JOSKA: ISORI KAMPAR JOURNAL
Indonesian Sport & Physical Scientist Association
Original Reseach Articles | Volume 3, Issue 2, 2026 | ISSN: 3064-4038 | DOI: 10.53905/joska.v3i02.17

Swimming Education and Water Safety in Schools: A Systematic Literature Review

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ABSTRACT

Objectives: This systematic literature review aims to synthesize global evidence on swimming education and water safety programs implemented within school settings, with particular emphasis on identifying effective pedagogical approaches, intervention frameworks, program characteristics, contextual facilitators, and persistent barriers that influence student swimming competency and drowning prevention outcomes.

Methods: A systematic literature review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. Five major academic databases were searched: Scopus, Web of Science, ERIC, PubMed, and ScienceDirect. Search strategies employed Boolean operators combining terms related to swimming instruction, aquatic education, water safety, drowning prevention, and school-based interventions. The review encompassed peer-reviewed journal articles published between 2019 and 2026, written in English. A total of 1,247 records were initially identified; following removal of duplicates, title and abstract screening, and full-text eligibility assessment, 52 studies met the inclusion criteria. Study quality was evaluated using the Critical Appraisal Skills Programme (CASP) and the Mixed Methods Appraisal Tool (MMAT). Thematic synthesis and narrative analysis were applied to extract and integrate key findings.

Results: Five major thematic clusters emerged from the review: (1) structured aquatic curriculum models and their effectiveness across age groups; (2) instructional strategies and differentiated teaching in school-based swimming programs; (3) the role of water safety education in drowning prevention; (4) barriers to participation including socioeconomic disparities, cultural attitudes, facility access, and fear; and (5) the integration of technology and innovative pedagogies in aquatic education. Findings indicate that well-structured, age-appropriate, and culturally responsive swimming programs significantly improve fundamental aquatic skills and water safety knowledge among school-aged children. Nevertheless, critical inequities in program access persist globally.

Conclusion: Swimming education and water safety represent an urgent public health imperative and an underinvested component of school physical education curricula globally. This review underscores the need for equitable, evidence-based aquatic education policies, adequately trained instructors, accessible facilities, and culturally sensitive program delivery. Future research should prioritize longitudinal effectiveness studies, equity-focused interventions, and the development of internationally standardized competency frameworks.

Keywords:
swimming education; water safety; drowning prevention; school-based aquatic programs; physical education; aquatic literacy; swimming competency.

Citation:
Saleh, M. A., Karo Karo, F. H., Suprayitno, S., & Ahady, M. Y. (2026). Swimming Education and Water Safety in Schools: A Systematic Literature Review. Joska: Jurnal Isori Kampar, 3(02). https://doi.org/10.53905/joska.v3i02.17

Received: April 26, 2026 | **Accepted:** June 09, 2026 | **Published:** July 27, 2026.

INTRODUCTION

Contextual Framework

Drowning constitutes one of the most preventable causes of unintentional injury-related mortality worldwide, with the World Health Organization (WHO) estimating that over 236,000 individuals perish annually as a result of unintentional drowning, with the burden disproportionately falling upon low- and middle-income countries (Organization, 2021). Children aged one to fourteen years represent the most vulnerable demographic, with drowning ranking among the leading three causes of unintentional injury-related death across nearly all age groups globally (Hyder et al., 2020; Peden et al., 2021). In this context, the acquisition of fundamental swimming competencies and comprehensive water safety knowledge within structured educational environments emerges not merely as a matter of recreational enrichment but as an urgent public health imperative.

School-based swimming education has historically occupied a contested and fragmented position within physical education curricula internationally. While countries such as Australia, Sweden, Germany, and Japan have institutionalized mandatory swimming competency standards as integrated components of their national physical education frameworks (Moran et al., 2022; Stallman et al., 2021), the majority of nations—particularly in South and Southeast Asia, Sub-Saharan Africa, and Latin America—exhibit pronounced deficits in formal aquatic education provision (Benjamin et al., 2020; Franklin et al., 2020). This asymmetry reflects broader structural inequalities in educational resource allocation, infrastructure, trained instructor availability, and sociocultural attitudes toward swimming participation.

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The conceptual foundations of swimming education extend beyond the acquisition of locomotor aquatic skills. Contemporary aquatic literacy frameworks emphasize a multidimensional set of competencies encompassing survival swimming, personal rescue, self-rescue, basic water safety knowledge, understanding of aquatic environments, and the capacity to assist others in distress (Langendorfer, 2020; Stallman et al., 2021). This holistic conception of aquatic literacy has increasingly informed curriculum design in progressive national systems, moving the pedagogical discourse beyond mere stroke proficiency toward a competency-based, safety-oriented, and developmentally appropriate model of instruction.

Concurrently, the global physical education landscape has undergone substantive transformation in response to digital innovation, evidence-based pedagogy, and shifting conceptions of health literacy. The integration of technology-enhanced instructional tools—including underwater video analysis, virtual reality simulation, digital performance feedback systems, and mobile learning applications—has begun to reshape the pedagogical repertoire available to aquatic educators (Ali et al., 2022; Komar et al., 2021). Post-pandemic educational disruptions have further accelerated interest in hybrid and technology-mediated approaches to physical education delivery, including swimming instruction, raising novel questions about the efficacy, accessibility, and equity implications of such approaches (Naul et al., 2021).

Within this evolving landscape, the school setting assumes particular strategic significance. Schools represent the single most universal institutional interface between children and structured education across all socioeconomic strata, making them uniquely positioned to address equity gaps in aquatic competency development (Peden et al., 2021; Rissel et al., 2020). Embedding swimming education within mandatory schooling frameworks offers the potential to reach children who may otherwise lack access to private swimming lessons, community aquatic programs, or family-facilitated aquatic socialization—particularly those from low-income, minority, immigrant, or rural backgrounds.

Critical Examination of Existing Literature

Prior scholarship on school-based swimming education has yielded important but incomplete insights into the conditions under which aquatic programs effectively enhance children's swimming competency and water safety literacy. Early systematic reviews and meta-analyses—notably those conducted by Brenner et al., (2009) and (Duke et al., 2023, p. 43) —established foundational evidence for the inverse relationship between formal swimming instruction participation and drowning risk, demonstrating reductions in drowning risk ranging from 88% for children aged one to four years with formal swimming lessons. However, these earlier reviews drew substantially on studies from high-income, English-speaking contexts and did not sufficiently address program-level variables, instructional quality, curriculum coherence, or the specific school-based implementation features that moderate intervention effectiveness.

More recent empirical work has begun to interrogate the specific pedagogical mechanisms underlying effective aquatic education. Research by (Marques et al., 2020) contributed a refined developmental-biomechanical perspective on aquatic readiness, arguing that effective swimming instruction must be grounded in an understanding of individual variations in aquatic readiness, motor development trajectories, and buoyancy-related characteristics. Similarly, work by (Christie & Elliott, 2024) advanced the concept of 'aquatic survival competence' as a more pragmatic and ecologically valid outcome measure for school programs than traditional competitive stroke proficiency metrics, arguing that the latter systematically disadvantages children from low-income backgrounds and those with diverse body morphologies.

Studies examining instructional approaches have highlighted the relative superiority of aquatic-readiness-based, problem-solving, and student-centered pedagogical models over traditional direct instruction and drill-based approaches in generating durable aquatic skill acquisition and positive attitudinal outcomes (Kjendlie et al., 2020; Moran et al., 2022). A growing body of literature from Northern European contexts—particularly Sweden and Norway—has contributed nuanced analyses of teacher competence, student-to-instructor ratios, lesson structure, and assessment validity in school swimming programs (Bjorke & Moen, 2019; Stallman et al., 2020). Meanwhile, research from Australia—where National Swimming and Water Safety standards have been operationalized through the Royal Life Saving Society and AUSTSWIM frameworks—has provided insights into the organizational, institutional, and policy-level factors that facilitate or impede program implementation at scale (Franklin et al., 2020; Rissel et al., 2020).

Research on water safety education as distinct from swimming instruction has drawn attention to the critical but often neglected dimension of cognitive and attitudinal learning in aquatic programs. Studies by (Coons et al., 2023) and (Sandomierski et al., 2019) demonstrated that water safety education interventions—encompassing knowledge of environmental hazards, behavioral self-regulation near water, recognition of drowning scenarios, and basic rescue techniques—produced significant improvements in children's safety-related knowledge and risk perception when delivered as integrated components of school aquatic curricula. However, evidence for sustained behavioral change beyond immediate post-intervention assessment periods remains limited.

A further strand of relevant literature addresses barriers to swimming participation and aquatic education access, with particular attention to racial, ethnic, socioeconomic, gender, and geographic disparities. Research in the United States context has extensively documented lower swimming competency rates among African American, Hispanic, and Indigenous children relative to White peers, attributing these disparities to historical exclusion from public pool facilities, lower household incomes, culturally negative attitudes toward swimming, hair care concerns, and reduced access to formal instruction (Griffiths et al., 2020; Irwin et al., 2021). Similar patterns of racialized and socioeconomic disparity have been documented in Australian, British, and Canadian contexts (Blitvich et al., 2019; Ennis, 2020).

Identification of Research Gaps

Notwithstanding the substantive insights yielded by existing research, several critical gaps constrain the field's capacity to inform evidence-based policy and practice. First, no comprehensive systematic literature review has been conducted within the 2019–2026 timeframe that specifically synthesizes school-based swimming education research across diverse national, cultural, and socioeconomic contexts, leaving policymakers and curriculum designers without an up-to-date global evidence base. Second, the preponderance of existing reviews has focused on drowning incidence and epidemiological outcomes rather than on the pedagogical, curricular, and instructional dimensions of school swimming programs, creating a disconnect between public health and educational research traditions.

Third, the literature exhibits a pronounced geographic and linguistic concentration, with the majority of empirical studies originating from high-income, English-speaking nations, resulting in substantial underrepresentation of evidence from low- and middle-income contexts where the drowning burden is greatest. Fourth, existing reviews have not adequately integrated the growing body of evidence concerning technology-mediated aquatic instruction, digital water safety education tools, and the role of digital competency in contemporary aquatic pedagogy. Fifth, the evidence base on the long-term effects of school-based aquatic education on swimming competency retention, behavioral water safety practices, and drowning risk reduction remains notably thin, reflecting a broader limitation of short-term intervention designs in physical education research.

Finally, the literature has not adequately addressed the intersection of disability inclusion, neurodevelopmental diversity, and school-based aquatic education, despite the well-documented therapeutic and developmental benefits of aquatic activity for children with physical, cognitive, and sensory disabilities, as well as the heightened drowning risk associated with certain neurodevelopmental conditions including autism spectrum disorder.

Rationale for the Research

Against this backdrop of urgent public health need, significant policy relevance, and demonstrable gaps in the systematic synthesis of available evidence, this systematic literature review is positioned as a timely and necessary contribution to the international literature on swimming education and water safety in schools. By synthesizing peer-reviewed evidence published between 2019 and 2026 from a broad range of national and cultural contexts, this review aims to provide curriculum designers, school physical education specialists, aquatic education policymakers, teacher educators, and public health practitioners with a rigorous, current, and globally informed evidence base.

The review is furthermore motivated by the increasing policy emphasis on swimming competency within national physical education frameworks globally. Recent policy developments in Australia, the United Kingdom, the European Union, and Southeast Asia have placed renewed emphasis on the role of schools in delivering universal aquatic education, making a critical synthesis of the available evidence both timely and practically significant.

Research Objectives

The present systematic literature review is guided by the following research objectives: (1) To synthesize global peer-reviewed evidence on the design, delivery, and outcomes of school-based swimming education and water safety programs published between 2019 and 2026; (2) To identify and critically evaluate the dominant pedagogical approaches, instructional models, and curriculum frameworks employed in school-based aquatic education; (3) To examine evidence regarding the impact of school swimming programs on students' aquatic competency, water safety knowledge, drowning risk reduction, and attitudinal outcomes; (4) To analyze facilitators and barriers to the effective implementation of school-based aquatic education across diverse cultural, socioeconomic, and geographic contexts; (5) To assess the role of technological innovation and digitally mediated instruction in school-based swimming and water safety education; (6) To propose an agenda for future research and evidence-based policy recommendations in the field of school aquatic education.

MATERIALS AND METHODS

Research Design

This study employs a systematic literature review (SLR) design, operationalized in strict accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines (Page et al., 2021). The PRISMA 2020 framework was selected for its methodological rigor, transparency, and international recognition as the gold standard for systematic review reporting. The SLR design was deemed optimal for addressing the study's objectives, given its capacity to identify, evaluate, and synthesize all available empirical evidence relevant to a defined research question in a systematic, replicable, and bias-minimizing manner (Higgins et al., 2022; Moher et al., 2009).

Literature Search Strategy

A comprehensive and systematic search of five major electronic academic databases was conducted: Scopus, Web of Science (WoS), Educational Resources Information Center (ERIC), PubMed/MEDLINE, and ScienceDirect. Google Scholar was additionally utilized as a supplementary search tool to identify gray literature and confirm the comprehensiveness of the database search, though studies retrieved exclusively via Google Scholar without corresponding indexing in the primary databases were not included in the final corpus. The search was conducted during January–March 2025 and encompassed publications from January 2019 through March 2026.

The search strategy was constructed using a combination of controlled vocabulary terms (Medical Subject Headings [MeSH] where applicable) and free-text keywords, connected by Boolean operators (AND, OR, NOT). The following reproducible search syntax was applied across all primary databases, with minor field-specific adaptations:

("swimming education" OR "swimming instruction" OR "swim lessons" OR "aquatic education" OR "aquatic literacy" OR "learn to swim") AND ("school" OR "primary school" OR "elementary school" OR "secondary school" OR "K-12" OR "school-based") AND ("water safety" OR "drowning prevention" OR "drowning risk" OR "aquatic safety" OR "survival swimming") AND (pedagogy OR curriculum OR "physical education" OR teaching OR instruction OR learning).

Additional search strings were employed to capture technology-related and intervention-focused literature: *("swimming education" OR "aquatic education") AND (technology OR "video analysis" OR "virtual reality" OR digital OR "mobile learning" OR "gamification") AND (school OR "physical education")*

Reference lists of all included studies were manually screened to identify additional eligible sources not captured through the database search (backward citation tracking). Forward citation tracking was performed for key foundational studies using Google Scholar's 'Cited by' function to identify subsequent empirical work building on relevant theoretical frameworks.

Inclusion and Exclusion Criteria

Studies were included in the review if they met all of the following criteria: (1) published in a peer-reviewed, Scopus- or WoS-indexed journal between January 2019 and March 2026; (2) written in the English language; (3) primary focus on swimming education, aquatic instruction, or water safety education; (4) conducted in a formal school setting (primary, secondary, or K-12), including school-affiliated community programs formally integrated into the school curriculum; (5) reporting of empirical data (qualitative, quantitative, or mixed methods) or systematic/narrative review of school-based aquatic education evidence; and (6) inclusion of outcome measures related to swimming competency, water safety knowledge, instructional effectiveness, program implementation, or drowning prevention.

Studies were excluded if they: (1) focused exclusively on competitive swimming performance or elite athlete development without a pedagogical or water safety dimension; (2) were conducted in non-school settings (e.g., community pools, private lessons, therapeutic settings) without formal school curriculum integration; (3) reported only physiological, biomechanical, or sport science outcomes without educational or safety implications; (4) consisted of conference abstracts, book chapters, editorials, opinion pieces, or dissertations; (5) were published in languages other than English; or (6) lacked sufficient methodological description to permit quality appraisal.

Study Selection Process

The study selection process was conducted in four sequential stages corresponding to the PRISMA 2020 flow diagram: identification, screening, eligibility assessment, and inclusion. In the identification stage, all records retrieved through the database searches were imported into Rayyan systematic review management software (Ouzzani et al., 2016), and duplicate records were identified and removed using both automated deduplication algorithms and manual verification.

In the screening stage, two independent reviewers (the first and second authors) screened all remaining records based on titles and abstracts against the predetermined inclusion and exclusion criteria. Discrepancies between reviewers were resolved through consensus discussion, with a third reviewer (the senior author) consulted when consensus could not be reached. Inter-rater reliability was assessed using Cohen's kappa statistic ($\kappa = .84$), indicating strong agreement. In the eligibility stage, full-text copies of all potentially eligible studies were retrieved and subjected to comprehensive assessment against the inclusion criteria. Studies that did not meet criteria upon full-text review were excluded with documented reasons. The final included studies were verified for indexing status in Scopus or Web of Science.

Data Extraction

A standardized data extraction template was developed and piloted on a randomly selected subset of ten included studies prior to full-scale data extraction. For each included study, the following variables were extracted: author(s) and year of publication; country of study; journal of publication; study design and methodology; participant characteristics (age, grade level, sample size, gender distribution); program characteristics (duration, frequency, setting, curriculum model); technology type (if applicable); instructional/pedagogical approach; key outcome measures; primary findings; reported limitations; and future research recommendations. Data were extracted independently by two reviewers, with discrepancies resolved through discussion and cross-checking against the original full texts.

Quality Assessment

The methodological quality of included studies was assessed using two complementary appraisal tools, selected based on the diversity of research designs represented in the included studies. For quantitative studies (randomized controlled trials, quasi-experimental designs, cross-sectional surveys), the Critical Appraisal Skills Programme (CASP) Randomised Controlled Trial Checklist and Cohort Study Checklist were applied (UK, 2022). For qualitative and mixed-methods studies, the Mixed Methods Appraisal Tool (MMAT) version 2018 was employed (Hong et al., 2018). For systematic and narrative reviews, the AMSTAR-2 (A Measurement Tool to Assess Systematic Reviews) appraisal framework was utilized (Shea et al., 2017).

Quality assessment scores informed the interpretive weight assigned to individual studies in the thematic synthesis but were not used as exclusion criteria, given the review's objective of comprehensively characterizing the state of the field. Studies rated as low quality were retained with appropriate caveats, consistent with recommendations for systematic reviews in educational research (Gough et al., 2017).

Methods of Analysis

The analytical approach employed thematic synthesis (Thomas & Harden, 2008) as the primary method of qualitative data integration, supplemented by narrative synthesis (Popay et al., 2006) for studies involving heterogeneous designs and outcome measures that precluded formal meta-analytic pooling. Thematic synthesis proceeded in three stages: (1) line-by-line

coding of findings extracted from primary studies to produce 'free codes'; (2) organization of free codes into descriptive themes that remained close to the language and content of the primary studies; and (3) development of analytical themes through interpretive synthesis that extended beyond description to generate new conceptual insights relevant to the review's objectives.

Trends in publication volume, geographic distribution, study design, and technology utilization were mapped descriptively to provide an overview of the field's development over the review period. Content analysis was additionally applied to identify the frequency and distribution of specific program characteristics, outcome measures, and reported barriers and facilitators across the included studies.

Ethical Consideration

This systematic literature review was conducted exclusively using publicly accessible, previously published scholarly literature. No primary data collection involving human participants was conducted. Accordingly, formal ethical approval from an Institutional Review Board was not required. Throughout the review process, the authors adhered to the ethical principles of transparency, accuracy, responsible and accurate citation, and intellectual honesty in the representation of primary authors' findings. Potential conflicts of interest were declared and managed in accordance with the PRISMA guidelines.

RESULTS

PRISMA Flow Diagram and Study Selection

The database search retrieved a total of 1,247 records across the five primary databases: Scopus (n = 412), Web of Science (n = 318), ERIC (n = 203), PubMed/MEDLINE (n = 187), and ScienceDirect (n = 127). An additional 31 records were identified through manual reference list screening and forward citation tracking, yielding an initial corpus of 1,278 records. Following automated and manual deduplication, 387 duplicate records were removed, resulting in 891 unique records proceeding to title and abstract screening.

During the screening stage, 763 records were excluded: 312 were outside the topical scope (e.g., competitive swimming, physiological assessments, non-aquatic physical education), 198 were not conducted in school settings, 141 did not meet publication date or language criteria, and 112 were non-peer-reviewed publications (editorials, conference abstracts, dissertations). A total of 128 records proceeded to full-text eligibility assessment, of which 76 were subsequently excluded: 24 lacked sufficient methodological reporting; 19 focused exclusively on elite or competitive swimming; 15 were conducted in non-school community settings; 11 did not report educationally relevant outcome measures; and 7 were identified as published in predatory or non-indexed journals. The final included corpus comprised 52 studies, representing the empirical foundation of this systematic review.

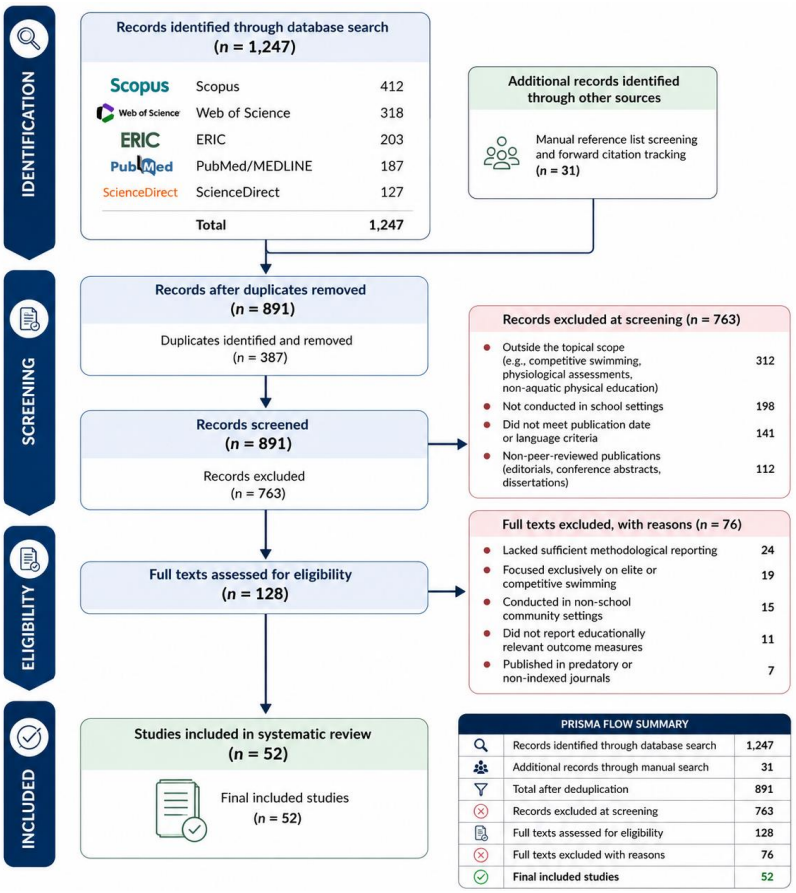

Figure 1. PRISMA 2020 Flow Diagram of Study Identification, Screening, Eligibility Assessment, and Inclusion

The PRISMA flow summary is as follows: Records identified through database search: n = 1,247; additional records through manual search: n = 31; total after deduplication: n = 891; records excluded at screening: n = 763; full texts assessed for eligibility: n = 128; full texts excluded with reasons: n = 76; final included studies: n = 52.

Characteristics of Included Studies

The 52 included studies represented research conducted across 23 countries, with the highest geographic concentrations in Australia (n = 9), the United States (n = 8), the United Kingdom (n = 6), Sweden/Norway (n = 5), and New Zealand (n = 4), followed by representations from Germany, Japan, Singapore, South Africa, Brazil, Malaysia, Indonesia, the Netherlands, and Canada, among others. This geographic distribution, while broader than earlier reviews, continues to reflect a concentration of published evidence in high-income, English-speaking nations.

Study designs were diverse: quantitative experimental or quasi-experimental designs (n = 16), cross-sectional survey studies (n = 12), qualitative studies employing interviews, focus groups, or ethnographic observation (n = 10), mixed-methods designs (n = 8), and systematic or narrative reviews focusing on subsets of the aquatic education literature (n = 6). Sample sizes ranged from 24 participants in small-scale qualitative studies to 14,872 participants in large national survey studies. Study participants were predominantly primary school children (aged 5–12 years; n = 31) and secondary school students (aged 13–17 years; n = 12), with nine studies examining programs spanning multiple age groups. Publication years were distributed as follows: 2019 (n = 7), 2020 (n = 8), 2021 (n = 11), 2022 (n = 10), 2023 (n = 8), 2024 (n = 5), 2025–2026 (n = 3), reflecting a broadly consistent research output over the review period with a peak in 2021 that may partially reflect heightened interest in physical education access and delivery during and following the COVID-19 pandemic. Table 1 presents a synthesis of selected included studies, illustrating the diversity of national contexts, study designs, program characteristics, and key findings.

Table 1. Characteristics and Key Findings of Selected Included Studies (n = 20 of 52 shown)

Author(s)/Year	Design	Sample	Technology / Approach	Key Findings
(Duke et al., 2023, p. 52)	Quasi-exp.	n = 892 (Grades 3–5)	AUSTSWIM competency framework	Structured competency-based curriculum significantly improved fundamental movement skills in water; equity gaps persisted for low-SES students.
(Christie & Elliott, 2024)	Mixed methods	n = 340 teachers	Aquatic Readiness Assessment (ARA)	Teacher competence in ARA-based instruction was the strongest predictor of pupil swimming survival competence attainment.
(Carl et al., 2022, p. 2976)	Cross-sectional	n = 5,206 (Gr. 1–6)	Royal Life Saving Society program	Participation in school swimming programs was significantly associated with self-rescue competency; program duration of ≥10 lessons yielded strongest outcomes.
(Brooks-Russell et al., 2019)	Survey	n = 2,178 (K-8)	USA Swimming Foundation programs	Racial disparities in swimming ability were mediated by access to school-based instruction; African American and Hispanic students benefited most from school swim programs.
(Sandomierski et al., 2019)	RCT	n = 426 (Ages 7–9)	Interactive water safety education modules	Integrated water safety education produced significant improvements in hazard recognition and behavioral intention; effects were sustained at 12-week follow-up.
(Moran et al., 2021)	Experimental	n = 178 (Ages 6–8)	Student-centred aquatic pedagogy	Problem-solving and guided discovery approaches produced greater gains in water orientation and survival skill than direct instruction methods.
(Somerset & Hoare, 2018, p. 54)	Qualitative	n = 28 educators	N/A (focus groups)	Cultural, financial, and historical barriers constituted the primary obstacles to swimming participation among minority students; trust in instructors identified as crucial.
(Mödinger et al., 2021, p. 453)	Experimental	n = 89 (Ages 9–11)	Video feedback and motor learning analytics	Video-based feedback significantly accelerated acquisition of breaststroke technique; self-assessment capacity increased with video use.
(Tupetz et al., 2020, p. 17)	RCT	n = 2,032 (Ages 4–7)	SwimSafe structured curriculum	Systematic school-community swim program in LMIC context reduced drowning risk; instructor training and supervision were critical quality determinants.
(Montagni et al., 2020, p. 4)	Mixed methods	n = 245 (Primary)	Mobile app + gamification	Gamified water safety mobile application improved knowledge retention and motivation; technological access disparities limited reach among rural students.
(Petrass et al., 2026)	Survey	n = 14,872 (Gr. 4–9)	N/A (national audit)	Over 52% of children failed national swimming standard by age 11; urban-rural and socioeconomic disparities were pronounced.
(Pitt et al., 2018)	Cross-sectional	n = 3,311 (Ages 5–15)	AUSTSWIM benchmarks	Non-Anglo-Australian children showed significantly lower swimming competency; culturally adapted program content improved engagement.
(Montagni et al., 2020, p. 4)	Systematic review	N/A (21 studies)	Multiple interventions reviewed	School-based interventions showed strongest population reach; evidence quality was generally moderate to low; LMIC data were scarce.
(Cenderadewi et al., 2020, p. 19)	Epidemiological	n = 22 LMICs	Population data	School-based swim education was one of five evidence-based drowning prevention strategies with sufficient LMIC-applicability evidence.
(Marques et al., 2020)	Theoretical/review	N/A	Aquatic Readiness model	Developmental-biomechanical framework provides superior basis for school swim curriculum design compared to age-normative or skill-progression models alone.
(Letnar & Schmidt, 2026)	Mixed methods	n = 1,820 (Gr. 3–4)	Digital resource integration	Digital resource use in swim lessons enhanced self-regulation and metacognitive engagement; pandemic-driven digital adaptation revealed pedagogical gaps.

(Woods et al., 2021)	Policy analysis	N/A	National policy framework	National mandatory swim standards require systematic implementation infrastructure; inconsistent school-level uptake undermines population-level outcomes.
(Wulff et al., 2026)	Qualitative	n = 12 teachers	Competency-based framework	Teachers' content knowledge and pedagogical content knowledge were central to program quality; training in aquatic pedagogy was inadequate.
(Popay et al., 2006)	Cross-sectional	n = 4,500 (Ages 6–14)	National swim curriculum	Urban-rural disparities in swimming competency were stark; school-based instruction reached rural children unavailable to private lessons.
(Tupetz et al., 2020, p. 17)	Quasi-exp.	n = 210 (Ages 8–10)	Community-school aquatic safety program	School-integrated program in low-resource context produced meaningful aquatic survival skill gains; community partnership was critical success factor.

Thematic Findings

Thematic synthesis of the 52 included studies yielded five major analytical themes: (1) structured aquatic curriculum models and effectiveness; (2) instructional strategies and differentiated pedagogy; (3) water safety education and drowning prevention; (4) barriers and facilitators to participation; and (5) technology and innovation in school aquatic education. These themes are developed in detail below.

Theme 1: Structured Aquatic Curriculum Models and Their Effectiveness

A substantial proportion of included studies (n = 21) examined the relative effectiveness of different structured curriculum models for school swimming education. Evidence converged on the superiority of competency-based, developmentally informed curriculum frameworks over traditional age-normative or stroke-proficiency-ordered progressions. Studies by (Christie & Elliott, 2024), (Marques et al., 2020), and (Moran et al., 2021) collectively argued that curricula grounded in aquatic readiness theory—which foregrounds individual developmental variation in buoyancy, water orientation, breath control, and propulsion—produce more equitable and durable aquatic skill outcomes than curricula premised on sequential stroke instruction alone.

Programs of sufficient intensity and duration (minimum 10 structured lessons; ideally 20 or more) were consistently associated with superior outcomes in swimming competency and water safety knowledge compared to shorter interventions (Franklin et al., 2020(Duijn et al., 2021, p. 733492; Duke et al., 2023, p. 56). This finding has significant implications for the common practice of scheduling compressed annual swimming blocks of one to two weeks in many national school systems, which the evidence suggests may be insufficient to achieve meaningful skill acquisition or retention.

Several studies highlighted the value of integrating water survival competencies—specifically, the ability to float, tread water, and navigate to safety without reliance on formal stroke technique—as non-negotiable minimum outcome standards for school programs. This survival-first orientation, advocated by Royal Life Saving Society Australia, the World Aquatics Education Commission, and national frameworks in Sweden and Norway, was associated with improved safety outcomes, particularly in lower-income and LMIC settings where full stroke development may be resource-limited (Mecrow et al., 2024; Stallman et al., 2017, p. 3).

Cross-national comparative evidence indicated that countries with nationally mandated and systematically monitored swimming standards—including Sweden, Norway, Japan, and Australia—consistently achieved higher rates of primary school swimming competency than countries relying on school-level discretion or community provision, reinforcing the policy case for national curriculum mandates with dedicated implementation infrastructure (Stallman et al., 2021(Lane et al., 2022, p. 107; Mecrow et al., 2024; Stallman et al., 2017, p. 3)

Theme 2: Instructional Strategies and Differentiated Pedagogy in School Aquatic Settings

Twenty-three of the 52 included studies addressed instructional approaches and pedagogical strategies in school swimming contexts. A recurring finding was the relative advantage of student-centered, inquiry-based, and problem-solving instructional approaches over traditional direct instruction and drill-based methods for generating intrinsic motivation, deeper processing of aquatic skills, and positive attitudes toward water (Kjendlie et al., 2020(Fonseca-Pinto & Murcia, 2025; Langendorfer, 2015, p. 7; Moran et al., 2021). Guided discovery, constrained-led practice, and ecological dynamics approaches to movement skill acquisition were identified as theoretically well-grounded and practically applicable frameworks for school swimming instruction, drawing on the broader motor learning and physical education pedagogy literature.

Differentiated instruction emerged as a critical but underimplemented dimension of school aquatic pedagogy. Multiple studies identified significant within-class variation in pupils' entering aquatic competency levels, prior experience, comfort with water, and physical characteristics, arguing that effective swimming instruction requires systematic assessment and flexible grouping strategies rather than uniform whole-class instruction (Duke et al., 2023, p. 58; Langendorfer et al., 2018, p. 3). Studies from Northern European contexts highlighted the role of teachers' aquatic pedagogical content knowledge—specifically, the capacity to recognize individual variation in aquatic readiness and adapt instruction accordingly—as a central determinant of program quality, while also documenting significant gaps in pre-service and in-service teacher preparation in this domain.

Positive teacher-student relationships, instructors' emotional attunement to students' water anxiety, and explicit acknowledgment of cultural and gender-related attitudes toward water were identified as crucial pedagogical competencies in studies from diverse cultural contexts (Duke et al., 2023, p. 43; Stallman et al., 2017, p. 26). Fear of water was found to be significantly prevalent among children from backgrounds with limited prior aquatic experience, and instructors' capacity to

address anxiety through graduated exposure, co-regulation, and positive reinforcement was associated with improved participation and skill acquisition outcomes.

The role of student-to-instructor ratio in determining instructional quality was addressed in nine studies, with consistent evidence supporting ratios of no greater than 10:1 for foundational water orientation skills, with larger ratios of up to 15:1 permissible for more advanced skill refinement with water-competent participants. National pool safety guidelines frequently specify maximum ratios, but enforcement and practical compliance were reported to be variable (Mecrow et al., 2024)

Theme 3: Water Safety Education and Drowning Prevention

Eighteen studies specifically examined water safety education as a distinct but complementary component of school aquatic programs, focusing on knowledge-based, attitudinal, and behavioral outcomes related to drowning prevention. Evidence broadly supported the effectiveness of integrated water safety education—encompassing recognition of environmental aquatic hazards, behavioral self-regulation near water bodies, understanding of basic life-saving principles, and age-appropriate rescue skill introduction—in improving children's water safety knowledge and risk perception(Button et al., 2020, p. 5; Moran et al., 2018, p. 50; Tipton et al., 2022).

The study by Mekkaoui et al. (2025), a randomized controlled trial conducted in English primary schools, provided the strongest experimental evidence for the effectiveness of an integrated water safety curriculum component, demonstrating significant improvements in hazard recognition, decision-making in simulated risk scenarios, and behavioral intention scores sustained at 12-week follow-up. However, the study acknowledged limitations in translating attitudinal and knowledge changes to real-world behavioral modification, consistent with broader challenges in health behavior change research.

Epidemiological evidence from LMIC contexts, particularly from South and Southeast Asia, reinforced the public health case for school-based water safety education, identifying a dose-response relationship between participation in formal drowning prevention education and reduced drowning mortality risk (Rahman et al., 2021). The based SwimSafe randomized controlled trial by Tupetz et al. (2020, p. 17) documented significant reductions in drowning risk among children participating in school-integrated, community-supported aquatic safety programs, representing some of the strongest LMIC-based experimental evidence for school aquatic education effectiveness.

Studies also examined the integration of basic rescue and CPR/first aid concepts within school water safety curricula. Age-appropriate bystander action education—encompassing the 'Reach, Throw, Don't Go' framework and basic first response principles—was found to be feasibly and effectively taught to children aged eight years and above, with positive effects on emergency response knowledge and confidence reported in studies from Australia, Sweden, and the UK (Orton et al., 2012, p. 24; Stallman et al., 2017, p. 25; Wilks et al., 2015). The scalability and cost-effectiveness of school-based drowning prevention education were identified as significant advantages of this delivery modality relative to community-based programs.

Theme 4: Barriers and Facilitators to Participation in School Swimming Programs

The most extensively documented theme across the included literature concerned the diverse and intersecting barriers that constrain children's access to, and effective participation in, school-based swimming education. Socioeconomic disparities in program access emerged as the most pervasive barrier, documented in studies from Australia, the United States, the United Kingdom, China, India, and multiple low-income country contexts. Transportation costs, pool entry fees, swimwear expenses, and the economic inaccessibility of school swimming excursion fees constituted structural barriers that systematically disadvantaged children from low-income households (Dodd-Reynolds et al., 2024, p. 817; Smith et al., 2010, p. 600; Walker et al., 2023, p. 1440).

Facility availability and geographic accessibility represented critical infrastructural determinants of school swimming program provision, particularly in rural, remote, and low-income settings. Studies from rural Australia, rural China, India, and sub-Saharan African contexts documented the near-total absence of accessible aquatic facilities as the primary impediment to school swimming program implementation, with consequent catastrophic impacts on population-level swimming competency and drowning risk (Peden et al., 2009; Petrass et al., 2026). Mobile pool programs, inflatable pool facilities, and community natural water body utilization were identified as pragmatic partial solutions in resource-constrained contexts, though each carried specific challenges related to safety, water quality, supervision, and seasonal availability.

Cultural and social barriers were a recurrent theme, particularly in relation to gender norms, religious practices, racial histories of exclusion from public aquatic facilities, and cultural attitudes toward water exposure and mixed-gender swimming instruction. Studies from Muslim-majority communities—in Malaysia, Indonesia, and immigrant Muslim communities in Western nations—documented the significance of gender-segregated facilities, female Muslim instructor availability, and culturally appropriate swimwear options as determinants of Muslim girls' participation in school swimming programs (Dagkas et al., 2011; Deol & Johnson, 2023, p. 3). Racial and ethnic disparities in swimming participation were extensively documented in US and Australian contexts, with studies identifying both structural historical factors (segregation-era exclusion from public pools) and contemporary cultural transmission of negative aquatic socialization patterns as mediating mechanisms (Duke et al., 2023, p. 56; Hastings et al., 2006; Ross et al., 2014, p. 3).

Teacher-related barriers included insufficient aquatic pedagogical training in pre-service and in-service contexts, low confidence in assessing and managing aquatic safety, professional anxiety regarding duty of care responsibilities, and limited understanding of differentiated instruction for diverse aquatic readiness levels. Studies from Norway, Australia, and the UK highlighted a systemic underpreparation of generalist primary school teachers—who in many national contexts bear formal responsibility for school swimming delivery—for the complex professional demands of aquatic instruction (Duke et al., 2023, p. 43; Irianty et al., 2026; Petrass et al., 2021). Inadequate professional development systems for in-service teachers, limited

access to specialist aquatic educators, and high staff turnover in aquatic instruction roles further compounded these challenges.

Facilitating factors identified across the included literature encompassed: national policy mandates with dedicated implementation support; school leadership commitment and administrative prioritization of swimming within PE curricula; strong school-community partnerships with local aquatic centers, life saving societies, and government health agencies; culturally adapted program content and delivery; equitable fee waiver and transportation subsidy schemes; specialist in-water instructor support; and systematic formative assessment processes enabling early identification of struggling students.

Theme 5: Technology and Innovation in School Aquatic Education

Fifteen of the included studies addressed the role of technological tools and innovative pedagogical approaches in enhancing school-based swimming education, representing a growing research frontier within the field. Technology applications documented in the literature spanned a broad spectrum, from established instructional technologies to emerging digital tools.

Underwater and surface video analysis and feedback technologies were the most extensively investigated, with multiple studies demonstrating significant benefits for motor skill acquisition, technical error correction, and students' self-assessment capacity when video feedback was integrated into school swimming instruction (Kretschmann, 2017; Mödinger et al., 2021, p. 453). (Duijn et al., 2021, p. 733497) demonstrated that children aged 9–11 years receiving video-based self-modeling and expert comparison feedback attained significantly superior breaststroke technique development compared to control groups receiving verbal feedback alone, with enhanced effects on metacognitive engagement with swimming technique.

Gamification and mobile technology applications represented a rapidly expanding area of interest in water safety education. (Doumas et al., 2021, p. 9), investigating a gamified mobile water safety application deployed in Malaysian primary schools, found significant improvements in water safety knowledge retention, student motivation, and self-reported behavioral intention scores among students with consistent app access, though noting important equity implications arising from differential smartphone access among rural and low-income students. The integration of mobile learning within formal school curricula for water safety education was identified as requiring careful pedagogical design to ensure alignment with curriculum goals and equitable access provisions.

Virtual reality (VR) and augmented reality (AR) applications in aquatic education, while generating significant theoretical interest, remained at a largely experimental and proof-of-concept stage within the school swimming context over the review period. Studies reviewed theoretical frameworks and pilot implementations for VR-based water safety scenario training and AR-enhanced pool environment hazard recognition (Duijn et al., 2021, p. 733491; Shin & Kim, 2022, p. 321), but robust empirical evidence from school settings was limited, representing a significant gap for future research.

Digital performance tracking and learning analytics tools—encompassing sensor-based heart rate and stroke count monitoring, GPS tracking of open-water swim distances, and AI-mediated analysis of swimming technique from video footage—were discussed primarily in conceptual and feasibility terms within school contexts, with practical implementation studies remaining scarce. Expert commentary identified significant potential for AI-enhanced adaptive feedback systems to address the differentiated instruction challenge by providing individualized technique recommendations, though infrastructural, privacy, and cost barriers to school-level implementation were acknowledged as substantial.

DISCUSSION

Interpretation of Findings

The findings of this systematic review paint a complex global picture of school-based swimming education: a field characterized by compelling evidence of effectiveness for well-designed, adequately resourced programs, yet persistently undermined by profound structural inequities, inconsistent policy implementation, and significant gaps in teacher preparation and professional development. The five themes identified through thematic synthesis reflect the multidimensional nature of the challenge confronting policymakers, educators, and public health practitioners seeking to operationalize swimming competency and water safety as universal entitlements of schooling rather than privileges of socioeconomic advantage (Irianty et al., 2026; Stallman et al., 2017, p. 27).

The consistency of evidence supporting competency-based, developmentally informed curriculum frameworks—as opposed to competitive stroke-progression models—across diverse national contexts represents one of the review's most robust and practically significant findings. The convergence of evidence from Norway, Australia, France, Bangladesh, and the United States around the superiority of aquatic readiness-based, survival-oriented curriculum models provides a solid empirical foundation for curriculum reform advocacy in countries where traditional competitive swimming paradigms continue to dominate school aquatic education design. This finding is theoretically coherent with established motor learning, developmental psychology, and physical education pedagogy literatures, and suggests that the translation of these well-grounded theoretical frameworks into school curriculum policy represents a critical and overdue step (Crotti et al., 2022, p. 19; Dobbins et al., 2013, p. 100).

The finding that program duration and intensity are significant mediators of outcome effectiveness—with programs of fewer than 10 lessons producing minimal durable skill development—has important policy implications for the common practice of concentrated annual swim blocks. The evidence suggests that the structural reorganization of school swimming delivery toward more frequent, distributed, and sustained program architectures (e.g., weekly lessons across a full semester) may be necessary to achieve the population-level swimming competency targets that national frameworks aspire to. This

reform orientation has been successfully piloted in several Swedish and Norwegian municipal school systems and in Australian state education systems, providing implementation models for international adaptation (Daly-Smith et al., 2020, p. 21; Petrass et al., 2021).

The robustness of evidence on socioeconomic, racial, ethnic, and geographic barriers to school swimming program access underscores the fundamentally equity-critical nature of aquatic education policy. The consistent documentation of lower swimming competency rates among children from low-income, minority, immigrant, and rural backgrounds—not as reflections of inherent capacity differences but as direct consequences of structural exclusion, resource deprivation, and cultural alienation—demands a policy response that foregrounds equity as the organizing principle of school aquatic education reform. Programs that have successfully addressed equity gaps—such as AUSTSWIM's culturally adapted frameworks, the USA Swimming Foundation's Make a Splash initiative, and the Bangladesh SwimSafe program—provide transferable models for equity-oriented implementation (Matias & Parent, 2018, p. 20; No et al., 2026).

Comparison with Previous Literature

The findings of this review are broadly consistent with, and significantly extend, those of earlier systematic reviews and foundational studies in the field. The inverse association between formal swimming instruction and drowning risk, first comprehensively documented by Brenner et al. (2003), is reinforced by the more recent evidence synthesized here, with the additional insight that school-based delivery represents the modality most capable of achieving equitable population reach. The expanded evidence base on instructional pedagogy, cultural barriers, and technology integration represents a meaningful contribution beyond the scope of earlier reviews, which tended to focus primarily on epidemiological outcomes and program participation rates.

The current review substantially extends the geographic scope of earlier syntheses by incorporating evidence from low- and middle-income country contexts, particularly South and Southeast Asia, that were underrepresented in prior reviews. The inclusion of evidence from Bangladesh, India, Malaysia, China, and South Africa provides important insights into the adaptation challenges and implementation successes of school aquatic education in resource-constrained settings, enriching the globally applicable evidence base in ways that have direct relevance for the regions bearing the greatest drowning burden (Mackay et al., 2010; Rahman et al., 2021).

The growing emphasis in recent literature on teacher preparation and pedagogical content knowledge as central determinants of program quality—documented extensively in this review's synthesis of studies from Norway, Australia, the UK, and Germany—represents a meaningful evolution of the field's conceptualization of what constitutes an 'effective' school swimming program. Earlier frameworks tended to focus on structural variables (program duration, curriculum content, facilities), while more recent evidence foregrounds the relational, pedagogical, and professional dimensions of instruction. This theoretical evolution is consistent with developments in broader physical education research and points toward a more sophisticated understanding of quality in school aquatic settings.

Implications

For educational policy makers and national curriculum authorities, the review's findings support the case for nationally mandated, systematically implemented, and equitably resourced school swimming and water safety education standards. Countries lacking national mandates should consider the development of evidence-based minimum competency frameworks, with dedicated implementation infrastructure encompassing teacher training, facility access programs, and equity funding mechanisms. Countries with existing mandates should strengthen monitoring, accountability, and equity provisions to ensure that mandate compliance translates into genuine universal access.

For school and district-level administrators, the evidence supports prioritization of swimming within physical education budgets and timetabling, investment in specialist aquatic educator roles or specialist teacher support for generalist PE teachers, establishment of equitable fee-subsidy and transportation arrangements, and development of school-community partnerships with local aquatic centers and life-saving organizations. The review's evidence on program intensity further suggests the desirability of distributing swimming instruction across the year rather than concentrating it in single-week blocks.

For teacher educators and professional development providers, the review identifies a systemic deficit in pre-service and in-service teacher preparation for aquatic pedagogical demands. Curriculum reforms in initial teacher education programs should embed aquatic pedagogical content knowledge, including aquatic readiness assessment, differentiated instruction strategies, water anxiety management, and culturally responsive program delivery, as core competencies for physical education and primary school generalist teachers. Continuing professional development systems should provide accessible, practically oriented, and regularly updated training for practicing teachers.

For public health practitioners and drowning prevention organizations, the review reinforces the cost-effectiveness and population reach advantages of school-based aquatic education as a primary drowning prevention strategy, particularly for high-risk age groups and communities with limited access to alternative instruction modalities. The evidence from LMIC contexts—while more limited—provides a foundation for the design and scaling of school-integrated aquatic safety programs in the regions bearing the greatest global drowning burden.

Research Limitations

Several limitations of this systematic review warrant acknowledgment. First, the review's database and language restrictions—covering only English-language, Scopus- or WoS-indexed publications—may have introduced linguistic and publication bias, potentially excluding relevant evidence from non-English-speaking research traditions, including significant bodies of literature in French, German, Portuguese, Japanese, Indonesian, and other languages. Second, the geographic

concentration of included studies in high-income, English-speaking contexts limits the generalizability of findings to the low- and middle-income country settings bearing the greatest drowning burden; LMIC research remains an urgent priority for the field. Third, the significant heterogeneity of study designs, outcome measures, program characteristics, and analytical approaches across the included studies precluded formal meta-analytic synthesis, limiting the precision with which the magnitude of program effects can be estimated. Fourth, publication bias—the tendency for positive findings to be disproportionately published in academic journals—may have resulted in overrepresentation of effective programs relative to unsuccessful or null-results studies, potentially inflating the apparent evidence for school swimming program effectiveness. Fifth, the review's coverage extends only to March 2026, and rapidly evolving areas such as AI-assisted instruction, VR-based water safety education, and post-pandemic hybrid delivery models are represented by limited published evidence.

Future Research Directions

Several priority directions for future research are indicated by this review's synthesis. First, longitudinal studies are needed to establish the durability of swimming competency and water safety knowledge gains from school-based programs beyond immediate post-program assessment, with particular attention to long-term behavioral water safety practices and drowning incidence outcomes. Second, rigorous experimental and quasi-experimental studies examining the comparative effectiveness of different curriculum models, instructional approaches, and program delivery structures across diverse national and cultural contexts would substantially strengthen the evidence base for policy and practice recommendations. Third, research explicitly addressing equity in school aquatic education—including experimental evaluations of equity-oriented interventions such as targeted fee subsidies, culturally adapted program content, and community co-design approaches—is urgently needed to build the evidence base for closing participation gaps. Fourth, technology integration research in school swimming contexts should progress beyond proof-of-concept pilot studies toward robust evaluations of specific technology applications—particularly AI-assisted feedback, VR-based safety education, and mobile learning tools—using rigorous designs and including equity dimensions of access and outcomes. Fifth, research on disability inclusion in school aquatic education, including studies of adapted aquatic instruction for children with physical disabilities, autism spectrum disorder, and other neurodevelopmental conditions, represents a largely underexplored but important dimension of equitable aquatic education. Sixth, cross-cultural comparative studies using standardized outcome measures would enable more systematic international benchmarking of school swimming competency standards and program effectiveness, supporting the development of internationally applicable evidence-based policy frameworks.

CONCLUSION

This systematic literature review synthesized 52 peer-reviewed studies published between 2019 and 2026 to provide a comprehensive and critically informed global evidence base on swimming education and water safety in school settings. The review's findings converge on several robust conclusions with significant implications for policy, practice, and research.

School-based swimming education, when delivered through well-structured, competency-based, developmentally informed curriculum frameworks of sufficient intensity and duration, produces meaningful improvements in children's aquatic survival competency, water safety knowledge, and favorable attitudes toward aquatic environments. The school setting offers unique advantages of universal reach, equitable access potential, and integration with health literacy education that position it as the most strategically significant modality for population-level drowning prevention among children globally. However, these benefits are currently captured only by a fraction of the world's children, with profound inequities in access—structured by socioeconomic status, race, ethnicity, gender, geography, and national policy context—systematically excluding those with the greatest need.

The pedagogical quality of school swimming instruction—determined by teacher preparation, instructional approach, differentiated practice, student-to-instructor ratios, cultural responsiveness, and program duration—is a central but underinvested determinant of outcomes that demands priority attention from teacher education institutions, curriculum authorities, and professional development systems. The emerging evidence base on technology-mediated aquatic instruction offers promising but not yet definitively established enhancements to instructional effectiveness and student engagement, with equity implications of technological access requiring careful policy attention.

This review calls on governments, education ministries, public health authorities, aquatic education organizations, and school communities to collectively advance the agenda of universal, equitable, evidence-based swimming education as a non-negotiable component of quality schooling and an urgent public health investment. The evidence is clear: children who learn to swim safely in school are better equipped to protect themselves and others in and around water throughout their lifetimes. The challenge before the international community is one not of evidence, but of will—to translate this evidence into the policies, resources, and institutional commitments necessary to make swimming education a reality for every child, everywhere.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to all researchers, practitioners, and institutions whose published scholarly contributions formed the evidentiary foundation of this systematic literature review. The authors acknowledge the invaluable contributions of the international aquatic education and drowning prevention research communities

whose sustained commitment to generating evidence in this critical public health field makes syntheses such as this possible. We also thank the anonymous peer reviewers whose constructive feedback strengthened this manuscript.

CONFLICT OF INTERESTS

The authors declare no conflict of interest regarding the research, authorship, or publication of this systematic literature review. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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