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Evaluating the impact of school- and communication-based health education on knowledge and safe practices for drowning prevention among adolescents; a quasi-experimental study in Thai Binh province, Vietnam

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Abstract

Introduction: Drowning is a leading cause of injury-related mortality among children and adolescents in many low- and middle-income countries, yet evidence on effective, school-based prevention strategies in community settings remains limited.

Objectives: This study evaluated the impact of a combined school- and community communication-based health education program on adolescents' knowledge and safe practices regarding drowning prevention in Thai Binh province, Vietnam, using a quasi-experimental design.

Materials and Methods: This quasi-experimental study was conducted on 12–14-year-old students in Vu Thu District, Thai Binh Province, Vietnam, between September 2022 and September 2023. A total of 2,028 students were enrolled and randomized to an intervention group, which received a multi-component school- and community-based drowning prevention education program, or a control group with usual schooling (979 intervention, 1,049 control). Data on drowning prevention knowledge and practices were collected at baseline and at the 6-month follow-up using a piloted, structured self-reported questionnaire and knowledge and practice scores, and were compared between the two time points.

Results: Among 2,028 adolescents, the 6-month school- and communication-based program produced larger gains in drowning prevention knowledge in the intervention group than in the control group (median score increase from 6.82 to 8.18 versus 6.36 to 7.27) and substantially greater improvements in self-rescue and bystander response practices (median score increase from 6 to 8 versus no change at 6). Multilevel mixed-effects linear regression confirmed a significant net intervention effect over time, with knowledge scores increasing by 0.746 points (CI: 0.509–0.984; $P < 0.001$) and practice scores by 0.579 points (CI: 0.314–0.845; $P < 0.001$).

Conclusion: The results indicated that a school- and communication-based health education program significantly improved adolescents' drowning prevention knowledge and safe practices. These findings support integrating structured drowning prevention education into school curricula and community communication platforms to strengthen adolescents' capacity to prevent and respond to drowning events.

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Introduction

Unintentional drowning remains one of the most common causes of mortality worldwide, disproportionately affecting children and adolescents (1,2). According to the Global Burden of Disease (GBD) 2021 study, drowning resulted in an estimated 274,200 deaths globally, representing an age-standardized mortality rate of 3.6 per 100,000 population, a 60.9% decline since 1990 (3). The Western Pacific and Southeast Asia regions jointly account for over 60% of global drowning mortality (4). Drowning ranks among the five leading causes of death for individuals aged 1–24 years across

all World Health Organization (WHO) regions and is the dominant mechanism of unintentional injury mortality in school-age children and adolescents (1,5). In Vietnam, situated within this high-burden subregion, the national government has formally committed to ensuring that by 2030, 60% of primary and lower secondary school children aged 6–16 years can swim and 70% possess water safety skills, reflecting the magnitude of the problem among youth (6). Despite measurable global progress, the actual burden is likely underestimated, as many fatal and non-fatal events remain unrecorded, particularly in remote and



Key point

This quasi-experimental study showed that the school- and communication-based program produced substantially greater improvements in drowning prevention knowledge in the intervention group than in the control group, with pronounced gains in recognizing hazardous environments, identifying warning signs, and understanding preventive strategies, alongside marked enhancements in self-rescue and bystander response practices.

flood-prone rural areas. Addressing these factors through evidence-based, contextually relevant prevention strategies is therefore a public health imperative, particularly for adolescents in high-burden countries such as Vietnam.

School-based health education strategies have been increasingly recognized as scalable, cost-effective approaches to promoting injury prevention knowledge and safe behaviors among young populations (7,8). A quasi-experimental study conducted in Greece by Terzidis et al demonstrated that exposure to age-specific, customized water safety educational content during mandatory schooling produced statistically significant gains in knowledge and attitudes among younger pupils; however, the magnitude of effect diminished with advancing age, highlighting the need for tailored and complementary communication strategies when targeting older adolescents (9). Communication-based approaches, including booklets, mass media campaigns, and audiovisual tools, have also demonstrated educational potential; Farizan et al conducted a quasi-experimental study in Malaysia among 719 parents of primary school children, finding that a structured health educational booklet intervention led to a 24.75% increase in drowning prevention knowledge scores one month after the intervention, with notable improvements in attitudes (10). Beyond print media, Shen et al demonstrated in a randomized controlled trial among rural Chinese school children that peer testimonial videos significantly improved water safety knowledge and reduced simulated risky behaviors near water, underscoring the behavioral influence of well-designed communication tools (11). A systematic review by Leavy et al synthesized evidence from high-, low-, and middle-income countries and concluded that community-based educational campaigns incorporating diverse communication channels represented one of the most promising approaches for improving drowning-related knowledge and awareness among children and youth, though sustained effects on actual safe practice were variable (12). These findings collectively suggest that combining structured school instruction with targeted health communication channels may deliver synergistic and wider-reaching effects on adolescents' water safety awareness.

Despite growing recognition of the problem, rigorous evidence on the impact of school- and communication-based health education specifically on drowning-

related knowledge and safe behavioral practices among adolescents remains limited, particularly in Southeast Asian. A global scoping review by Ashraf et al classified community-based water safety education and awareness interventions as "promising," consistently reporting improvements in knowledge and attitudes, though effects on behavioral practices were more heterogeneous across study contexts; the same review noted that basic swimming, water safety, and safe rescue skills training for children aged 6 years and older had been elevated from "emerging" to "promising" evidence status since the 2008 WHO world report on child injury prevention, reflecting an expanding evidence base (13). In a study focused specifically on adolescents, Petrass and Blitvich evaluated a short water safety educational program in Australia and found significant post-intervention improvements in knowledge, attitudes, and self-reported safe behaviors, indicating that targeted programs can meaningfully shift water safety practices even in this older age group (14). Wilks et al further reported that a structured beach safety education program for school children yielded measurable gains in water safety knowledge, supporting the integration of such curricula into national educational frameworks (15). Nevertheless, quasi-experimental evaluations that specifically assess the combined and independent effects of school-based instruction alongside broader community communication strategies on both knowledge and safe practices for drowning prevention in adolescents remain scarce, particularly for the Southeast Asian context. The present study therefore sought to evaluate the impact of a combined school- and communication-based health education intervention on knowledge and safe practices for drowning prevention among adolescents in Thai Binh province, Vietnam.

Objectives

To assess the effectiveness of a combined school-based and community communication health education program on adolescents' knowledge and safe practices related to drowning prevention in Thai Binh province, Vietnam, by comparing changes in knowledge and practice scores over a 6-month period between intervention and control groups while accounting for individual sociodemographic characteristics and clustering at the school level.

Patients and Methods***Study design and participants***

This quasi-experimental study was conducted in Thai Binh province, Vietnam, from September 2022 to September 2023. The study population comprised secondary school students enrolled in grades 6 to 8 from six secondary schools located in Vu Thu District, Thai Binh province. First, six wards were randomly selected from the list of wards in Vu Thu district, Thai Binh province, each containing one secondary school. All students in grades 6 to 8 at these schools were then

invited to participate, yielding a total of 2,160 students who completed the baseline assessment. Using computer-generated randomization, participants were allocated to either the control arm ($n = 1,093$) or the intervention arm ($n = 1,067$). After the 6-month follow-up, 132 students were lost to follow-up (overall loss rate 6.11%) and were excluded from the analysis. The final analytic sample comprised 979 students in the intervention arm and 1,049 students in the control arm.

Inclusion and exclusion criteria

Students were eligible for inclusion if they were 12–14 years of age (corresponding to grades 6–8), were enrolled in one of the selected secondary schools in Vu Thu District, and provided written informed consent to participate (student consent and parental/guardian consent, as applicable). Students were excluded if they did not meet the age or grade requirements, were not regularly attending the selected schools during the study period, were absent at either baseline or 6-month follow-up data collection, or were unwilling to continue the study or did not receive the allocated education program completely. To ensure comparability between groups and valid estimation in the multilevel models, students with missing data on key sociodemographic variables or on the drowning prevention knowledge and practice items were also excluded from the final analytic sample.

Group classification and allocation

Group classification was based on school-level allocation within Vu Thu District. Secondary schools selected for implementation of the health education and communication program on drowning prevention were assigned to the intervention group, and all eligible students from these schools were classified as intervention participants. In contrast, students from comparable secondary schools that did not receive the program during the study period were classified as the control group and continued with usual curricular activities without exposure to the drowning-prevention education.

Data collection

Data were collected at two time points, at baseline and six months after initiation of the intervention, using a structured, self-administered questionnaire completed in the classroom setting under the supervision of trained data collectors. The questionnaire captured sociodemographic information (age, parents' occupations, and family size) and assessed drowning prevention knowledge and safe practices through a series of closed-ended items, which had been pretested in a pilot group of students to ensure clarity and appropriateness. Before data collection, field staff received standardized training on administering the questionnaires, providing instructions, and addressing students' questions neutrally. Completed questionnaires were checked on site for missing or inconsistent responses

and subsequently double-entered into an electronic database to minimize data-entry errors and ensure data quality.

Intervention

Participants in the intervention group received a multi-component health education and communication program designed to improve their knowledge and practices related to drowning prevention, whereas students in the control group did not receive any drowning-specific intervention and continued with usual school activities. The program comprised an expert-led health education session delivered at each participating secondary school during the intervention period, complemented by indirect communication activities in the students' communities, including repeated messages broadcast by local loudspeakers and distribution of informational leaflets to reinforce key drowning-prevention messages.

Drowning prevention questionnaire

Drowning prevention questionnaire data were collected using a structured instrument that was piloted in a classroom of a secondary school not included in the study sample, allowing refinement of item wording and logic before formal data collection. The questionnaire comprised two domains. First, drowning prevention knowledge was assessed through 14 items covering common drowning locations, signs and symptoms of drowning, and essential preventive measures; each correct response was assigned 1 point, and the summed raw score was linearly converted to a 10-point scale using a simple summative scoring approach, with all items contributing equally because the tool was exploratory and no validated weighting scheme for specific knowledge domains was available. Second, drowning prevention practices were evaluated using 13 items addressing self-rescue techniques and appropriate methods for assisting drowning victims; each correct response was similarly awarded 1 point, and the total practice score was converted to a 10-point scale using the same summative method to yield an overall, easily interpretable measure of reported drowning-related practices.

Outcome measurement

The primary outcomes were students' drowning prevention knowledge and safe practice scores, assessed at baseline and at the 6-month follow-up using a structured questionnaire. Knowledge was measured through a set of closed-ended items covering common drowning locations, signs and symptoms of drowning, and key preventive strategies; each correct response was awarded one point, and item scores were summed to generate a total knowledge score on a 0–10 scale, with higher scores indicating better knowledge. Safe practices were evaluated using items related to self-rescue behaviors, actions to assist a drowning victim, and appropriate post-rescue

first-aid responses; responses were similarly scored and summed to obtain a total practice score ranging from 0 to 10, with higher scores denoting better adherence to recommended practices. Changes in knowledge and practice scores between baseline and 6-month follow-up were used to quantify the impact of the intervention.

Statistical analysis

Data were analyzed using STATA version 17. Continuous variables (knowledge and practice scores) were summarized using medians and interquartile ranges, whereas categorical variables (sociodemographic characteristics and individual questionnaire items) were described using frequencies and percentages. Baseline comparability between the intervention and control groups in terms of demographic and socioeconomic characteristics was assessed using the chi-square test. Within-group changes in the proportions of correct responses to individual knowledge and practice items between baseline and 6-month follow-up were evaluated using McNemar’s test, and changes in total knowledge and practice scores were examined with the Wilcoxon signed-rank test. To estimate the effect of the intervention while accounting for clustering at the school level and repeated measurements over time, multilevel mixed-effects linear regression models were fitted for knowledge and practice scores, including group, time, and their interaction term as main predictors and adjusting for relevant individual-level covariates. A two-sided *P* value < 0.05 was considered statistically significant.

Results

The frequency distribution comparison of demographic and socioeconomic characteristics indicated that the

intervention and control groups are broadly comparable in terms of age distribution, with no meaningful imbalance in the proportion of students across the different age categories. The pattern of fathers’ occupations is also similar between the two groups, with no statistically significant difference in the distribution of employment types. In contrast, the distribution of mothers’ occupations differs between groups, with mothers in the intervention group more frequently engaged in non-blue-collar positions, leading to a statistically significant divergence in maternal employment profiles. Family size is likewise balanced between the groups, as most students in both arms belong to households of moderate size, and the proportion of those from larger families does not differ significantly between the intervention and control groups (Table 1).

Table 2 presents the changes in specific drowning prevention knowledge components before and after the 6-month intervention. Following the health education communication program, the intervention group showed pronounced improvements in recognizing key environmental risks, with awareness of unprotected water tanks increasing from 45.15% to 62% and recognition of deep water holes rising from 64.76% to 79.78%. The intervention group also demonstrated enhanced understanding of drowning signs and preventive measures, including an increase in knowledge about covering water containers from 64.66% to 75.38% and about the importance of swimming only with adults from 70.99% to 81.31%. These domain-specific gains were reflected in a marked rise in the median total knowledge score, which increased from 6.82 to 8.18 points. By contrast, the control group exhibited only modest, naturally occurring

Table 1. The frequency distribution of demographic and socioeconomic characteristics of the studied students between the intervention and control

Characteristics	Group		Total (N = 2028)	P value*
	Control (n = 1049)	Intervention (n = 979)		
Age (years)				
12-year-old	374	311	685	0.154
13-year-old	328	335	663	
14-year-old	347	333	680	
Father's occupation				
White-collar worker	44	56	100	0.080
Blue-collar worker	685	578	1,263	
Business	102	138	240	
Freelance	133	124	257	
Others	70	64	134	
Mother's occupation				
White-collar worker	74	92	166	0.001
Blue-collar worker	772	638	1,410	
Business	93	113	206	
Freelance	75	100	175	
Others	24	25	49	
Family member				
2-4 members	364	334	698	0.846
5-7 members	544	486	1,030	
8 members and above	28	29	57	

*Chi-square.

improvements in a limited number of items, with the median total knowledge score increasing from 6.36 to 7.27 points over the same period (Table 2).

The comparative analysis of changes in specific drowning prevention practices showed that the educational program effectively translated into meaningful behavioral improvements in the intervention group, particularly in safe rescue and first-aid responses. The proportion of students who knew how to safely instruct a victim to grab a stick or rope increased from 68.23% to 78.55%, indicating enhanced familiarity with non-contact rescue techniques. Critical post-rescue actions also improved substantially, with calling emergency services (115) rising from 60.88% to 73.95% and placing the victim in the recovery position (on their side) increasing from 42.80% to 62.31%. These practice-specific gains were reflected in a notable rise in the median practice score in the intervention group from

6.00 to 8.00 points, whereas the control group's overall practice score remained unchanged at 6.00 points over the same period (Table 3).

The impact of the intervention and the individual-level determinants of knowledge and practice scores were estimated using a multilevel mixed-effects linear regression model. After adjustment for demographic characteristics, the intervention group demonstrated a statistically significant net increase in both knowledge and practice scores relative to the control group, beyond the control group's natural temporal trajectory. With respect to individual characteristics, age was inversely associated with both outcomes: students aged 13 and 14 years had significantly lower knowledge and practice scores compared with 12-year-old students. In addition, students whose fathers were employed in non-white-collar occupations (e.g., blue-collar, business, freelance)

Table 2. Comparative analysis of changes in drowning prevention knowledge before and after intervention within each of the intervention and control groups

Characteristics	Control group (n = 1049)		P value*	Intervention group (n = 979)		P value*
	Baseline N (%)	Follow-up N (%)		Baseline N (%)	Follow-up N (%)	
Common drowning locations						
Anywhere there is a water source	465 (44.33)	500 (47.71)	0.120	460 (46.99)	544 (55.57)	<0.001
Water tanks, wells, tubs/bathtubs... do not have lids	459 (43.76)	509 (48.52)	0.029	442 (45.15)	607 (62.00)	<0.001
Ponds, lakes, rivers, streams, swimming pools... no barriers	835 (79.60)	795 (75.79)	0.036	814 (83.15)	840 (85.80)	0.105
Deep water holes (such as lime pits...) are no longer in use and have not been filled	690 (65.78)	696 (66.35)	0.782	634 (64.76)	781 (79.78)	<0.001
Water tanks, rockeries, fish tanks...	268 (25.55)	346 (33.02)	<0.001	257 (26.25)	386 (39.43)	<0.001
Signs and symptoms of drowning when swimming						
Falling into deep water without knowing how to swim	795 (75.79)	817 (77.88)	0.255	785 (80.18)	846 (86.41)	<0.001
Falling into a whirlpool or a strong current	752 (71.69)	807 (76.93)	0.006	737 (75.28)	846 (86.41)	<0.001
While swimming, I had cramps and couldn't swim to shore	762 (72.64)	764 (72.90)	0.894	768 (78.45)	843 (86.11)	<0.001
While swimming, I felt very tired and lethargic, and couldn't continue swimming	609 (58.06)	601 (57.35)	0.743	602 (61.49)	715 (73.03)	<0.001
Go swimming in the pool, wearing a life jacket or using a buoy to float	173 (16.49)	190 (18.15)	0.317	111 (11.34)	183 (18.69)	<0.001
Drowning prevention						
Do not play near open water sources such as ponds, lakes, and rivers	841 (80.17)	847 (80.74)	0.741	828 (84.58)	885 (90.40)	<0.001
Do not use objects that fall into the water	588 (56.05)	660 (62.92)	0.001	597 (60.98)	712 (72.73)	<0.001
Cover tanks, wells... cover buckets and pots when not in use	650 (61.96)	649 (61.87)	0.964	633 (64.66)	738 (75.38)	<0.001
You should only go swimming in the pool and be accompanied by an adult	703 (67.02)	715 (68.16)	0.576	695 (70.99)	796 (81.31)	<0.001
Swimming when there is a storm or heavy rain	155 (14.78)	185 (17.65)	0.074	117 (11.95)	174 (17.77)	<0.001
Have fun while swimming or jumping off a bridge	157 (14.97)	197 (18.80)	0.019	132 (13.48)	172 (17.57)	0.013
Jump into the water to save your friend while not knowing how to swim	133 (12.68)	132 (12.60)	0.954	110 (11.24)	138 (14.10)	0.057
	Median (IQR)	Median (IQR)	P value**	Median (IQR)	Median (IQR)	P value**
Total knowledge score (unit: 0–10 points)	6.36 (3.64-8.18)	7.27 (4.09-8.64)	<0.001	6.82 (5.00-8.18)	8.18 (6.36-9.09)	<0.001

IQR: Interquartile range, *McNemar's test, **Wilcoxon test.

Table 3. Comparative analysis of changes in drowning prevention practices before and after intervention within each of the intervention and control groups

Characteristics	Control group (n = 1049)		P value*	Intervention group(n = 979)		P value*
	Baseline N (%)	Follow-up N (%)		Baseline N (%)	Follow-up N (%)	
When drowning, what will you do to save yourself?						
Stay calm and shout, call an adult for help	677 (64.54)	713 (67.97)	0.096	694 (70.89)	768 (78.53)	<0.001
Look around for floating objects to hold on to	790 (75.31)	802 (76.45)	0.540	782 (79.88)	868 (88.66)	<0.001
Try to perk up by taking a deep breath, and then relax your body	686 (65.40)	734 (69.97)	0.025	647 (66.09)	759 (77.61)	<0.001
Swim along the current, try to swim to shore (if you know how to swim)	538 (51.29)	576 (54.91)	0.096	506 (51.69)	693 (70.79)	<0.001
I tried to struggle out of fear, and I was slowly sinking into the water	104 (9.91)	104 (9.92)	0.994	77 (7.87)	86 (8.80)	0.453
What will you do when you encounter a case of drowning?						
Stay calm and shout, call an adult for help	814 (77.60)	828 (79.01)	0.434	815 (83.25)	864 (88.25)	0.002
Look around for long sticks or floating objects to compress for the victim	693 (66.06)	744 (70.92)	0.017	696 (71.09)	830 (84.78)	<0.001
Instruct the victim to grab the stick or rope and slowly pull to shore	666 (63.49)	721 (68.73)	0.011	668 (68.23)	769 (78.55)	<0.001
Don't do anything because you don't know how to swim, and don't know the victim	96 (9.15)	98 (9.35)	0.875	52 (5.31)	85 (8.69)	0.003
Jump down to save the victim	185 (17.64)	195 (18.62)	0.557	160 (16.34)	172 (17.59)	0.464
In case you have rescued a drowning person, what should you do to help?						
Stay calm and shout, call an adult for help	703 (67.02)	746 (71.12)	0.042	695 (70.99)	806 (82.33)	<0.001
Call emergency 115	599 (57.10)	700 (66.73)	<0.001	596 (60.88)	724 (73.95)	<0.001
Remove foreign objects (mud, vomit...) from the victim's nose and mouth	479 (45.66)	574 (54.72)	<0.001	522 (53.32)	682 (69.66)	<0.001
Place the victim on their side with their head tilted to the side	434 (41.37)	554 (52.81)	<0.001	419 (42.80)	610 (62.31)	<0.001
Comfort and support the victim (if they are still conscious)	567 (54.05)	612 (58.34)	0.048	572 (58.43)	701 (71.60)	<0.001
Cover with blankets and clothes to keep the victim warm	451 (42.99)	508 (48.43)	0.012	465 (47.50)	575 (58.73)	<0.001
Stand around the victim to watch	90 (8.58)	86 (8.21)	0.758	52 (5.31)	69 (7.05)	0.111
	Median (IQR)	Median (IQR)	P value**	Median (IQR)	Median (IQR)	P value**
Practice score (0–10 points)	6 (2-8)	6 (4-8)	0.061	6 (4-8)	8 (6-8)	<0.001

IQR: Interquarter range, *McNemar's test, **Wilcoxon test.

exhibited significantly lower knowledge scores than those whose fathers held white-collar positions; however, paternal occupational status was not significantly associated with practice scores. Maternal occupation was not significantly related to either knowledge or practice outcomes (Table 4).

Discussion

The present study addressed this gap by evaluating a multi-component program combining school-based health education with community communication channels, enrolling 2,028 adolescents aged 12–14 years over a six-month period in Vu Thu District, Thai Binh province, Vietnam. The results demonstrated that the intervention group achieved substantially greater gains in drowning prevention knowledge and considerably larger improvements in self-rescue and bystander response practices compared with the control group receiving usual schooling. These findings are consistent with the broader evidence base suggesting that structured, educational

interventions can meaningfully shift both cognitive and behavioral outcomes related to drowning prevention. The improvement in drowning prevention knowledge observed in the intervention group aligns closely with patterns reported in prior studies examining the effect of educational programs on water safety knowledge among school-aged children and adolescents. A systematic review and update by Criel et al synthesizing evidence from 33 controlled studies found that water safety training, whether delivered in isolation or as part of a broader injury prevention curriculum, was effective in increasing knowledge of safe behavior in and around water. Their review noted that water safety training consistently led to statistically significant increases in water safety knowledge across programmers ranging from brief single-session interventions to multi-component curricula, suggesting that even modestly structured programmers may exert a meaningful cognitive impact (16). The present study extends this observation to the Vietnamese adolescent context, demonstrating that knowledge gains are

Table 4. Multilevel mixed-effects linear regression identifying factors associated with changes in drowning prevention knowledge and practice scores

Characteristics	Knowledge score			Practice score		
	B	95% CI	P value	B	95% CI	P value
Group						
Control			Reference			
Intervention	0.367	0.131; 0.602	0.002	0.340	0.093; 0.586	0.007
Time of study						
Baseline			Reference			
6-months follow-up	0.405	0.229; 0.581	< 0.001	0.188	-0.003; 0.378	0.054
Time x group						
Control group x Baseline			Reference			
Intervention x Follow-up	0.746	0.509; 0.984	< 0.001	0.579	0.314; 0.845	< 0.001
Individual characteristics						
Age						
12-year-old			Reference			
13-year-old	-0.466	-0.708; -0.223	< 0.001	-0.469	-0.711; -0.226	< 0.001
14-year-old	-0.364	-0.602; -0.125	0.003	-0.471	-0.711; -0.232	< 0.001
Father's occupation						
White-collar worker			Reference			
Blue-collar worker	-0.534	-0.992; -0.077	0.022	-0.290	-0.794; 0.213	0.259
Business	-0.707	-1.237; -0.176	0.009	-0.415	-0.986; 0.156	0.154
Freelance	-0.598	-1.118; -0.078	0.024	-0.363	-0.924; 0.198	0.205
Others	-0.657	-1.230; -0.084	0.025	-0.410	-1.025; 0.205	0.191
Mother's occupation						
White-collar worker			Reference			
Blue-collar worker	0.167	-0.217; 0.551	0.393	0.253	-0.151; 0.658	0.219
Business	0.232	-0.260; 0.724	0.356	0.333	-0.171; 0.838	0.195
Freelance	0.145	-0.344; 0.634	0.561	0.215	-0.296; 0.727	0.410
Others	0.124	-0.630; 0.877	0.748	0.109	-0.627; 0.846	0.771

B: Unstandardized coefficient, CI: Confidence interval.

achievable within a six-month, school-and-community hybrid framework.

A global scoping review by Ashraf et al examining drowning prevention interventions for children and adolescents under 20 years similarly documented that community-based water safety education and awareness campaigns had been reclassified from “ineffective” to “promising” based on accumulating evidence from multiple settings, including low and middle-income (LMICs). The authors noted that educational interventions involving structured curricula, booklets, seminars, and practical sessions produced improvements in knowledge scores among both children and parents (13). Specifically, a quasi-experimental study in Malaysia reported that the mean knowledge score among parents who received a drowning prevention booklet increased by 25% at one-month follow-up, while scores for those receiving both a booklet and a seminar increased by 22% (10). The magnitude of improvements in knowledge reported in the current study among Vietnamese adolescents is broadly comparable to these findings, reinforcing the generalizability of education-based approaches across LMIC settings. A longitudinal study conducted in Rio de Janeiro, Brazil, monitored changes in the Drowning Prevention Knowledge Level (DPKL) among schoolchildren across three academic years following

repeated classroom-based interventions. By the third year of follow-up, 99% of students were classified as having excellent DPKL, demonstrating that repeated, school-embedded educational exposures confer durable and cumulative improvements in drowning-related knowledge (17). Although the present study employed a single 6-month intervention cycle, its results are consistent with this trajectory of knowledge improvement, suggesting that sustainable gains might be further amplified through continued programming.

Beyond knowledge acquisition, the present study yielded substantively greater improvements in self-rescue and bystander response practices among adolescents in the intervention group compared with controls. This finding is particularly noteworthy given that practice-level change is generally more difficult to achieve through educational programs than knowledge change alone. The distinction between knowledge and behavioral practice has been documented in multiple studies; for instance, a quasi-experimental study in Malaysia found that post-intervention practice scores declined relative to pre-intervention values across all study groups, which the investigators attributed to the brief duration of the intervention period and the complexity of hands-on cardiopulmonary resuscitation skill acquisition (10). That the present six-month program succeeded in producing

measurable practice gains in both self-rescue and bystander response is therefore a meaningful and clinically relevant outcome.

The emphasis on bystander response practices in the present study reflects a key strategic priority in the drowning prevention literature. Meddings et al highlighted that the WHO's recommended portfolio of drowning prevention strategies explicitly includes the training of bystanders in safe rescue and resuscitation methods, alongside other community-level measures (6). A systematic review and meta-analysis on pediatric drowning outcomes found that bystander resuscitation demonstrated nearly double the survival success rates compared with emergency medical personnel or lifeguards responding at the scene, underscoring the life-saving potential of bystander competence (18). By demonstrating measurable gains in bystander response practices among 12–14-year-old adolescents, the present study suggests that this age group can meaningfully acquire and apply such skills through structured educational programming. Furthermore, the scoping review by Ashraf et al confirmed that training on rescue and CRP was classified as a “promising” intervention for drowning prevention based on evidence from Bangladesh, where community-volunteer programmes enabled trained individuals aged 16–25 years to provide first-responder services to drowning casualties (13). The integration of basic rescue and bystander response training into school curricula, as implemented in the present study, represents a scalable and resource-efficient approach to achieving similar outcomes at the population level.

A critical feature of the present study was the multi-component nature of the intervention, combining structured school-based instruction with community communication platforms. This design reflects a growing consensus in the literature that integration of drowning prevention education across multiple channels and settings enhances both reach and effectiveness. Vincenten and Meddings, in a previous study emphasized that combining school-based curricula with multi-sectoral community engagement is essential for strengthening children's and adolescents' capacity to prevent and respond to drowning events (19). They specifically cited Vietnam's national action plan as a model example of government-level commitment to integrating swimming and water safety knowledge into school curricula across all primary and lower secondary school levels. The systematic review by Criel et al further noted that programs delivering water safety training as part of broader injury-prevention curricula produced consistent improvements in water safety knowledge across elementary school-aged children (16). The observed outcomes in the present study align with the characteristics of effective programs identified in this review, which emphasized the importance of structured content delivery, repeated exposure, and real-world contextualization of safety messages. The community communication component of the present intervention

likely reinforced school-based learning by extending the message beyond the classroom, consistent with evidence from school-based health education programs in analogous Southeast Asian contexts, where combined school-and-community approaches produced greater and more sustained improvements in health-related knowledge and behavior than school-only programs.

The epidemiological context of Vietnam further underscores this priority. In a previous study Meddings et al noted that Vietnam had adopted a national action plan aiming for 60% of children aged 6–16 years were able to swim and 70% to possess water safety skills by 2030 (6). The present study, demonstrating that a structured 6-month intervention can meaningfully improve both knowledge and practices in this age group, contributes directly to the evidentiary foundation supporting the implementation of this national strategy.

In summary, the findings of this quasi-experimental study demonstrate that a six-month, school- and communication-based health education program significantly improved drowning prevention knowledge and safe practices, including self-rescue and bystander response, among 12–14-year-old adolescents in Thai Binh province, Vietnam. These results are consistent with an emerging body of evidence supporting the effectiveness of structured, multi-component drowning prevention programs delivered in school and community settings in LMICs. The observed gains in both knowledge and practice-level outcomes are particularly noteworthy, as practice change represents a higher-order and clinically meaningful endpoint. The study adds to the currently limited evidence base for adolescent-targeted, school-integrated drowning prevention in Southeast Asia and supports the broader call, enshrined in both WHO guidance and Vietnam's national action plan, to mainstream water safety education within school curricula and community communication platforms. Policymakers, school health authorities, and public health agencies should consider scaling evidence-based, multi-component drowning prevention programs as a core element of adolescent health promotion strategies in high-burden settings.

Conclusion

This quasi-experimental study demonstrated that a school- and communication-based health education program substantially improved both drowning prevention knowledge and safe practices among adolescents compared with usual conditions. The educational intervention led to pronounced gains in recognition of high-risk environments, understanding of drowning signs and symptoms, and adoption of key preventive behaviors, with only modest, naturally occurring improvements observed in the control group. The program also translated into meaningful enhancements in self-rescue and bystander response practices, including increased familiarity with non-contact rescue techniques, appropriate activation of

emergency services, and correct post-rescue positioning, which were not mirrored in the control arm. Multilevel mixed-effects linear regression confirmed a significant net effect of the intervention on both knowledge and practice scores beyond temporal trends, while highlighting that older students had lower knowledge levels, suggesting important equity and targeting considerations for future programming. Collectively, these findings indicate that integrating structured drowning prevention education into school-based and community communication platforms is an effective strategy to enhance adolescents' capacity to prevent, recognize, and appropriately respond to drowning events in this setting.

Limitations of the study

Several limitations of the present study should be acknowledged. First, the quasi-experimental design precludes complete elimination of confounding, as differences in classroom environments, teacher quality, or community characteristics between intervention and control groups could have influenced outcomes independently of the intervention. Second, all data on practices were collected via a self-reported questionnaire, which may introduce social desirability bias, particularly in the domain of bystander response skills that are more easily misrepresented than directly observable behaviours. Third, the six-month follow-up period, while informative, does not address the durability of knowledge and practice gains over longer timeframes; sustained improvements would require further longitudinal assessment. Fourth, the study was conducted in a single district of Thai Binh province, which may limit generalisability to other geographical and sociocultural contexts within Vietnam or across the broader LMIC setting. Future research should consider randomised controlled designs, objective assessment of rescue skill competency, and extended follow-up durations to more robustly characterise intervention effectiveness.

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Authors' contribution

Conceptualization: Linh Gia Vu and Hai Minh Vu.

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Formal Analysis: Hai Minh Vu.

Investigation: Hai Minh Vu and Vung Dang Nguyen.

Methodology: Linh Gia Vu and Vung Dang Nguyen.

Resources: All authors.

Supervision: All authors.

Validation: Linh Gia Vu.

Writing—original draft: All authors.

Writing—review and editing: All authors.

Conflicts of interest

The authors declare no conflict of interest.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of generative artificial intelligence (AI) and AI-assisted technologies in the writing process

While preparing this work, the authors utilized AI ([Grammarly](#) and [Perplexity](#)) to refine grammar points and language style. Subsequently, they thoroughly reviewed and edited the content as necessary, assuming full responsibility for the publication's content.

Ethical issues

This study was approved by the Institutional Review Board of Vietnam - Korea Institute for Medical and Pharmaceutical Research and Training (Decision No.55/VKIM-HDDD, date 1/8/2022). Written informed consent was obtained from the parent or legal guardian of each participating student. Written informed assent was obtained from each student. All procedures were conducted in accordance with the ethical standards of the Helsinki Declaration (2013 revision). Besides, the authors have ultimately observed ethical issues (including plagiarism, data fabrication, and double publication).

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