

Sensation Seeking and Swimming Self-Efficacy in High-Risk Swimming Behaviour among Malaysian Adolescents: A Moderated Mediation Analysis

Md Asraf Zulzali, Razif Sazali, Azman Ahmad Tajri

Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Kampus Seremban,
Cawangan Negeri Sembilan, 70300 Seremban, Negeri Sembilan, Malaysia

Corresponding Author Email: razifsazali@uitm.edu.my

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Abstract

Drowning remains a preventable cause of adolescent death, and Malaysian water-safety research has not established how safety knowledge is translated into conduct around water. This study tested whether sensation seeking mediates the association between water safety knowledge and high-risk swimming behaviour, and whether swimming self-efficacy conditions that association, among Malaysian secondary school students. A cross-sectional survey of 684 students from 36 government secondary schools across four states measured all four constructs by self-report. A path-analysis structural equation model estimated direct, indirect and interaction effects, controlling for age, sex, grade level and recent swimming frequency, with 5,000 school-cluster bootstrap resamples. Water safety knowledge was negatively associated with sensation seeking and with high-risk swimming behaviour, while sensation seeking was positively associated with high-risk swimming behaviour. The interaction between knowledge and self-efficacy was not significant. The interaction between sensation seeking and self-efficacy was negative, and the conditional indirect association weakened from -0.068 at low self-efficacy to -0.038 at high self-efficacy, with an index of moderated mediation of 0.00197 . Safety knowledge relates to behaviour both directly and indirectly, and the indirect route varies with how capable students believe themselves to be in water.

Keywords: Water Safety Knowledge, Sensation Seeking, Swimming Self-Efficacy, High-Risk Swimming Behaviour, Malaysian Adolescents

Introduction

Drowning remains a preventable cause of mortality, with around 300,000 deaths worldwide each year and a disproportionate burden among children and young people (World Health Organization, 2026). People aged 0 to 29 years account for 57 per cent of global drowning deaths, and 92 per cent of those deaths occur in low- and middle-income countries (World Health Organization, 2026). Malaysia continues to carry a substantial childhood burden. A

national hospital-registry analysis recorded 4,247 fatal and non-fatal childhood drowning cases between 2000 and 2022, with a case-fatality rate of 3.7 per cent and rising fatality between 2010 and 2022 (Alias et al., 2025). These patterns make adolescent water-safety behaviour a consequential prevention target.

Drowning risk among adolescents cannot be reduced to swimming ability alone, because exposure, judgment and voluntary behaviour shape how young people act around water (Sakamoto et al., 2020). High-risk swimming behaviour covers actions that disregard water-safety rules, overestimate personal capability, or otherwise increase exposure to aquatic danger (Shi et al., 2025). Malaysian evidence illustrates the scale of the behavioural problem. Among 525 secondary school students aged 13 to 17 years from five regions, 57 per cent reported being unable to swim and only 17 per cent reported adequate swimming ability, while girls reported lower-risk practices for swimming alone, in prohibited areas, and in water of unknown depth (Abadi et al., 2025). A separate Selangor study of 502 schoolchildren reported preferences for swimming alone, swimming without adults, and swimming before learning to swim (Yusoff et al., 2024). Prevention therefore requires attention to the psychological processes through which safety knowledge is translated into conduct in aquatic settings.

The purpose of this study is to test whether sensation seeking mediates the association between water safety knowledge and high-risk swimming behaviour among Malaysian secondary school students, and whether swimming self-efficacy moderates the direct and the indirect pathway. The contribution is contextual and mechanistic. The moderated-mediation mechanism has been demonstrated in Chinese secondary school students (Shi et al., 2025), but it has not been tested in Malaysia, where the prevention literature has addressed epidemiology and parent-directed education rather than the psychological route from what adolescents know to what they do.

Literature Review

Water Safety Knowledge and High-Risk Swimming Behaviour

Water safety knowledge is a resource for recognising hazards and making decisions during aquatic activity (Cho et al., 2024; Shi et al., 2025). Research on open-water activities has treated safety knowledge as central to understanding safety perceptions and to informing training and public awareness (Cho et al., 2024). Among Chinese secondary school students, greater water safety knowledge predicted lower high-risk swimming behaviour after adjustment for sex, age and grade (Shi et al., 2025). Knowledge, however, can protect only when adolescents apply what they know under conditions that invite risk-taking.

The knowledge to behaviour relationship is central to a water-safety knowledge, attitude and practice (KAP) framework, because KAP-oriented research treats knowledge, attitudes and practice as distinguishable domains rather than assuming that information and behaviour are interchangeable (Farizan et al., 2020). Malaysian evidence supports that distinction. In a quasi-experimental intervention involving 719 parents and guardians of primary school children, water-safety education produced significant gains in knowledge and attitudes, whereas the within-group change in practice was not significant (Farizan et al., 2020). Adolescent studies show the same pattern, with marked variation in swimming ability and water-safety practice among Malaysian secondary school students (Abadi et al., 2025) and

with water-safety behaviour associated with broader risk-taking patterns in other populations (Sakamoto et al., 2020). Shi et al. (2025) found that water safety knowledge retained a significant negative association with high-risk swimming behaviour after sensation seeking entered the model, but that the direct effect represented only part of the total association. The question is therefore not whether knowledge matters but how its behavioural effect is transmitted.

Sensation Seeking as a Mediating Mechanism

Sensation seeking offers a plausible mechanism for why similar levels of safety knowledge do not yield similar behaviour (Leavy et al., 2022; Shi et al., 2025). In swimming research, sensation seeking captures a preference for novelty and stimulation that bears directly on choices involving excitement and perceived challenge. Among 730 young people aged 15 to 24 years in Western Australia, higher sensation-seeking scores were associated with swimming after drinking alcohol, with each one-unit increase corresponding to higher adjusted odds of that behaviour (Leavy et al., 2022). Experimental work with intermediate swimmers found that high sensation seekers responded more slowly to aquatic hazards, particularly hidden hazards, than low sensation seekers (Zhang et al., 2023). Shi et al. (2025) reported that water safety knowledge negatively predicted sensation seeking and that sensation seeking positively predicted high-risk swimming behaviour, with the indirect effect accounting for 25 per cent of the total effect. Sensation seeking is also developmentally salient during adolescence, which is precisely the period in which aquatic exposure becomes less supervised (Steinberg et al., 2008).

Swimming Self-Efficacy as a Boundary Condition

The strength of that pathway may depend on how capable adolescents believe themselves to be in water. Swimming self-efficacy reflects confidence in one's swimming ability and can alter how knowledge is expressed in risky situations (Shi et al., 2025). Such confidence is not uniformly protective. Among Chinese secondary school students, swimming self-efficacy moderated both the direct association between water safety knowledge and high-risk swimming behaviour and the association between sensation seeking and risky behaviour, with the protective association of knowledge becoming stronger at higher self-efficacy while the positive association between sensation seeking and high-risk behaviour also strengthened (Shi et al., 2025). Related work with primary school students found that self-efficacy partially mediated the positive association between water safety skills and high-risk swimming behaviour, with water safety knowledge moderating that process (Tan et al., 2025). Latent-profile evidence has identified progressively higher high-risk behaviour across swimming self-efficacy profiles, with an overconfident subgroup showing the highest-risk pattern (Yang et al., 2026). Self-efficacy is therefore a boundary condition whose effect depends on the pathway it qualifies.

The Malaysian Evidence Gap

The main limitation in this body of evidence is contextual. The moderated-mediation mechanism has been demonstrated in Chinese secondary school students (Shi et al., 2025). Malaysian drowning research has addressed different parts of the prevention problem. National registry work has characterised childhood drowning epidemiology and identified demographic and regional patterns (Alias et al., 2025). Malaysian KAP-oriented intervention research has focused on parents and guardians rather than on secondary school students

(Farizan et al., 2020). Student-focused studies have described water-safety awareness, swimming ability, attitudes and risky practices among Malaysian adolescents, but they have not tested sensation seeking as a mediator together with swimming self-efficacy as a moderator (Abadi et al., 2025; Yusoff et al., 2024). Within an adapted water-safety KAP framework, the pathway from knowledge to high-risk swimming behaviour therefore remains insufficiently specified in the Malaysian context.

Hypotheses

Four hypotheses were derived from the literature above.

H1: Greater water safety knowledge is associated with lower high-risk swimming behaviour.

H2: Sensation seeking mediates the association between water safety knowledge and high-risk swimming behaviour.

H3: Swimming self-efficacy moderates the direct association between water safety knowledge and high-risk swimming behaviour.

H4: Swimming self-efficacy moderates the association between sensation seeking and high-risk swimming behaviour, and therefore the conditional indirect association.

Methodology

Research Design and Participants

This cross-sectional survey was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology recommendations (von Elm et al., 2007). The required sample size was determined a priori by Monte Carlo power analysis of the hypothesised moderated mediation model, using a minimum 80 per cent power criterion at $\alpha = .05$ (Muthén & Muthén, 2002). The target was 720 students, based on standardised path coefficients of 0.20 for main effects and 0.10 for interaction effects, an intraclass correlation of 0.05, 36 school-class clusters averaging 20 students, 5,000 Monte Carlo replications and a 10 per cent allowance for non-response.

The final analytic sample comprised 684 students recruited from 36 government secondary schools in Selangor, Perak, Johor and Terengganu through multistage stratified cluster sampling, stratified by state and by urban or rural location. Schools were the primary sampling units and intact classes the secondary cluster units, with one intact class sampled per participating school. Eligibility required current enrolment in a sampled class, parental or guardian permission together with student assent, and prior swimming experience sufficient to answer swimming-specific items. Students were excluded if they had no swimming or recreational water participation during the preceding 12 months, were absent on the scheduled survey day, or could not complete the questionnaire independently in Bahasa Melayu. Data were collected in a single assessment window between 19 January 2026 and 24 April 2026.

Instruments

Water safety knowledge, the predictor, was measured with the water-safety knowledge subscale of the Water Safety Knowledge, Attitude and Practice questionnaire developed for school students (Xia et al., 2012). The subscale contains 10 items answered on a five-point familiarity scale, with no reverse-coded items, and the composite was the item mean, so that higher scores represent greater knowledge.

Sensation seeking, the mediator, was measured with the eight-item Brief Sensation Seeking Scale (Hoyle et al., 2002), which represents thrill and adventure seeking, experience seeking, disinhibition and boredom susceptibility. Participants responded on a five-point agreement scale and the item mean was used.

Swimming self-efficacy, the moderator, was assessed with a six-item measure derived from Theodorakis (1995), in which students rate confidence in completing swimming tasks of increasing difficulty from 1 to 10. The score was the sum of the six items, giving a possible range from 6 to 60.

High-risk swimming behaviour, the outcome, was measured with the 20-item Adolescent Swimming Risk Behaviour Scale (Lu et al., 2026), which represents wrong behaviour, mistake behaviour, general violation and aggressive violation. Responses were recorded on a five-point scale with no reverse-coded items and the composite was the item mean.

Reliability was evaluated with Cronbach's alpha and composite reliability, and convergent validity with standardised factor loadings and average variance extracted (Fornell & Larcker, 1981). Measurement properties are reported in Table 2. All four constructs were measured within the same survey wave, so no temporal precedence was imposed by the measurement schedule.

Procedure

The study was conducted under institutional human-research ethics oversight and with authorisation from the participating education authorities and schools. Ethics approval was granted by the Universiti Kebangsaan Malaysia Research Ethics Committee under approval number [to be inserted], with further administrative approvals from the Ministry of Education Malaysia, the four participating State Education Departments and the principals of the participating schools. Written parental or guardian consent and student assent were obtained before participation. Participation was voluntary, students could discontinue without penalty, and confidentiality was protected through anonymous numeric study codes, separate storage of consent documents and questionnaires, and encrypted password-protected electronic files.

The questionnaire was administered as a supervised, self-administered school-based survey during a scheduled class period by trained research personnel, using paper-and-pencil forms in Bahasa Melayu following independent forward and backward translation and reconciliation by two bilingual researchers and a secondary-school language teacher. Completion required approximately 25 minutes. Selection and information bias were addressed through state and urban or rural stratification, recruitment of all eligible students within sampled classes, standardised administrator scripts, private completion, and the absence of classroom teachers during completion. Common-method bias was addressed through anonymous responding, separation of predictor and outcome blocks, neutral instructions stating that there were no right or wrong responses, and different response anchors across instruments (Podsakoff et al., 2003).

Data Analysis

Analyses were conducted in R version 4.5.2 with the lavaan package version 0.6-20 (Rosseel, 2012). Confirmatory factor analysis preceded structural testing, with model fit evaluated using the chi-square statistic, CFI, TLI, RMSEA and SRMR, interpreted jointly against established approximate-fit guidance rather than as pass or fail rules (Hu & Bentler, 1999). Scale composites were then entered into a path-analysis structural equation model in which water safety knowledge predicted sensation seeking and high-risk swimming behaviour, sensation seeking predicted high-risk swimming behaviour, and swimming self-efficacy moderated both the knowledge to behaviour path and the sensation seeking to behaviour path. This specification tests moderation of the direct effect and of the second stage of the indirect effect. Continuous variables entering interaction terms were mean-centred before product terms were formed.

Conditional direct and indirect effects were estimated at low, mean and high levels of swimming self-efficacy, defined as one standard deviation below the mean, the mean, and one standard deviation above the mean. The index of moderated mediation was used to test whether the indirect effect varied linearly with the moderator (Hayes, 2015; Preacher et al., 2007). Because students were clustered within schools and classes, variance estimation accounted for the school level, which was equivalent to the class level because one intact class was sampled per school, and bootstrap resampling was conducted at that cluster level using 5,000 resamples and 95 per cent confidence intervals. Statistical significance was set at $p < .05$. Sampling weights were not applied because the study estimated associations within the analytic sample rather than population prevalence. Missing data were handled with full-information maximum likelihood under a missing-at-random assumption after scale scores were computed when at least 80 per cent of the constituent items were available. Age, sex, grade level and frequency of swimming during the preceding 12 months were included as covariates, selected a priori for their plausible associations with sensation seeking, swimming self-efficacy and aquatic risk behaviour.

Results

Participant Characteristics

The analytic sample comprised 684 students with a mean age of 15.02 years ($SD = 1.39$), of whom 337 were male (49.27 per cent) and 347 female (50.73 per cent). No values were missing for age, sex, grade level, state or stratum, so all 684 participants contributed to the descriptive analysis. Table 1 reports the profile.

Table 1

Participant characteristics of the analytic sample (N = 684)

Characteristic	Category	n	%
Sex	Male	337	49.27
	Female	347	50.73
Grade level	Form 1	141	20.61
	Form 2	138	20.18
	Form 3	143	20.91
	Form 4	136	19.88
	Form 5	126	18.42
State	Selangor	169	24.71
	Perak	169	24.71
	Johor	172	25.15
	Terengganu	174	25.44
Stratum	Urban	341	49.85
	Rural	343	50.15

Note. Mean age was 15.02 years (SD = 1.39).

Measurement Properties

Table 2 reports reliability and confirmatory factor analysis results for the three multi-item reflective constructs. Composite reliability exceeded .80 for all three and standardised factor loadings were positive throughout. For water safety knowledge, loadings ranged from .49 to .69 and the average variance extracted was .33, which falls below the conventional .50 benchmark. The scale was retained on two grounds. First, convergent validity may still be judged adequate where average variance extracted is below .50 but composite reliability exceeds .60 (Fornell & Larcker, 1981). Second, the instrument samples a content domain of safety facts rather than indicators of a single latent disposition, so high inter-item redundancy is not expected. The low average variance extracted is nonetheless treated as a measurement limitation.

For high-risk swimming behaviour, standardised loadings ranged from .64 to .80 and correlations among the four latent domains ranged from .31 to .42. The four-domain structure was therefore retained, and the prespecified overall mean score was carried forward as the aggregate outcome for structural modelling rather than treated as evidence of a unidimensional latent construct.

Table 2

Reliability and confirmatory factor analysis results for the study instruments

Construct	Items	α	CR	AVE	χ^2 (df)	CFI	TLI	RMSEA	SRMR
Water safety knowledge	10	.83	.83	.33	59.64 (35)	.984	.979	.032	.028
Sensation seeking	8	.83	.84	.51	$\chi^2/df = 2.18$	.961	.945	.042	.033
Swimming self-efficacy	6	[insert]	[insert]	[insert]	[insert]	—	—	—	—
High-risk swimming behaviour	20	.88	.92	.54	241.08 (164)	.986	.984	.026	.029

Note. α = Cronbach's alpha; CR = composite reliability; AVE = average variance extracted. Cronbach's alpha for water safety knowledge was computed on 665 complete item profiles and for high-risk swimming behaviour on 640 complete item profiles; composite reliability and average variance extracted were estimated across all 684 participants using full-information maximum likelihood. Reliability and validity statistics for the swimming self-efficacy measure are to be inserted before submission.

Structural Paths Within the Moderated Mediation Model

The adjusted structural model included 684 participants nested within 36 school clusters. The observed-variable recursive specification had zero degrees of freedom and was just identified, so global chi-square based fit indices were not informative. The model accounted for 5 per cent of the variance in sensation seeking and 18 per cent of the variance in high-risk swimming behaviour.

Water safety knowledge was negatively associated with sensation seeking, $B = -0.22$, $SE = 0.05$, $z = -4.84$, $p < .001$, $\beta = -.20$, 95% bootstrap CI $[-.27, -.12]$. Water safety knowledge was also negatively associated with high-risk swimming behaviour, $B = -0.11$, $SE = 0.02$, $z = -4.68$, $p < .001$, $\beta = -.14$, 95% bootstrap CI $[-.20, -.08]$, supporting H1. Sensation seeking was positively associated with high-risk swimming behaviour, $B = 0.24$, $SE = 0.03$, $z = 9.26$, $p < .001$, $\beta = .34$, 95% bootstrap CI $[.27, .40]$. Table 3 and Figure 1 summarise these estimates.

Table 3

Adjusted standardised structural paths

Structural path	β	95% CI lower	95% CI upper
Water safety knowledge $\rightarrow$ sensation seeking	-.20	-.27	-.12
Water safety knowledge $\rightarrow$ high-risk swimming behaviour	-.14	-.20	-.08
Sensation seeking $\rightarrow$ high-risk swimming behaviour	.34	.27	.40

Note. Estimates are adjusted for age, sex, grade level and swimming frequency during the preceding 12 months. Confidence intervals are from 5,000 school-cluster bootstrap resamples.

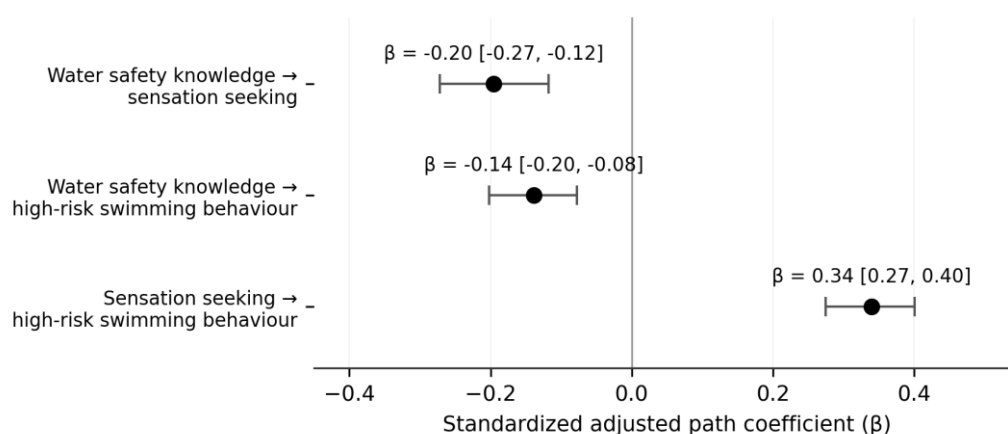


Figure 1 Adjusted standardised path coefficients with 95 per cent confidence intervals from 5,000 school-cluster bootstrap resamples

Moderating and Conditional Effects of Swimming Self-Efficacy

Residual normality was not supported, Shapiro-Wilk $W = 0.98$, $p < .001$, so inference used the prespecified school-cluster robust variance estimator and 5,000 cluster-bootstrap resamples. The interaction between water safety knowledge and swimming self-efficacy was not statistically significant, $B = -0.005$, $SE = 0.004$, $z = -1.35$, $p = .178$, $\beta = -.04$, 95% bootstrap CI $[-.10, .02]$. H3 was therefore not supported. The conditional direct association between water safety knowledge and high-risk swimming behaviour was negative and significant at every level of the moderator, as Table 4 shows, but because the interaction test was null these conditional estimates cannot be read as evidence that self-efficacy strengthened the knowledge to behaviour association.

Table 4

Conditional direct effect of water safety knowledge on high-risk swimming behaviour

Self-efficacy level	Score	B	SE	95% CI lower	95% CI upper
Low (-1 SD)	29.40	-0.073	0.030	-0.130	-0.015
Mean	37.04	-0.110	0.024	-0.159	-0.062
High (+1 SD)	44.69	-0.147	0.042	-0.228	-0.065

Note. All three conditional direct effects were significant ($p = .013$, $p < .001$ and $p < .001$ respectively), but the knowledge $\times$ self-efficacy interaction was not significant, so the gradient across levels should not be interpreted as moderation.

The interaction between sensation seeking and swimming self-efficacy was negative and significant, $B = -0.009$, $SE = 0.004$, $z = -2.44$, $p = .015$, $\beta = -.10$, 95% bootstrap CI $[-.17, -.02]$. The conditional indirect association through sensation seeking weakened in absolute magnitude as swimming self-efficacy increased, and the index of moderated mediation excluded zero, supporting H2 and H4. Table 5 reports these estimates and Figure 2 displays both sets of conditional effects.

Table 5

Conditional indirect effects and index of moderated mediation

Effect	Score	Estimate	Bootstrap SE	95% CI lower	95% CI upper
Indirect effect, low self-efficacy	29.40	-0.0680	0.01689	-0.1039	-0.0375
Indirect effect, mean self-efficacy	37.04	-0.0529	0.01246	-0.0786	-0.0296
Indirect effect, high self-efficacy	44.69	-0.0377	0.01130	-0.0617	-0.0179
Index of moderated mediation	—	0.00197	0.00093	0.00043	0.00410

Note. The indirect path runs from water safety knowledge through sensation seeking to high-risk swimming behaviour. Score refers to the swimming self-efficacy total, which ranges from 6 to 60.

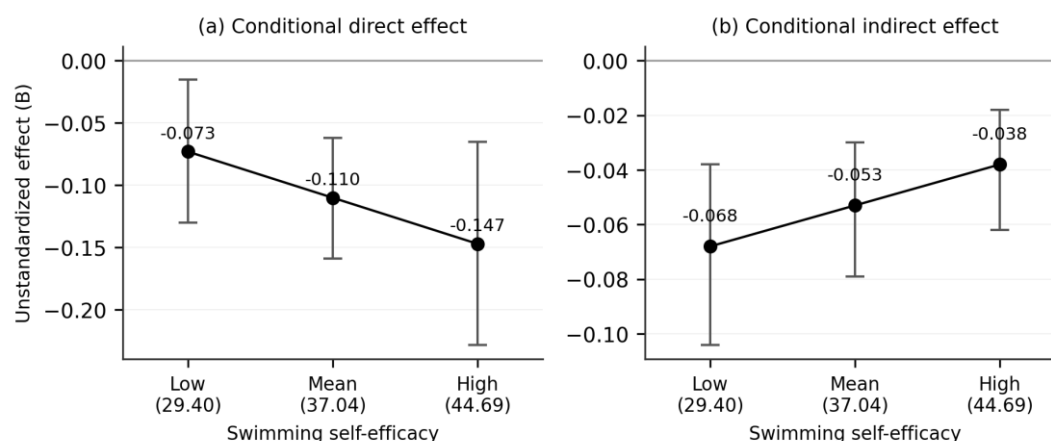


Figure 2. Conditional direct effect (panel a) and conditional indirect effect (panel b) of water safety knowledge on high-risk swimming behaviour across levels of swimming self-efficacy. Error bars represent 95 per cent confidence intervals from 5,000 school-cluster bootstrap resamples.

Discussion

This study examined a moderated mediation model linking water safety knowledge, sensation seeking, swimming self-efficacy and high-risk swimming behaviour among Malaysian secondary school students. The model was supported in part. Water safety knowledge was negatively associated with both sensation seeking and high-risk swimming behaviour, and sensation seeking was positively associated with high-risk swimming behaviour, supporting H1 and H2. Swimming self-efficacy did not moderate the direct association, so H3 was not supported. It did moderate the sensation seeking association and the conditional indirect association, supporting H4 and indicating second-stage moderated mediation. These associations were estimated after adjustment for age, sex, grade level and recent swimming frequency, although such adjustment cannot remove unmeasured confounding.

Sensation Seeking as a Mediating Mechanism

At mean swimming self-efficacy the conditional indirect association was -0.053 , 95% bootstrap CI $[-0.079, -0.030]$. This is consistent with sensation seeking functioning as a psychological correlate within the knowledge to behaviour relationship, though the single-wave design does not establish that knowledge preceded or changed sensation seeking.

The negative direct association between water safety knowledge and high-risk swimming behaviour aligns with evidence that adolescents with greater drowning-prevention knowledge report fewer risky aquatic behaviours (Luo et al., 2024; Zhong et al., 2026) and with the Chinese moderated mediation study on which the present model was based (Shi et al., 2025). The present study extends that literature by showing that the association remained observable in a Malaysian secondary-school sample after sensation seeking and swimming self-efficacy were incorporated into the same structural model. The distinction matters because knowledge should not be treated as a proxy for water competence. Water competence frameworks position cognitive knowledge alongside physical skills and affective capacities rather than assuming that knowledge alone is sufficient for safe behaviour (Stallman et al., 2017), and Malaysian evidence indicates substantial heterogeneity in swimming ability among adolescents (Abadi et al., 2025). One plausible reading of the retained direct association is that the present sample comprised students with prior swimming experience and recent aquatic participation, making safety knowledge directly relevant to choices they had opportunities to make. That reading remains speculative because specific exposure contexts and decision episodes were not measured.

Swimming Self-Efficacy as a Boundary Condition

The moderation pattern diverges from Shi et al. (2025) in two respects. First, the direct interaction was null here, whereas higher swimming self-efficacy strengthened the protective knowledge association in the Chinese sample. The increasingly negative conditional direct estimates across levels of the moderator therefore cannot be read as evidence of moderation, because the interaction test did not support it. Second, the significant second-stage interaction ran in the opposite direction. The conditional indirect association became smaller

in absolute magnitude as swimming self-efficacy increased, from -0.068 at low self-efficacy to -0.038 at high self-efficacy.

One explanation is that swimming self-efficacy may represent different combinations of calibrated competence and overconfidence across populations. Latent-profile research has identified qualitatively distinct swimming self-efficacy profiles, including an overconfident group, with substantial differences in high-risk behaviour across profiles (Yang et al., 2026). Evidence from competitive freediving supports treating self-efficacy and sensation seeking as distinct constructs in risky aquatic settings, because each contributed differently to performance (Baretta et al., 2017). Evidence from Bangladesh, in contrast, found no increase in water exposure or risky water entry among children taught swimming through a structured programme, which argues against assuming that greater capability necessarily produces risk compensation (Mecrow et al., 2015). The Malaysian pattern may reflect a subgroup for whom greater confidence is accompanied by better self-regulation or more experience, but this mechanism was not measured and should not be inferred from the interaction alone.

The moderation was modest in standardised magnitude, $\beta = -.10$, and its relevance lies in its direction and in the supported index of moderated mediation rather than in statistical significance alone. The model explained 18 per cent of the variance in high-risk swimming behaviour, and the available results do not isolate the incremental variance attributable to the interaction term. The result should therefore be read as evidence of conditional association rather than as evidence that swimming self-efficacy is a dominant determinant of risky behaviour. Its divergence from Shi et al. (2025) strengthens the case for replication rather than for a universal moderator claim. Future replications should separate self-efficacy from objectively assessed swimming skill, perceived water competence and overconfidence, and should examine whether peer context or aquatic setting changes the sensation seeking association, because adolescent water-safety behaviour co-occurs with broader risk-taking patterns (Sakamoto et al., 2020).

Theoretical Contribution

The findings support an expanded KAP interpretation in which knowledge relates to behaviour through more than a simple knowledge to practice sequence. The indirect pattern through sensation seeking is consistent with psychological dispositions being relevant to how safety knowledge and risky behaviour covary, while the self-efficacy interaction indicates that this indirect association is not constant across students. This extends KAP-oriented drowning research that has emphasised risk perceptions and attitudes as intervening correlates (Luo et al., 2024) and remains consistent with evidence that sensation seeking is developmentally salient during adolescence (Steinberg et al., 2008). The Malaysian result also shows that a mechanism established in one national setting should not be assumed to transfer intact, because the boundary condition reversed direction across the two samples.

Implications for Practice

The findings caution against water-safety programmes that rely on knowledge transmission as their sole behavioural strategy. Schools and recreation agencies can reasonably pair water-safety knowledge with activities that require students to identify sensation-seeking triggers, evaluate situational risk, and compare perceived capability with actual aquatic competence. This is consistent with water-competence models that integrate cognitive and physical

capacities (Stallman et al., 2017) and with intervention research showing that a comprehensive adolescent aquatic programme can improve both water-safety knowledge and swimming ability (Petrass & Blitvich, 2014).

The null direct interaction also means that swimming self-efficacy should not be treated as a simple lever that strengthens the association between knowledge and safer behaviour. Practitioners should instead assess whether confidence is calibrated to demonstrated skill and to safe decision making. Because the present evidence is cross-sectional, these recommendations identify intervention targets for testing rather than demonstrating that changing knowledge, sensation seeking or self-efficacy will reduce high-risk swimming behaviour.

Limitations and Future Directions

Several limitations constrain interpretation. All focal constructs were measured during the same cross-sectional window, so the indirect and moderated indirect estimates describe statistical patterns among concurrently measured variables and do not establish temporal ordering or causal mediation. All focal variables were assessed by self-report, and although anonymous administration, private completion, neutral instructions, separated construct blocks and different response anchors reduced some common-method pressures, they cannot eliminate recall error, social desirability or shared-method covariance (Podsakoff et al., 2003).

The sampling frame also limits generalisability. Eligibility required prior swimming experience and recent aquatic participation, so the findings should not be extended automatically to Malaysian adolescents who do not swim, a group that Malaysian evidence suggests is substantial (Abadi et al., 2025). The final sample fell modestly below the planned recruitment target, and the null knowledge by self-efficacy interaction should therefore not be read as evidence that moderation is absent, because its confidence interval remained compatible with small effects in either direction. High-risk swimming behaviour was represented by an aggregate mean across four correlated but distinguishable domains, and aggregation can conceal domain-specific associations. The average variance extracted for water safety knowledge fell below the conventional benchmark, which warrants caution in interpreting that construct. Finally, translated and adapted instruments may not capture identical meanings across cultural settings even when translation procedures are rigorous, so direct measurement-invariance testing across Malaysian and Chinese samples would provide a stronger basis for interpreting the observed divergence in moderation.

Reciprocal processes remain plausible. Repeated engagement in risky swimming could be associated with later confidence, perceived competence, sensation seeking or attention to safety knowledge, while accumulated aquatic experience could alter how these constructs relate to one another. A prospective multiwave design could separate within-person change from stable between-person differences and test competing temporal orderings. An intervention study could then manipulate water-safety instruction and calibrated skill feedback while measuring sensation seeking, self-efficacy and observed risk decisions over follow-up. Such work would test directly whether the Malaysian moderation pattern replicates and whether its divergence from the Chinese findings reflects cultural context, measurement, aquatic experience or genuinely different conditional processes.

Conclusion

Among 684 Malaysian secondary school students, water safety knowledge was associated with high-risk swimming behaviour both directly and indirectly through sensation seeking, and the indirect route varied with swimming self-efficacy. Knowledge alone is therefore an incomplete account of how adolescents behave around water. The route through sensation seeking indicates that safety education competes with a disposition towards stimulation, and the conditional pattern indicates that students differ in how strongly that competition plays out. Contrary to expectation, the indirect association was weaker rather than stronger among students who felt more capable in water, which reverses the pattern reported in Chinese secondary school students and argues against treating the moderator as universal. For Malaysian schools and recreation agencies, the practical reading is that knowledge-based drowning prevention should be paired with work on risk appraisal and on calibrating confidence against demonstrated competence. For researchers, the reversal is an argument for longitudinal replication with objective skill measurement before the mechanism is used to design national programmes.

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Consent: Written parental or guardian informed consent and student assent were obtained from all participants.

Data Availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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