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Participation and Policy Support for a Campus-Based Community Recycling Initiative in Yogyakarta, Indonesia

Iswanto^{1*}, Sepsiana Puspitasari², Furaida Khasanah³¹ Department of Environmental Health, Poltekkes Kemenkes Yogyakarta, Yogyakarta, Indonesia² Department of Biostatistic, Epidemiology, and Population Health, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia³ Doctoral Student at College of Medical, Veterinary & Life Sciences, University of Glasgow, Scotland, United KingdomCorrespondence: iswanto@poltekkesjogja.ac.id

A campus-based community recycling initiative was implemented in a higher health vocational education in Yogyakarta, Indonesia, through a mandatory institutional policy to promote sustainable monthly campus waste management. This study aimed to assess participation, routine waste management behavior, and support for the continuation of the policy. A cross-sectional online survey was conducted among campus community members, including students, lecturers, and administrative staff. A total of 607 respondents completed the questionnaire and were included in the analysis. Univariate and multivariate logistic regression analyses with 95% confidence intervals (CIs) were used to identify factors associated with routine monthly waste management and support for policy continuation. Overall, 91.4% of respondents were registered as member of this initiative, 88.5% were aware of the mandatory policy, and 96.5% reported sorting waste before disposal. However, only 46.1% reported routine monthly waste management. In the adjusted model, routine monthly waste management was associated with perceived availability of digital services (AOR 3.20; 95% CI 2.15–4.77) and waste reduction with family or close friends (AOR 1.99; 95% CI 1.28–3.08). Respondents with compliance-only motivation had lower odds of routine participation than those with a compliant-internalized profile (AOR 0.40; 95% CI 0.21–0.76). Support for policy continuation was associated with routine monthly waste management (AOR 3.09), perceived availability of digital services (AOR 2.57), perceived environmental cleanliness (AOR 3.90), perceived program effectiveness (AOR 4.47), and higher overall perception scores (AOR 2.92). The mandatory campus-based recycling policy achieved high formal participation, but routine monthly participation remained limited. Sustained participation depends not only on institutional enforcement, but also on internalized motivation, access to digital services, social support, and perceived program benefits.

Keywords: Campus-based, Waste behavior, Waste-management program, Waste recycling.

INTRODUCTION

Solid waste remains a major environmental and public health challenge in Indonesia. Indonesia generates around 19.5 to 23 million tons of waste per year, with plastic waste contributing approximately 15.5% to 18.5%, and about 31% to 65% of the total waste remaining unmanaged (Lestari et al., 2025; Voronkova et al., 2023; Yuliansyah et al., 2026). Recent analyses estimate that Indonesia generates around 9.20 ± 1.52 million tons of plastic waste each year, with approximately 1.16 million tons leaking into the environment, including about 0.64 ± 0.11 million tons entering rivers and drains and 0.52 ± 0.09 million tons dumped illegally on land (Ramadan et al., 2026). Land-based mismanaged waste is also the dominant source of marine plastic pollution, placing

Indonesia among the top global contributors (Budiawan et al., 2024; Purba et al., 2019; Winardi & Putri, 2024). Organic waste also remains a dominant waste stream in Indonesia, while electronic waste is projected to increase by 14.91% annually and reach approximately 487,416 tons by 2028. These figures indicate the need for waste-management strategies that do not rely solely on downstream disposal, but also promote source separation, recycling, and sustained community participation (Aye & Widjaya, 2006; Hidayat et al., 2019; Sakti et al., 2021; Verstappen et al., 2016).

Higher education institutions are recognized as important settings for sustainable waste-management interventions. Indonesian Waste Management Law No.

18/2008 mandates waste management as a systematic, comprehensive, and continuous activity encompassing waste reduction and waste handling, with responsibilities assigned to government, local governments, communities, business actors, and waste-generating legal entities (Apriandini et al., 2024). Although higher-education institutions are not explicitly named, these institutions included within the law's scope insofar as they function as legal entities, facility managers, and generators of household-like waste. However, institutional commitment such as clear policies, education efforts, and supportive university governance plays a critical role in sustaining campus waste-management performance (Abdullah et al., 2017; Budiardjo et al., 2021). Recent studies indicate that continuous improvement mechanisms, including regular monitoring, feedback, and adjustments to infrastructure and engagement strategies, are necessary for long-term effectiveness (Ulhasanah et al., 2026).

In Indonesia, there's as a community-based approach to improve recycling and transform waste into an economic resource, in which locally known as *waste bank*. This concept adopts a banking-like system in which sorted recyclable waste is deposited, recorded, and converted into savings or other economic value (Budiarto et al., 2025; Fatmawati et al., 2022). Beyond economic incentives, this approach may also support environmental education and promotion, household waste sorting, community empowerment, and reduction of waste sent to final disposal sites (Almaidah et al., 2019; Nugroho, 2022; Purwendah & Wahyono, 2022; Raharjo et al., 2017). This approach has also been recognized in Indonesian regulation through Minister of Environment and Forestry Regulation No. 14 of 2021 on waste-bank management (Budiarto et al., 2025).

A health higher-education vocational institution in Yogyakarta adopt this community-based approach as part of its campus-based waste-management initiative, and implemented a mandatory policy requiring all members of the academic community, including students and employees, to monthly deposit sorted recyclable waste through this campus-based community recycling initiative. This policy was intended to improve recyclable waste management on campus and to foster routine waste-sorting and environmentally responsible behavior within a institutional setting. Although this community-based waste management program have been widely examined in community and household settings in Indonesia, empirical evidence on mandatory waste management policies within higher-education institutions remains limited. Most previous studies have focused on voluntary participation, community empowerment, economic benefits, or household-level recycling practices. Less attention has been given to how institutional mandates influence participation, compliance, internalized motivation, and policy support in institutional settings. Evidence remains limited on how mandatory waste-management policies operate in higher-education institutions, where students

and staff are expected to model healthy and sustainable practices. Therefore, this study aimed to evaluate participation in this initiative, routine monthly recyclable-waste management behavior, and support for continuation of the mandatory waste-bank policy among campus community members.

METHODS

Research Design

This study used an cross-sectional survey to evaluate the campus-based community recycling initiative, in which implemented a mandatory policy requiring all members of the academic community, including students and employees, to deposit sorted recyclable waste through the program every month. Data were collected at a single time point, therefore, the study assessed associations between respondent characteristics, program exposure, perceptions, and participation behavior, but did not establish causal or temporal relationships.

Population and Sample

The target population consisted of all campus community members covered by the mandatory waste management policy, including students, lecturers, educational staff, administrative staff, outsourced staff, and campus managerial team. The questionnaire was distributed online to the reachable target population through institutional communication channels. Respondents were eligible if they were members of the institution, were included in the target group of the campus waste management policy, and completed the online questionnaire during the data-collection period. Respondents with incomplete key outcome data were excluded from the relevant analyses. A total of 607 respondents completed the questionnaire and were included in the final analysis. Because participation was voluntary and the denominator of all individuals who received or opened the survey link not be fully verified, a precise response rate could not be calculated. This limitation is acknowledged in the interpretation of the findings.

Data Collection Instruments

The questionnaire was developed by the research team based on the objectives of the program evaluation and relevant concepts in the program participation, institutional policy compliance, environmental awareness, operational service experience, and policy support. The instrument covered respondent characteristics, awareness of the mandatory policy, program registration, routine waste-management behavior, motivation for participation, understanding of procedures, perceived accessibility, digital service availability, family or close-person involvement, perceived environmental cleanliness, perceived program effectiveness, satisfaction, and support for continuation of the policy. Content validity was assessed through expert judgment by individuals with relevant expertise in environmental health, waste management, and public health. The experts reviewed the questionnaire for relevance, clarity, comprehensiveness,

and contextual appropriateness. Items were revised based on their feedback before data collection. Because the questionnaire was specifically developed for this program evaluation and was not intended as a standardized psychometric scale, formal construct validation was limited. Data were collected online using online for on October 28–31, 2025.

Data analysis

Respondent characteristics, program exposure, participation, operational experience, and perceptions of the campus-based community recycling program were summarized descriptively. Categorical variables were reported as frequencies and percentages, while skewed numerical variables, including age and distance from residence to campus, were summarized using medians and interquartile ranges. The overall perception score was calculated as the mean of 14 Likert-scale items covering procedural clarity, accessibility, staff support, transparency, environmental and economic benefits, intention to continue participation, recommendation, and satisfaction; each item was scored from 1 to 5, with higher scores indicating more favorable perceptions. Two primary outcomes were assessed, routine monthly waste-managing behavior and support for continuation of the mandatory waste-management policy. Routine behavior was defined as reporting monthly waste management at the campus. Policy support was defined as answering "yes" to continuation of the mandatory policy, while "no," "maybe," and "do not know" were classified as not fully supporting the policy.

Key explanatory variables included respondent group, sex, age, motivation profile, procedural clarity, schedule accessibility, digital service availability, family or close-person involvement, perceived environmental cleanliness, perceived program effectiveness, and the overall perception score. Motivation profile was operationalized using two questionnaire items: whether respondents became program member because of the mandatory institutional policy and whether they recycling waste due to personal environmental awareness.

Respondents who answered "yes" to both items were categorized as having a compliant-internalized motivation profile, indicating both policy compliance and internalized environmental motivation. Respondents who answered "yes" only to the mandatory-policy item were categorized as compliance-only, while those who answered "yes" only to the personal-awareness item were categorized as intrinsic-only. Respondents who answered "no" to both items were categorized as low motivation/resistant. Because the low motivation/resistant group was very small, this category was excluded from multivariable regression analysis to avoid unstable estimates.

Routine monthly waste-managing behavior was defined based on respondents' answer to the questionnaire item asking whether they routinely report the recycling waste every month. Respondents answering "yes" were classified as having routine monthly waste-

managing behavior, while those answering "no" were classified as not routinely report the recycling waste every month. Because this outcome was based on self-report and was not verified using waste-bank transaction records, recall bias and subjective interpretation remain possible.

Support for continuation of the mandatory waste-management policy was measured using the item asking whether respondents agreed that the mandatory waste-management policy should be continued. Respondents answering "yes" were categorized as supporting policy continuation. Responses of "no," "maybe," and "do not know" were categorized as not fully supporting continuation of the mandatory policy. This classification was used to distinguish clear support from uncertain or negative responses.

Bivariate associations were examined using crude logistic regression and reported as crude odds ratios with 95% confidence intervals. Multivariable logistic regression was used to identify factors independently associated with each outcome, with adjusted odds ratios and 95% confidence intervals estimated using robust standard errors. Model diagnostics were conducted to assess multicollinearity and model performance.

Multicollinearity among predictors was examined using variance inflation factors after fitting linear regression models with the same sets of predictors as the logistic regression models. Model fit and discrimination were assessed using goodness-of-fit testing and receiver operating characteristic curve analysis after fitting the logistic regression models. Robust standard errors were used in the multivariable logistic regression models.

RESULTS AND DISCUSSION

Respondent characteristics

A total of 607 campus community members participated in this study. Table 1 summarizes respondents' sociodemographic characteristics and program registration status. Categorical variables are presented as frequencies and percentages, whereas numerical variables are summarized as medians, interquartile ranges, and minimum–maximum values.

Table 1 presents that most of the respondents were student (70.7%), female (82.7%), and registered as member of waste-management program at the campus (91.4%). We further describe the exposure, participation, and compliance with the program in table 2.

Table 1
Characteristics of respondents (N=607)

Characteristics of respondents (N=607)

Characteristics				n	%
Respondent status					
Student				429	70.7
Lecturer/Head of SPI				76	12.5
Educational staff/PLP				76	12.5
Staff				19	3.1
Outsourcing staff				7	1.2
Respondent group					
Student				429	70.7
Employee/staff				178	29.3
Sex					
Female				502	82.7
Male				105	17.3
Registered as member of waste-management program					
Yes				555	91.4
No				52	8.6
Numerical characteristics		n	Median	IQR	Min–Max
Age, years		605	20	19.0–35.0	17.0–68.0
Age among students, years		429	19	18.0–21.0	17.0–59.0
Age among employees/staff, years		176	45	35.5–55.0	24.0–68.0
Distance from residence to campus, km		585	3.2	0.6–15.0	0.0–64.0

Data are presented as n (%) unless otherwise indicated. Numerical variables are presented as median, interquartile range (IQR), and minimum–maximum values. Differences in n across numerical variables reflect missing data.

Exposure, participation, and compliance with the waste-management program

Table 2 presents respondents' exposure to the mandatory waste-management policy, participation in waste-recycling activities, and compliance with key program practices. Most respondents were aware of the waste-management policy and reported that they became member of the

program because of the mandatory policy. The table also summarizes respondents' understanding of accepted waste types, waste-sorting behavior, routine monthly waste reporting, household or close-person involvement, and participation.

Table 2. Exposure, participation, and compliance with the waste-management program

Variable	Valid n	Yes n(%)	No n (%)	Don't know/ Maybe, n (%)
Aware of the waste-management policy	607	537 (88.5)	17 (2.8)	53 (8.7)
Became a program member because of the mandatory policy	598	524 (87.6)	62 (10.4)	12 (2.0)
Recycling waste due to personal environmental awareness	590	505 (85.6)	83 (14.1)	2 (0.3)
Waste types accepted by the program were clear/easy to understand	600	564 (94.0)	15 (2.5)	21 (3.5)
Sorted waste by type before report it	600	579 (96.5)	15 (2.5)	6 (1.0)
Report waste-management routinely every month	594	274 (46.1)	320(53.9)	0 (0.0)
Managing waste together with family/close persons	597	398 (66.7)	199(33.3)	0 (0.0)
Participated in the program outside the campus	598	157 (26.3)	441(73.7)	0 (0.0)

Overall, 88.5% of respondents were aware of the waste-management policy, and 87.6% reported becoming program member because of the mandatory policy. Most respondents also reported recycling waste due to personal environmental awareness (85.6%), understanding the types of waste accepted by the waste bank (94.0%), and sorting waste by type before report it (96.5%). However, routine monthly waste reporting was less consistent, with only 46.1% of respondents reporting monthly participation, while 53.9% did not report waste routinely every month. In addition, 66.7% reported waste recycling together with family members or close persons, whereas participation in the programs outside the institution was relatively low at 26.3%.

Operational experience and perceived program effectiveness

Table 3 summarizes respondents' operational experience with the waste-management program and their perceptions of program effectiveness. This includes respondents' understanding of waste-management procedures, perceived accessibility of the service schedule, and other operational aspects related to the implementation of the campus waste-management policy.

Table 3. Operational experience and perceived program effectiveness

Variable	Valid n	Yes n (%)	No n (%)	Don't know/ Maybe, n(%)
Clearly understood the waste-management procedure	599	545 (91.0)	54 (9.0)	0 (0.0)
Service schedule was accessible/suitable with respondents' free time	597	507 (84.9)	58 (9.7)	32 (5.4)
Waste weighing process was transparent/trustworthy	591	572 (96.8)	9 (1.5)	10 (1.7)
Staff support was adequate when respondents faced difficulties	581	547 (94.1)	30 (5.2)	4 (0.7)
Location was strategic/easy to reach	580	538 (92.8)	38 (6.6)	4 (0.7)
Digital service was available for schedule/price/balance information	583	307 (52.7)	124 (21.3)	152 (26.1)
Surrounding environment became cleaner	591	506 (85.6)	22 (3.7)	63 (10.7)
Program was running well and effectively	587	505 (86.0)	17 (2.9)	65 (11.1)
Agreed that the mandatory waste-management policy should be continued	590	484 (82.0)	17 (2.9)	89 (15.1)

Most respondents clearly understood the waste-management procedure (91.0%), perceived the waste-weighing process as transparent and trustworthy (96.8%), considered staff support adequate when they encountered difficulties (94.1%), and reported that the location was strategic or easy to reach (92.8%). Most respondents also perceived that the surrounding environment had become cleaner (85.6%) and that the program was running well and effectively (86.0%). In total, 82.0% of respondents agreed that the mandatory waste-management policy should be continued. However, digital service availability remained relatively limited, with only 52.7% reporting that

digital services were available for schedule, price, or balance information.

Factors associated with routine monthly waste-managing behavior

Table 4 presents the crude and adjusted associations between respondent characteristics, motivation profile, operational experience, and routine monthly waste-managing behavior.

Table 4. Factors associated with routine monthly waste-depositing behavior

Predictor Category	OR (95% CI)	p-value	AOR (95% CI)	p-value
Respondent group				
Student	Reference		Reference	0.107
Employee/staff	3.25 (2.24–4.71)	<0.001	1.94 (0.87–4.35)	
Sex				
Male	Reference		Reference	0.333

Female	0.87 (0.57–1.33)	0.52	1.35 (0.73–2.49)	
Age (10-year increase)	1.42 (1.25–1.62)	<0.001	1.06 (0.81–1.40)	0.658
Motivation profile				
Compliant-internalized	Reference		Reference	
Compliance-only	0.26 (0.15–0.47)	<0.001	0.40 (0.21–0.76)	0.005
Intrinsic-only	0.96 (0.56–1.67)	0.893	1.11 (0.59–2.11)	0.741
Clear waste-management procedure				
No/do not know	Reference		Reference	
Yes	5.44 (2.52–11.77)	<0.001	2.39 (0.92–6.23)	0.075
Accessible service schedule				
No/do not know/maybe	Reference		Reference	
Yes	3.34 (1.99–5.61)	<0.001	1.71 (0.90–3.24)	0.099
Digital service available				
No/do not know/maybe	Reference		Reference	
Yes	4.70 (3.30–6.70)	<0.001	3.20 (2.15–4.77)	<0.001
Managing waste with family/close persons				
No	Reference		Reference	
Yes	3.22 (2.23–4.65)	<0.001	1.99 (1.28–3.08)	0.002

Outcome: routine monthly waste-managing behavior. Reference categories: student, male, compliant-internalized motivation profile, no/do not know/maybe for operational variables, and no family/close-person involvement. Note: The low motivation/resistant group was excluded from regression analysis because of its very small frequency.

No serious multicollinearity was detected among predictors included in the final regression models. For the routine monthly waste-management behavior model, the maximum variance inflation factor was 3.68 and the mean variance inflation factor was 1.71. For the policy-support model, the maximum variance inflation factor was 1.32 and the mean variance inflation factor was 1.23. These results indicate that multicollinearity was unlikely to substantially affect the regression estimates. In the adjusted model, respondents with a compliance-only motivation profile had lower odds of routinely report waste recycling every month than those with a compliant-internalized motivation profile (AOR, 0.40; 95% CI, 0.21–0.76). Availability of digital services was independently associated with higher odds of routine monthly waste-managing behavior (AOR, 3.20; 95% CI, 2.15–4.77), as was managing waste together with family members or close persons (AOR, 1.99; 95% CI, 1.28–3.08). Although

employee/staff status, older age, clear understanding of procedures, and accessible service schedules were associated with routine waste-managing behavior in crude analyses, these associations were attenuated after adjustment.

Factors associated with support for continuation of the mandatory waste-management policy

Table 5 shows factors associated with support for continuation of the mandatory waste-management policy. After adjustment, routine monthly waste-managing behavior remained independently associated with support for policy continuation (AOR, 3.09; 95% CI, 1.53–6.2

Table 5. Factors associated with support for continuation of the mandatory waste-bank policy

Category	OR (95% CI)	p-value	AOR (95% CI)	p-value
Respondent group				
Student	Reference		Reference	
Employee/staff	2.33 (1.35–4.00)	0.002	1.05 (0.49–2.25)	0.900
Motivation profile				
Compliant-internalized	Reference		Reference	

Compliance-only	0.19 (0.11–0.31)	<0.001	0.66 (0.30–1.44)	0.299
Intrinsic-only	2.01 (0.70–5.77)	0.195	1.89 (0.70–5.10)	0.21
Routine monthly waste-managing behavior				
No	Reference		Reference	
Yes	5.48 (3.20–9.39)	<0.001	3.09 (1.53–6.23)	0.002
Digital service available				
No/do not know/maybe	Reference		Reference	
Yes	5.94 (3.56–9.91)	<0.001	2.57 (1.26–5.26)	0.01
Environment became cleaner				
No/do not know/maybe	Reference		Reference	
Yes	8.54(5.14–14.18)	<0.001	3.90 (1.97–7.73)	<0.001
Program perceived as effective				
No/do not know/maybe	Reference		Reference	
Yes	8.27(4.97–13.77)	<0.001	4.47 (2.09–9.56)	<0.001
Overall perception score				
Per 1-point increase	5.70(2.84–11.42)	<0.001	2.92 (1.82–4.70)	<0.001

Outcome: support for continuation of the mandatory waste-management policy. Reference categories: student, compliant-internalized motivation profile, no routine monthly saving, and no/do not know/maybe for digital service availability, perceived environmental cleanliness, and perceived program effectiveness. Note: Responses of “no,” “maybe,” and “do not know” regarding policy continuation were categorized as not fully supporting continuation of the mandatory policy.

Respondents who reported that digital services were available also had higher odds of supporting continuation of the policy (AOR, 2.57; 95% CI, 1.26–5.26). Positive perceptions of program impact were strongly associated with policy support, including perceiving that the surrounding environment had become cleaner (AOR, 3.90; 95% CI, 1.97–7.73) and perceiving the program as effective (AOR, 4.47; 95% CI, 2.09–9.56). Each 1-point increase in the overall perception score was also associated with greater odds of supporting continuation of the mandatory policy (AOR, 2.92; 95% CI, 1.82–4.70). In contrast, respondent group and motivation profile were not independently associated with support for policy continuation after adjustment.

This study shows that the campus-based waste management program is a feasible model of campus-based community recycling initiative in a health higher-education institution. The program is also consistent with Indonesia’s waste-management framework, which positions waste management as a comprehensive effort involving waste reduction, handling, government responsibility, community participation, and behavioral change. Indonesia’s Ministerial Regulation Number 14/2021 provides a formal regulatory basis for waste-bank management, including the organization and governance of waste banks(Budiyarto et al., 2025) . Within this policy context, campus waste management program demonstrates how a higher-education institution can translate national waste-management principles into an operational campus policy. However, since this study used a cross-sectional design, the observed associations should

not be interpreted as causal relationships. For example, although digital service availability was associated with routine monthly waste depositing and policy support, the study cannot determine whether digital services increased participation or whether more active participants were more likely to notice and use digital services. Therefore, these findings should be interpreted as evidence of association.

The levels of awareness, program registration, understanding of accepted waste types, and waste sorting observed in this study suggest that mandatory institutional policy can establish initial participation. A recent review of waste management in higher-education institutions emphasized that effective campus waste systems require stakeholder engagement, communication, source separation, and acceptance by the campus community (Rodríguez-Guerreiro et al., 2024). Previous campus-based research similarly showed that 3R (*reduce, reuse, recycle*) initiatives can improve environmental attitudes, although voluntary approaches alone may not be sufficient to change actual recycling behavior (Tangwanichagapong et al., 2017). The program demonstrated high levels of awareness, registration, and reported waste-managing behavior, suggesting that the mandatory policy was able to establish formal participation and basic compliance. However, only 46.1% of respondents reported routine monthly waste reporting. This indicates that formal registration and awareness do not automatically translate into sustained behavior.

Despite most respondents were aware of the program and reported sorting and recycling waste, fewer

than half reported waste routinely every month. This pattern is consistent with behavioral studies showing that environmental knowledge or positive attitudes do not always translate into consistent waste-sorting or recycling behavior. Studies among university students have reported an intention-behavior gap in waste managing, and intervention studies suggest that clear rules, repeated prompts, and practical behavioral supports are needed to improve actual campus waste practices (Fenitra et al., 2025; Masukujjaman et al., 2025; Uehara et al., 2022). In the present study, respondents with a compliance-only motivation profile had lower odds of routine monthly waste reporting than those with compliant-internalized motivation, suggesting that obligation may initiate participation but internalized environmental values may be needed to sustain behavior.

The findings also highlight digital service availability was independently associated with both routine monthly waste reporting and support for continuation of the mandatory policy, yet only around half of respondents reported that such services were available. This suggests that digitalization is a practical priority for program strengthening. Evidence from digital waste-management program initiatives in Indonesia indicates that mobile applications and digital records can improve transparency, transaction tracking, communication, and customer engagement (Fahriza, & Yuliana, 2024). For the program in this study, digital features such as service schedules, price updates, balance tracking, reminders, and waste-reporting history may reduce operational friction and improve sustained participation.

This study also contributes to the literature by extending waste-management initiative evidence beyond household and community settings. Previous Indonesian studies have shown that collective waste management can support recycling potential, improve community awareness, generate economic value, and strengthen local participation (Ismiraj et al., 2023; Khair et al., 2019). Campus waste management program is therefore a useful example of how a waste-management model intervention can be adapted from community-based practice into an institutional health-education setting.

This study has several limitations. First, the cross-sectional design limits causal interpretation because exposure, perception, and outcome variables were measured at the same time. Second, the study relied on self-reported data, which may be affected by recall bias and social desirability bias, particularly because the program was implemented as a mandatory institutional policy. Third, because the questionnaire was distributed online through institutional communication channels, selection bias and non-response bias may have occurred. Fourth, routine monthly waste reporting was not verified using objective program records. Fifth, although the perception scale was assessed for internal consistency, the questionnaire was developed specifically for this program evaluation and was not a previously standardized instrument. Sixth, the study was conducted in a institution in Yogyakarta, which may limit generalizability to other

institutional settings. The study assessed current participation and policy support but did not evaluate long-term behavioral change or objective environmental outcomes.

The findings provide practical evidence that a mandatory campus waste-management policy can achieve high awareness, broad participation, and strong policy support. With improvements in digital services, routine engagement strategies, feedback systems, and reinforcement of internal motivation, the program has potential to be replicated in other higher-education institutions, especially health campuses seeking to integrate environmental responsibility into institutional culture.

CONCLUSION

This study found no statistically significant association between indoor environmental conditions, namely temperature, humidity, ventilation, and household density, and the presence of airborne microbes or the incidence of pulmonary tuberculosis among riverbank households in Alalak Selatan. These findings should be interpreted cautiously, as the study was conducted in a setting where environmental characteristics were highly homogeneous across households, limiting the ability to detect meaningful differences between case and control groups. Moreover, the cross-sectional design, small sample size, and absence of adjustments for individual-level confounders such as immune status, smoking, nutritional condition, and interpersonal contact patterns further constrain the generalizability of the results.

Rather than indicating that indoor environmental factors are unimportant, the findings suggest that in uniformly dense and ventilationally constrained riverbank settlements, structural housing characteristics alone may not sufficiently explain variations in TB incidence. Practical implications therefore include prioritizing behavioral and clinical determinants, such as early case detection, treatment adherence, smoking cessation, and nutritional support, while broader housing improvements remain relevant for long-term respiratory health. Future studies should incorporate larger sample sizes, multivariate approaches, and longitudinal environmental assessments to better disentangle the combined effects of environmental and host-level factors on TB transmission in similar communities.

SUGGESTION

Mandatory waste-management policies can serve as a feasible institutional model, but their long-term effectiveness depends on strengthening digital services, operational convenience, behavior-oriented education, and visible environmental outcomes. The program offers a practical and potentially replicable model for waste-management policy in higher-education institutions.

ETHICAL APPROVAL

The study received ethical approval from the Health Research Ethics Committee of Poltekkes Kemenkes Yogyakarta, No. DP.04.04/e-KEPK.1/1186/2025.

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The authors acknowledge the support program team during the implementation of this study. The first author is the initiator of the waste-management program. To minimize potential conflict of interest, the evaluation process, data handling, and initial interpretation were conducted primarily by the second author, who was not part of the campus community being evaluated and was not involved in the implementation of the program. The authors used AI-assisted tools solely to support language refinement, grammar, and clarity within the manuscript. The study concept, analytical framework, data analysis, interpretation, and conclusions were independently developed, reviewed, and approved by the authors.

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DECLARATIONS

The authors considered transparency and potential bias in the design and reporting of this study. Because the first author was directly involved in the development of the campus waste management program, evaluation procedures were independently assigned by second author to reduce potential influence on data interpretation.

AUTHOR CONTRIBUTIONS

The first author conceptualized the program and supervised the study. The second author conducted the evaluation process, data handling, and initial interpretation. The third author contributed to study design and program evaluation framework. All authors contributed to manuscript preparation, reviewed the final version, and approved the manuscript for submission.

CONFLICTS OF INTEREST

The first author is the initiator of the evaluated program. This potential conflict of interest was mitigated by assigning the evaluation process and initial data interpretation to the third author, who was independent from the evaluated campus community and program implementation. The other authors declare no additional conflicts of interest.

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