

Title: A review of drowning prevention interventions for children and young people in high, low and middle income countries.

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Abstract

Background Globally, drowning is one of the ten leading causes of child mortality. Children aged less than 5 years are particularly at risk, and children and young people continue to be overrepresented in drowning statistics. Accordingly, evidence informed interventions to prevent children drowning are of global importance. This review aimed to identify, assess and analyse public health interventions to reduce child drowning and investigate the use of behavioural theories and evaluation frameworks to guide child drowning prevention.

Methods Fourteen databases were searched for relevant peer reviewed articles. The systematic review was guided by the PRISMA criteria and registered with PROSPERO. Fifteen articles were included in the final review.

Results Studies were delivered in high, middle and low income countries. Intervention designs varied, one third of studies targeted children under five. Almost half of the studies relied on education and information to reduce drowning deaths, only three studies used a multi-strategy approach. Minimal use of behavioural theories and/or frameworks was found and just one third of the studies described formative evaluation.

Conclusion This review reveals an overreliance on education and information as a strategy to prevent drowning, despite evidence for comprehensive multi-strategy approaches. Accordingly, interventions must be supported that use a range of strategies, are shaped by theory and planning and evaluation frameworks, and are robust in intervention design, delivery and evaluation methodology. This approach will provide sound evidence that can be disseminated to inform future practice and policy for drowning prevention.

INTRODUCTION

Globally, drowning is one of the ten leading causes of child mortality irrespective of country of residence [1, 2]. Children aged less than 5 years and young males aged 15 – 19 years are particularly at risk [3]. Drowning prevention in children and young people is a complex public health issue. Rarely the result of a single cause, child drownings may vary by the aquatic setting and the activity being undertaken prior to the event [2]. There are international guidelines that support the use of diverse individual and environmental prevention strategies. These strategies include teaching basic swim skills, installing barriers to control exposure to water hazards, provision of community based crèches, close supervision and use of personal flotation devices (PFDs) [4]. These approaches vary between high and low income countries.

Historically, high income countries (HICs) have considered risk factors such as age, proximity to water, supervision or swimming ability as well as social, environmental and structural factors [2] when developing intervention strategies to reduce drownings. For example, Australia has achieved considerable success in reducing drownings through the introduction of home pool fencing [5], and targeting priority populations using community based prevention/education campaigns in settings such as homes with pools or at the beach [6]. More recently, low income and middle income countries (LMICs) have started to introduce a combination of low-cost, culturally feasible, community based strategies such as community crèches and basic swim skills [7].

Despite considerable efforts worldwide, children and young people continue to be over represented in fatal and non-fatal drowning statistics, having a significant impact on families, communities and public health systems [1]. Accordingly, evidence informed interventions to reduce and/or prevent non-fatal and fatal drowning in children and young people are of global importance. For interventions to have a greater likelihood of resulting in sustained behaviour change, the public health literature reinforces the importance of interventions that employ appropriate study designs, are informed by theory and /or frameworks, use objective and reliable measures, have a sufficient sample size, are of sufficient length, and have dedicated funding for robust evaluation [2, 8-11]. In spite of this evidence, two recent systematic reviews [2, 10] have highlighted that very few drowning prevention interventions employ rigorous methodologies and provide adequate levels of evidence to determine their impact on reducing drowning.

The aim of this review is to identify, assess and critically analyse public health interventions designed to reduce fatal and non-fatal drowning, specifically in children and young people (aged 18 years and under); investigate the utilisation of behaviour change theories and evaluation frameworks to guide

child drowning preventions; and establish which child drowning prevention strategies are effective in preventing drowning in HIC and LMICs.

METHODS

The following is a summary of the review methods. Full methods are described in the review protocol, published elsewhere [8] and based on procedures used in a previously published systematic review of adult drowning prevention interventions [10]. The review was registered with the PROSPERO International Prospective Register of Systematic Reviews (registration number: CRD42013004984).

Information sources and search strategy

Databases were searched for relevant peer reviewed articles written in English, describing drowning prevention interventions for children and young people 0 - 18 years, published before May 31 2013. The databases and search terms used are listed in Table 1. Studies were included in the review if they met the following criteria: (1) Described drowning prevention interventions for those aged 0-18 years; or (2) interventions aimed at both those aged 0-18 years and aged over 18 years, when there was clear reporting on the impact of the intervention on children; (3) described interventions that constituted primary prevention [12]; and (4) reported on interventions developed at an individual, community or population level.

Table 1. List of databases and search terms used in the systematic review

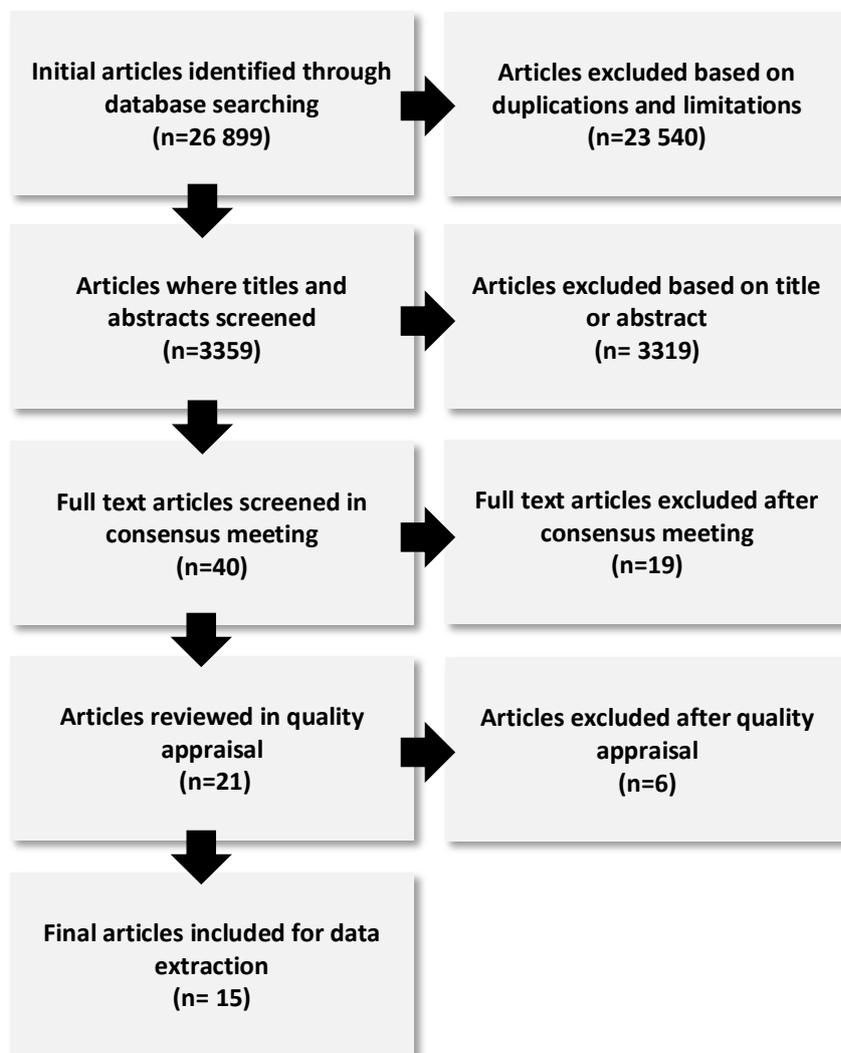
Databases searched	JSTOR, CINAHL, EMBASE, ERIC, Proquest, PsycINFO, Science Direct, Scopus, Global Health, Web of Science, Current Contents, Wiley Online Library and PubMed (Medline)
Search terms	(1) infant OR child* OR adolescen* OR kid* OR boy* OR girl* OR young OR youth OR teen* (2) drown* OR submers* OR "water safety" (3) injur* OR mortality OR morbidity (4) interven* OR evaluat* OR "best practice" OR "good practice" OR "best practise" OR "good practise" (5) "health promot*" OR "public health" OR polic* OR research* OR prevent*

For the purposes of this review, the definition of drowning from the World Health Organization (WHO) has been used which states that *"drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid; outcomes are classified as death, morbidity and no morbidity"* [3].

Eighteen years of age has been designated as the age at which childhood ends by the *UNICEF Convention on the Rights of the Child* [13]. Secondary and tertiary interventions [12] that occur after the prevention period, (e.g. resuscitation), were excluded from the review.

The review was conducted following criteria for the evidence-informed implementation and reporting of systematic reviews using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [14]. Fifteen articles were included in the final review. Figure 1 shows the process used to screen articles.

Figure 1: Search strategy schematic



Two reviewers (LRD, EH) identified potentially eligible articles and screened titles and abstracts. The full text for 40 articles were then assessed against the inclusion and exclusion criteria by two reviewers (JL, JJ) and where there were inconsistencies regarding inclusion, the paper was independently assessed by a third reviewer (GC) and consensus achieved. Two reviewers (FL, LN) independently appraised the methodological quality of all included studies using a checklist adapted from the National Institute for Health and Care Excellence (NICE) Quality Appraisal Checklist [15] and the Joanna Briggs series of assessment and review instruments [16]. The checklist covered five areas: study population; study methods; outcomes; analyses; and summary (including validity and limitations). The reviews were conducted independently and upon completion the reviewers met to discuss any discrepancies. Any differences in quality ratings between the two reviewers were resolved via a consensus meeting with all reviewers.

Data extraction

The following data were extracted from the articles: study characteristics, intervention description, key elements, behavioural theory and/or formative research, outcome measures (including process, impact and outcome measures), results and methodological limitations (e.g. self-report and recall bias). The data analysis consisted of de-identified, publicly available data and therefore is IRB exempt.

The studies were then categorised and analysed under the four ‘themes’ identified as the drowning prevention chain - control measures, published by the International Life Saving Federation (ILSF) [4]. These being: 1) education and information; 2) denial of access – barriers and regulations; 3) provision of supervision; and 4) acquisition of survival skills. If two or more ILSF themes were found in the one intervention it was classified as a ‘multi-strategy’ drowning prevention intervention.

RESULTS

Of the 15 studies reviewed, seven intervention studies were delivered in the United States (US) [17-23] four in Australia [5, 24-26], two in Bangladesh [7, 27], one in Greece [28] and Grenada [29]. The intervention designs included: randomised control trials [21, 22]; pre-post-tests [29]; an intervention and control group comparison study [28]; a case-control study [23]; a mixed methods study using both a cohort and a case control design [20]; a randomised trial with no control group [18]; observational and audit designs [26, 27]; and time series [17] (see Table 2). Ages included in the studies ranged from pre-birth to 20 years, with one third of studies (n=5) targeting children under 5 years [5, 18, 22, 26, 27].

Table 2 goes here is at end of document

Education and information

Five of the studies were categorised under the ILSF theme as education and information interventions. These included using mass media [19], comprehensive home safety parental education [22], and curriculum embedded swimming and water safety education strategies [21, 28, 29].

Two studies included drowning prevention education as part of an overall injury prevention program where drowning was just one of many injury and/or trauma modules covered [21, 22]. These interventions were delivered within the school setting, targeting children 6-8 years [21], and a brief intervention in an emergency department (ED) [22] targeted at parents of infants and toddlers. The *'Think First for Kids'* (TFFK) Program, underpinned by Social Cognitive Theory (SCT) constructs including self-efficacy [21], demonstrated that across the intervention schools, year one students performed significantly better than control schools in all six education modules (water safety $P < 0.01$), year two in all modules except violence prevention, and year three in four of the six modules (water safety $P = < 0.001$). In comparison, the ED intervention aimed at parents of infants and toddlers [22] concluded that there were no significant differences between parent groups who did, and did not receive the brief intervention on water safety ($P = < 0.33$). The ED questionnaire was designed by a multidisciplinary panel of injury experts who used available home safety literature and recommendations. Both these studies used self-report measures and accordingly reporting bias cannot be excluded.

A further two education interventions were delivered in schools; one in Greece [28] and *WHALE Tales* in Grenada [29], a low-middle income country (LMIC) [29]. Both studies delivered a compulsory school based drowning prevention intervention exploring water safety attitudes and knowledge among children aged 5-15 years [28] and 5-12 years [29]. Initially Terzidis et al. [28] distributed three age-specific questionnaires to school students in Greater Athens to assess knowledge and attitudes with regard to water safety and drowning prevention. Data acquired was used to help inform the design of an educational package for students of the corresponding years and socio-demographic profiles attending different schools in the same area. Post exposure data was collected one month later from each age-group. The researchers found that kindergarten and year one students who received the intervention had significantly higher scores for knowledge ($P = 0.005$) and attitudes ($P = 0.02$). However, among elementary and high school students the gains in knowledge and attitudes were less evident [28]. A number of limitations were noted in the study by Terzidis et al. [28] including the short duration of the intervention, use of self-report measures and difficulty in evaluating the differential impact of the intervention on student behaviour, as the mass media component of the campaign commenced immediately after the post-exposure evaluation. In addition, the children who contributed to the collection of the background knowledge and attitudes data were

not part of the intervention and post-exposure evaluation so the overall results may not reflect a before and after exposure effect [28].

In contrast, the *WHALE Tales* study, [29] which adapted a pre-existing program, *Longfellow's WHALE Tales*, from the American Red Cross, found the highest increase in water safety knowledge to be in year two students (33% increase, $P < 0.001$) and the lowest in year ones (5% increase, $P = 0.248$). However, this intervention was not without limitations as the educational materials were developed in the US and adapted for use with Grenadian primary school children, which presented language and translation barriers [29]. Further, it was not clear that any formative evaluation was conducted to adapt materials for Grenadian schools from the existing Red Cross program.

'*Stay on Top of it*' was a three-year US mass media campaign delivered in Washington [19] aimed at parents of children aged 14 years and under. The campaign focused on increasing life vest use and used financial incentives as part of the strategy mix to increase life vest uptake. Formative evaluation for the campaign used survey results and the child injury prevention literature to guide the intervention. Message development for the campaign was guided by constructs from SCT [30] and Protection Motivation Theory [31] including: self-efficacy, skill practice, reinforcement, and role modelling. Campaign awareness and reported life vest ownership increased post campaign ($n=230$; 69% compared with $n=361$; 75%). However, high income families were overrepresented in the sampling, which reduces the generalisability of the findings to lower income families [19].

Denial of access – barriers and regulations

Five studies were allocated to the theme of denial of access and examined the effects of swimming pool regulations on childhood drowning [5, 17, 20, 25, 26]. The *Seattle-King County Department of Public Health Pool Program* (SKCHPH) was first implemented in 1959 to ensure all public spas and swimming pools provided a safe, healthy environment for patrons [17]. The specific objectives included inspection of all public and semi-public spas and swimming pools for compliance with regulations at the beginning of each season, and then periodic inspections to determine compliance with health standards. Results included a decrease in drowning at lifeguarded spas, pools and bathing beaches from 0.21 drownings per 100,000 population in 1975 to a rate of 0.02 per 100 000 population in 1987 [17]. From 1981, the program expanded to include additional activities including lifeguard CPR training and increased supervision. However, the lack of non-fatal drowning data meant the authors could not determine whether this additional training or supervision could explain the changes. Three of the five studies were conducted in Australia. An early study conducted in 1980 retrospectively analysed drowning and near drowning deaths (1970-1979) in fenced and unfenced pools in Queensland and found that no children had drowned in fenced pools during 9200 pool years in a local Shire [25]. The second Australian study [26] completed a comparative audit of childhood

(0-4 years) drowning deaths in the decade before (1982-1991) and after (1992-2001) pool barrier isolation legislation was introduced. The study found that the introduction of safety legislation reduced age-specific pool drowning death rates from 6.54 to 1.85 per 100,000 per year [26]. Recently, in Australia, in the state of New South Wales pool compliance inspections coupled with pool owner and local council interviews were conducted to ascertain pool compliance rates in three local councils. A modest increase in compliance rates were seen in one council on second inspection (from 49% to 55%) [5]. The authors note that the use of a convenience sample was a limitation. Finally, a US study [20] measured the effect of pool fencing ordinances, rather than fencing itself. The study failed to produce positive results, reporting that pool fence ordinances were not associated with a reduced rate in childhood drowning in those aged 1-4 years, and that 81% of all drownings occurred in pools regulated by pool-fencing ordinances [20]. However, the authors question these findings in part because of perceived inadequacies of pool fencing laws in the county, and secondly the adequacy of local ordinances [20].

Provision of supervision

Two interventions both from Bangladesh employed strategies to increase supervision by caregivers as part of a multi-strategy approach [7, 27]. The first study, the *Prevention of Child Injuries through Social-Intervention and Education* (PRECISE) had two components: an Anchal which is a village-based crèche designed to increase supervision of children aged 1-5 years; and SwimSafe which consisted of basic swimming, water safety and safe rescue skills targeted at children aged 4-12 years. A demographic surveillance system (DSS) collected baseline census data and then periodically captured all deaths via in-home interviews. PRECISE reported high retention rates for the Anchals, and a steady decrease in mortality rates of children aged over 2 years. The unadjusted drowning mortality rates were higher in non-participants of the program compared with participants [7]. There were a number of potential limitations for this study including the differences in the demographic profile of participants and non-participants as well as the non-randomised design. The second intervention was a community-based pilot of two supervision tools, a door barrier and a playpen [27]. Six villages were selected to participate in the pilot and a convenience sample of households comprising children aged 6-54 months were recruited. Three groups were randomly assigned to: 1) educational drowning prevention messages; or 2) educational messages and a door barrier; or 3) educational messages and a play pen. This study used a convenience sample, did not have a control group and the authors acknowledged it was not an effectiveness trial. Despite this, those households that received education only were more likely to leave their children unsupervised (5.6%) compared with those households who were given either a door barrier (2.0%) or playpen (1.3%) [27].

Acquisition of survival skills

In this review, the interventions that targeted the acquisition of survival skills (n=3) [18, 23, 24] were delivered in either the US or Australia, both HICs. All three studies had different designs and target populations.

The effect of training in swimming and water safety on pre-school aged children (2-3 years) in middle-income Seattle, (US) was examined by Asher et al. [18]. The study was a randomised trial, (no control), with two intervention arms of either eight or 12 weeks duration. The results found that swimming and water safety lessons improved swimming capabilities of young children. However, both the comparison group (8 week) and treatment group (12 week) received the training, it was a self-selected sample, and incentives were offered [18] suggesting the results need to be interpreted with caution.

The second study described a unique water safety training program delivered to 11 remote Australian communities which targeted children (n=668) and adults (n=219) [24]. The program was designed to develop context specific strategies in consultation with local communities and based on previous research findings. *Water Safety in the Bush (WSB)* included three elements: the coordination by a local organisation; a water safety instruction program based on Royal Life Saving Society of Australia's (RLSSA) curriculum materials; and strategies for sustainability. Evaluation of *Water Safety in the Bush* reported parents and organisations were very satisfied with the program, and parents and instructors demonstrated children's increase in water safety skills, swimming ability, life-saving and water confidence. However, it was recognised that a more culturally appropriate model was required to fully engage the remote and isolated Indigenous communities [24]. Methodological limitations including low response rates and poor adherence to the standardised evaluation forms which resulted in findings that could not be generalised.

Finally, a case control study by Brenner et al. [23] estimated the association between swimming lessons and the risk of drowning among children (1-19 years) by identifying drowning cases from medical examiners/coroners with matched controls. The study found a protective association between past participation in swimming lessons and risk of drowning in children aged 1-4 years; however these results did not extend to children aged 5-19 years. The results of this study have limitations including a small sample size, small number of cases who had participated in formal swimming lessons and noted difficulty in interviewing next of kin. However, the study did attempt to control for confounders such as age, income, education, race and medical condition [23].

DISCUSSION

This review of 15 drowning prevention studies delivered and published before May 2013 included interventions delivered in high, middle and low income countries. Interventions varied by target age group, duration, strategies employed, diversity of evaluation measures and outcomes. More than

seven different interventions designs were utilised across the studies. Using the *themes* identified as the drowning prevention chain - control measures by ILSF, 40% of the studies relied solely on 'education and information' as the key strategy to reduce drowning deaths, and only three studies used a multi-themed approach, combining education and information, denial of access and supervision. Interestingly, supervision was the key theme in just two of the studies reviewed. Overall, there was minimal use of behavioural theories and/or frameworks and just one third of the studies described using formative evaluation as part of the development of the drowning prevention intervention. The 15 drowning prevention intervention studies focussed mostly on short term effects such as awareness and satisfaction, and intermediate effects such as knowledge, perceptions and intention. The reported methodologies had an over reliance on self-report measures, lacked a control group and had small samples, all of which diluted the robustness and generalisability of the findings.

Education and information

In this review, all of the studies used education and information as a key strategy to prevent drowning. Of these, five used education and information only to prevent drowning in children and young people [19, 21, 22, 28, 29], with a further three studies reporting a more comprehensive (multi-strategy) approach [7, 24, 27]. The injury prevention literature acknowledges the importance of raising awareness of risk factors for child injury as well as the knowledge and skills to address these risks [22]. Furthermore, water safety experts support education as a key factor in decreasing the number of submersion events [1, 32]. However, the literature also highlights that valuing and recalling prevention information alone does not ensure behaviour change [28, 33].

The appropriateness of, and the context in which the educational intervention is delivered needs to be carefully considered as safety prevention messages are often competing for parental attention, and messages are often content heavy and delivered in a short space of time [22]. A recent review suggests successful education interventions should be: content specific, use age group appropriate settings, and tailored to the target group [2]. This contrasts with the significant findings from Posner et al. [22] and Gresham et al. [21] who positioned drowning prevention in the context of broader injury and safety prevention messages. Interestingly, there is a growing body of literature on the concept of intervention-generated interpersonal discussion [34]. This posits that interpersonal discussion can amplify intervention effects by extending the reach of the message to those not directly exposed, and by facilitating deeper message processing among those who have been exposed to the intervention [34]. Interpersonal discussion generated by educational sessions on drowning prevention is one low-cost option worthy of further exploration in the area of drowning prevention and water safety. This may be more so in less-resourced countries where the challenges of delivering educational messages to large population groups may benefit from culturally appropriate 'extended reach' produced by interpersonal discussion.

Denial of access – barriers and regulations

Since the 1990's, high income countries, including Australia and New Zealand have passed laws requiring the fencing of private and public pools [35]. The erection of barrier fencing may be inappropriate in some HICs in rural regions such as creeks and dams. There are recommendations from peak injury prevention organisations in countries such as Australia for yard fencing whereby it may be more desirable to fence the home paddock than the water body in order to provide a safe play space for children [36]. Similarly, in LMICs where child drowning occurs more often in natural bodies of water like ponds, ditches and irrigation canals barrier fencing may not be practical [7, 37]. There are some examples in the grey literature of simple, low cost, barrier measures, such as well, drain and water storage tank covers that have successfully been used as drowning prevention strategies [38]. However, there is a lack of effectiveness data on low cost alternatives to conventional barriers (e.g. fencing and self-closing, self-latching gates) that can be utilised in LMICs to prevent access to bodies of water [39]. In addition, the regulations which support barrier installation and compliance need to be captured within legislation, and also enforced, which brings an extra set of challenges for LMICs. Notwithstanding, simple low cost barrier measures such as lids on nappy buckets, playpens and door barriers have been shown to be promising and appropriate strategies in resource-poor settings, and need to be implemented, and then evaluated.

Provision of supervision

Provision of supervision was reported in just two studies, notably both delivered in LMICs [7, 27]. When child drownings occur, a lapse in, or lack of caregiver supervision is often cited as a contributing factor [40-42]. Noteworthy, parental supervision has been shown to be one of the most effective injury prevention strategies in HICs [27, 43], and universally is a low cost, socially acceptable method to prevent drowning across all cultures. Therefore, it is understandable that supervision in the form of a community crèche has been actively pursued by LMICS as a strategy to reduce drowning. The use of community based supervision in the PRECISE program together with environmental supports such as playpens for children under 18 months and door barriers [27] to prevent children accessing bodies of water, was reported to have good uptake and a way to improve supervision [7, 27]. Supervision should continue to be a realistic and integral component for all drowning prevention programs globally.

Acquisition of survival skills

Swimming and water safety education differs from basic learn to swim in that it includes a mix of swimming, survival and rescue skills, and water safety knowledge suitable for use in a range of aquatic environments. Acquisition of these skills has been identified as a drowning prevention strategy for those 18 years and under [44]. This review found all three studies whose main focus was

acquisition of survival skills were in HICs and the target populations were children, [18, 23] and children and their parents [24]. The PRECISE program implemented in Bangladesh delivered the SwimSafe program consisting of water safety and safe rescue skills for children aged 4 to 12 years as part of a multi-strategy approach. The delivery of survival and rescue skills is integral to the prevention of non-fatal drowning events and should be considered a key component of a multi-strategy approach. Additionally, intervention programs should emphasise the swimming and water safety education rather than just basic swimming lessons.

Multi-strategy interventions

This review defined multi-strategy interventions as those which combined two or more ILSF 'themes'. Briefly, of the 15 studies included in the review, only three were deemed multi-strategy interventions [7, 24, 27]. Of interest, all three used a community based approach to reduce non-fatal and fatal drowning in children ranging from 6 months to 14 years. The PRECISE Program described two strategies namely the SwimSafe Program and Anchals [7]. Whilst the second study also delivered in Bangladesh [27] included education and information, the provision of supervision and denial of access by provision of either a playpen or door barrier [27]. The final intervention *Water Safety in the Bush (WSB)* [24] (Australia) combined three elements, education and information, denial of access, and the acquisition of survival skills in a variety of rural/remote settings. The outcomes reported by all three multi-strategy interventions varied, and it is difficult to interpret the findings from these three studies due to less than robust methodologies and evaluation methods. Hence, the call for multi-strategy interventions that do not over rely on one strategy or ILSF theme alone, but work as a combination with adequate and sustained resources, ongoing advocacy, legislation and compliance will ultimately reduce the incidence of child drowning deaths globally. The reinforcement of health education messages in conjunction with on-the-ground activities, environmental supports and legislation has been shown to further encourage and sustain behaviour change across a variety of health domains [2, 26].

Child drowning intervention outcomes

Eight of the interventions in the review reported significant outcomes [7, 18, 19, 21, 22, 27-29] which were measured and assessed in various ways. The '*Stay on Top of it*' media campaign reported on a proximal outcome with an increased awareness of the campaign [19]. Intermediate effects such as water safety knowledge and beliefs were significant in three studies [21, 28, 29]. All three interventions were delivered to school-age children, which supports some comparison between studies. Two studies reported a decrease in drownings as a result of fencing legislation [17, 26]. In terms of the distal outcome and the impact on drowning deaths, just one third commented on a reduction in the number of drownings or an observed downward trend [7, 17, 19, 22, 26]. The consistency of the outcomes varied across the 15 interventions. The variety of study designs, and the

reliance on self-report and observational data reduces confidence in the reported findings. The need for comparable groups, reliable and objective measures [2, 10], along with the selection of appropriate outcome measures is crucial to determine the impact of future drowning interventions.

Behavioural theory and evaluation frameworks

Only two of the studies, both from the US, used behavioural theory or frameworks to underpin intervention design and/or strategy development. Elements of SCT and Protection Motivation Theory were used to guide message development in a drowning prevention campaign targeted at parents of children aged 1- 14 [19]. The *TFFK* intervention also used self-efficacy and other SCT constructs to guide the development of the year specific injury prevention curricula [21]. Interventions need to be informed by theory to ensure that the strategies are appropriate and comprehensive. The use of theory needs to be promoted to improve drowning prevention programs.

Whilst only one study [19] indicated the use of a planning/evaluation framework (the PRECEDE component of the PRECEDE-PROCEED framework [45]), five of the interventions reported using formative evaluation to either inform the design of the strategies delivered as part of the prevention intervention [19, 24, 27, 28] or to inform the measures used to evaluate the intervention post-delivery [22]. Noteworthy the *WSB* intervention largely failed to engage remote Aboriginal community leaders in their planning stages, rendering their program less culturally appropriate for those in remote and isolated Australian communities. [24] Consistently across the public health literature there has been a call for greater use of behavioural theory and planning frameworks as key drivers of successful programs [10, 11, 26].

Methodological limitations of studies in the review

In this review methodological limitations were diverse and frequently cited. Our findings concur with the findings of a recent review by Wallis and colleagues [2]. The most noteworthy limitations included: a different sampling method used pre-campaign than the method used at post campaign [19, 28]; an over reliance on self-report measures [21, 22, 28]; small sample size [23, 29]; lack of a control group [18]; demographic differences between the intervention and non-intervention participants [7]; short follow-up time between the intervention delivery and data collection [21, 28]; non-use of standardised instruments for data collection by evaluators [24]; and self-selection bias including participants recruited from areas where child drowning occurs frequently [18]. In addition language barriers and/or participants who were functionally illiterate [29] and culturally inappropriate strategies were highlighted [24, 29]. Whilst there is an urgent call for methodological improvements to inform the design and delivery of interventions, the reality and pragmatics of the practitioner experience must

be considered [46]. Developing research – practice partnerships may assist to generate practice based evidence for use in both HIC and LMICs to reduce fatal and non - fatal drowning.

Strengths and limitations

This review has a number of strengths. The review has been registered with the PROSPERO International Prospective Register of Systematic Reviews, a protocol paper has been published and the search strategy was not restricted by a starting time limit. All final interventions included in the review were delivered in both high income and low and middle income countries potentially increasing its relevance to those working in drowning prevention in these countries. However, the studies were restricted to publications in the English language. In addition, studies reported outside peer-reviewed journals were not captured and no grey literature was reviewed.

CONCLUSION

Children (those under 18 years) continue to be over represented in fatal and non-fatal drowning episodes, resulting in a significant impact on families and communities. Drowning in children and adolescents is a complex issue, highlighted in this review by the range of drowning prevention intervention designs in both HIC and LMICs. The *themes* identified as the drowning prevention chain control measures by ILSF (education and information; denial of access – barriers and regulations; provision of supervision; and acquisition of survival skills), are presented in this systematic review. This review reveals an over reliance on education and information as an intervention strategy to prevent drowning, with only three studies providing evidence of a multi-strategy approach to this important public health issue. There is an immediate requirement to support interventions that use a range of strategies that are shaped by theory and planning and evaluation frameworks, and are robust in regard to intervention design, delivery and evaluation methodology. This approach will provide sound evidence that can be disseminated to inform future practice and policy for drowning prevention.

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Table 2: Characteristics, evaluation design and outcomes of 15 child drowning prevention interventions

Study characteristics	Intervention description	Key element(s)	Inclusion of behavioural theory (BT) and/or formative research (FR) and/or planning frameworks (PF)	Evaluation design & measures	Intervention outcomes	Limitations of the intervention
ILS Theme 1: Education and information						
<p>Bennett et al, 1999</p> <p>Drowning prevention campaign</p> <p>Parents of children 1-14 years</p> <p>USA</p>	<p>Media campaign “Stay on Top of It”</p> <p>Key media messages:</p> <ul style="list-style-type: none"> - “Wear a life vest” - “Supervise children around water” - “Learn guidelines for water safety” 	<p>To increase life vest use at beaches, docks, swimming pools. Loan programs implemented, discount coupons offered.</p> <p>-</p>	<p>BT: Social Cognitive Theory and Protection Theory guided message development</p> <p>FR: Program elements guided by pre-survey results, drowning prevention literature, and the Seattle bicycle helmet campaign</p> <p>PF: Survey questions guided by PRECEDE model</p>	<p>Pre/post-test design</p> <p>Telephone interviews with parents assessed:</p> <ul style="list-style-type: none"> - awareness of campaign and primary messages; - changes in child life vest use; - change in ownership of child life vests. <p>Four telephone surveys conducted: a baseline (pre-campaign) survey in 1992 (n=332), two tracking surveys in 1992 (n=400) and 1993 (n=400), and a post-campaign survey in 1994 (n=480)</p> <p>Drowning fatality rates – 3 years prior to vs 3 years during campaign</p> <p>Other variables: demographics, parent confidence, child swimming ability, perceived susceptibility of child drowning, perceived life vest efficacy</p>	<p>Tracking survey: 1992 and 1993 38% of parents were aware of campaign, increased to 50% in 1994</p> <p>Reported ownership of vests for all age groups increased from 69% in the pre-campaign survey to 75% post campaign survey</p> <p>Predictors of life vest use by children:</p> <ul style="list-style-type: none"> - Child vest ownership OR=2.6 95% CI 1.5-4.4 p<0.001 - Parental age <40 years OR=2.3 95% CI 1.5-3.6 p<0.001 - Parent confident fitting a vest OR=3.2 95% CI 1.5-7 p=0.003 - Child does not swim well OR=1.6 95% CI 1.1-2.4 p=0.03 - Parent recalls campaign OR=1.6 95% CI 1.1-2.5 p=0.02 <p>Drowning fatalities: 12 deaths in 3 years pre campaign, 8 deaths in 3 years during the campaign</p>	<p>Random digit dialling not used - could have biased results</p> <p>Over-representation high income families - findings may not apply to low income families</p> <p>Pre-campaign survey used a different sampling method than the tracking & post-campaign survey</p> <p>Self-reporting may have over-represented positive behaviours</p> <p>Results may be attributable to other educational efforts</p>

Study characteristics	Intervention description	Key element(s)	Inclusion of behavioural theory (BT) and/or formative research (FR) and/or planning frameworks (PF)	Evaluation design & measures	Intervention outcomes	Limitations of the intervention
<p>Gresham et al, 2001</p> <p>School-based water safety education</p> <p>Children 6-9 years (grades 1-3)</p> <p>USA</p>	<p>Think First for Kids (TFFK) Program</p> <p>Integrated curricula, evaluation on injury & risk behaviour. Classroom delivery over 6-week period</p> <p>15 schools: 8 intervention (n=851) and 7 control (n=1126), matched on SES, reading scores and race</p>	<p>To increase water safety knowledge.</p> <p>Trained teachers and school nurses delivered 6-week injury prevention curriculum - water safety 1 of 6 topics</p>	<p>BT: Social Cognitive Theory - curriculum was based applied learning and behavioural constructs including role modelling and visual reinforcement.</p>	<p>Randomised control trial (RCT)</p> <p>Self-report knowledge pre and post-test surveys. Water safety assessment including:</p> <ul style="list-style-type: none"> - Knowledge of hazard of brain and spinal cord injury - Knowledge of safety rules - Awareness of preventing water-related injury and drowning - Individual responsibility in prevention <p>Validity and reliability testing of pre/post instruments</p>	<p>Water safety knowledge improved from pre- to post-intervention (p<0.01 each grade)</p>	<p>Self-report nature of the survey; no actual observations of behaviour recorded; inability to control all threats to internal validity; results may be attributable to other educational efforts</p> <p>Post-test administered within a short time of the intervention - affects may not have been sustained for any length of time and scores may have been higher for more recently reviewed material</p>
<p>Posner et al, 2004</p> <p>Home safety information and safety device distributed to emergency department (ED) parents</p> <p>Parents of children <5 years</p> <p>USA</p>	<p>Care-givers of child presented to ED with unintentional injury sustained at home completed structured home safety questionnaire then randomly assigned to intervention (n=49) and control (n=47)</p>	<p>To improve care-givers' behaviour and practices related to home safety.</p> <p>Care-givers (intervention) given comprehensive home safety education, delivered by trained research assistant, & free safety devices kit vs usual care discharge instructions - injury focused (control).</p> <p>Drowning 1 of 7 topics</p>	<p>FR: Questionnaire designed by injury experts, supported by literature</p> <p>BT: Health Belief Model - perceived susceptibility and severity constructs</p>	<p>RCT pre-post design</p> <p>Survey delivered in ED and by telephone 2 months post-ED visit. Knowledge of caregivers surveyed on 51-item multi-choice home safety questionnaire to obtain overall safety score (submersion category = 4 items)</p> <p>Other: demographic and injury characteristic information</p>	<p>No significant improvement (p>0.05) observed for drowning prevention</p> <p>Significant improvement (p<0.01) in overall safety scores in intervention group vs control group, attributed to increase in use of safety devices (p>0.001)</p>	<p>Self-reported safety practices may have introduced reporting bias, which may have influenced safety practice reporting, resulting in overestimation of effectiveness</p> <p>Safety practices vs home injury events outcome of interest</p> <p>Feasibility of delivery in other EDs may be limited compared with paediatric ED</p>

Study characteristics	Intervention description	Key element(s)	Inclusion of behavioural theory (BT) and/or formative research (FR) and/or planning frameworks (PF)	Evaluation design & measures	Intervention outcomes	Limitations of the intervention
<p>Terzidis et al, 2007</p> <p>School-based systematic water safety education</p> <p>Children and adolescents 5-15 years</p> <p>Greece</p>	<p>2 phase intervention.</p> <p>Phase 1: Knowledge and attitudes were assessed among 3 grade categories of pupils: kindergarten/grade 1, elementary school, and first 3 grades secondary school.</p> <p>Phase 2: Educational materials delivered to pupils with similar socio-demographic characteristics from different schools from the ones participating in phase 1.</p>	<p>To improve water safety knowledge and attitudes.</p> <p>Stage 1: Formative evaluation: Water safety knowledge, attitude, skill & socio-demographic variables assessed via questionnaires distributed to sample target group.</p> <p>Stage 2: Pre-intervention questionnaire, educational material delivered in class and take-home materials distributed.</p>	<p>FR: Stage 1 involved the development and delivery of a questionnaire to assess water safety knowledge, attitude and skills. Provided the basis for intervention materials development.</p> <p>Age-specific questionnaires to assess water safety knowledge & attitudes; educational materials developed in collaboration with multi-disciplinary experts.</p>	<p>Intervention and control comparison study</p> <p>Post questionnaire delivered to pupils from both phases one month post phase 2.</p> <p>Phase 1 pupils = control group Phase 2 pupils = intervention group</p> <p>Knowledge and attitudes assessed</p>	<p>Survey numbers: kindergarten and grade 1 (n=202 pre and n=115 post), elementary school (n=220 pre and n=205 post) and high school pupils (n=337 pre and n=231 post)</p> <p>Kindergarten/grade 1 pupils, who received the intervention scored significantly higher for knowledge (17.40%, 95% CI 6.41-28.39) and attitudes (23.64%, 95% CI 4.48-42.79)</p> <p>Elementary school pupils, knowledge gains were less (14.58%, 95% CI 23.05-32.21) and almost null in attitudes (5.64%, 95% CI 11.47-22.77)</p> <p>High school students showed no improvement in knowledge (20.15%, 95% CI 25.30-4.99) and minimal, insignificant increase in attitudes (6.32%, 95% CI 21.87-14.52)</p> <p>The effect of the intervention was significantly different across grade category ($p < 0.001$ for knowledge and $p = 0.01$ for attitudes)</p>	<p>Scarce resources/ relied on volunteers</p> <p>Short duration -evaluation conducted shortly after exposure</p> <p>Children who participated in the assessment of background knowledge and attitudes were not the same individuals as those involved in the intervention and the post-exposure evaluation</p> <p>Self-reported information</p> <p>Difficult to evaluate the differential impact of the educational intervention on the behavioural modification of pupils who participated in the study as the mass media components of the campaign commenced immediately after the post-exposure evaluation</p>

Study characteristics	Intervention description	Key element(s)	Inclusion of behavioural theory (BT) and/or formative research (FR) and/or planning frameworks (PF)	Evaluation design & measures	Intervention outcomes	Limitations of the intervention
<p>Solomon et al, 2012</p> <p>School-based water safety education</p> <p>Children aged 5-12 years</p> <p>Grenada</p>	<p>WHALE Tales training</p> <p>Adaption of water safety education programme developed by American Red Cross for primary school students</p> <p>Separate training sessions for each grade, total 7 sessions. Each session taught by principal investigator</p>	<p>To improve water safety knowledge</p> <p>School-based water safety education.</p>	<p>None noted</p>	<p>Pre and post-test design</p> <p>Water safety knowledge before and after the training session assessed using a 9-question evaluation tool</p> <p>Post training survey administered to teachers to assess the adaptability and effectiveness of the WHALE Tales training</p>	<p>56 students (30% males) completed the training</p> <p>Participants' water safety knowledge increased 15% (p<0.01)</p> <p>Mean scores of correct answers increased for every grade level, ranging from a 5% increase for first graders to 33% increase for second graders</p>	<p>WHALE Tales course materials were not designed for the specific cohort of Grenadian primary school children – cultural differences may have biased outcomes.</p> <p>Language barrier between the WHALE Tales instructor and students</p> <p>Small sample size hindered ability to detect significant differences & limited generalisability of results</p>
ILS Theme 2: Denial of access – barriers and regulations						
<p>Quan & Gomez, 1990</p> <p>Swimming pool safety inspections</p> <p>Children and adolescents 0-20 years</p> <p>USA</p>	<p>Seattle-King County Department of Public Health (SKCDPH) Pool Program; extends to all semi-public and public pools and spas in the county</p> <p>Staff review plans for public and semi-public swimming pools, spas prior to construction and conduct pre-opening inspections</p>	<p>To assess the effectiveness of the SKCDPH on submersion injuries</p> <p>Program utilises education, develops legislation and enforcement, provides re-evaluation of standards to mitigate 4 factors that contribute to submersion injuries: inadequate supervision, lack of barriers, poor water clarity, and failure to execute timely and competent</p>	<p>None noted</p>	<p>Time series design</p> <p>The following checked monthly for seasonal, & three times a year for year-round facilities:</p> <ul style="list-style-type: none"> - Water quality for pH, free chlorine, and clarity; - Recirculation and filtering equipment ; - Disinfecting equipment; - Pool environment such as pool fencing, decks and hand rails - Safety equipment such as life rings with ropes, reach poles, first aid kits, & emergency 	<p>Pools under SKCDPHs jurisdiction increased almost 6 fold between 1975 (n=224) and 1987 (n=1337)</p> <p>Lifeguard survey reported increase in numbers of lifeguards. Responding facilities reported 13% increase in lifeguards with CPR training between 1982 (lifeguards n=200, CPR trained n=160) and 1987 (lifeguards n=897, CPR trained n=834)</p> <p>Drowning in lifeguarded spas, pools, bathing beaches decreased</p>	<p>No data on non-fatal drowning& it could not be determined if additional lifeguard CPR training or increased supervision explained the decrease in deaths</p>

Study characteristics	Intervention description	Key element(s)	Inclusion of behavioural theory (BT) and/or formative research (FR) and/or planning frameworks (PF)	Evaluation design & measures	Intervention outcomes	Limitations of the intervention
	Issues annual permits required to operate facilities and conducts routine inspections to determine compliance with pertinent rules and regulations	rescue. Enforcement is achieved by suspending or revoking permits Fee-supported		numbers; - Review of operator records; - Bacteriological sampling.	1975-1976 n=10 (rate 0.21 per 100,000) to 1985-1986 n=1 (rate 0.02 per 100,000) Number and rate per 100,000 population of swimming pool submersions of victims under 20 years old between 1974 and 1983 showed a downwards trend, n=16 and n=7 respectively	
<p>Morgenstern et al, 2000</p> <p>Pool deaths matched to pools with no deaths</p> <p>Children <10 yrs</p> <p>USA</p>	<p>Incidence of drowning deaths in residential swimming pools (n=146) matched to pools with no drowning (1:5) between January 1990 and December 1995</p> <p>Cases stratified by age and location for comparison including housing and property characteristics</p>	<p>To assess the effectiveness of pool fencing ordinance</p> <p>Whether a pool fencing ordinance was in effect when pool was built and the effect on pool drowning fatalities</p>	None noted	<p>Stage 1 retrospective dynamic cohort study</p> <p>Stage 2 matched case-control study</p> <p>Outcome: incidence of fatal pool drowning</p> <p>Exposure: presence or absence of pool fencing ordinance when pool built or altered</p> <p>Demographics and potential confounders also investigated</p>	<p>Pool fencing ordinances and drowning not significantly ass'd RR=1.27 95% CI 0.72-2.25</p> <p>Average drowning rate 1.77/100,000/year 1-9 years. 1-4 years 3.61/100,000/year</p> <p>81% of all drownings occurred in pools regulated by pool-fencing ordinances</p> <p>Positive associations were observed between drowning and age 1-4 years, male, ethnicity, summer season, high and medium pool density, low parental education, high family income</p>	<p>Local ordinance standards may not have been effective (eg. 4-sided fencing not required until recently)</p> <p>Inadequate enforcement of the ordinances & inadequate operation or maintenance of pool-barrier equipment by owners may have reduced effectiveness of pool fencing codes</p> <p>Differential access to pools not taken into consideration</p>
<p>van Weerdenburg,</p>	Three NSW councils underwent pool	To assess the effectiveness of local government	None noted	Mixed methods convenience /cross sectional survey, interviews, audit	Compliance increased over the two periods in Council A (from	Councils were a convenience sample

Study characteristics	Intervention description	Key element(s)	Inclusion of behavioural theory (BT) and/or formative research (FR) and/or planning frameworks (PF)	Evaluation design & measures	Intervention outcomes	Limitations of the intervention
<p>Mitchell & Wallner, 2006</p> <p>Swimming pool compliance inspections</p> <p>Children less than five</p> <p>Australia</p>	<p>compliance inspections, pool owner surveys and interviews with council employees to determine pool owner's compliance with pool legislation, opinions of swimming pool fencing inspections, and councils long term management of swimming pools and enforcement of legislation</p>	<p>management approaches to backyard swimming pool fencing compliance</p>		<p>Pool owner survey: general demographics, the exposure of children aged less than five years to their pool, and the pool owners' opinions of swimming pool fencing and inspections</p> <p>Inspection results: compliant or non-compliant</p> <p>Faults: fence-related, gate-related, latch-related or other faults</p>	<p>49% to 55%), while in Council B compliance was high at 97%.</p> <p>15.6% of survey respondents (n=32) had children less than five years of age residing in their home with the average age being 2.5 years and approximately two-thirds of respondents (n=135, 65.9%) reported that children aged less than five years had visited their home in the previous six months</p>	<p>Two of the three councils (B and C) had recently completed or had a swimming pool inspection program in operation at the time of the study, therefore compliance may have been higher than had they not have just had inspections</p>
<p>Pearn et al, 2008</p> <p>Audit of the effects of safety legislation</p> <p>Children 0-4 years</p> <p>Australia</p>	<p>Comparative audit of childhood drowning deaths in the decade before (1982-1991) and after (1992-2001) pool barrier isolation legislation was introduced</p> <p>Secular trends in age specific sub-populations obtained from ABS & Office of Economic and Statistical Research</p> <p>Individual drowning deaths records obtained from published data, coronial</p>	<p>To assess the effectiveness of safety legislation on child home-swimming pool drowning</p> <p>Comparison of home swimming pool childhood drowning deaths pre and post introduction of pool barrier isolation legislation</p>	<p>None noted</p>	<p>Retrospective data analysis</p> <p>Assessing age-corrected drowning rates for pool and non-pool drowning deaths</p>	<p>55 pre-school (0-4 years) children drowned in Brisbane over 20-year period</p> <p>Age-specific drowning death rates fell after introduction of safety legislation (6.54 cf. 1.85 per 100,000 per year); as did ratio of pool drowning deaths to all drowning deaths in this age group (0.85 cf. 0.50 per 100,000 per year)</p> <p>Age-specific annual drowning death rates for non-pool drowning deaths (1.17 cf. 1.85 per 100,000 per year) did not change</p>	<p>None noted in article</p>

Study characteristics	Intervention description	Key element(s)	Inclusion of behavioural theory (BT) and/or formative research (FR) and/or planning frameworks (PF)	Evaluation design & measures	Intervention outcomes	Limitations of the intervention
	files, hospital admission and intensive-care registers, Queensland Injury Surveillance Unit and Australian Pre-Hospital Care Research Unit					
<p>Milliner, Pearn & Guard, 1980</p> <p>Effectiveness of protective safety legislation on child-drowning</p> <p>Children 0-14 years</p> <p>Australia</p>	<p>The study measures baseline child drowning rates, introduced protective safety legislation, and accessed effectiveness</p>	<p>To assess the effectiveness of protective safety legislation on child-drowning</p> <p>Rigidly policed pool safety legislation since 1960 – barrier must be erect between the pool and the house and laws stiffened by prosecution</p>	<p>None noted</p>	<p>Retrospective data analysis</p> <p>Child drowning occurrences checked in coronial files</p> <p>Number of dwellings, population, the number of registered pools, by year, and by Shire were obtained from the Mulgrave Shire Council</p> <p>Total pool estimates (pool: house ratios) were obtained by means of the measured ratios of in-ground versus above-ground pool ratios</p>	<p>Pool: house ratios were very high (1:17 for registered pools, and an estimated 1:6 for total pool numbers)</p> <p>One child had drowned over past decade, occurring in an unfenced pool which had been exempt from regulation</p>	<p>None noted</p>
	ILS Theme 3: Provision of supervision					
<p>Callaghan et al, 2010</p> <p>Analysis of supervision practices with and without supervision aids</p> <p>Children 6 months to 4.5</p>	<p>Six villages purposively selected to participate in study, 2 villages randomly assigned to each of 3 intervention packages: (1) educational drowning prevention messages, (2) educational messages and door barrier, (3) educational</p>	<p>To improve supervision practices</p> <p>Observations of effectiveness of education messages and barriers (door and playpen) occurred at staggered times.</p>	<p>FR = Playpen and door barrier were identified and developed in a pilot feasibility study</p>	<p>Observational audit</p> <p>Recorded supervision practices and tool use on a standardised observation form by CHW</p>	<p>Statistical analysis of 2694 observations revealed that children were directly supervised or protected by a preventive tool in 96.8% of visits</p> <p>In the education-only arm, 61 observations with child unprotected, statistically significantly more than that observed in the playpen and door</p>	<p>This was not an effectiveness trial; did not include a control group; & used a convenience sample.</p>

Study characteristics	Intervention description	Key element(s)	Inclusion of behavioural theory (BT) and/or formative research (FR) and/or planning frameworks (PF)	Evaluation design & measures	Intervention outcomes	Limitations of the intervention
years Bangladesh	<p>messages and playpen</p> <p>Convenience sample of village households with children 6-54 months recruited via community meetings conducted by community health workers (CHW)</p> <p>Participating households received initial visit from CHW during which the intervention was delivered. Afterwards, CHW made up to 11 unannounced follow-up observations</p>				<p>barrier arms</p> <p>CHW observed intervention tool use during 56.6% of observations in the playpen arm and only 18.7% of observations in the door barrier arm ($p < 0.01$)</p> <p>The door barrier group accounted for 49% of negative intervention comments and 86% of mechanical problems</p> <p>Families that received a playpen had 6.89 times the odds of using it at the time of the visit than families that received a door barrier</p>	
<p>Rahman et al, 2012</p> <p>Analysis of cost-effectiveness of a low-cost, scalable injury and drowning prevention program</p> <p>Children 1-12</p>	<p>PRECISE: Prevention of Child Injuries through Social-Intervention and Education, has two components:</p> <p>Anchal: focused on children aged 1-5, involved village-based crèches. Crèches staffed by two women from the community</p>	<p>To reduce the relative risk of drowning through participation in crèche or swimming lessons. To assess the cost-effectiveness of the interventions</p> <p>Anchal: Childcare provided while parents working</p> <p>SwimSafe: Instruction of</p>	<p>FR: Injury prevention committee of local leaders participated in planning and promotional activities</p>	<p>Retrospective cohort study matched to fatalities.</p> <p>A demographic surveillance system (DSS) was introduced in three regions in rural Bangladesh capturing all deaths via in-home interviews.</p> <p>The retrospective cohort study compared mortality outcomes between those who did or did not</p>	<p>Anchal (n=18,596 participants) costs between \$50.74 and \$60.50 per child per year. SwimSafe (n=79,421 participants) costs \$13.46 per child</p> <p>For Anchal participants, the relative risk of a drowning death was 0.181 ($p = 0.004$). The relative risk of all cause mortality was 0.56 ($p = 0.001$)</p>	<p>Not a randomized trial, and, therefore, differences in the composition of the intervention and non-intervention participants may provide potential bias</p> <p>Differences in average age and gender between participants and non-participants</p> <p>Possible that SwimSafe</p>

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years Bangladesh	SwimSafe: basic swimming, water safety, and safe rescue skills for children aged 4-12 years. Formal curriculum, developed specifically for children in LMICs, delivered over three weeks by trained local instructors in village ponds modified with submerged platforms to facilitate safe training	basic swimming and lifesaving skills PRECISE incorporated community education programs that reinforced injury prevention and other health messages.		participate in the PRECISE program, control group = all children in DSS who did not participate.	For SwimSafe, the relative risk of a drowning death was 0.072 (p<0.0001). The relative risk of all-cause mortality was 0.750 (p=0.024) For Anchal, the cost per disability adjusted life-year (DALY) averted is \$812 (95% confidence interval: \$589–\$1777) For SwimSafe, the cost per DALY averted is \$85 (\$51–\$561). Combined, the cost per DALY averted is \$362 (\$232–\$1364)	graduates rescued both Anchal participants and control individuals from drowning, which would introduce another source of potential bias Cost effectiveness estimates may be conservative as the study focused solely on the mortality benefits of PRECISE Possibility that children in the control group were exposed to the community education and prevention aspects of PRECISE, therefore results would be understated
ILS Theme 4: Acquisition of survival skills						
Asher et al, 1995 Swimming and water safety skill development Children 24-42 months USA	Water safety skills and swimming lessons delivered to two groups twice weekly for 8 weeks (n=48) or 12 weeks (n=61) Participants recruited via letters sent to child care centres located near public pools from middle-income Seattle area	To improve swimming ability and water safety behaviour Curriculum was designed for preschool age children, based upon American Red Cross program Instruction provided in groups of approximately 6 children by trained instructors, accompanied in the pool by their parents	None noted	Randomised trial, no control Independent observation assessed three skill sets: - Out-of-water safety behaviour - Swimming ability - In-water safety skills Swimming instructors rated swimming ability, three times for 12 week group and twice for 8 week group Self-report child developmental and behavioural, and parental	Swimming ability significantly improved in both the 8 and 12 week groups p<0.0001 No significant difference between 8 and 12 week group in deck behaviour p<0.03 Water recovery significantly improved in both groups p<0.0001 Jump and swim improved in both groups p<0.005	Used simulated risk as a proxy for drowning and non-fatal drowning The comparison group (8 week) received training as well as the full treatment group (12 week), diminishing possible differences (no control) Study sample was self-selected and thus were more likely to have interest in water safety The artificiality of the study

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		Participants received \$50 upon completion		educational and occupational survey's completed by parents		<p>setting (participating in research and training and receiving payment) may have affected the behaviour of the children and their parents</p> <p>The relatively short duration of children's involvement in the study limited the ability to assess how long effects</p> <p>Study did not attempt to measure any potentially negative effects of the intervention</p>
<p>Beattie et al, 2008</p> <p>Community based water safety-training program</p> <p>Children 5-14 years and parents and infants</p> <p>Australia</p>	<p>Water Safety in the Bush (WSB) training program 3 elements:</p> <ol style="list-style-type: none"> 1. Coordination by a local organisation 2. A water safety instruction program based on RLSSA curriculum & delivered by AUSTSWIM accredited swimming instructors 3. Sustainability strategies 	<p>To assess the effectiveness of community-tailored swimming and lifesaving programs in remote Australia</p> <p>Delivery of swimming /water safety program, tailored to meet community need, as determined by local organisations</p>	<p>FR: Develop context specific strategies in consultation with local communities and based on previous focus group data.</p>	<p>Pre post design with observational Audit</p> <p>Evaluation indicators included:</p> <ul style="list-style-type: none"> - Coverage of eligible participants; - Parental satisfaction; - Standardised assessment of swimming skills; - Documented implementation of a sustainability strategy. 	<p>WSB provided swimming and Water safety instruction to 887 remote and isolated people (n=668 children; n=219 adults), 47 adults and older children received specialised first aid training, and 38 community members became accredited AUSTSWIM instructors</p> <p>Parental satisfaction evaluation not rigorously enforced only 10% (n = 82) of the expected number of forms were completed. Although 99% expressed satisfaction with the project and agreed that their child had</p>	<p>Most instructors did not use the standardised training progress form but did attempt to describe the progress made by each participant. Hence, the information provided could not be translated into a single scale of progress.</p>

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					<p>enjoyed the training</p> <p>Parents perceived an increase in skills for life saving and water safety (increases of a mean of 2.8 and 2.3 points, respectively) compared with swimming ability which exhibited lowest perceived advancement (1.7 points increase).</p>	
<p>Brenner et al, 2009</p> <p>Formal swimming lessons vs informal/no swimming lessons</p> <p>Children and adolescents 1-19 years</p> <p>USA</p>	<p>Cases identified from coroners' offices mid-2003 and mid-2005</p> <p>Cases (n=88): 1-4 yrs n=61, 5-19 yrs n=27</p> <p>Interviews conducted with 88 families of children who drowned & 213 matched controls (matching variables age, sex, county of residence, presence of home swimming pool 1-4 yrs only)</p> <p>Matched controls identified through random-digit dialling or mail with next of kin</p>	<p>Formal and informal/no swimming lessons assessed for association with fatal drowning</p> <ul style="list-style-type: none"> - Formal lessons: child received paid lessons or lessons through day care, school or camp - Informal lessons: child received informal instructions, pointers, or tips about swimming or water safety when he/she went swimming - Non swimmers: those who reported no exposure to water 	<p>None noted</p>	<p>Case-control study</p> <p>Children who died as a result of unintentional drowning matched with controls</p> <p>Interviews with families assessed:</p> <ul style="list-style-type: none"> - exposure to water - swimming ability - participation in formal and informal swimming lessons - parent self-report: child development, temperament (1-4 yrs only), risk taking, medical conditions and household characteristics 	<p>61 cases in the 1-4 yr age group, 2 (3%) had participated in formal swimming lessons vs 35 of 134 matched controls (26%) (AOR=0.12 95% CI 0.01-0.97)</p> <p>Cases were more likely to be non-white p=0.4; low income p=0.03; low education p=0.003; risk takers p=0.03; temperament p=0.06; other medical condition p=0.07</p> <p>27 cases aged 5-19 years, 7 (27%) had ever taken formal swimming lessons vs 42 of 79 matched controls (53%) (adjusted OR=0.36 95% CI 0.09-1.51)</p> <p>Cases more likely to be non-white, low income or have seizure disorder p<0.01</p>	<p>Small sample size, particularly in older age group</p> <p>Able to interview next of kin for only 38% of identified drowning deaths in the 1-4 yr age group and 26% in the 5-19 yr age group</p> <p>Possible bias of participants vs non-participants (control group).</p>

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					No statistically significant ass'n between informal instruction & drowning risk	
<p>AOR – Adjusted Odds Ratio; ABS - Australian Bureau of Statistics; BT- Behavioural Theory; CI - Confidence Interval; CPR – Cardio Pulmonary Resuscitation; FR - Formative Research; LMICs - Low and Middle Income Country; RCT - Randomised Control Trial; OR - Odds Ration; PF - Planning Frameworks; RLSSA - Royal Life Saving Society; Y/N- yes/no; SES – Socio Economic Status</p>						