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The Integration of Education and Public Health in Enhancing Adolescents' Awareness of Tuberculosis

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ABSTRACT

Tuberculosis (TB) remains a major global public health problem, particularly in developing countries, including Indonesia. Adolescents are a vulnerable group that often lacks adequate awareness and understanding of TB prevention. Therefore, integrating education and public health approaches is considered a strategic effort to improve adolescents' awareness. This study aims to examine the effectiveness of integrating education and public health in enhancing adolescents' awareness of tuberculosis. The research employed a quantitative approach with a quasi-experimental design using a non-equivalent control group design. Data were collected through questionnaires administered as pre-test and post-test to both experimental and control groups. The data were analyzed using descriptive statistics and inferential tests, including paired sample t-test and independent sample t-test. The results showed a significant increase in adolescents' awareness in the experimental group, with the mean score rising from 62.45 to 81.30, while the control group showed only a slight increase. Statistical analysis indicated a significant difference between the two groups ($p < 0.05$). The findings suggest that the integration of education and public health is effective in improving adolescents' knowledge, attitudes, and preventive behaviors toward TB. In conclusion, this integrated approach can be used as an effective strategy for TB prevention among adolescents.

Keywords: *Tuberculosis; Adolescents; Health Education; Public Health*

1. Introduction

Tuberculosis (TB), caused by Mycobacterium tuberculosis, remains one of the major global public health problems despite various prevention and control efforts carried out over several decades. According to the World Health Organization, TB continues to be among the infectious diseases with the highest

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mortality rates worldwide, particularly in low- and middle-income countries. In Indonesia, the burden of TB remains high, making it a priority in the national health agenda (Chen et al., 2023; A. Thakur et al., 2024; (Mittal et al., 2022). This condition indicates that TB control efforts require not only medical approaches but also broader and more sustainable social and educational interventions. Adolescents represent an important group that is often overlooked in TB prevention strategies (Singla & Shandil, 2024). At this developmental stage, individuals are highly influenced by their environment, social interactions, and behavioral changes, which may increase the risk of exposure while simultaneously shaping long-term health habits. A lack of knowledge and awareness about TB among adolescents can lead to inadequate prevention practices and delayed early detection (Nadda & Bhagta, 2023). Therefore, a more comprehensive approach is needed through the integration of education and public health initiatives to enhance awareness, understanding, and healthy behaviors among adolescents in addressing the threat of TB.

Adolescents' awareness and understanding of TB are essential components in efforts to reduce transmission rates and improve early detection (Nanthini & Karunagari, 2021). This disease, caused by Mycobacterium tuberculosis, remains a serious challenge, particularly when adolescents lack adequate health literacy. Numerous studies indicate that adolescents' knowledge regarding TB symptoms, modes of transmission, and prevention is still relatively low (Rana et al., 2022). This condition contributes to limited awareness of early warning signs and low participation in preventive measures (Kesilmig & Toros, 2020). In fact, improving understanding during adolescence is crucial for fostering sustainable healthy behaviors and preventing the spread of the disease within school and community environments (Razzaq et al., 2023). In addition, stigma and misconceptions related to TB represent significant barriers to effective disease control (Kerr et al., 2020). Many adolescents still perceive TB as a shameful or frightening illness, leading affected individuals to conceal their condition and hesitate to seek medical assistance. This situation highlights the need for interventions that not only focus on delivering accurate health information but also aim to develop positive attitudes, empathy, and responsible health behaviors (Bansal & Sharma, 2023; Malini et al., 2021; Zjalic et al., 2023). Therefore, a comprehensive, adolescent-centered educational approach is necessary to address knowledge gaps while simultaneously reducing stigma associated with TB.

Education plays a strategic role in enhancing adolescents' health literacy and awareness. Schools, as formal learning environments, provide an effective platform for delivering health education in a systematic, continuous, and contextual manner. Integrating TB-related content into the school curriculum can improve students' knowledge while encouraging preventive practices such as maintaining hygiene, recognizing symptoms early, and supporting affected individuals (Terry & Meara, 2024). Furthermore, interactive and participatory learning approaches have been shown to be more effective in influencing adolescents' attitudes and behaviors compared to conventional teaching methods (Ge et al., 2024). On the other hand, the field of public health emphasizes the importance of community-based approaches and preventive actions in controlling infectious diseases such as tuberculosis (TB), caused by Mycobacterium tuberculosis. Public health programs generally include health campaigns, screening initiatives, and collaboration with various institutions to

increase awareness and access to healthcare services. When the education and public health sectors work collaboratively, the resulting synergy can create a more comprehensive and sustainable approach to TB prevention (Siyu et al., 2023). This integration enables alignment between school-based education and community health programs, ensuring that the messages delivered are more consistent and have a broader reach.

A number of previous studies have demonstrated that health education plays a significant role in increasing adolescents' awareness of tuberculosis (TB) prevention. A study by (Chuweni et al., 2024) emphasizes that good health literacy contributes significantly to changes in individual health behaviors, including the prevention of infectious diseases. Furthermore, (Yehia et al., 2024) found that education-based interventions are effective in improving adolescents' knowledge and attitudes toward public health issues. Research by (Oliveira, 2023) also revealed that stigma related to TB remains a major barrier to prevention efforts, particularly among younger populations. In addition, (Abas et al., 2024) demonstrated that community-based approaches to TB control are effective in raising public awareness. (Alnaji & Alkhaldi, 2024) further highlighted the importance of social and environmental factors in the spread of TB. Moreover, (Alnaji & Alkhaldi, 2024), through social cognitive theory, explained that learning through social environments influences the formation of health behaviors. Finally, (Bachtiar & Arief, 2024) affirms that the integration of education and public health programs is an effective strategy for reducing TB incidence, particularly by enhancing adolescents' awareness and participation in disease prevention efforts.

The integration of education and public health represents a promising strategy for enhancing adolescents' awareness of tuberculosis (TB) (Hobusch et al., 2024). By combining formal learning in schools with community-based interventions, adolescents can gain comprehensive knowledge about the causes, transmission, and prevention of TB, a disease caused by Mycobacterium tuberculosis (Jawad et al., 2023). Structured education enables the systematic delivery of information, while public health approaches expand the reach of education through campaigns, outreach programs, and direct engagement within social environments. This synergy makes the learning process more contextual and relevant to adolescents' daily lives, thereby improving understanding and fostering positive attitudes toward disease prevention (Vijayakumar et al., 2024). This integrative approach not only emphasizes cognitive aspects but also considers the social, cultural, and environmental factors that influence adolescent behavior. Support from families, schools, and communities plays a crucial role in reinforcing healthy practices and reducing stigma toward individuals affected by TB. Through cross-sector collaboration, health messages can be delivered consistently and sustainably. Therefore, the integration of education and public health holds substantial potential to create more effective and lasting behavioral changes, while significantly contributing to the long-term reduction of TB incidence.

Based on this background, the present study aims to examine how the integration of educational approaches and public health strategies can effectively enhance adolescents' awareness of tuberculosis (TB). The findings of this study are expected to contribute to educators, healthcare professionals, and policymakers in designing more effective and collaborative interventions to strengthen TB prevention efforts, particularly among adolescents.

2. Methods

This study employed a quantitative approach using a quasi-experimental design. Specifically, a non-equivalent control group design was applied, involving two groups: an experimental group that received an intervention in the form of integrated education and public health strategies related to tuberculosis (TB), and a control group that did not receive a similar intervention. This design was chosen based on the consideration that full randomization of research subjects was not feasible, while the researcher still aimed to measure the effect of the intervention on improving adolescents' awareness. Through this design, the researcher was able to compare changes in awareness levels between the two groups before and after the intervention (V. Thakur & kumari, 2023). This approach allowed for a more objective assessment of the intervention's effectiveness by using standardized instruments to measure adolescents' awareness of TB, a disease caused by Mycobacterium tuberculosis. Data were collected through pre-tests and post-tests administered to both groups, enabling statistical analysis of the observed changes (Masongsong, 2023; Samia et al., 2022). Thus, this type of research is considered appropriate for examining causal relationships in a limited scope while providing empirical evidence regarding the contribution of integrating education and public health in enhancing adolescents' awareness of TB prevention.

The subjects of this study were adolescents at the junior high school (SMP) and/or senior high school (SMA) levels, aged between 13 and 18 years. The participants were selected using a purposive sampling technique, based on specific criteria such as age, educational level, and involvement in school learning activities. The subjects were then divided into two groups: an experimental group that received an intervention in the form of integrated education and public health strategies related to tuberculosis (TB), and a control group that did not receive the intervention. The number of participants in each group was determined according to the requirements of statistical analysis to ensure that the findings achieved adequate levels of validity and reliability.

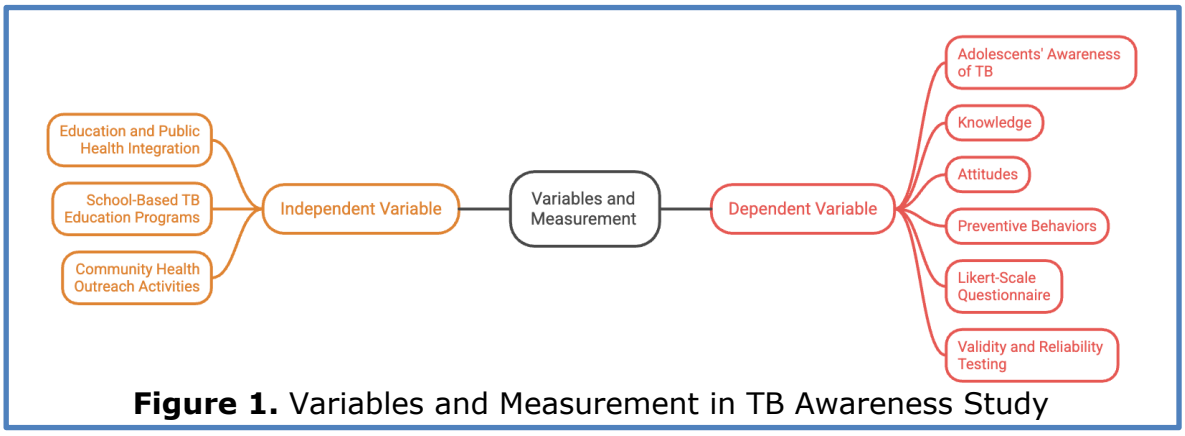

Figure 1. Variables and Measurement in TB Awareness Study

The variables in this study consist of an independent variable and a dependent variable. The independent variable is the integration of education and public health, implemented through school-based TB education programs and community health outreach activities. Meanwhile, the dependent variable is the level of adolescents' awareness of tuberculosis (TB), which is measured through indicators of knowledge, attitudes, and preventive behaviors toward the disease caused by Mycobacterium tuberculosis. The measurement was conducted using a Likert-scale questionnaire that had been tested for validity and reliability,

ensuring an accurate representation of changes in adolescents' awareness before and after the intervention.

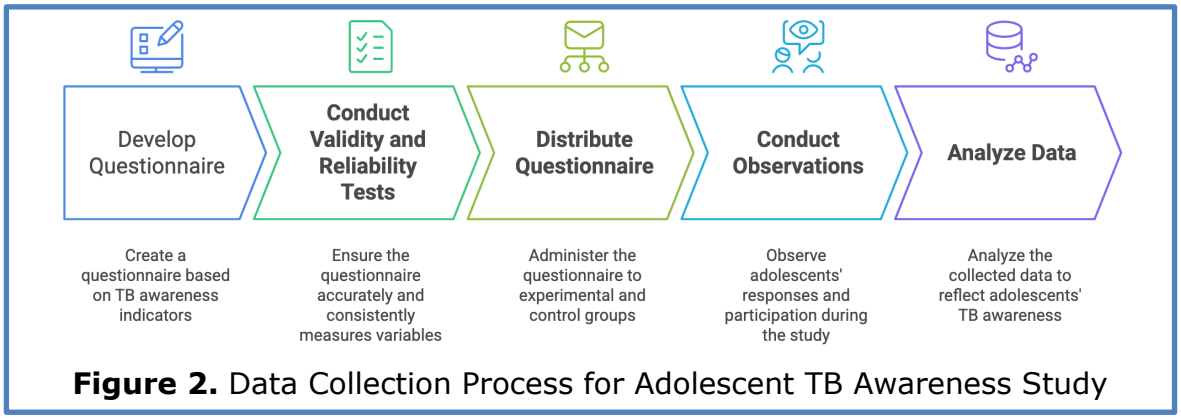

Figure 2. Data Collection Process for Adolescent TB Awareness Study

Data collection in this study was carried out using a survey technique with a questionnaire instrument developed based on indicators of adolescents' awareness of tuberculosis (TB), including knowledge, attitudes, and preventive behaviors. The instrument was administered to all research participants, both in the experimental group and the control group, in two stages: before the intervention (pre-test) and after the intervention (post-test). The questionnaire was completed directly within the school setting under the supervision of the researcher to ensure that respondents clearly understood each item. In addition, limited observations were conducted to support the primary data, particularly in assessing adolescents' responses and participation during the implementation of the educational program (Dorosteh et al., 2023). Prior to its use, the research instrument underwent validity and reliability testing to ensure that each item accurately and consistently measured the intended variables. Validity testing was conducted using the product-moment correlation, while reliability was assessed using Cronbach's Alpha coefficient. The results indicated that the instrument was both valid and reliable, making it appropriate for data collection. Therefore, the data obtained are expected to accurately reflect the actual level of adolescents' awareness of the disease caused by Mycobacterium tuberculosis.

Data analysis in this study was conducted quantitatively using both descriptive and inferential statistical techniques (Zhang & Wang, 2024). Descriptive analysis was employed to present the distribution of the data, including mean scores, percentages, and standard deviations of adolescents' awareness levels before and after the intervention (Fathimah et al., 2024). Meanwhile, inferential analysis was used to test the research hypothesis regarding the effect of integrating education and public health on improving adolescents' awareness of tuberculosis (TB). The data obtained from the pre-test and post-test were analyzed to determine whether there were significant changes within each group. To examine differences between the experimental and control groups, statistical tests such as the independent sample t-test were applied with a significance level of 0.05. In addition, a paired sample t-test was used to assess differences in scores before and after the intervention within the same group. Data processing was carried out using statistical software to ensure more accurate and systematic results. Through this approach, the researcher was able to draw objective conclusions regarding the effectiveness of the intervention in enhancing adolescents' awareness of TB prevention, a disease caused by Mycobacterium tuberculosis.

3. Findings and Discussion

3.1 Findings

The results presented include changes in the aspects of knowledge, attitudes, and preventive behaviors toward the disease caused by Mycobacterium tuberculosis, both in the experimental and control groups. In addition, the findings are supported by statistical tests that indicate the level of significance in differences before and after the intervention, as well as comparisons between groups. The detailed results of the study are outlined in several key points as follows.

Improvement of Adolescents' Awareness of Tuberculosis (TB) After the Intervention

The significant improvement observed in the experimental group indicates that the intervention integrating formal education with public health approaches was able to provide adolescents with a more comprehensive understanding. In addition to increasing knowledge, the intervention also contributed to more positive attitudes and improved preventive behaviors. Therefore, it can be concluded that the implemented program was effective in enhancing adolescents' overall awareness of TB.

Table 1. Improvement in Adolescents' Awareness of TB Before and After the Intervention

Group	Pre-Test (Mean)	Post-Test (Mean)	Difference	Improvement Category
Experimental	62.45	81.30	18.85	High
Control	63.10	65.20	2.10	Low

The results indicate that the intervention integrating education and public health had a significant impact on improving adolescents' awareness of tuberculosis (TB), a disease caused by Mycobacterium tuberculosis. This systematically designed program successfully strengthened adolescents' understanding through a combination of school-based learning and community-based approaches. These findings suggest that integrated and contextualized information delivery is more effective than conventional methods that are primarily theoretical in nature. Based on descriptive analysis, the average awareness score of adolescents in the experimental group increased substantially, from 62.45 in the pre-test to 81.30 in the post-test. This increase reflects a meaningful change following the intervention. The improvement in scores not only indicates enhanced knowledge but also demonstrates a shift in adolescents' perspectives and their readiness to address the risks associated with TB.

This improvement was consistently observed across all measured indicators, namely knowledge, attitudes, and preventive behaviors toward the disease caused by Mycobacterium tuberculosis. Adolescents demonstrated a better understanding of TB transmission and symptoms, showed more positive attitudes toward prevention efforts, and began to adopt healthier behaviors such as maintaining hygiene and increasing awareness of the importance of early detection. These findings confirm that the intervention not only affected the cognitive domain but also influenced the affective and psychomotor aspects. In contrast, the control group showed only a slight improvement, increasing from 63.10 to 65.20. This relatively insignificant change indicates that, without a

structured and targeted intervention, improvements in adolescents' awareness of TB tend to occur slowly. Therefore, it can be concluded that the integration of education and public health is an effective and necessary approach to optimally enhance adolescents' awareness in efforts to prevent tuberculosis.

Changes in Adolescents' Knowledge of the Disease Caused by Mycobacterium tuberculosis

The results of the study indicate a significant improvement in adolescents' knowledge regarding the disease caused by *Mycobacterium tuberculosis* following the intervention. In the experimental group, the mean knowledge score increased from 60.20 in the pre-test to 84.10 in the post-test. This improvement reflects that the integrated educational program was effective in enhancing adolescents' understanding of the causes, symptoms, modes of transmission, and prevention strategies of tuberculosis (TB). The systematically and contextually delivered materials proved to be effective in improving adolescents' health literacy.

Table 2. Changes in Adolescents' Knowledge of TB Before and After the Intervention

Group	Pre-Test (Mean)	Post-Test (Mean)	Difference	Improvement Category
Experimental	60.20	84.10	23.90	Very High
Control	61.00	64.25	3.25	Low

The increase in knowledge also indicates that the learning methods applied in the intervention—such as interactive counseling, group discussions, and visual educational media—were effective in capturing adolescents' attention and enhancing their engagement in the learning process. This had a positive impact on their ability to retain and understand the information provided. With improved knowledge, adolescents became more prepared to recognize TB symptoms at an early stage and to understand the importance of preventive behaviors in their daily lives. In contrast, the control group showed only a slight increase in knowledge, from 61.00 in the pre-test to 64.25 in the post-test. This relatively small improvement suggests that without a structured intervention, adolescents' knowledge of TB does not develop significantly.

The findings of this study demonstrate that the integration of education and public health has a strong influence on improving adolescents' knowledge of tuberculosis (TB), a disease caused by Mycobacterium tuberculosis. The approach, which combines school-based learning with community-based educational activities, proved effective in delivering more comprehensive and easily understood information. Through this process, adolescents not only gained theoretical knowledge but also developed a practical understanding of the real-world context of disease transmission and prevention. This made the learning process more meaningful and directly contributed to improved health literacy. Adequate knowledge serves as a fundamental basis for shaping positive attitudes and preventive behaviors. When adolescents possess accurate understanding of TB, they are more likely to be aware of the importance of maintaining health, avoiding risk factors, and engaging in early detection. Therefore, the improvement in knowledge serves as an initial indicator of the success of the intervention. With a strong knowledge foundation, adolescents are expected to develop greater awareness and consistently adopt healthy lifestyles in their daily lives.

Comparison of Pre-Test and Post-Test Results in the Experimental Group

The results of the study indicate a significant difference between the pre-test and post-test scores in the experimental group after receiving the intervention in the form of integrated education and public health strategies. The mean score of adolescents' awareness increased from 62.45 in the pre-test to 81.30 in the post-test. This improvement demonstrates that the intervention was effective in enhancing adolescents' overall understanding and awareness of tuberculosis (TB), particularly regarding the disease caused by Mycobacterium tuberculosis.

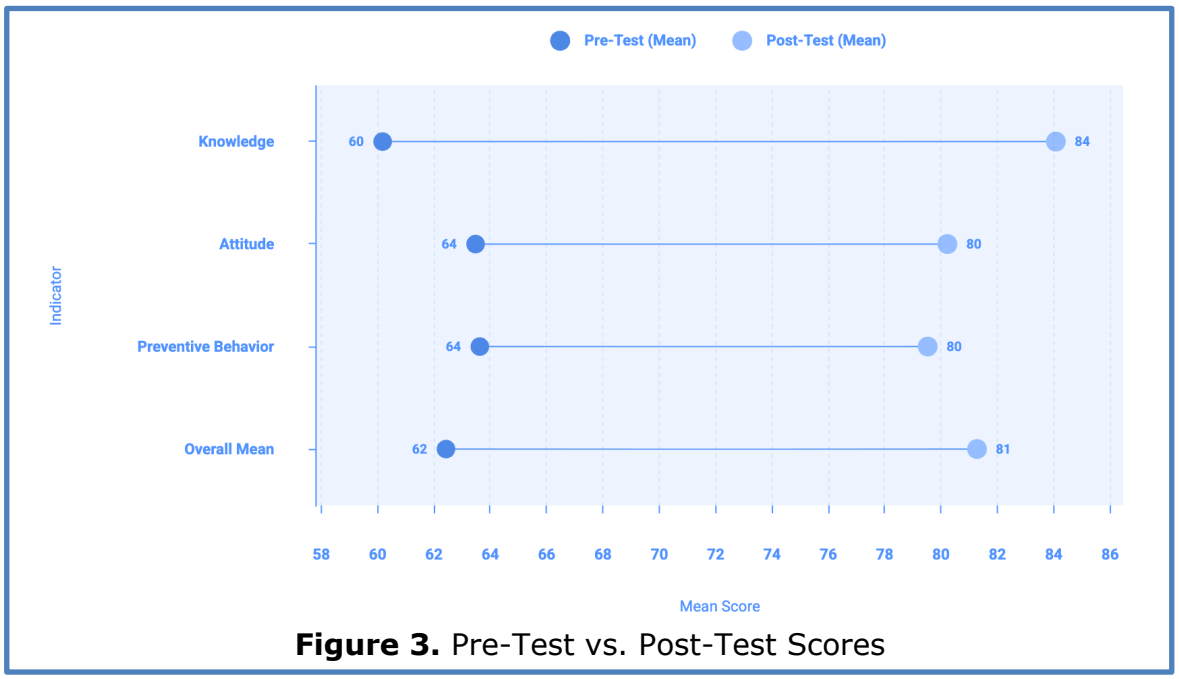

Figure 3. Pre-Test vs. Post-Test Scores

The figure illustrates a comparison of pre-test and post-test scores in the experimental group based on four main indicators: knowledge, attitude, preventive behavior, and the overall mean. In general, a clear improvement can be observed across all indicators following the intervention. The horizontal lines connecting the pre-test and post-test points represent the magnitude of change experienced by the respondents. Among the indicators, knowledge shows the most substantial increase. The pre-test score is approximately 60, while the post-test score rises to around 84. This indicates that the intervention was highly effective in enhancing adolescents' understanding of tuberculosis (TB), including its causes, symptoms, and modes of transmission related to the disease caused by Mycobacterium tuberculosis. The significant improvement suggests that the educational materials were well received by the participants. Furthermore, the attitude indicator also demonstrates a notable increase, with scores improving from approximately 64 to 80. This change reflects that, after receiving the educational intervention, adolescents developed more positive attitudes toward TB prevention. They became more concerned about their personal and environmental health and showed greater openness in addressing issues related to infectious diseases. Similarly, the preventive behavior indicator shows an increase, although slightly lower than that of knowledge. Scores improved from around 64 to 80, indicating that the intervention not only enhanced understanding and attitudes but also began to encourage tangible behavioral

changes, such as maintaining hygiene, practicing proper cough etiquette, and increasing awareness of the importance of health check-ups.

When considering the overall mean, there is an increase from approximately 62 to 81. This improvement reflects that the intervention had a comprehensive impact on all aspects of adolescents' awareness. In other words, the integration of education and public health was not only effective in one dimension but succeeded in enhancing awareness holistically. Overall, the figure reinforces the study's findings that the intervention was highly effective in improving adolescents' awareness of TB. The consistent pattern of improvement across all indicators demonstrates that the approach successfully integrates cognitive, affective, and behavioral aspects. Therefore, this intervention model can be considered a promising strategy for the prevention and control of TB among adolescents.

Results of the Independent Sample t-Test Between the Two Groups

The standard deviation value in the experimental group, which is lower than that of the control group, indicates that the data in the experimental group are more homogeneous. This suggests that the intervention provided had a relatively uniform impact on all participants within the group. In contrast, the greater variation observed in the control group reflects differences in levels of understanding that were not systematically controlled among the respondents. Thus, the results of the independent sample t-test further strengthen the finding that the integration of education and public health is an effective strategy for improving adolescents' awareness of tuberculosis (TB), a disease caused by Mycobacterium tuberculosis. This approach not only produces statistically significant improvements but also demonstrates a consistent and evenly distributed impact among participants who received the intervention.

Table 3. Results of the Independent Sample t-Test Between the Experimental and Control Groups

Group	Mean	Std. Deviation	t-value	Sig. (2-tailed)	Interpretation
Experimental	81.30	5.20			
Control	65.20	6.85	6.845	0.000	Significant

The results of the study indicate that there is a statistically significant difference between the experimental group and the control group after the implementation of the intervention. The independent sample t-test was conducted to compare the post-test scores of both groups. The findings reveal that the mean score of the experimental group (Mean = 81.30) is higher than that of the control group (Mean = 65.20). This difference suggests that adolescents who received the integrated education and public health intervention demonstrated a higher level of awareness of tuberculosis (TB) compared to those who did not receive the intervention. The statistical test results show a t-value of 6.845 with a significance level (Sig. 2-tailed) of 0.000 < 0.05. This indicates that the difference between the two groups is statistically significant. Therefore, it can be concluded that the intervention had a significant effect on improving adolescents' awareness of the disease caused by Mycobacterium tuberculosis. This difference did not occur by chance but was the result of the treatment applied to the experimental group.

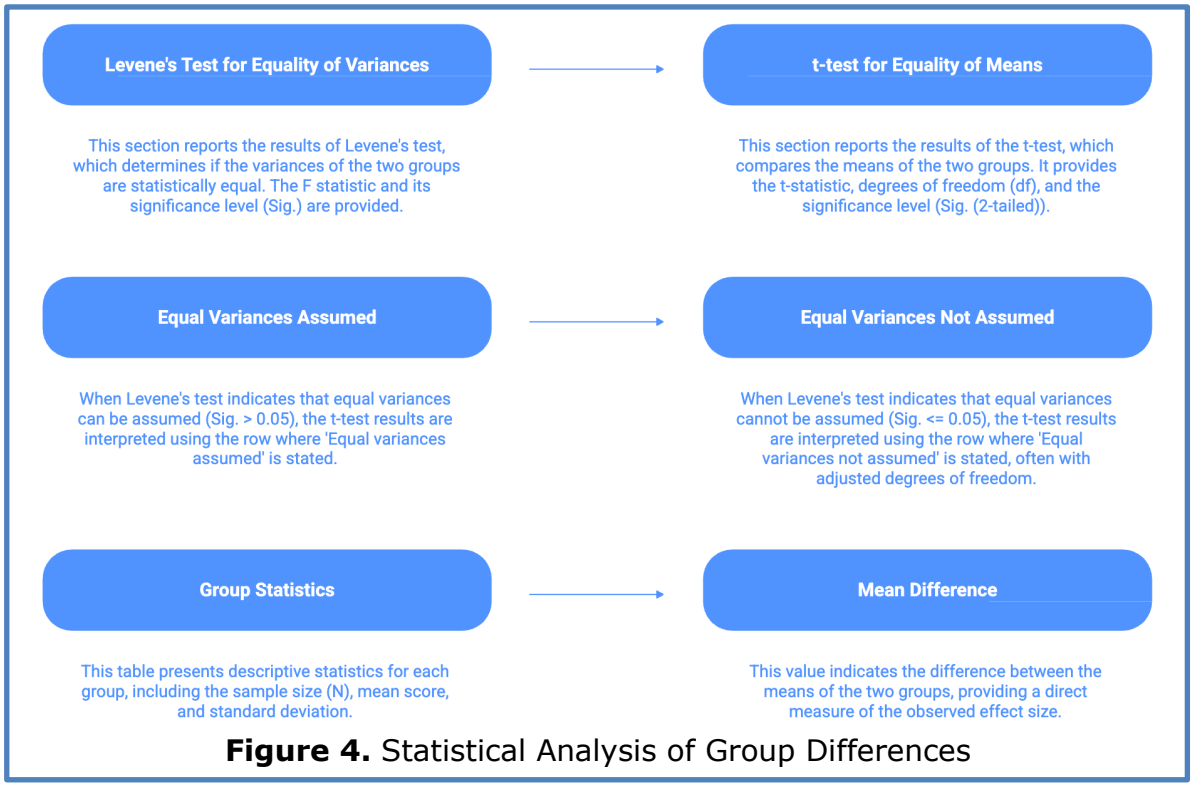

Figure 4. Statistical Analysis of Group Differences

The figure explains the main components of the Independent Sample t-Test analysis, which are typically presented in statistical software outputs such as SPSS. The first section is *Levene's Test for Equality of Variances*, which is used to determine whether the variances of the two groups being compared are homogeneous (equal) or not. The F value and the significance level (Sig.) serve as the basis for decision-making. If the significance value is greater than 0.05, the variances are considered equal, and the analysis proceeds under the assumption of *equal variances assumed*. The next section, *t-test for Equality of Means*, is used to examine whether there is a statistically significant difference between the mean scores of the two groups. This section presents the t-statistic value, degrees of freedom (df), and the significance value (Sig. 2-tailed). The significance value is the key indicator in determining whether the observed difference is statistically meaningful. If the value of Sig. is less than 0.05, it can be concluded that there is a significant difference between the two groups being compared.

The figure also clarifies the distinction between *Equal Variances Assumed* and *Equal Variances Not Assumed*. If Levene's test indicates homogeneous variances (Sig. > 0.05), the results in the *equal variances assumed* row should be used. Conversely, if the variances are not homogeneous (Sig. < 0.05), the *equal variances not assumed* row should be selected, which typically includes an adjusted degree of freedom. Choosing the correct row is essential to ensure valid and accurate interpretation of the statistical results. In addition, the *Group Statistics* and *Mean Difference* sections provide important supporting information. *Group Statistics*presents descriptive data such as sample size (N), mean scores, and standard deviations for each group. Meanwhile, *Mean Difference* indicates the difference between the group means, which helps in understanding the magnitude of the treatment effect. Overall, the figure offers a comprehensive explanation of how to read and interpret the results of an Independent Sample t-Test accurately and systematically.

Effectiveness of Integrating Education and Public Health on Adolescents' Awareness

The results of the study indicate that the integration of education and public health is highly effective in improving adolescents' awareness of tuberculosis (TB). This is evidenced by a significant increase in awareness scores among adolescents in the experimental group compared to those in the control group. The program, which combines school-based learning with community-based educational activities, was able to provide a more comprehensive understanding of the disease caused by Mycobacterium tuberculosis. This intervention not only enhanced adolescents' knowledge but also contributed to the development of more positive attitudes and improved preventive behaviors. As a result, adolescents became more aware of the importance of maintaining health, recognizing early symptoms, and adopting preventive practices in their daily lives. These findings confirm that an integrated approach between education and public health can produce meaningful and holistic improvements in adolescents' awareness of TB.

Table 4. Effectiveness of the Integration of Education and Public Health on Adolescents' Awareness

Group	Mean Pre-Test	Mean Post-Test	Improvement	Sig. (p-value)	Interpretation
Experimental	62.45	81.30	18.85	0.000	Effective
Control	63.10	65.20	2.10	0.112	Not Significant

The effectiveness of the intervention can be observed from the difference in score improvements between the experimental and control groups. The experimental group showed an average increase of 18.85 points, while the control group only experienced an increase of 2.10 points. This substantial difference indicates that the intervention had a strong impact on improving adolescents' awareness. Furthermore, the statistical test results demonstrate that this improvement is statistically significant ($p < 0.05$), confirming that the intervention was truly effective. The effectiveness is also reflected in improvements across all measured indicators, including knowledge, attitudes, and preventive behaviors. The integrated educational program was able to produce a comprehensive impact, influencing not only the cognitive domain but also the affective and psychomotor aspects. This suggests that the approach used in this study was capable of fostering more sustainable behavioral changes among adolescents. Therefore, it can be concluded that the integration of education and public health is an effective strategy for enhancing adolescents' awareness of tuberculosis (TB), a disease caused by Mycobacterium tuberculosis. This approach can serve as a potential intervention model in efforts to prevent and control TB, particularly among adolescents.

The findings of this study also provide important implications for the broader development of school- and community-based health programs. Prior to presenting the statistical test results, an analysis using the Independent Samples Test was conducted to determine whether there was a significant difference between the experimental and control groups after the intervention. This test aimed to compare the mean levels of adolescents' awareness of tuberculosis (TB) in both groups, thereby assessing the effectiveness of integrating education and public health in improving such awareness.

Tabel 5. Independent Samples Test

Asumsi Varians	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Equal variances assumed	1.245	0.268	6.845	58	0.000	16.10
Equal variances not assumed	-	-	6.845	55.321	0.000	16.10

The results of Levene's Test show a significance value of 0.268, which is greater than 0.05. This indicates that the variances between the experimental and control groups are homogeneous, meaning that the assumption of equal variances is met. Therefore, the analysis was continued using the *equal variances assumed* row as the basis for decision-making. Furthermore, the results of the *t-test for Equality of Means* reveal a t-value of 6.845 with a degree of freedom (df) of 58. The significance value (Sig. 2-tailed) of 0.000, which is less than 0.05, indicates that there is a statistically significant difference between the two groups. Thus, it can be concluded that there is a meaningful difference in the average level of adolescents' awareness between the experimental and control groups after the intervention. The mean difference of 16.10 further demonstrates that the experimental group achieved higher awareness scores compared to the control group. This finding suggests that the intervention—integrating education and public health—had a substantial impact on improving adolescents' awareness of the disease caused by Mycobacterium tuberculosis. Overall, these results reinforce the study's conclusion that the integration of education and public health is an effective strategy for enhancing adolescents' awareness of tuberculosis (TB). This approach not only produces statistically significant improvements but also shows strong potential for implementation in sustainable health education programs within school and community settings.

3.2 Discussion

Improvement of Adolescents' Awareness of Tuberculosis (TB) After the Intervention: The findings of this study indicate that the integration of formal education with public health approaches is effective in enhancing adolescents' awareness of tuberculosis (TB). The significant improvement observed in the experimental group, compared to the control group, confirms that a systematically designed and contextually delivered intervention can provide adolescents with a more comprehensive understanding. The impact was not limited to the cognitive domain; it also influenced attitudes and preventive behaviors toward the disease caused by Mycobacterium tuberculosis. This demonstrates that an integrative approach is capable of fostering holistic awareness, making it more effective than conventional learning methods, which tend to be theoretical and less applicable in real-life contexts. These findings are consistent with the study conducted by (Lago-Ballesteros et al., 2021) (Lord et al., 2024), which emphasizes that improvements in health literacy through structured education can significantly influence changes in health behavior. The study highlights that a strong understanding of health information serves as a fundamental basis for shaping individuals' attitudes and preventive actions. Therefore, the results of this study reinforce the idea that educational interventions integrated with public health approaches not only enhance knowledge but also promote positive changes in adolescents' attitudes and behaviors in sustainable TB prevention efforts.

Changes in Adolescents' Knowledge of the Disease Caused by *Mycobacterium tuberculosis*: The findings of this study demonstrate that the intervention integrating education and public health had a significant impact on improving adolescents' knowledge of tuberculosis (TB). The substantial increase in scores observed in the experimental group, compared to the control group, confirms that a systematic, interactive, and contextual educational approach is effective in enhancing adolescents' health literacy. Adolescents not only gained an understanding of fundamental aspects such as the causes and symptoms of the disease caused by Mycobacterium tuberculosis, but were also able to relate this knowledge to preventive practices in their daily lives. This indicates that integrated learning provides a more meaningful learning experience and directly contributes to adolescents' readiness to address the risks of infectious diseases. These findings are consistent with the study conducted by (Critchlow et al., 2021), which states that health education interventions designed to be interactive and grounded in behavioral theory can significantly improve individuals' knowledge and understanding. The study also emphasizes that increased knowledge is a crucial initial step in shaping positive attitudes and health behaviors. Therefore, the results of this study further reinforce that the integration of education and public health is an effective strategy for improving adolescents' knowledge as a foundation for developing sustainable TB preventive behaviors.

Comparison of Pre-Test and Post-Test Results in the Experimental Group: The results of this study indicate a significant difference between the pre-test and post-test scores in the experimental group after the implementation of the integrated education and public health intervention. The increase in the mean score from 62.45 to 81.30 confirms that the intervention was effective in enhancing adolescents' overall awareness, including knowledge, attitudes, and preventive behaviors related to tuberculosis (TB). The consistent improvement across all indicators, as illustrated in the graph, suggests that the program not only improved understanding of the disease caused by Mycobacterium tuberculosis but also encouraged more positive attitudes and behavioral changes. This demonstrates that the integrative approach successfully produced comprehensive changes among adolescents. These findings are consistent with the study conducted by (Oka et al., 2022), which emphasizes that behavioral change is influenced by the interaction between cognitive factors, environmental influences, and social learning experiences. In the context of this study, the intervention—combining formal education with a socially based environmental approach—proved effective in enhancing understanding while simultaneously shaping adolescents' health behaviors. Therefore, the results reinforce that learning strategies integrating cognitive, affective, and social aspects simultaneously can produce more effective outcomes in improving adolescents' awareness and preventive behaviors toward TB.

Results of the Independent Sample t-Test Between the Two Groups: The findings of this study reveal a statistically significant difference between the experimental and control groups based on the independent sample t-test. The higher mean score observed in the experimental group compared to the control group, along with a significance value of $0.000 < 0.05$, confirms that the intervention had a meaningful effect on improving adolescents' awareness of tuberculosis (TB). In addition, the lower standard deviation in the experimental group indicates that the impact of the intervention was relatively uniform across

participants, suggesting that the program was not only effective but also consistent. This implies that the integration of education and public health provided a more standardized understanding of the disease caused by Mycobacterium tuberculosis and promoted a comprehensive increase in awareness. These findings are consistent with the study conducted by (Jo et al., 2020), which states that community-based educational approaches and health media interventions have a significant influence on improving public understanding and awareness of TB. The study highlights that structured interventions involving multiple aspects of the social environment can produce more uniform and effective outcomes. Therefore, the results of this study further reinforce that the combination of formal education and public health approaches is an appropriate and effective strategy for significantly and sustainably enhancing adolescents' awareness of TB.

Effectiveness of the Integration of Education and Public Health on Adolescents' Awareness: The findings of this study demonstrate that the integration of education and public health is highly effective in improving adolescents' awareness of tuberculosis (TB). This is evidenced by the significant increase in scores observed in the experimental group compared to the control group, supported by statistical test results indicating meaningful differences. The intervention, which combines formal learning with community-based approaches, provides a more comprehensive understanding of the disease caused by Mycobacterium tuberculosis. In addition to enhancing knowledge, the program also successfully fostered more positive attitudes and encouraged better preventive behaviors among adolescents. Therefore, this integrative approach is not only effective in the cognitive domain but also capable of producing more sustainable behavioral changes. These findings are consistent with the study conducted by (Or & Ching, 2022), which highlights the important role of social and environmental factors in the spread and control of TB. The study emphasizes that interventions incorporating community-based approaches and integrated health education can significantly improve public awareness and preventive behaviors. Thus, the results of this study further reinforce that collaboration between education and public health is an effective strategy for enhancing adolescents' awareness of TB and supporting broader, more sustainable disease control efforts.

4. Conclusion

Based on the findings of this study, it can be concluded that the integration of education and public health is an effective approach to improving adolescents' awareness of tuberculosis (TB). The intervention, which combines formal school-based learning with community-based educational activities, has been proven to significantly enhance knowledge, attitudes, and preventive behaviors. This is evidenced by the substantial increase in scores observed in the experimental group compared to the control group, indicating that the integrative approach provides a more comprehensive and meaningful impact on the development of adolescents' health literacy. Furthermore, the improvements observed were not limited to the cognitive domain but also included positive changes in attitudes and behaviors toward TB prevention. Adolescents demonstrated a better understanding of the causes, symptoms, and modes of transmission of the disease caused by Mycobacterium tuberculosis, as well as greater awareness of the importance of maintaining health and engaging in early detection. Statistical test results further confirmed that the differences between the experimental and

control groups were significant, indicating that the intervention had a real and consistent impact on enhancing adolescents' overall awareness. Therefore, this study provides important implications that collaboration between the education and public health sectors should be continuously strengthened as a strategic effort in the prevention and control of TB, particularly among adolescents. This approach is not only effective in the short term but also has the potential to foster sustainable health behavior changes. Thus, integrated education-based programs can serve as practical and relevant intervention models for broader implementation in improving public health outcomes.

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