% of predicted values. Post-COVID-19, the healthcare landscape has shifted, with decreased physical accessibility to healthcare providers, increased reliance on online health services, online prescriptions, and delayed specialist consultations (von Humboldt et al., 2022). Telemedicine, defined as the use of technology to assess, evaluate, and diagnose patients remotely, has proven beneficial in managing various diseases.

The Community Service initiative under the Program Kemitraan Masyarakat (PKM) seeks to educate the public on the empowerment of telemedicine[4]. This initiative aims to increase knowledge, control asthma symptoms, address risk factors for asthma patients in the post-COVID-19 era and evaluate the effectiveness of telemedicine use[5][6][7].

II. METHODS

The design of this community service activity employed a descriptive approach [8]. The targeted participants included residents of productive age, the elderly, and families at risk of Bronchial Asthma. Specifically, the program aimed to engage 40 community members. The procedure involved identifying and inviting participants based on predefined criteria, registering them, conducting pre-tests, delivering educational sessions through lectures and Q&A, measuring Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), heart rate, and respiratory rate using telemedicine-based spirometry and oximetry devices, and finally conducting post-tests. After the educational component, health checks were carried out, and the results were documented.

The media utilized during the activity included an LCD projector, PowerPoint presentations with visual aids, and telemedicine-based spirometry and oximetry tools. The primary objectives of this community service activity, conducted under the PKM scheme, were to enhance participants' knowledge and to conduct health screenings for residents at risk of non-communicable diseases, particularly Bronchial Asthma[9][10][11]. The expected outcome was an improvement in participants' understanding of Bronchial Asthma management.

To achieve these objectives, the activity method involved lectures on Bronchial Asthma, followed by discussions and Q&A sessions. Additionally, demonstrations of lung volume assessments (FVC and FEV1), pulse counting, and respiratory rate measurements were conducted [5]. To evaluate the effectiveness of the activity, participants' knowledge was assessed through pre-test and post-test sessions. The evaluation was based on the number of correct answers provided by participants. The materials used during the implementation included a laptop, PowerPoint slides, and an LCD projector.

III. IMPLEMENTATION

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

A. PREPARATION

The activity commences with the administration of a 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.

B. IMPLEMENTATION

The community service activity was conducted in a single meeting on Friday, July 5, 2024. It began with attendance registration followed by the presentation of material on the education about Bronchial Asthma.

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

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FIGURE 3: Handing over of grants to Candi Puskesmas

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

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 4 Health education about asthma

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.

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

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.

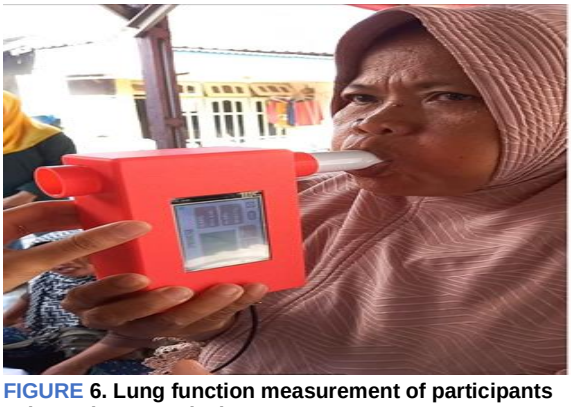

FIGURE 6. Lung function measurement of participants using spirometry device

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Health promotion was given by a team of lecturers and health workers from Candi Health Centre about bronchial asthma.

IV. RESULT

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 shown in TABLE 1.

TABLE 1
Respondent age data

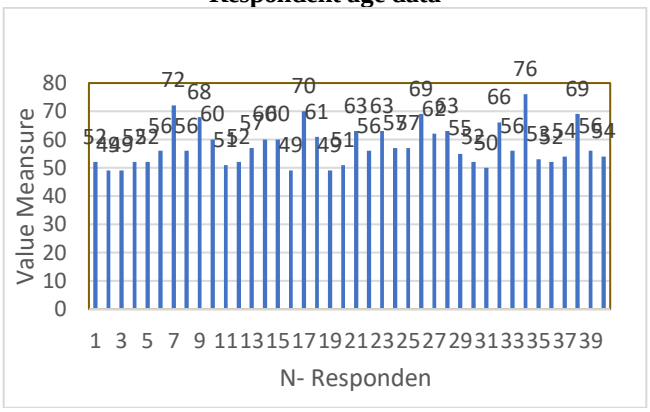

FIGURE 8 shows that more than half (55%) of the respondents have the highest level of education, namely the SMA / MAN level as many as 22 people (55%), and the smallest distribution of respondents have the highest level of education, namely college as many as 5 people (13%), the

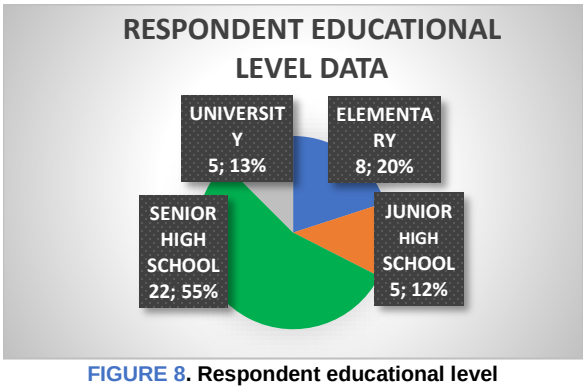

FIGURE 8. Respondent educational level

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].

FIGURE 9 shows 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

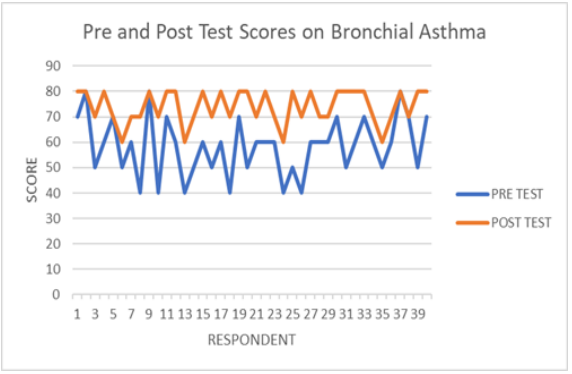

FIGURE 9. Pre and post-test scores for bronchial asthma

(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

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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 spirometers can accurately measure certain parameters such as vital capacity, forced expiratory volume in one second (FEV1) and peak expiratory flow. 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.

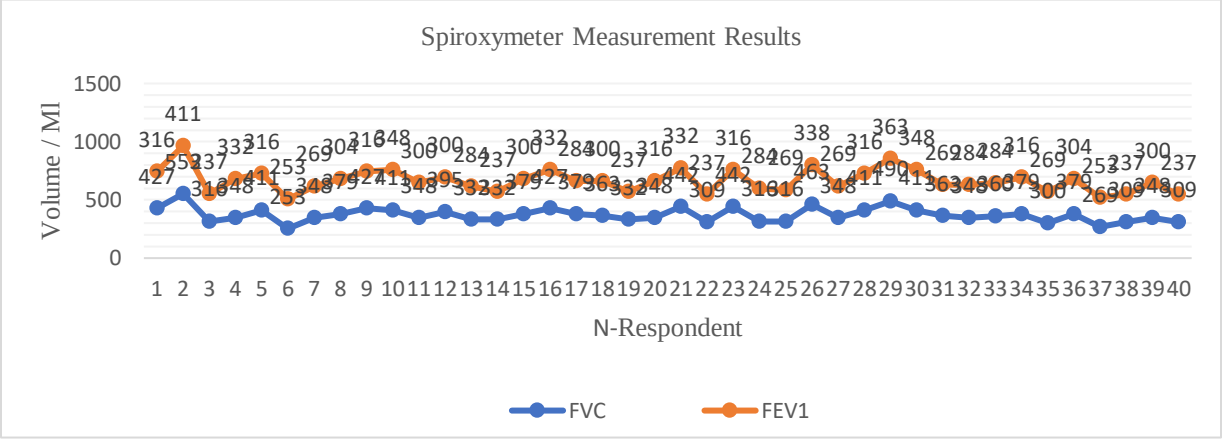

Figure 10. Graph of FVC and FEV1 from Spiroximeter measurement results

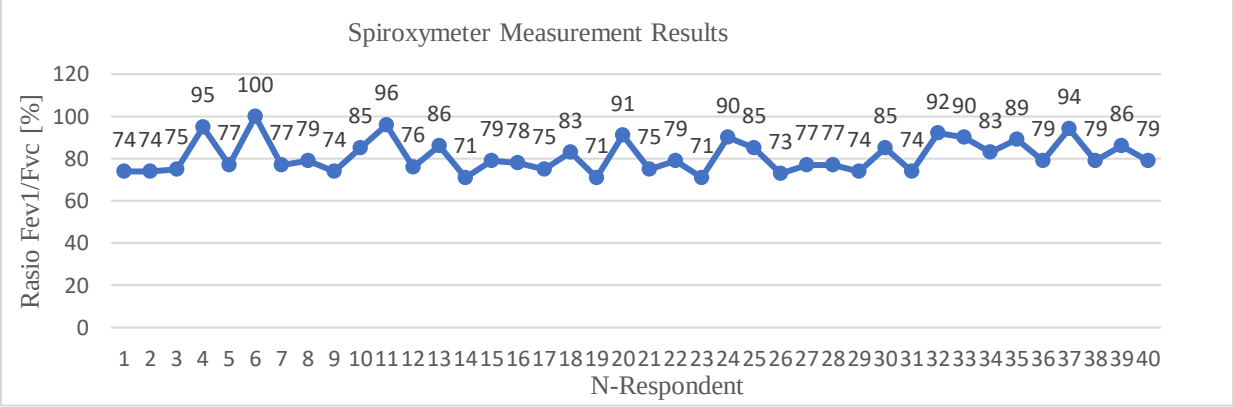

Figure 11. Graph of Ratio FVC and FEV1 from Spiroximeter measurement results

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 10 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 FIGURES 11. The vertical axis is represented by: The figure 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

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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

V. DISCUSSION

Asthma is a global health problem that cause of burden of disease particularly in low and middleincome countries (LMICs). The one of the important assesment of asthmatic patients is an assesment of asthma symptoms control. It is a common misconception that asthma is a disease that affects only a particular group of people[3]. In fact, it can affect anyone, regardless of age, gender or social status. The precise aetiology of asthma remains unclear. However, several factors have been identified as potential triggers, including cigarette smoke, dust, animal dander, physical exertion, cold air, viral infections and exposure to chemicals. The Candip subdistrict of Sidoarjo Regency represents the epicenter of the tofu-making industry in Sidoarjo.

Of the 67 small and medium-sized enterprises [Usaha Kecil Mikro dan Menengah / UMKM] engaged in tofu production, 28, representing 42% of the total, utilise wood fuel. A total of 16 industries, representing 24% of the total, utilise plastic waste as a fuel source. The remaining 16 industries, representing 24% of the total, utilise a combination of plastic and wood as fuel sources. In addition to wood and plastic waste, the tofu industry also utilises shoe industry waste as fuel and LPG. The utilisation of waste materials derived from the shoe industry is, in fact, prohibited due to the presence of rubber in these materials. The combustion of this rubber results in the pollution of the atmosphere. Furthermore, the combustion of plastic waste has the potential to result in the contamination of the air environment with microplastics. The combustion of plastic waste can result in the production of CO_2, NOx, and organic carbon gases, which contribute to the pollution of the atmosphere. Furthermore, the combustion of plastic waste results in the production of dioxin chemical compounds, which are detrimental to the environment and human health.

One of the key challenges faced by individuals with asthma is the lack of awareness about the specific indicators of an asthma attack, the means of managing asthma symptoms, and the underlying risk factors associated with the condition. Furthermore, there is a dearth of expertise in self-management among asthma patients, as well as a lack of effort to monitor the signs and symptoms of asthma[20].

A. *IMPROVEMENT IN RESPONDENTS' KNOWLEDGE OF BRONCHIAL ASTHMA*

Table 1 illustrates a notable enhancement in the respondents' comprehension of bronchial asthma. This is evidenced by the elevated scores on the post-test, indicating a discernible growth in their understanding of the subject matter. The diagram in the document illustrates the pre-test and post-test scores on the topic of bronchial asthma. The horizontal axis (X) represents the number of respondents, while the vertical axis (Y) depicts the corresponding scores. The pre-test results are presented below. The line represents the initial score obtained by the respondents prior to the implementation of the intervention or learning activity. The post-test scores are presented below. The subsequent line illustrates the scores obtained subsequent to the intervention or learning activity. The mean value of the pre-post assessment is 58.25, while the mean value of the post-test is 74, indicating a statistically significant increase in the mean value obtained. The Wilcoxon test is employed for the comparison of two paired samples in instances where the data does not adhere to a normal distribution, or when ordinal data is being analysed. The results demonstrated a statistically significant increase in scores from the pre-test to the post-test. All non-zero changes were positive, indicating a consistent improvement in scores.
The intervention or learning method applied between the pre-test and post-test appears to be highly efficacious in enhancing the participants' scores[21].
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The results of the study indicate a positive change in respondents' knowledge following the administration of the pregnancy application media intervention. Following the completion of the data analysis, the results demonstrated that the findings of this study had a statistically significant impact on the knowledge of the respondents following the delivery of a lecture on asthma.
As defined by Notoatmodjo, knowledge is the result of the process of "knowing," which occurs after individuals perceive a particular object. The process of sensing is achieved through the five senses: sight, hearing, smell, taste and touch. The eyes and ears represent a significant aspect of human knowledge acquisition. The knowledge domain is comprised of six levels of knowledge, namely knowing, understanding, application/application, analysis, synthesis and evaluation. The factors that influence knowledge can be divided into two categories: internal and external. The internal factors that contribute to an individual's knowledge include their level of education, occupation, and age[9]. In contrast, external factors encompass environmental and socio-cultural elements[22].

The results of this study indicate that a person's knowledge is influenced by several things, one of which is the age factor. Someone who is of productive age has good knowledge skills. So, at this age has an influence on the level of knowledge. A person's age can also affect one's comprehension and mindset. Whereas you get older, the level of thinking will be more mature and more mature. Besides that, there are educational factors, education also plays an important role in knowledge and perception of something. Education has the authority to

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influence a person's lifestyle and determine goals and achieve these goals. Someone will start the learning process through education and will try to update the knowledge that needs to be learned and will manage or use something that is considered appropriate for him, including knowledge of pregnancy. The higher the education, the higher the knowledge a person will have. Based on the theory and data that have been obtained by researchers there is harmony, because the older you are, the more mature and more mature your level of thinking will be. And with higher education, the higher one's knowledge will be[23][24]. The efficacy of health education in enhancing knowledge has been demonstrated in numerous studies. For instance, a study on bronchial asthma indicated that health education can effectively improve health knowledge. The efficacy of educational initiatives can be enhanced by the actions of those responsible for their delivery. The efficacy of health workers as educators is contingent upon the extent of client knowledge. In fulfilling its role as an educator, the Community Service Team assists clients in enhancing their health by imparting knowledge pertaining to health issues. Clients will receive accurate information and guidance on the optimal management strategies for their specific health issues.

B. SPIROMETRY EXAMINATION RESULT

The objective of a spirometry examination is to quantify the volume of the lungs to ascertain whether the individual in question exhibits normal lung function or presents with any abnormalities. Abnormalities may manifest as restriction, obstruction, or a combination of both. The indication for a spirometry examination is not merely to ascertain lung function; it can also be employed as a means of evaluating the efficacy of a treatment plan or as a diagnostic tool prior to surgical intervention. Abnormalities obtained from spirometry, such as those indicative of restriction lung disorders, represent a heterogeneous group of lung diseases. These are characterised by a decreased lung ability to stretch due to decreased lung elasticity or by problems related to chest wall expansion during inspiration, which reduces lung capacity. Restrictive lung disorders may be caused by abnormalities within the lungs themselves, or by abnormalities in other organs. Obstructive lung disorders are characterised by increased airflow resistance, due to partial or total obstruction at any point from the trachea to the terminal bronchioles.

The spirometry examinations conducted included those for FEV1, FVC and FEVR. The indices FEV1 (Forced Expiratory Volume in One Second), FEVR (Forced Expiratory Volume Ratio) and FVC (Forced Vital Capacity) are sensitive indicators of lung development and are correlated with anthropometry and age. FVC and FEV1 are indices that are frequently employed to ascertain abnormalities of airway obstruction, bronchoconstriction, or bronchodilatation. While FEVR can assist in determining the efficacy of bronchodilators. The normal values for FEV1 and FEVR are ≥80%. A value of <80% for FEVR indicates an increase in respiratory abnormalities, systemic inflammation and mortality. The normal FVC is approximately 4 litres. An examination with a spirometer is an essential component of a comprehensive assessment of lung ventilation function. Indeed, a considerable number of individuals exhibit spirometry values that are below the normal range. For instance, FEVR values below 80% are indicative of an elevated risk for respiratory disorders, systemic inflammation, and mortality. Decreased FEV1 values and the FEV1/FVC index are indicative of obstruction disorders, while decreased FVC values, in conjunction with a normal FEV1/FVC index, suggest restriction disorders. Combined disorders are indicated by decreased FVC and FEV values. A reduction in FEV1, FEVR, and FVC values may be attributed to the presence of airborne pollutants.

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The results of spirometry measurements on 40 respondents at Puskesmas Candi mean that the volume of air that can be exhaled in the first second (FEV1) is 80% of the total forced vital capacity (FVC). An FEV1/FVC ratio of 0.80 is considered to be within the normal range. This ratio is used to assess whether there is airflow resistance in the respiratory tract. A normal FEV1/FVC ratio value is generally 0.70 or higher. If this ratio value is lower than 0.70, it could indicate the presence of airway obstruction which may be caused by conditions such as asthma or chronic obstructive pulmonary

disease (COPD)[3][25][26]. With an FEV1/FVC ratio of 0.80, it indicates that airflow through the respiratory tract is not significantly restricted. In other words, the respondents' lungs were able to exhale air properly without any significant constriction or obstruction. Overall, an FEV1/FVC ratio of 0.80 is an indicator that the respondent's lung function is within normal limits and there are no signs of significant airway obstruction.

VI. CONCLUSION

The purpose of the Community Service Programme through the PKM scheme is to increase knowledge about asthma to the community in Candi District who are exposed to the combustion products of tofu factories, and also to determine lung capacity and function through measurement with an IoT-based spirometry device.

The results of this community service demonstrated a statistically significant increase in respondents' knowledge about asthma following the administration of a lecture, as evidenced by elevated scores on the knowledge assessment. The spirometry measurements demonstrated that the respondents' lungs were functioning optimally, with no significant airway obstruction. This evidence demonstrates that the intervention was effective in enhancing knowledge and asthma management among the participants. Alternative intervention through telemedicine especially for continuing education and may therapeutic strategies can be performed as an effort to obtain well controlled asthma in community[5]. Telemedicine may benefit as an alternative approach of healthcare service in the context of pandemic era. This community service program may give an insight as an alternative of conventional medical services in pandemic era, but further studies is still needed with a large number of subjects and using pre and post evaluation to get the clear benefits of telemedicine in asthmatic patients

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