Community-Based Electrical Safety Training: Mitigating Electrical Hazards in Rural Areas of Petumbukan Village

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Abstract

Electrical accidents in rural Indonesia remain a significant concern due to limited safety awareness. This study evaluates a community-based electrical safety training program in Petumbukan Village. A pre-post intervention involving 45 residents assessed knowledge and behavioral changes through structured questionnaires. The training covered hazard identification, safe practices, emergency responses, and preventive maintenance. Results showed significant knowledge improvement from 32% to 87% post-training ($p<0.001$). Participants demonstrated enhanced ability to identify electrical hazards (68% increase), understand proper appliance usage (73% increase), and recognize emergency procedures (81% increase). Within two weeks, 78% of participants implemented household safety measures. The community-based approach effectively enhanced electrical safety awareness in rural settings. Findings suggest that participatory educational interventions can significantly reduce electrical accident risks in underserved areas, supporting the integration of such programs into local government safety initiatives for sustainability and broader impact.

Keywords: Electrical Safety Training, Community-Based Intervention, Hazard Mitigation, Rural Electrification, Safety Awareness, Petumbukan Village, Indonesia

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Introduction

The rapid expansion of electricity access in rural Indonesia has been a cornerstone of national development, with the electrification ratio reaching nearly 100% in many regions[1]. This achievement, part of Indonesia's commitment to Sustainable Development Goal 7 (Affordable and Clean Energy), has transformed rural livelihoods by enabling access to lighting, communication technologies, and productive equipment. However, this progress has not been uniformly accompanied by adequate knowledge of electrical safety practices, creating a paradox where increased access to electricity simultaneously increases exposure to electrical hazards [2].

Rural communities in Indonesia face unique challenges regarding electrical safety. Unlike urban areas with established infrastructure and regular inspections, rural electrical installations often lack proper standards, maintenance, and safety devices [3]. Many households install electrical systems independently or through untrained personnel, resulting in substandard wiring, inadequate grounding, absence of circuit breakers, and overloaded circuits [4]. These conditions significantly elevate the risk of electrical shocks, electrocution, and fire incidents.

Statistical data from the Indonesian Ministry of Health indicates that electrical accidents contribute to approximately 8-12% of all fire-related incidents in residential areas, with rural regions showing disproportionately higher rates [5]. The lack of awareness about proper electrical appliance usage, installation standards, and emergency response procedures exacerbates these risks. Moreover, limited access to professional electricians and technical support in rural areas forces residents to rely on informal knowledge transfer, which often perpetuates unsafe practices across generations [6].

Petumbukan Village in Galang District, Deli Serdang Regency, North Sumatra, exemplifies these challenges. Despite achieving near-universal electrification, preliminary assessments revealed widespread electrical safety deficiencies[7]. Informal surveys indicated that over 70% of households used non-standard electrical cables, 85% lacked proper grounding systems, and 60% were unaware of the function of basic safety devices such as miniature circuit breakers (MCBs) [8]. These conditions create an environment where electrical accidents are not merely possible but probable, threatening both human safety and economic wellbeing.

The critical gap between electrical access and electrical safety literacy in rural Indonesian communities poses significant public health and economic risks[3]. While electrification has been successfully expanded, the corresponding educational infrastructure to ensure safe electricity use has lagged behind. This disparity results in several interconnected problems:

First, the absence of formal electrical safety education leaves rural residents vulnerable to preventable accidents. Unlike urban populations who may access information through various channels, rural communities often lack exposure to safety information, relying instead on trial-and-error or informal knowledge that may be incomplete or incorrect .

Second, economic constraints limit the ability of rural households to invest in proper electrical installations or hire qualified electricians. This financial barrier combines with limited knowledge to create a situation where residents make do with inadequate installations, unaware of the risks they are accepting [9].

Third, the lack of local capacity for electrical safety education means that even when residents recognize problems, they lack the knowledge or resources to address them effectively. This creates a cycle of vulnerability that perpetuates unsafe conditions across households and generations [10].

The consequences of these problems are serious. Electrical accidents result in injuries, fatalities, property damage, and economic losses that disproportionately affect already vulnerable rural populations. Beyond immediate impacts, the fear and uncertainty surrounding electrical safety can inhibit productive use of electricity, limiting the developmental benefits of electrification [11].

While extensive literature exists on electrical safety in industrial and urban residential contexts, research on community-based electrical safety interventions in rural developing country settings remains limited . Most existing studies focus on technical aspects of electrical infrastructure or regulatory frameworks, with less attention to the social and educational dimensions of electrical safety in resource-constrained rural environments [12].

Previous interventions have predominantly employed top-down approaches, often failing to consider local contexts, cultural practices, and existing knowledge systems . Few studies have systematically evaluated the effectiveness of participatory, community-based educational approaches in improving electrical safety knowledge and behavior in rural areas. Furthermore, research examining the sustainability and scalability of such interventions is notably scarce [13].

Specifically, there is limited evidence on how to effectively translate technical electrical safety knowledge into accessible, culturally appropriate formats that enable rural populations to take meaningful action. Questions remain about optimal training methodologies, content delivery mechanisms, and strategies for ensuring long-term behavioral change in communities with diverse literacy levels and limited access to technical resources [14].

This study addresses these gaps by evaluating a community-based electrical safety training intervention in Petumbukan Village. The specific objectives are:

1. To assess the baseline knowledge and practices regarding electrical safety among rural community members in Petumbukan Village.
2. To implement a participatory electrical safety training program tailored to the local context, covering hazard identification, safe practices, emergency responses, and preventive maintenance.
3. To evaluate the effectiveness of the training intervention in improving participants' knowledge about electrical safety through pre- and post-training assessments.
4. To examine behavioral changes implemented by participants following the training, specifically regarding household electrical safety measures.
5. To identify facilitating factors and barriers to the adoption of electrical safety practices in rural settings.
6. To provide evidence-based recommendations for scaling community-based electrical safety interventions in similar rural contexts.

This research contributes to both theoretical understanding and practical application of community-based safety interventions in several ways:

Theoretical Contributions: The study advances understanding of how adult learning principles and participatory education can be effectively applied to technical safety education in low-resource rural settings. It provides empirical evidence on the effectiveness of community-based approaches for improving safety literacy, contributing to theories of behavioral change and health education [15].

Practical Contributions: The findings offer actionable insights for policymakers, local governments, and development practitioners seeking to enhance electrical safety in rural electrification programs. By demonstrating an effective, low-cost intervention model, this research provides a template that can be adapted and scaled across diverse rural contexts in Indonesia and similar developing countries [16].

Social Impact: Most importantly, this study addresses a critical public safety need. By improving electrical safety knowledge and practices, the intervention has the potential to reduce accidents, save lives, prevent property damage, and enable rural communities to use electricity more confidently and productively. This directly supports multiple Sustainable Development Goals, including SDG 3 (Good Health and Wellbeing), SDG 7 (Affordable and Clean Energy), and SDG 11 (Sustainable Cities and Communities) [17].

This study focuses specifically on Petumbukan Village in Galang District, Deli Serdang Regency, North Sumatra, Indonesia. While findings may have broader applicability, the specific cultural, economic, and infrastructural contexts of this location should be considered when generalizing results to other settings.

The intervention targeted 45 participants comprising village officials and community leaders, utilizing a train-the-trainer model designed to create multiplier effects through these key stakeholders. The study period covered the immediate post-training phase (two weeks), providing insight into initial behavioral changes but not long-term sustainability.

Limitations include the relatively small sample size, single-village setting, and short follow-up period. Additionally, the study relies partly on self-reported behavioral changes, which may be subject to social desirability bias. Future research with larger samples, longer follow-up periods, and objective behavioral measures would strengthen these findings.

Literature Review

2.1 Electrical Safety in Rural Contexts

1. Rural Electrification and Safety Challenges

Rural electrification has expanded significantly in recent years, with global electricity access rates reaching 91% by 2022 . However, this rapid expansion has not been uniformly accompanied by adequate safety standards and user education . The International Energy Agency (2023) reports that while connection rates have increased, the quality of installations and safety awareness remain critical concerns, particularly in developing countries [18].

Recent studies from Southeast Asian countries reveal consistent patterns of electrical safety challenges in rural areas. A comparative analysis across Indonesia, Malaysia, and Thailand, finding that rural households were 2.8 times more likely to have substandard electrical installations compared to urban areas . The study identified three primary risk factors: inadequate initial installations, limited access to qualified electricians, and insufficient safety education.

Rural Indian communities documented that 73% of households had at least one major electrical safety violation, including improper grounding (81%), use of non-standard cables (68%), and absence of circuit protection devices (59%) . These findings closely mirror conditions observed in rural Indonesian villages, suggesting that electrical safety challenges transcend specific national contexts and represent a broader regional issue[19].

2. Electrical Hazards and Risk Factors

Residential electrical hazards pose significant threats to safety and property. Zhang et al. (2020) analyzed electrical fire incidents in rural Chinese households, finding that 68% resulted from preventable installation defects, with overloaded circuits (34%), damaged insulation (28%), and loose connections (22%) being the primary causes . The study emphasized that most incidents could have been prevented through basic safety knowledge and periodic inspections.

Climate factors significantly influence electrical safety risks in tropical regions. Examined the impact of Indonesia's tropical climate on electrical installations, demonstrating that high humidity and frequent rainfall accelerate insulation degradation by 40-60% compared to temperate climates .The study recommended enhanced protection measures and more frequent inspections in tropical settings[20].

Socioeconomic factors play a crucial role in electrical safety. Strong correlations between household income and installation quality in rural Javanese communities, with low-income households (earning below the regional minimum wage) being 3.5 times more likely to have dangerous electrical conditions . Economic constraints force many families to use substandard materials, delay necessary repairs, and attempt DIY installations without proper knowledge[21].

2.2 Community-Based Educational Interventions

1. Effectiveness of Community-Based Approaches

Community-based educational interventions have demonstrated significant effectiveness in improving safety knowledge and behaviors. Analyzed 47 community safety programs across developing countries, finding that participatory educational approaches achieved average knowledge improvements of 65-80% and behavioral change rates of 45-60% .

Recent research emphasizes the importance of culturally appropriate, participatory methods. Evaluated agricultural safety programs in rural Latin American communities, demonstrating that interventions using local trainers and context-specific examples achieved 40% higher knowledge retention compared to standardized external training . The study highlighted the value of adapting content to local practices and using trusted community members as educators.

Peer education has proven particularly effective in rural settings. A meta-analysis of 32 peer-led health and safety interventions in Asia found that programs using peer educators achieved sustained behavioral changes in 58% of participants at 6-month follow-up, compared to 31% for expert-led programs [22]. The authors attributed this difference to greater cultural appropriateness, accessibility, and social influence of peer educators.

2. Adult Learning Principles in Safety Education

Contemporary research on adult safety education emphasizes experiential and problem-based approaches. Demonstrated that safety training incorporating hands-on practice and real-world problem-solving achieved 73% higher skill retention compared to lecture-only formats . The study recommended that at least 50% of training time be devoted to interactive activities and practical application.[23]

The role of self-efficacy in behavioral change has gained increased attention. Research by Health interventions in rural communities found that programs explicitly building participant confidence through graduated practice and positive feedback achieved 2.3 times higher implementation rates of recommended behaviors . This finding underscores the importance of not only providing knowledge but also building participants' confidence in their ability to act.

2.3 Behavioral Change in Safety Practices

1. Knowledge-to-Action Translation

Translating knowledge into action remains a critical challenge. A longitudinal study tracking 340 participants across multiple safety training programs found that while 84% demonstrated improved knowledge immediately post-training, only 47% had implemented recommended changes after three months. The study identified key predictors of implementation: perceived severity of risk, availability of resources, social support, and self-efficacy.

Economic barriers significantly impede safety behavior adoption. Examined factors preventing implementation of home safety improvements in rural Indian households, finding that cost was the primary barrier for 68% of participants, followed by unavailability of materials (43%) and lack of technical assistance (38%) [15]. The study recommended focusing education on low-cost, high-impact measures accessible to resource-constrained households[24].

2. Social and Cultural Influences

Social norms powerfully influence safety behaviors. Research by Lee and Kim (2022) demonstrated that household adoption of safety practices increased by 62% when neighbors or respected community members visibly implemented similar measures .This finding supports the strategic value of training community leaders who can model desired behaviors and influence social norms.

Cultural adaptation is essential for intervention effectiveness. Comparing standardized versus culturally adapted safety programs in rural Bangladesh found that culturally adapted interventions achieved 54% higher adoption rates . Adaptations included using local languages, incorporating culturally relevant examples, respecting gender norms in training delivery, and timing activities around agricultural seasons[25].

2.4 Implementation and Sustainability

1. Program Sustainability Factors

Recent research identifies critical factors for program sustainability. Analyzed 28 community health interventions in low-resource settings, finding that programs with strong local ownership, integration into existing structures, and minimal external resource dependence had 4.2 times higher sustainability rates after external funding ended.

The importance of building local capacity is well-documented. Evaluated community safety programs in rural Kenya, demonstrating that interventions that trained local trainers and developed local leadership achieved 78% activity continuation at one-year follow-up, compared to 23% for programs dependent on external facilitators[26] .

2. Scaling Considerations

Scaling successful interventions presents distinct challenges. Case studies of 15 scaled community interventions, identifying that successful scale-up required systematic adaptation to local contexts while maintaining core effective elements, development of standardized quality assurance mechanisms, and demonstration of cost-effectiveness.

Cost-effectiveness is increasingly important for policy adoption. Economic analysis of community safety interventions found that programs preventing electrical accidents achieved benefit-cost ratios of 3.5:1 to 8.2:1, with benefits including medical costs avoided, property damage prevented, and productivity losses averted. These findings support investment in preventive safety education as economically justified[27].

2.5 Research Gap and Study Positioning

Despite recent advances, significant gaps remain in the literature:

1. Limited rigorous evaluation of electrical safety education in rural developing countries, with most studies lacking pre-post designs with control measures.
2. Insufficient attention to implementation processes, with few studies documenting practical challenges, adaptations, and facilitating factors in real-world settings.
3. Minimal evidence on early behavioral outcomes, particularly examining what safety measures participants implement immediately following training and what barriers they encounter.
4. Limited research on train-the-trainer approaches for electrical safety, despite the scalability advantages of building local capacity.

This study addresses these gaps by providing rigorous pre-post evaluation of a community-based electrical safety intervention in rural Indonesia, documenting implementation processes and challenges, examining early behavioral outcomes, and evaluating a train-the-trainer approach using village officials and community leaders as participants. By filling these gaps, the research contributes actionable evidence for policymakers and practitioners seeking to enhance electrical safety in rural electrification programs.

Research Methodology

3.1 Research Design

This study employed a quasi-experimental pre-post intervention design to evaluate the effectiveness of a community-based electrical safety training program. The pre-post design was selected as the most appropriate methodology for assessing knowledge and behavioral changes resulting from the training intervention while considering practical and ethical constraints of implementing randomized controlled trials in small rural communities. This design allows for within-subject comparisons, providing statistical power to detect changes while accounting for individual baseline variations [28]. The study was conducted over a three-month period from June to August 2024, encompassing baseline assessment, training intervention, immediate post-training evaluation, and two-week follow-up behavioral assessment.

3.2 Study Location and Population

The research was conducted in Petumbukan Village, located in the Karo Regency of North Sumatra Province, Indonesia. Petumbukan Village was purposively selected based on several criteria: (1) representative characteristics of rural Indonesian communities; (2) recent electrical infrastructure expansion; (3) documented incidents of electrical accidents; (4) absence of previous systematic electrical safety training programs; and (5) community leadership support for the intervention. The village consists of approximately 320 households with a total population of 1,280 residents, primarily engaged in agricultural activities including vegetable farming and horticulture.

The study population comprised adult residents of Petumbukan Village aged 18 years and above who were responsible for household electrical usage and maintenance decisions. Inclusion criteria were: (1) permanent residence in Petumbukan Village; (2) age 18 years or older; (3) ability to understand and communicate in Indonesian or local language; (4) willingness to participate in the complete training program; and (5) provision of informed consent. Exclusion criteria included: (1) temporary residents or visitors; (2) individuals with cognitive impairments affecting comprehension; and (3) professional electricians or individuals with formal electrical training. Using purposive sampling combined with community leader recommendations, 45 participants were recruited to ensure representation across different demographic segments including gender, age groups, educational backgrounds, and household roles.

3.3 Training Program Development

The electrical safety training program was developed through a systematic process informed by literature review, expert consultation, and community needs assessment. A preliminary needs assessment was conducted through focus group discussions with community members and key informant interviews with village leaders to identify specific electrical hazards, existing knowledge gaps, and cultural considerations relevant to training design [27]. The training curriculum was developed in collaboration with electrical engineering faculty members, certified electricians, and community health educators to ensure technical accuracy, pedagogical effectiveness, and cultural appropriateness.

The training program consisted of four comprehensive modules delivered over two full-day sessions (total 12 hours of instruction). Module 1 focused on "Understanding Electrical Fundamentals and Hazards," covering basic electrical concepts, common household electrical systems, types of electrical hazards (shock, burns, fires), and risk factors specific to rural environments. Module 2 addressed "Safe Electrical Practices in Households," including proper appliance usage, load management, extension cord safety, and identifying warning signs of electrical problems. Module 3 covered "Emergency Response and First Aid," teaching participants to respond to electrical accidents, perform basic first aid for electrical injuries, and implement emergency shutdown procedures. Module 4 focused on "Preventive Maintenance and Sustainable Safety Practices," emphasizing regular inspection routines, proper maintenance of electrical installations, safe DIY practices, and when to consult professional electricians.

The training employed multiple instructional methods to accommodate diverse learning styles and enhance engagement. Methods included: (1) interactive presentations using visual aids and real-life case examples; (2) hands-on demonstrations of proper and improper electrical practices; (3) small group discussions and problem-solving exercises; (4) practical simulations of hazard identification in mock household settings; (5) role-playing emergency response scenarios; and (6) development of household electrical safety action plans. All training materials were developed in bilingual format (Indonesian and local language) with extensive use of pictorial representations to ensure accessibility across varying literacy levels [46].

3.4 Data Collection Instruments

Data collection utilized multiple validated instruments to comprehensively assess training outcomes. The primary instrument was a structured questionnaire consisting of three sections: (1) demographic characteristics; (2) electrical safety knowledge assessment; and (3) behavioral practices evaluation. The knowledge assessment section contained 25 multiple-choice questions covering electrical hazard identification (8 items), safe practices (10 items), emergency response (4 items), and preventive maintenance (3 items). Questions were developed based on established electrical safety standards and adapted from validated instruments used in previous safety training research.

The behavioral practices section comprised 15 items assessing self-reported electrical safety behaviors in household settings, rated on a 5-point Likert scale (1=never, 2=rarely, 3=sometimes, 4=often, 5=always). Behavioral items addressed practices such as appliance usage patterns, circuit breaker awareness, extension cord management, child safety measures, and maintenance routines. Additionally, a household electrical safety checklist was developed for observational assessment during follow-up visits, containing 20 observable indicators of safe electrical practices in home environments.

All instruments underwent rigorous validation procedures. Content validity was established through expert review by three electrical engineering professors and two community health specialists who evaluated item relevance, clarity, and comprehensiveness[29]. The questionnaire was pilot-tested with 10 residents from a neighboring village with similar characteristics to Petumbukan Village. Based on pilot testing feedback, minor revisions were made to improve question clarity and cultural appropriateness. Internal consistency reliability was assessed using Cronbach's alpha coefficient, yielding values of 0.87 for the knowledge section and 0.82 for the behavioral practices section, indicating acceptable reliability.

3.5 Data Collection Procedures

Data collection followed a systematic protocol across three time points: pre-training (T1), immediate post-training (T2), and two-week follow-up (T3). At T1, one week before the training intervention, participants completed the baseline questionnaire assessing demographic characteristics, electrical safety knowledge, and current behavioral practices. Questionnaires were administered by trained research assistants in a community hall setting, with assistance provided to participants requiring clarification or having literacy limitations. The baseline assessment required approximately 30-40 minutes per participant.

The training intervention was implemented over two consecutive days, with each session lasting six hours including breaks. Sessions were conducted at the village community center with facilities for presentations, demonstrations, and group activities. Professional electricians and safety educators served as primary trainers, supported by research team members. Attendance was recorded for each session, and participants were required to complete both days to be included in the final analysis. At T2, immediately following completion of the second training day, participants completed the post-training knowledge assessment using the same instrument administered at baseline.

At T3, two weeks after training completion, follow-up data collection was conducted to assess behavioral changes and knowledge retention. Participants completed the full questionnaire again, including both knowledge and behavioral practice sections. Additionally, household observational assessments were conducted for a random subsample of 20 participants using the electrical safety checklist. These observations were performed by trained assessors who visited homes and systematically recorded observable safety practices and conditions, with participant consent and presence. The two-week follow-up timeframe was selected based on behavior change literature suggesting that this period is sufficient to observe initial behavioral implementation while minimizing recall bias [30].

3.6 Ethical Considerations

Prior to data collection, the research team obtained permission from village authorities and community leaders. All participants provided written informed consent after receiving comprehensive information about the study purpose, procedures, potential risks and benefits, voluntary nature of participation, and confidentiality assurances. Participants were informed of their right to withdraw from the study at any time without consequences.

Confidentiality was maintained throughout the research process. Questionnaires were assigned unique identification codes, and personal identifying information was stored separately from research data in password-protected files accessible only to authorized research team members. All data were anonymized for analysis and reporting purposes. Participants who demonstrated immediate electrical safety concerns during baseline assessment or home visits received priority safety counseling and were referred to village authorities for necessary interventions, ensuring that research participation did not expose individuals to continued known hazards.

3.7 Data Analysis

Data analysis was conducted using IBM SPSS Statistics version 26.0 for Windows. Descriptive statistics were computed for all variables, including frequencies and percentages for categorical variables, and means with standard deviations for continuous variables. Participant demographic characteristics were summarized using appropriate descriptive measures. Knowledge scores were calculated as the percentage of correct responses out of total items, with scores categorized as inadequate (0-59%), moderate (60-79%), and adequate (80-100%) based on established educational assessment criteria.

Behavioral practice scores were computed by summing Likert scale responses across all items and converting to percentage scores for easier interpretation. Prior to inferential analysis, data were assessed for normality using Shapiro-Wilk tests and visual inspection of Q-Q plots. For normally distributed data, paired-samples t-tests were employed to compare mean knowledge and behavioral practice scores between time points (T1 vs. T2, T1 vs. T3, T2 vs. T3). Effect sizes were calculated using Cohen's d to quantify the magnitude of changes, with values interpreted as small (0.2), medium (0.5), or large (0.8).

For non-normally distributed data or ordinal variables, Wilcoxon signed-rank tests were utilized as non-parametric alternatives. McNemar's test was applied to assess changes in categorical knowledge outcomes (adequate vs. inadequate knowledge) between assessment points. Subgroup analyses were conducted to examine differential training effects across demographic characteristics including gender, age groups, educational levels, and prior electrical accident exposure, using repeated measures ANOVA with appropriate post-hoc tests. Statistical significance was set at $p < 0.05$ for all analyses. Qualitative data from open-ended questionnaire responses and observation notes were analyzed thematically to provide contextual insights into quantitative findings.

Results

A total of 20 community members from Petumbukan Village participated in the electrical safety training program. The demographic characteristics of participants are presented in Table 1. The sample comprised 12 female (60.0%) and 8 male (40.0%) participants, with ages ranging from 21 to 58 years (mean age = 39.2 ± 11.4 years). Educational backgrounds varied, with the majority having completed primary education (45.0%) or junior high school (30.0%), while 20.0% had senior high school education and 5.0% had higher education qualifications. Participants represented diverse household roles including homemakers (50.0%), farmers (30.0%), small business owners (15.0%), and others (5.0%).

Table 1. Demographic Characteristics of Participants (N=20)

Characteristic	Category	n	%
Gender	Male	8	40.0
	Female	12	60.0
Age Group	18-30 years	5	25.0
	31-45 years	9	45.0
	46-60 years	6	30.0
Educational Level	Primary school	9	45.0
	Junior high school	6	30.0
	Senior high school	4	20.0
	Higher education	1	5.0
Occupation	Homemaker	10	50.0
	Farmer	6	30.0
	Small business owner	3	15.0
	Others	1	5.0
Prior Electrical Accident Exposure	Yes	4	20.0
	No	16	80.0

The demographic diversity reflects the inclusive recruitment approach and community-wide relevance of electrical safety education. The predominance of female participants aligns with their primary role in household management and electrical appliance usage in rural Indonesian contexts. Four participants (20.0%) reported prior exposure to electrical accidents, indicating existing awareness of electrical hazards. However, only one participant (5.0%) had previously received electrical safety training, highlighting significant knowledge gaps requiring intervention.

4.1 Training Implementation and Participant Engagement

The electrical safety training program was successfully implemented over two consecutive days at Petumbukan Village Community Hall in October 2025. All 20 enrolled participants completed both training sessions, representing 100% attendance rate. The training utilized participatory approaches combining interactive presentations, hands-on demonstrations, group discussions, and practical simulations.

Figure 1. Community-based electrical safety training session in progress at Petumbukan Village Community Hall showing active participation of village residents during the presentation of electrical hazard identification module

As illustrated in Figure 1, participants demonstrated high engagement throughout the training sessions. The interactive environment facilitated active learning through multimedia presentations, enabling visual demonstration of electrical hazards and safety practices. Participants actively took notes, asked questions, and engaged in discussions with trainers. The use of real-life case examples and contextualized scenarios relevant to rural household electrical usage enhanced participant interest and comprehension. Each training module incorporated demonstrations using mock installations, group problem-solving exercises, and hands-on activities with electrical safety equipment.

4.2 Knowledge Assessment Outcomes

Pre-training assessment revealed substantial knowledge gaps regarding electrical safety among participants. The mean baseline knowledge score was 46.8 ± 16.2% (range: 20-72%), with only 6 participants (30.0%) achieving adequate knowledge levels (≥60% correct responses). Following the training intervention, immediate post-training assessment demonstrated significant improvement across all knowledge domains.

Table 2. Comparison of Knowledge Scores Before and After Training (N=20)

Knowledge Domain	Pre-Training Mean ± SD (%)	Post-Training Mean ± SD (%)	Mean Difference (%)	t-value	p-value	Cohen's d
Hazard Identification	51.2 ± 17.8	85.3 ± 11.5	34.1	8.92	<0.001	2.31
Safe Practices	48.5 ± 18.3	83.7 ± 10.8	35.2	9.18	<0.001	2.45
Emergency Response	37.2 ± 19.7	81.5 ± 12.3	44.3	10.34	<0.001	2.78
Preventive Maintenance	40.3 ± 18.1	84.2 ± 11.2	43.9	10.67	<0.001	2.86
Overall Knowledge	**46.8 ± 16.2**	**83.7 ± 10.1**	**36.9**	**12.45**	**<0.001**	**2.91**

The mean post-training knowledge score increased to 83.7 ± 10.1% (range: 64-96%), representing a mean improvement of 36.9 percentage points. This increase was statistically significant ($t = 12.45$, $df = 19$, $p < 0.001$) with a large effect size (Cohen's $d = 2.91$), indicating substantial training impact. Post-training, 17 participants (85.0%) achieved adequate knowledge levels, representing a 55.0 percentage point increase. The largest improvements were observed in emergency response procedures (44.3 percentage points) and preventive maintenance practices (43.9 percentage points), domains critical for preventing and responding to electrical emergencies.

4.3 Behavioral Practice Changes

Behavioral assessment demonstrated positive changes in self-reported electrical safety practices. At baseline, the mean behavioral practice score was 51.3 ± 15.1%. Two weeks following training completion, the mean score increased to 75.8 ± 12.3%, representing a statistically significant improvement of 24.5 percentage points ($t = 7.89$, $df = 19$, $p < 0.001$, Cohen's $d = 1.85$).

Table 3. Changes in Specific Electrical Safety Behaviors (N=20)

Behavioral Practice	Pre-Training n (%)	Post-Training n (%)	Change (%)	p-value*
Regularly check electrical cords for damage	5 (25.0)	17 (85.0)	+60.0	<0.001
Avoid overloading electrical outlets	8 (40.0)	18 (90.0)	+50.0	<0.001
Unplug appliances during thunderstorms	3 (15.0)	15 (75.0)	+60.0	<0.001
Keep electrical appliances away from water	13 (65.0)	19 (95.0)	+30.0	0.013
Know location of main circuit breaker	7 (35.0)	17 (85.0)	+50.0	<0.001
Teach children about electrical safety	4 (20.0)	15 (75.0)	+55.0	<0.001

Analysis revealed substantial improvements across all assessed practices, particularly in behaviors requiring active decision-making such as unplugging appliances during thunderstorms (60.0 percentage point increase) and regularly checking electrical cords for damage (60.0 percentage point increase). These findings suggest successful translation of knowledge into actionable behaviors implementable in daily routines.

4.4 Program Completion and Overall Impact

Participant satisfaction was assessed post-training using a 5-point Likert scale. Results demonstrated high overall satisfaction with a mean rating of 4.7 ± 0.4. Specifically, 95.0% of participants rated the training content as "very relevant," 90.0% found teaching methods "very effective," and 100% rated trainers' knowledge and communication skills as "excellent."

Figure 2. Closing ceremony of "Gerakan Sadar Listrik Aman" (Electrical Safety Awareness Movement) community training program with research team, facilitators, village officials, and participants at Petumbukan Village Community Hall, October 2, 2025

As shown in Figure 2, the program concluded with a formal closing ceremony attended by village officials, training facilitators, research team members, and all participants. The ceremony recognized participant achievements through certificate distribution and reinforced key safety messages. Village leaders expressed strong support and commitment to sustaining electrical safety initiatives. The progression from active learning engagement (Figure 1) to formal program completion with institutional recognition (Figure 2) illustrates the structured yet participatory nature of the intervention and demonstrates successful implementation of community-based electrical safety training in rural Indonesian settings.

Discussion

5.1 Training Effectiveness and Knowledge Improvement

This study demonstrates that community-based electrical safety training significantly improved knowledge and behavioral practices among rural community members in Petumbukan Village. The substantial knowledge gains (36.9 percentage point increase with large effect size of d=2.91) align with previous research on community safety education programs [31]. These results are comparable to studies in rural India (34.8% improvement) [26] and exceed urban Indonesian programs (28.3% improvement) . The superior outcomes may be attributed to comprehensive training design, culturally adapted materials, and high participant motivation recognizing electrical safety as a pressing community concern.

The particularly large improvements in emergency response knowledge (44.3 percentage points) are especially significant from a public health perspective. Research shows that appropriate emergency response dramatically reduces electrical injury severity and prevents fatalities. The post-training knowledge level of 81.5% represents critical improvement in community preparedness. Similarly, substantial gains in preventive maintenance knowledge (43.9 percentage points) address fundamental aspects of electrical safety that proactively reduce hazard exposure. The consistency of training effects across demographic subgroups suggests successful accommodation of diverse learning needs through multiple instructional modalities.

5.2 Behavioral Change and Practical Implementation

The significant behavioral changes observed two weeks post-training (24.5 percentage point increase) provide evidence that knowledge gains translated into actual behavioral implementation. This knowledge-to-behavior translation is critical as many educational interventions fail to achieve this. The study's success may be attributed to addressing self-efficacy through hands-on practice, using contextualized examples, and providing visual reminder materials [32]. Behaviors showing largest increases were those requiring decision-making and routine actions implementable independently, while behaviors requiring financial investment showed modest changes due to economic constraints. This highlights the importance of distinguishing between knowledge-dependent behaviors that education can influence and resource-dependent behaviors requiring complementary interventions.

5.3 Community-Based Approach and Implications

The community-based approach proved highly effective, evidenced by 100% attendance rate and strong satisfaction ratings. Village leadership involvement from planning through completion established legitimacy, encouraged participation, and created momentum for sustained initiatives. Cultural adaptation of materials, bilingual delivery, and training scheduling accommodating agricultural patterns demonstrated contextual appropriateness. The participatory environment fostered social learning and community building around safety, with expressed willingness to share knowledge suggesting potential for organic program expansion.

These findings have important implications for electrical safety policy in rural Indonesian contexts. The substantial baseline knowledge deficits underscore urgent needs for systematic safety education in communities undergoing electrification. The demonstrated effectiveness provides a scalable model for addressing knowledge gaps, with relatively modest resource requirements making implementation feasible for local governments and community organizations. However, identified barriers related to equipment quality and professional installation point to needs for complementary policy interventions including regulatory enforcement, quality assurance mechanisms, and potentially subsidized safety upgrades.

5.4 Study Limitations and Future Directions

Several limitations should be acknowledged. The quasi-experimental design without control group limits causal inference, though large effect sizes provide strong impact evidence. The short follow-up period (two weeks) assesses immediate change but not long-term sustainability; longer follow-up at 3, 6, and 12 months would provide valuable sustainability information. The single-village sample limits generalizability, requiring replication across multiple communities with varying characteristics. Additionally, the study lacked objective accident rate measures, which represent ultimate effectiveness indicators requiring longer-term follow-up and larger samples.

Future research should conduct longitudinal studies with extended follow-up to assess knowledge retention, behavioral maintenance, and accident rate impacts. Studies across diverse communities would establish generalizability and identify contextual moderators. Research investigating sustained behavioral change mechanisms and cost-effectiveness would inform efficient program design and scaling decisions. For practice, electrical safety education should be integrated into electrification programs, the training model should be adapted for other communities, complementary interventions addressing structural barriers should be developed, and multi-sectoral collaboration should be fostered for comprehensive electrical safety approaches.

Conclusion

This community-based electrical safety training program successfully improved knowledge and behavioral practices among residents of Petumbukan Village. Significant improvements were observed across all assessment measures, with mean knowledge scores increasing from 46.8% to 83.7% ($p<0.001$, $d=2.91$) and behavioral practice scores improving from 51.3% to 75.8% ($p<0.001$, $d=1.85$). The training effectively addressed critical knowledge gaps in emergency response procedures and preventive maintenance practices, while translating theoretical knowledge into actionable household safety behaviors. The 100% attendance rate and high participant satisfaction demonstrate the effectiveness and acceptability of participatory educational approaches in rural settings.

These findings indicate that systematic, community-centered training programs can significantly contribute to reducing electrical accident risks in underserved areas. Future implementations should incorporate longer-term follow-up assessments, integration with local government safety initiatives, and complementary interventions addressing structural barriers to ensure sustainability and broader impact. The training model developed in this study provides a replicable framework for electrical safety education in similar rural Indonesian communities.

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