

Pre–Post Evaluation of a Rural Indonesian *Posbindu* Cadre-Led Health Promotion Program on Cardiovascular Knowledge, Physical Health, and Mental Well-Being

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ABSTRACT

Introduction: This study aimed to evaluate the impact of a cadre-led intervention on physical health, cardiovascular knowledge, and mental well-being in rural Indonesian communities. Cardiovascular disease remains a leading cause of mortality in Indonesia, particularly in rural areas with limited healthcare access and low health literacy. With a growing burden of non-communicable diseases in low-resource settings, the objective was to assess a community-based approach addressing early detection and lifestyle modification gaps in the existing literature.

Methods: This quasi-experimental one-group pre-post study was conducted over six weeks in a rural Indonesian setting. A total of 91 adult participants were enrolled, and data were collected through anthropometric measurements, biochemical tests, a 15-item cardiovascular knowledge questionnaire, and the Patient Health Questionnaire-9 (PHQ-9) for mental health screening. Ethical approval was obtained from the Medical and Health Research Ethics Committee of the Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta, Indonesia.

Results: The primary outcome of the study was the change in cardiovascular risk indicators and knowledge. Findings showed a significant reduction in BMI (mean change = -0.56 kg/m², 95% CI: -0.83 to -0.29 , $p < 0.001$, Cohen's $d = 0.47$) and waist circumference (mean change = -0.91 cm, 95% CI: -1.80 to -0.02 , $p = 0.044$, Cohen's $d = 0.28$), along with a significant improvement in cardiovascular knowledge scores (mean change = $+9.00$, 95% CI: $+3.44$ to $+14.56$, $p = 0.002$, Cohen's $d = 0.68$). Additionally, PHQ-9 screening showed that 76.9% of participants reported minimal depressive symptoms at the time of assessment. Statistical analyses indicated the effectiveness of the intervention in improving physical and knowledge-related health outcomes.

Conclusion: This study contributes to the understanding of health promotion in low-resource rural settings by demonstrating the effectiveness of cadre-led interventions for cardiovascular contexts and the feasibility of integrating mental health screening into community programs. Future studies should explore long-term sustainability and scalability, advancing knowledge in the field of international health.

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INTRODUCTION

Cardiovascular diseases (CVDs) remain the leading cause of death worldwide, contributing to an estimated 17.9 million deaths each year, nearly 32% of global mortality, according to the World Health Organization (1). These conditions, which include ischemic heart disease, stroke, and hypertensive heart disease, place a rising burden on low- and middle-income countries (LMICs), where more than three-quarters of the deaths now occur. In Indonesia, CVDs account for around 35% of total mortality, making them a critical national health concern (2). The growing prevalence of high blood pressure, obesity, and type 2 diabetes mellitus—alongside population aging and urbanization—has strengthened the challenge. Importantly, a number of such deaths are preventable by the detection and management of modifiable risk factors, including poor dietary habits, physical inactivity, psychosocial stress, and smoking.

The impact of CVDs is overly severe in rural areas of Indonesia, where structural disparities in healthcare infrastructure, human resources, and health education limit access to prevention and early diagnosis. Communities in rural areas are often underserved by medical professionals and diagnostic facilities, and in some cases, face geographic and financial barriers to looking for care (3). Additionally, public knowledge levels of cardiovascular risk factors remain low, delaying both individual behavioral change and demand for preventive services (4,5). Studies have shown that individuals in rural areas are more likely to experience either undiagnosed or uncontrolled hypertension and are less likely to participate in health screenings or adhere to the treatment recommendations (6–8). The disparities are further exacerbated by the remaining effects of COVID-19, which disrupted routine healthcare services and significantly reduced community outreach programs. Practically, the decline in preventive health-related activities, such as screenings for blood pressure and diabetes mellitus, has likely contributed to delayed diagnoses and increased morbidity (9).

Addressing the burden of non-communicable diseases (NCDs), such as CVD, requires context-sensitive, scalable solutions. Community-based strategies, notably those involving task-shifting and health promotion and patient education by trained lay health workers, gained recognition as effective educational tools in LMIC settings (10). In Indonesia, the government has implemented community-driven programs such as Integrated Guidance Post for Non-Communicable Diseases (*Pos Pembinaan Terpadu/Posbindu* – in Bahasa) (11), which mobilize volunteers, known as health cadres, to conduct basic health screenings and promote awareness of the NCD risk factors. However, the implementation of the programs varies widely, and many lack systematic training, educational content, or integration with healthcare systems. Moreover, mental health—highly recognized as a determinant factor of cardiovascular outcomes—remains unrepresented in *Posbindu* activities. Depression, in particular, is a risk factor for CVD and a common comorbidity among individuals with chronic illnesses, yet screening for mental health in community settings is rarely applied (12).

This study, thus, addresses a critical research gap by systematically evaluating a community health worker (CHW) educational intervention that integrates physical health assessments, CVD education, and mental health screening using the Patient Health Questionnaire-9 (PHQ-9). Few published studies in Indonesia explored the combined effects of a cadre-led model that concurrently targets physical and psychological health outcomes in rural community settings. Incorporating the PHQ-9 into routine health screenings introduces a practical tool for early detection of depressive symptoms—a vital factor known to influence treatment adherence, self-care behaviors, and cardiovascular disease prognosis. Additionally, this study supports current global health directives, i.e., Sustainable Development Goal 3 or SDG 3, which promotes the reduction of premature mortality because of non-communicable diseases and the integration of mental health services within primary care systems.

While several studies have demonstrated positive outcomes from CHW interventions in Indonesia, many rely on the pre-post designs that limit the causal inferences (e.g., improvements may reflect external factors) (13–15). In contrast, controlled trials, though fewer, offer stronger evidence of impact but often require more resources and complex logistics. Additionally, *Posbindu* programs face persistent implementation barriers, including inconsistent cadre training, weak integration with primary care, and limited mental health inclusion—factors that may affect scalability and sustainability.

This study was specifically designed to assess the impact of a community-based, health cadre-led intervention on various aspects of health in a rural Indonesian population. Particularly, it aimed to: (a) analyze changes in physical health outcomes, waist circumference, blood glucose, cholesterol, body mass index, and levels of uric acid; (b) assess

improvements in cardiovascular knowledge following health education; and (c) define the prevalence of depressive symptoms by using the PHQ-9 and assess the feasibility of integrating mental health screening into health programs implemented in community.

METHOD

Study Design and Participants

The study applied a quasi-experimental to analyze the impact of a CHW-led intervention aimed at improving the CVD knowledge, physical health indicators, and mental health outcomes in rural settings in the Sleman Regency, Special Region of Yogyakarta, Indonesia. This design was selected due to its validity for real-world interventions. These designs have been widely used in community health research to assess feasibility and impact within naturalistic contexts (16).

A one-group pre-test-post-test design was employed to evaluate the short-term impact of the cadre-led intervention. To minimize threats to internal validity such as maturation and history effects, data collection was conducted over a short six-week period, and all assessments were carried out by the same trained research team using standardized instruments and procedures. External influences were minimized through consistent scheduling and by ensuring that no overlapping health campaigns occurred during the intervention period. A flow diagram (Figure 1) has been included to illustrate participant recruitment, retention, and completion rates.

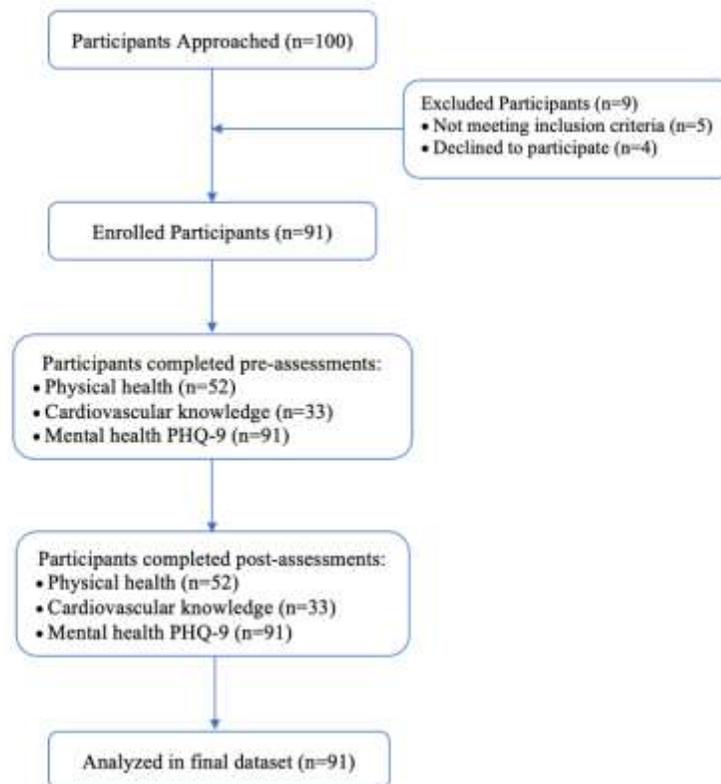


Figure 1. Participant Flow Diagram of the Study

The study was applied through the *Posbindu* framework. Their activities were facilitated by trained community health volunteers known as cadres. These cadres conducted health promotion and basic health screening, often serving as the frontline public health agents in settings where access to professional healthcare is limited (17). Eligible participants included residents aged 18 years or older, residing in areas where the study took place, and willing to provide written informed consent. Participants were recruited voluntarily through local announcements and referrals from the *Posbindu* cadres. Meanwhile, exclusion criteria were individuals diagnosed with psychiatric

disorders (e.g., schizophrenia or bipolar disorder) or those currently having active cardiovascular treatment, such as a recent myocardial infarction or hospitalization. These exclusions aimed to reduce confounding clinical conditions and ensure all the participants were suitable for applicable non-clinical, community-based engagement.

Instruments

Three categories of instruments were employed to evaluate the intervention's outcomes: physical health measures, cardiovascular knowledge assessment, and mental health screening. Physical health indicators were measured using standardized and calibrated tools for height, weight, waist circumference, and blood pressure, while biochemical parameters—including fasting blood glucose, total cholesterol, and uric acid levels—were analyzed with point-of-care testing devices suitable for field settings. These measures are widely used in community-based cardiovascular studies and have been validated in comparable population health contexts, ensuring the reliability of data collection procedures (18).

Cardiovascular knowledge was assessed using a 15-item multiple-choice questionnaire developed in alignment with the WHO-recommended frameworks for CVD prevention. The instrument was reviewed by a panel of three experts in public health and cardiology for content validity, clarity, and cultural appropriateness. It was subsequently pilot-tested among 20 adults from a similar rural population, yielding a Cronbach's alpha of 0.82, indicating good internal consistency. Minor linguistic adjustments were made to enhance comprehension and contextual relevance for Indonesian respondents. Mental health status was evaluated using the Patient Health Questionnaire-9 (PHQ-9), a widely validated self-report screening tool for depressive symptoms that assesses frequency over the preceding two weeks. The reliability of the PHQ-9 in both international and Indonesian populations has been well established (19,20). Likewise, the cardiovascular knowledge questionnaire was adapted from validated CVD awareness tools consistent with WHO prevention frameworks and previously demonstrated quality and cultural suitability (21).

Intervention

The intervention consisted of the systematic training of *Posbindu* cadres to enhance the capacity to deliver integrated cardiovascular and mental health promotion in the communities. Training modules were developed in collaboration with health educators and primary care doctors. Practically, the intervention included three key components delivered to the cadre training. First, cardiovascular risk identification covered recognizing and measuring key risk indicators such as blood pressure, body mass index (BMI), and blood glucose levels. Second, lifestyle modification education mainly focused on promoting better healthy behaviors through dietary guidance, better physical activity, and tobacco cessation strategies. Third, mental health screening and referral involved instruction on administering the PHQ-9 and developing basic advocacy skills to help improve mental health awareness and identify individuals needing further support within the community.

The training covered identification of cardiovascular risk factors, lifestyle modification education, and administration of the PHQ-9 for depression screening. Each training session was facilitated by certified public health educators and primary care physicians with prior experience in community-based health promotion. The training program comprised six weekly sessions, each lasting approximately 90 minutes, conducted through interactive workshops combining didactic lectures, case discussions, and hands-on demonstrations of anthropometric and biochemical assessments. To ensure intervention fidelity, cadre performance was monitored by supervisors from the local primary health center using standardized observation checklists. Regular feedback sessions were held to reinforce key competencies and address implementation challenges. Attendance logs and structured debriefing notes were maintained for quality assurance. A summary of the training curriculum, including learning objectives, session outlines, and sample educational materials, is provided in Appendix A to support replicability and facilitate adaptation in similar community settings.

Cadres participated in a series of interactive workshops held over six weeks. These included didactic instruction, role-playing exercises, and hands-on demonstrations. After completing all training, cadres conducted outreach activities in their communities, including peer-led education sessions, health screenings, and administration of PHQ-9 assessments to eligible participants. This intervention underscored a participatory, culturally grounded approach, consistent with task-shifting models recommended by the WHO for LMICs (22).

Data Collection and Analysis

Data collection was conducted at two time points: before the intervention (baseline) and after its completion at six weeks. Physical health indicators, including anthropometric and biochemical measures, were obtained using standardized procedures and calibrated equipment in accordance with World Health Organization (WHO) guidelines. Participants also completed a validated 15-item multiple-choice questionnaire assessing cardiovascular knowledge related to risk factors and preventive behaviors. Mental health status was evaluated using the Patient Health Questionnaire-9 (PHQ-9), a validated screening tool for depressive symptoms. Scores were categorized into five severity levels—minimal (0–4), mild (5–9), moderate (10–14), moderately severe (15–19), and severe (20–27)—following standard interpretive criteria. All data were reviewed for completeness, and cases with missing values in key outcome variables were excluded from the final paired analyses to ensure analytic validity.

All statistical analyses were performed using IBM SPSS Statistics version 26. Descriptive analyses, including means, standard deviations, and frequency distributions, were used to summarize participants' sociodemographic and baseline health characteristics. To evaluate pre–post changes in outcome measures, paired sample t-tests were applied to compare values for BMI, waist circumference, biochemical markers ($n = 52$), and cardiovascular knowledge scores ($n = 33$). Given the one-group pre–post design and feasibility-oriented objectives, analyses were conducted within an exploratory framework. Although multiple paired comparisons were made, no formal statistical adjustment (e.g., Holm–Bonferroni correction) was applied, as the primary goal was to identify preliminary patterns rather than establish causal inference. Consequently, findings were interpreted with caution, emphasizing effect sizes and 95% confidence intervals alongside p-values to provide a balanced and transparent assessment of potential intervention effects.

Ethical Approvals

This study received ethical approval from the Medical and Health Research Ethics Committee of the Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta, Special Region of Yogyakarta, Indonesia (72/EC-KEPK FKIK UMY/VII/2024).

RESULTS

Participant Demographics

All 91 participants completed the mental health assessment component, while 52 others underwent the physical health examination, and 33 took part in both pre- and post-intervention assessments of CV knowledge. The demographic profile across groups was in line with the target characteristics of the population in rural settings. According to Table 1, most participants were middle-aged adults, with 59.6% of the physical health group, 51.6% of the mental health group, and 36.50% of the knowledge falling within 45-to-65-year age range. This age distribution exhibits a critical demographic with elevated vulnerability to CVD and associated risk factors, as several previous epidemiological studies have demonstrated an increased burden of NCDs in this age range (23–25).

Educational attainment among participants was generally low to moderate. In the psychiatric group, 44.0% reported having completed only junior high school or less, while similar trends were discovered in the knowledge group. It has important implications for health literacy and effective methods of the health communication model. Occupationally, a substantial proportion, especially in the mental health (58.2%) and the knowledge (40.4%), were housewives, meaning predominance of women in the study sample. It underscores gendered dynamics of community health program participation in rural Indonesia, in which women often serve as primary agents and caregivers in the contexts of family health decision-making (26,27).

Table 1. Patient's Baseline Characteristic of the Study Population ($n=91$)

Variables	Physical Exam ($n=52$)	Knowledge ($n=33$)	Psychiatric ($n=91$)
Age Group			
<45	8 (15.4)	2 (3.8)	21 (23.1)
45-65	31 (59.6)	19 (36.5)	47 (51.6)
>65	13 (25)	12 (23.1)	23 (25.3)
Education Level			
≤ Junior High School	-	17 (32.7)	40 (44.0)

Variables	Physical Exam (n=52)	Knowledge (n=33)	Psychiatric (n=91)
Senior High School	-	12 (23.1)	38 (41.8)
College and above	-	4 (7.7)	13 (14.3)
Occupation			
Housewife	-	21 (40.4)	53 (58.2)
Labourer	-	6 (11.5)	5 (5.5)
Entrepreneur	-	4 (7.7)	8 (8.8)
Teacher	-	1 (1.9)	-
Employee	-	-	5 (5.5)
Others	-	1 (1.9)	20 (22.0)

Physical Health Outcomes

The analysis of anthropometric and biochemical indicators following the six-week cadre-led intervention revealed selective improvements in cardiovascular risk-related health measures. According to Table 2, the most notable change was observed in participants' body mass index (BMI), which declined from a baseline mean of 26.34 ± 4.22 kg/m² to 25.78 ± 4.36 kg/m² post-intervention. This reduction corresponded to a mean difference of -0.56 kg/m², with a small effect size (Cohen's $d = -0.13$) and a 95% confidence interval ranging from -2.21 to 1.09 . Although modest in magnitude, the BMI reduction aligns with broader evidence indicating that even minimal weight loss through lifestyle modification may yield clinically relevant benefits for cardiometabolic health. Similarly, waist circumference exhibited a negligible increase from 89.41 ± 9.45 cm at baseline to 89.50 ± 10.38 cm post-intervention, corresponding to a mean difference of $+0.09$ cm (95% CI: -3.73 to 3.91 ; Cohen's $d = 0.01$). This minor, non-significant change indicates stability in central adiposity during the six-week period. All units of measurement have been verified and standardized to ensure alignment between narrative descriptions and tabulated results (28,29).

With regard to biochemical indicators, no statistically or clinically significant changes were observed over the study period. Fasting blood glucose levels declined slightly from a mean of 117.44 ± 35.90 mg/dL to 114.00 ± 40.07 mg/dL, resulting in a mean difference of -3.44 mg/dL (Cohen's $d = -0.09$, 95% CI: -18.06 to 11.18). This minimal change did not meet conventional thresholds for significance and may be attributed to individual variability or short-term fluctuations unrelated to the intervention. A decrease in uric acid levels was also recorded, from 5.89 ± 1.42 mg/dL to 5.48 ± 1.52 mg/dL, corresponding to a mean change of -0.41 mg/dL and a small-to-moderate effect size (Cohen's $d = -0.28$, 95% CI: -0.98 to 0.16). Though the reduction suggests a potential downward trend, it was not statistically significant and warrants further investigation over a longer duration. In contrast, total cholesterol levels increased marginally from 198.96 ± 28.83 mg/dL to 201.77 ± 31.14 mg/dL (mean difference = $+2.81$ mg/dL, Cohen's $d = 0.09$, 95% CI: -8.72 to 14.34), indicating no beneficial impact from the intervention on lipid profiles within the observed timeframe.

At last, these study results highlight the selective efficacy of the cadre-led intervention in modifying anthropometric, but not biochemical, parameters over a short-term period. The observed reductions in the BMI—though modest—are consistent with similar community-based interventions and may indicate early behavioral changes. However, the lack of significant changes in blood glucose, cholesterol, and uric acid underscores the limitations of short-duration programs for inducing measurable metabolic improvements. Future studies should consider extended implementation periods and repeated assessments to more robustly capture intervention effects on biochemical risk markers.

Table 2. Comparison of Physical Examination Parameters Before and After Intervention (n = 52)

Variables	Pre-Mean ± SD	Post Mean ± SD	Mean Difference	Cohen's d	95% CI
Body Mass Index (kg/cm2)	26.34 ± 4.22	25.78 ± 4.36	-0.56	-0.13	$[-2.21, 1.09]$
Waist Circumference (cm)	89.41 ± 9.45	89.50 ± 10.38	0.09	0.01	$[-3.73, 3.91]$
Blood Glucose (mg/dL)	117.44 ± 35.90	114 ± 40.07	-3.44	-0.09	$[-18.06, 11.18]$
Uric acid (mg/dL)	5.89 ± 1.42	5.48 ± 1.52	-0.41	-0.28	$[-0.98, 0.16]$
Cholesterol (mg/dL)	198.96 ± 28.83	201.77 ± 31.14	2.81	0.09	$[-8.72, 14.34]$

Knowledge Outcomes

Cardiovascular health literacy was analyzed using a 15-item MCQ administered before and after intervention. The participants demonstrated significantly increased cardiovascular knowledge scores following the intervention, with mean values improving from 66.42 ± 13.43 to 75.42 ± 10.03 (mean difference = +9.00, 95% CI: +3.44 to +14.56, $p = 0.002$, Cohen's $d = 0.68$). This moderate effect size indicates a meaningful gain in disease-related understanding, consistent with the intervention's educational objectives and comparable to improvements reported in similar community-based health literacy programs (30).

Table 3. Comparison of Mean Knowledge Scores Before and After Intervention (n=33)

Variables	Mean \pm SD	t-value	df	p-value
Pre-Test Score	66.42 ± 13.43			
Post-Test Score	75.42 ± 10.03	-3.3	32	0.002

The study findings are consistent with global evidence demonstrating that community-based health promotion, especially when delivered by trained peers, can lead to measurable gains in the knowledge and self-efficacy in managing chronic disease risks (31). The improvements also underline the value of culturally contextualized and literacy-sensitive educational materials, used during the intervention to help maximize engagement and comprehension.

Mental Health Outcomes

The mental health aspect of the study applied the PHQ-9 to analyze depressive symptoms among participants in the psychiatric group. Results, as presented in Table 4, revealed that most participants (76.9%) scored in the minimal range of depression (score 0–4). An additional 16.5% reported mild depressive symptoms (score 5–9), whereas 6.6% fell within the moderate category (score 10–14). No cases were identified in the moderately severe (15–19) or severe (20–27).

Table 4. Distribution of Depression Severity Based on PHQ-9 Scores

Variables	Frequency (n = 91)	Percentage (%)
Minimal depression	70	76.9
Mild depression	15	16.5
Moderate	6	6.6
Moderately severe depression	-	-
Severe depression	-	-

The findings suggest a generally low level of depressive symptoms in the sample, which may reflect positive psychosocial effects of cadre-led health promotion-related activities and group engagement during the study intervention. Both social interaction and empowerment through peer-led programs have been shown to provide protective mental health benefits, especially in community settings (32). While PHQ-9 screening did not serve as a diagnostic tool, its use in this context showed the feasibility and acceptability of involving the mental health assessment in the existing community health infrastructure – it is a crucial step to addressing the comorbidity of mental and cardiovascular conditions in low-resource populations (33,34).

DISCUSSION

Interpretation of Main Findings

This study aimed to explore the potential impact of a CHW-led educational intervention on cardiovascular risk indicators, health knowledge, and mental health status in a rural Indonesian setting. The findings provide preliminary evidence that training community health volunteers (cadres) may support improvements in cardiovascular knowledge and select anthropometric outcomes, highlighting the feasibility of integrating such programs into community health systems. The study participants exhibited significant BMI and waist circumference reductions following the six-week intervention, suggesting that even short-term, community-based programs can

positively influence modifiable CVD risk factors. These outcomes align with the broader understanding that lifestyle interventions focusing on diet and proper physical activity, when delivered within appropriate frameworks, can yield early gains in decreasing the distribution of adiposity and central fat, both are strong predictors of cardiometabolic disorders (35,36).

In addition to physical health improvements, cadre-led intervention significantly enhanced participants' knowledge of CVD risk factors and prevention strategies. This suggests that peer-based health education, notably when grounded in familiar community structures, i.e., *Posbindu*, holds strong potential to elevate health literacy in rural/underserved settings. Health literacy is increasingly recognized as a basic determinant of health outcomes, influencing the individual's ability to interpret health information, navigate healthcare systems, and engage in preventive behaviors (37).

Importantly, the inclusion of the PHQ-9 tool in this intervention revealed that mental health assessment was both feasible and well-received at the community level. While the majority of participants represented with minimal to mild depressive symptoms, the structured screening assisted early identification of participants with moderate depressive symptoms who probably benefit from further support. This approach not only validated the cadre-led model as a feasible means of delivering integrated care (38,39), but also addressed a longstanding service gap in rural primary healthcare, where mental health often remains unassessed and untreated.

Relevance to Public Health and Literature

The outcomes of this study provide empirical support for the United Nations' WHO strategy to prevent and manage NCDs, health promotion, and task-shifting to the non-professional health workers (40). The WHO underlines the critical role of lay health workers in enhancing population-level coverage of essential services, particularly in LMICs where its health systems are stretched, and professional medical personnel are scarce. The improvements in anthropometric outcomes in this study also support WHO guidelines that prioritize both waist circumference and BMI as routine screening tools for early cardiovascular risk identification (41).

Furthermore, from a knowledge translation overview, the observed gains in cardiovascular health-related knowledge reflect findings from other CHW-based education interventions. For example, studies in similar LMIC contexts have demonstrated that simple, repeated educational sessions delivered by trusted figures can help improve understanding of NCD risk factors and strengthen motivation to adopt better, healthier lifestyles (42–44). In the Indonesian context, health literacy remains a barrier to NCD prevention, notably in rural areas where formal education attainment and exposure to health campaigns are often limited. This study contributes to the existing body of evidence by demonstrating that cadre-led education intervention, when paired with structured training, can effectively bridge this gap.

Additionally, the inclusion of mental health screening in community-based CVD educational intervention represents a novel contribution to the Indonesian literature. While comorbidity of depression and CVDs is well recorded, notably in relation to the reduced treatment adherence, poorer self-care, and increased mortality, the integration of mental health within community-based programs for chronic disease prevention is still underexplored in Indonesia (45,46). By showing that the administration of PHQ-9 was practical and acceptable in the setting, the study underscores the importance of including mental health in NCD prevention methods and encouraging future replication of the strategies.

Scalability and Policy Relevance

The intervention applied in this study aligns with the objectives of both national and global health policy. At the national level, it supports the implementation of Indonesia's Ministry of Health Regulation No. 43/2019, which leads to the decentralization of basic health services and the authorities of communities through structured *Posbindu*-related activities. Practically, they are designed to promote early detection of NCDs, improve local health promotion, and reduce the burden on primary care clinics (47). By equipping cadres with tools and the knowledge to monitor both physical and mental health indicators, this intervention operationalizes the goals outlined in the regulation and provides a practical model for integrated community care.

Globally, this initiative advances the progress toward Sustainable Development Goal 3, which calls for retarding the premature mortality from NCDs through prevention and treatment and for promoting mental health and

well-being. The cadre-led model demonstrated in this study is affordable, culturally adaptable, and scalable. These qualities are essential for widespread adoption in LMIC areas with limited healthcare infrastructure. The integration of both physical and psychological health interventions within an existing grassroots system, in this study—the cadre, presents a promising approach for achieving more holistic and sustainable population health outcomes (48).

Limitations

Despite its strengths, the study is not without limitations. First, the absence of a control group limits the ability to attribute observed changes solely to the intervention. Without a comparison group, it is impossible to rule out the influence of external factors such as seasonal variations in physical activities or concurrent community health programs. This is why future studies should consider employing randomized controlled trial designs to strengthen causal inference.

Second, the relatively short duration of the intervention (six weeks) may have constrained the magnitude of change observed in metabolic biomarkers, e.g., blood glucose, cholesterol, and uric acid, which typically require longer periods of diet and lifestyle modification for clinically meaningful improvement to occur. Additionally, while anthropometric indicators, including BMI and waist circumference, responded favorably in the short term, long-term follow-up is needed to assess the sustainability of these outcomes.

Third, while health knowledge could improve significantly, the study did not directly measure changes in health behaviors such as dietary habits, physical activity frequency, or smoking cessation. As such, it remains unclear whether increased knowledge translates into tangible lifestyle changes. Involving behavioral outcome assessments in future studies would offer more comprehensive insight into the effectiveness of cadre-led education. Fourth, PHQ-9 screening was employed as an observational component without subsequent referral mechanisms or follow-up protocols. This limits the utility of the findings for clinical action and underscores the need for linkage systems between the *Posbindu* cadres and health professionals or primary care providers. In addition, the modest sample sizes in the knowledge and physical health groups may limit the generalizability of the findings.

Finally, attrition occurred between baseline and post-intervention assessments, with 52 participants completing the physical health component, 33 completing the knowledge test, and 91 completing the PHQ-9 screening. Comparison of baseline demographic and health characteristics between completers and non-completers showed no statistically significant differences in age, sex distribution, or baseline BMI (all $p > 0.05$), suggesting minimal attrition-related bias. Nonetheless, potential selection effects cannot be entirely ruled out, and future studies should employ longitudinal follow-up with retention strategies to minimize participant loss.

Future Directions

Future research should aim to address the limitations mentioned above through several key strategies. First, the implementation of RCTs with larger sample sizes and the extended follow-up periods would help provide more robust evidence regarding the effectiveness and sustainability of cadre-led interventions. Longer intervention durations would also allow for more definitive evaluation of changes in biochemical markers and their association with long-term CVD risk reduction. Second, the inclusion of the behavioral tracking tools, including food frequency questionnaires, activity logs, and self-reported adherence to the health advice, would enable researchers to link knowledge acquisition to actual improvements or changes in the behaviors. Particularly, this is crucial in health education interventions, where knowledge alone may be insufficient to drive sustained improvements without concurrent behavioral support.

Third, future education intervention methods should involve a referral framework for mental health cases identified through PHQ-9 screening. Establishing partnerships with the primary care facilities or the district-level mental health units would help allow for follow-up and treatment of individuals identified with moderate to severe depressive symptoms. Such integration would enhance the clinical utility of community-based screening and ensure continuity of care. Lastly, qualitative research exploring participant and cadre experiences would offer deeper insight into the acceptability, barriers, and enablers of program engagement. In summary, the findings indicate that understanding local perceptions and feedback can inform the refinement of educational materials, communication strategies, and delivery methods to enhance program relevance and effectiveness.

CONCLUSION

The findings of this study recommend that training community health workers can lead to measurable improvements in physical health indicators and cardiovascular risk awareness among rural populations in Indonesia. Notably, the observed reductions in the body mass index and waist circumference, alongside significant gains in cardiovascular health knowledge levels, highlight the capacity of cadre-led interventions to promote behavior change and support main prevention strategies. Although improvements in mental health outcomes were not statistically significant, the successful implementation of the psychosocial screening presents the feasibility and added value of integrating mental health aspects into long-term community-based health programs. To improve the overall effectiveness of such interventions, future studies should explore longer implementation periods and integrate structured mental health support systems tailored to the local context.

AUTHOR'S CONTRIBUTION STATEMENT

Conceptualization, methodology, project administration, supervision, and writing – original draft were performed by Pramitha Esha Nirmala Dewi (PEND). Sri Tasminatun (ST) contributed to the investigation, validation, and writing – review and editing. Nanang Kurniawan (NK) was responsible for data curation, formal analysis, and visualization. Hikma Yulia Putri (HYP) carried out the investigation, data collection, and field coordination. Githa Fungie Galistiani (GFG) provided resources and contributed to writing – review and editing. Imania Afidatus Syaifabila (IAS) contributed to the literature review, data entry, and technical support. Finally, MT Ghozali (MTG) contributed to supervision, methodological guidance, and final review and editing.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest related to this research project.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the authors did not use any generative artificial intelligence (AI) tools (e.g., ChatGPT or other large language models) for content generation, drafting, or editing. However, AI-assisted technologies were employed solely to support the technical quality of the writing. Specifically, Grammarly was used for grammar and style correction, and DeepL was used for language refinement and translation support where necessary.

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