Socio-Ecological Nature of Drowning in Low- and Middle-Income Countries: A Review to Inform Health Promotion Approaches

Muthia Cenderadewi
James Cook University, Australia; the University of Mataram, Indonesia, muthia.cenderadewi@my.jcu.edu.au

Richard Charles Franklin
James Cook University, Australia, richard.franklin@jcu.edu.au

Susan Devine
James Cook University Australia, sue.devine@jcu.edu.au

Follow this and additional works at: https://scholarworks.bgsu.edu/ijare

Part of the Clinical Epidemiology Commons, Community Health and Preventive Medicine Commons, Educational Assessment, Evaluation, and Research Commons, Exercise Physiology Commons, Exercise Science Commons, Health and Physical Education Commons, Leisure Studies Commons, Other Public Health Commons, Public Health Education and Promotion Commons, Sports Sciences Commons, Sports Studies Commons, and the Tourism and Travel Commons

Recommended Citation
Cenderadewi, Muthia; Franklin, Richard Charles; and Devine, Susan (2020) "Socio-Ecological Nature of Drowning in Low- and Middle-Income Countries: A Review to Inform Health Promotion Approaches," International Journal of Aquatic Research and Education: Vol. 12 : No. 2 , Article 6.
DOI: https://doi.org/10.25035/ijare.12.02.06
Available at: https://scholarworks.bgsu.edu/ijare/vol12/iss2/6

This Scientific Literature Review is brought to you for free and open access by the Journals at ScholarWorks@BGSU. It has been accepted for inclusion in International Journal of Aquatic Research and Education by an authorized editor of ScholarWorks@BGSU.
Socio-Ecological Nature of Drowning in Low- and Middle-Income Countries: A Review to Inform Health Promotion Approaches

Cover Page Footnote
The authors thankfully acknowledge the College of Public Health, Medical and Veterinary Sciences, James Cook University, for providing a supportive research environment.

This scientific literature review is available in International Journal of Aquatic Research and Education: https://scholarworks.bgsu.edu/ijare/vol12/iss2/6
Abstract
Most deaths by drowning (91%) have occurred in low- and middle-income countries (LMICs), particularly in Southeast Asia (35%) and Africa (20%), in proportion to total drowning deaths worldwide. Poor data collection in LMICs hinders the planning, implementation, and evaluation of prevention strategies. The objective of this study was to review the rates and risk factors of unintentional drowning in LMICs and to identify drowning prevention strategies within a socio-ecological health promotion framework. A systematic search, guided by PRISMA, was conducted on Ovid MEDLINE, CINAHL, Informit health, PsycINFO (ProQuest), Scopus, SafetyLit, Google Scholar, and BioMed Central databases for all relevant studies published between 2012 and 2017. McMaster appraisal guideline was used for critical review. The disparity of available drowning data was observed across selected countries. The highest rates were identified in low-middle income South-east Asian countries. The socio-economic background of the family, overcrowding, and living close to water bodies were important predictors for paediatric drowning in LMICs, while the presence of mother as caregiver was identified as a protective factor. The over-reliance on active injury prevention strategies was identified. Further research focusing on developing relevant upstream drowning prevention and water safety promotion is needed to ensure the sustainability of drowning prevention in LMICs.

Keywords: drowning, drowning prevention, injury prevention, health promotion, low- and middle-income countries (LMIC)

Background
Drowning represents a major threat to global public health. In 2012, a total of 372,000 lives were lost to drowning, making it the world’s third leading cause of death by unintentional injury after road injury and falls (World Health Organization, 2014; 2016). According to the 2014 Global Report on Drowning by the World Health Organization (WHO), the highest mortality rate for drowning was in the age group of 1-4 year olds, with higher rates observed amongst male children, with 11.4 per 100,000 individuals, in comparison to the rate of 8.6 per 100,000 amongst female children from the same age group (World Health Organization, 2014). In 2015, drowning was the third leading cause of death for children aged 5 – 14 years worldwide, after lower respiratory infections and diarrhoea (World Health Organization, 2014, 2017). Focusing drowning prevention for younger age groups corresponds with achieving Sustainable Development Goals, particularly in ensuring children’s health, safety, and well-being and reducing preventable deaths in children under 5 years of age worldwide, with a global aim for all countries to reduce under-5 mortality rate to as low as 25 per 1,000 live births (United Nations, 2019).
Most deaths by drowning occurred in low and middle-income countries (LMICs) (91%), particularly in Southeast Asia (35%), Africa (20%), and Western Pacific (20%), in proportion to total drowning deaths worldwide (World Health Organization, 2014). In Bangladesh, drowning is an important cause of death for children, accountable for 43% of deaths in children aged 12-59 months, with a consistent increase on the drowning mortality rate from 3 per 1,000 live births in 2004 to 5 per 1,000 live births in 2011 (National Institute of Population Research and Training Dhaka Bangladesh, 2012). In contrast to high-income countries where most paediatric drowning cases take place in swimming pools (Dai et al., 2013; Ferretti et al., 2014; Lin et al., 2015a; Wallis et al., 2015), an observational study on deaths by drowning in Fiji revealed that most drowning fatalities occurred in natural water environments, such as rivers (50%), ocean (28%), and creeks (11%), where people carried out various daily activities (Murray & Carter, 2017). The high number of drowning deaths in LMICs is also related to the lack of preventive measures, weak regulations on water safety, inadequate supervision for children and infants, and ineffective basic skills in swimming and water safety awareness (Matthews et al., 2016; World Health Organization, 2014).

Data on drowning deaths in LMICs itself are potentially underrepresented as a result of inaccurate data collection and insufficient continuity of data (Linnan et al., 2012; Linnan et al., 2013; World Health Organization, 2014). Moreover, the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) for drowning deaths has excluded intentional drowning by suicide and homicide and drowning cases related to natural disasters and water transport incidents, which further undermined the magnitude of drowning as a leading health problem in LMICs where natural disasters such as meteorological and hydrological disasters and water transport-related injuries frequently take place (Leaning & Guha-Sahapir 2013; Linnan et al., 2012; Linnan et al., 2013; World Health Organization, 2014). In addition, the nature of drowning deaths, for example when victims have suffered a quick death on location and never reach medical facilities, continue to undermine the accuracy of data collection in countries with conservative dependence on facility-based reporting system (Linnan et al., 2012; Linnan et al., 2013; World Health Organization, 2014).

Drowning has most likely only been reported as fatal outcomes (Kanchan & Monteiro, 2012). A retrospective population-based study by Wallis and colleagues (2015) on fatal and non-fatal drowning cases among children aged 0 - 19 years in Queensland reported the ratio of death to survival in drowning incidents was 1:10 with only two out of three surviving victims admitted to hospital. Several factors strictly related to the scene and time of the incident, included the duration of submersion, the performance of advanced life support at the site, the availability of cardio-pulmonary resuscitation and support, and the Emergency Medical
Services’ response time, were important predictors to the survival of drowning victims (Quan et al., 2016; Quan et al., 2014; Suominen & Vahätalo, 2012). Furthermore, although limited information on non-fatal drowning existed, a retrospective study of admitted drowning cases in children in Pittsburgh (USA) revealed that 81% of patients had a poor neurologic outcome at hospital discharge (Mtaweh et al., 2015), thus emphasising need for effective preventive measures in intercepting mortalities and devastating neurological injuries due to drowning.

Drowning prevention involves multiple underlying determinants and processes such as safe water supply, water safety regulation, rural development, transportation management, disaster risk management, and occupational risk management (An, 2012; Forjuoh, 2013; Hassan et al., 2014; Yang et al., 2014). The multi-faceted aspects of drowning prevention underlines the certitude that no single preventive measure alone will be an effective solution. In fact, the prevention of drowning encompasses a wide extent of preventive measures, ranging from individual-focused approaches such as swimming training programmes and the use of personal floatation devices (PFD) to community-based actions such as community participation in controlling access to open water bodies and in creating safe environment for children, and policy development on water safety regulations and providing access to safe water (Crawford et al., 2014; Leavy et al., 2016; Leavy et al., 2015). This emphasises the urgent need for cohesive strategies across an upstream, midstream, downstream continuum to prevent drowning (Brownson et al., 2010a; Guevarra et al., 2015; Linnan et al., 2012; Linnan et al., 2013; World Health Organization, 2014). Upstream interventions aim to modify at a nation-wide or community level and involve policy development and allocation of economic investment (Brownson et al., 2010b; Pettigrew et al., 2014). Midstream factors are employed at the organisational or household level such as swimming and water safety policy regulated for schools in the state of Victoria, Australia (State Government of Victoria, 2017). Downstream interventions control disease or injury at individual levels including medical and behavioural approaches and happen to be the main focus of most research in disease and injury prevention (Brownson et al., 2010b).

Drowning prevention is closely linked to health promotion, as the two processes share common functions and aims (Plitponkarpm & Chinapa, 2014). By connecting drowning prevention and health promotion, a broader understanding of injury prevention can be achieved, which includes the process of empowering individuals and communities in taking control over their own health-related behaviours and practices (Giles et al., 2017; Leavy et al., 2016; World Health Organization Regional Office for the Eastern Mediterranean, 2017). Talbot and Verrinder (2014) illustrated the concepts of health promotion in the Health Promotion Framework, which comprises medical, behavioural, and socio-
environmental approaches at an individual level through to a population level. This framework is used throughout this review to assess the socio-ecological dimension of drowning prevention approaches in LMICs.

To provide comprehension on the magnitude and eminence of drowning as a public health priority, it is important to provide as much information as possible on the rates and risk factors of drowning, particularly in low-resource settings in LMICs, where 90% of global drowning incidents occur (World Health Organization, 2014). A recent study on the epidemiology of drowning in LMICs by Tyler et al. (2017) highlighted the notable contribution of drowning as a cause of injury-related deaths amongst LMICs and provided valuable information on several preventative strategies available in these countries. To further extend the understanding of drowning in LMICs, this paper aims to examine the risk factors and preventive interventions of drowning available in LMICs, and the interconnection of these aspects with socio-ecological approaches of health promotion and of drowning prevention. Improving the availability of information on the socio-ecological dimensions of drowning is an essential prerequisite in establishing, implementing, and evaluating the appropriate prevention strategies for drowning in LMICs where different prevention interventions to the preventive measures implemented in high income countries may be needed. (Guevarra et al., 2015)

**Aims**
This systematic review aims to describe the mortality and morbidity rates and risk factors for unintentional drowning in LMICs and to identify prevention strategies within a socio-ecological health promotion framework.

**Research Questions**
This scientific literature review study addressed these following questions:
1. What are the reported rates of unintentional drowning across different LMICs?
2. Which LMICs have studies published on the epidemiology of drowning and which do not?
3. What are the risk factors of drowning incidents in LMICs?
4. What drowning prevention strategies have been studied and published in LMICs?

**Method**
A systematic search was conducted following The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (Moher et al., 2009), using Ovid MEDLINE, CINAHL, Informit health databases, PsycINFO (ProQuest), Scopus, SafetyLit, Google Scholar, and BioMed Central databases for
all relevant studies published between 2012 and 2017. The selection of studies included three aspects of unintentional drowning which reflected the research questions: (1) mortality and or morbidity rates, (2) risk factors, and (3) prevention strategies. To further ensure the comprehensiveness of the study result, publications on the rate of accidental drowning and submersion due to water transport incidents and disasters/cataclysms were explored to include all possible coding of unintentional drowning or submersion cases based on the ICD-10. The search terms applied in the systematic search were varied in accordance to the search method utilised within each database as can be seen in Appendix 1. The search strings used were those with the most exhaustive results out of other similar strings.

Eligibility Criteria
A set of inclusion and exclusion criteria was used to narrow down the systematic search of published studies in correspondence to the research objective (Table 1).

Selection Process
The selection process was conducted in 2 steps: a) title and abstract screening and b) full text screening.

Title and Abstract Screening
The inclusion and exclusion criteria were used to screen titles and abstracts of identified records to assess the potential eligibility (Table 1). In order to ensure the study be all-inclusive, studies investigating unintentional drowning cases only, or both unintentional and intentional drowning cases, or unspecified manner of drowning cases were included in the selection. The articles included were those published within the last six (6) years in order to provide contextual information of drowning rates, risk factors, and prevention interventions.

Full-text screening
The full text version of all screened studies was obtained to ensure their eligibility. In this final stage of study appraisal, the McMaster appraisal guideline was used for critical review and identifying biases in primary studies. Primary studies were to be excluded if they did not fulfill the criteria. The PRISMA flow diagram was used for reporting stages of the review, as can be seen in Figure 1 (Moher et al., 2009).

Data Abstraction
The following data were abstracted from the studies: authors, year of study and publication, country and region, data source, study design, scale of study, manner of drowning cases, relevant findings on the mortality and morbidity rate, risk factors, and prevention of drowning. The classification of region used in this study was based on the World Health Organisation (WHO) regional groupings: African Region, Region of The Americas, South-East Asia Region, European Region,
| Table 1 | Inclusion and exclusion criteria |
|--------|----------------------------------|
| **Inclusion Criteria** | **Exclusion Criteria** |
| • Published between 2012 and 2017 | • Non peer-reviewed journal articles, other types of publications |
| • Peer-reviewed journal articles | • Comprehensive scientific reviews, meta-analysis, statements of clinical standards, case reports, opinion pieces |
| • Original research paper | • Only includes intentional drowning cases, without investigating unintentional drowning incidents |
| • Full-text available | |
| • Published in English | |
| • Incidents in humans | |
| • Incidents specifically take place in LMICs | |
| • All unintentional drowning cases, including studies that include both unintentional and intentional drowning, or does not specify the manner of drowning cases studied | |
| • Drowning incidents related to disasters and water transport incidents | |
Eastern Mediterranean Region, and Western Pacific Region (World Health Organization). The countries of study were also classified into four income groups (low, lower-middle, upper-middle, and high income) based on the World Bank list of analytical income classification of economies for the current 2017 fiscal year (as stated in the World Bank’s list of economies per December 2016), which was based on the country’s gross national income per capita (World Bank, 2018).
Morbidity and mortality rates were extracted from the identified studies as epidemiological measures of unintentional drowning, either at a sub-national or national scale. Relative risk (RR) or odds ratio (OR) of exposures, associated with fatal or non-fatal unintentional drowning incidents, were obtained from studies about risk factors of unintentional drowning in LMICs. The Health Promotion Framework by Talbot and Verrinder (2014) (Figure 2), which comprises medical, behavioural, and socio-environmental approaches, was used to assess studies on the socio-ecological dimension of drowning prevention in LMICs identified in the systematic search. Meta-analysis was not performed due to the diverse methods and definitions used in the selected studies.

**Figure 2**
Health Promotion Framework (Talbot & Verrinder, 2014)

Results

Despite the need to better understand the magnitude of drowning as a leading health problem in LMICs, limited literature assessing the epidemiology and risk factors of drowning within these countries existed. The limited literature hindered conclusions but also provided potential explanations for the dearth of studies on the planning, implementation, and evaluation of drowning prevention strategies in LMICs. Out of 4913 potentially relevant records initially identified from our database searches, only 72 papers met the eligibility criteria as applied to the research objectives and were then included in this study. The flow of the review and selection process can be viewed in Figure 1.

The mortality and morbidity of unintentional drowning in LMICs were the topics covered in 60 identified studies (Abdullah & Flora, 2013; Adewole et al., 2012; Ae-Ngibise et al. 2012; Ambade et al., 2013; Armour-Marshall et al., 2012; Arun Kumar & Prasad, 2014; Barlas & Beji, 2016; Beydilli et al., 2017; Chasimpha et al., 2015; Chattypadhyay et al., 2013; Ching et al., 2015; Chowdhury & Gulshan, 2016; Dirlik & Bostancıoğlu, 2015; Donson & Van
Niekerk, 2013; Fang et al., 2014; Guevarra et al., 2015; Guzel et al., 2013; Halawa et al., 2015; Hanifi et al., 2014; He et al., 2015; Mosharaf et al., 2015; Hss et al., 2014; Jagnoor et al., 2012; Kitulwatte & Edirisinghe, 2014; Kuchewar et al., 2013; Kumar et al., 2013; Laosee et al., 2014; Lapa et al., 2012; Lili et al., 2017; Lin et al., 2015b; Lin et al., 2016; Liu et al., 2012; Mamady et al., 2012; Martinez et al., 2016; Martins & de Mello-Jorge, 2013; Mateen et al., 2012; Mecrow et al., 2015; Morris et al., 2016; Murray & Carter, 2017; Paul et al., 2013; Pereira et al., 2013; Prameprart et al., 2015; Pretorius & Van Niekerk, 2015; Radosavljevic et al., 2017; Raghavendra Babu et al., 2012; Razzak et al., 2013; Samaneh et al., 2012; Seleye-Fubara et al., 2012; Shaikh 2014; 2016; Shen et al., 2015, 2016; Srinivas et al., 2012; Sultana et al., 2016; Thaker & Guleria, 2015; Wang et al., 2014; Weldearegawi et al., 2013; Weraarchakul et al., 2012; Yin et al., 2015; Zhu et al., 2015a; Zhu et al., 2015b).

Risk factors and prevention of drowning were investigated in twenty-five studies (Abdullah & Flora, 2013; Arun Kumar & Prasad, 2014; Banerjee et al., 2016; Beydilli et al., 2017; Chasimpha et al., 2015; Ching et al., 2015; Chowdhury & Gulshan, 2016; Donson & Van Niekerk, 2013; Fang et al., 2014; Guzel et al., 2013; Hanifi et al., 2014; Hossain et al., 2015; Hossain et al., 2016; Laosee et al., 2014; Lapa et al., 2012; Martinez et al., 2016; Mateen et al., 2012; Morris et al., 2016; Murray & Carter, 2017; Prameprart et al., 2015; Rahman et al., 2014; Rahman et al., 2015; Shen et al., 2015; Zhu et al., 2015a; Zhu et al., 2015b) and ten (Cao et al., 2015; Davoudi-Kiakalayeh et al., 2013; Guevarra et al., 2015; Hossain et al., 2016; Rahman et al., 2012; Sansiritaweesook & Kanato, 2015; Shen et al., 2015; Silva et al., 2016; Solomon et al., 2013; Turgut et al., 2016). Fifty-four percent (n=39) of the studies only included unintentional drowning cases, while a much smaller proportion of studies (13.9%, n=10) included both unintentional and intentional drowning cases. From a total of 52 countries identified to be the origin of the articles reviewed, most studies (69.4%, n=50) were performed at a sub-national scale, while 30.6% (n=22) were conducted on a national scale.

An existed disparity among regions regarding the presence of unintentional drowning studies. Most of the studies identified in this study (35.8% of all publications reviewed) investigated unintentional drowning in South-East Asian countries (Table 2). Meanwhile, a limited number of studies included in this review reported unintentional drowning cases in The Americas, Eastern Mediterranean, and African countries (5.3%, 8.4% and 12.6% of all studies included, respectively).

A small proportion (5.3%) of studies investigated unintentional drownings in low income countries while 49.5% and 45.3% originated from studies done in upper and lower middle-income countries (Table 2). Of 60 epidemiological studies identified in this review, 53.3% (n=32) reported the epidemiology of unintentional drowning deaths in LMICs by gender and 58.3%
(n=35) classified the cases by age groups, with most of these studies located in upper and lower-income countries (Table 2). Only 26.7% (n=19) and 8.3% (n=6) of studies analysed in this review reported drowning deaths in LMICs by location and activities prior/during drowning, respectively (Table 2). Of the 16 studies that included location of drowning, only 18.8% (n=3/16) classified in-line with the ICD-10 coding (bath-tub, swimming pool, natural water including lake, open sea, river, stream, and others), while majority of the studies (62.5%, n=10/16) classified cases by different types of water body such as lake, river, sea, dam, creek, and ditch.

**Rates of Unintentional Drowning in LMICs**

Out of 140 LMICs listed by the World Bank, there were 60 studies identified investigating mortality and morbidity rates of unintentional drowning in 51 LMICs, most of them being descriptive observational (epidemiological) studies. Most of these countries (90.2%) reported mortality rates as epidemiological measures of unintentional drowning, either at a sub-national or national scale, while the rest reported the epidemiological measures of drowning mortality and morbidity as count, proportion, or ratio (details presented in Appendix 2). In terms of regional groupings, the highest drowning rates were found in the South-East Asian region, ranging between 6.4/100,000 and 104.8/100,000, particularly amongst lower middle-income countries within the area (Table 3).

A wide range of data sources were used to describe drowning in LMICs. The sources included health and demographic surveillance data, medical/autopsy records, police/fire department records, and national health reports (Table 4). Eight percent of studies used more than one data source. Online news was mostly used for cataclysm and natural hazard-related unintentional drowning incidents, such as those resulting from flooding, rip-currents, and water-transport related fatalities (Lapa et al., 2012; Martinez et al., 2016; Pereira et al., 2013). Most of the 60 data sources were for fatal drownings (n=44, 73.3%).
Table 2
The World Health Organization and World Bank classification on the countries of origin

| Region                        | Number of countries in region | Number of countries with unintentional drowning publications | Proportion of countries in WHO/World Bank group (%) | Proportion of countries in review (%) | Number of studies | Proportion of studies in review (%) | The proportion of epidemiological studies |
|-------------------------------|------------------------------|-------------------------------------------------------------|-----------------------------------------------------|---------------------------------------|-------------------|-------------------------------------|------------------------------------------|
|                               |                              |                                                             |                                                     |                                       |                   |                                     | By gender By age group By location By activity |
| World Health Organization regions |
| Western Pacific               | 27                           | 4                                                           | 14.8                                                | 7.7                                   | 14                | 8                                   | 3 25 26.3 4 (6.7%) 6 (10%) 4 (6.7%) 3 (5%) |
| South-East Asia               | 11                           | 4                                                           | 36.4                                                | 7.7                                   | 20                | 11                                  | 3 34 35.8 11 (18.3%) 12 (20%) 5 (8.3%) 1 (1.7%) |
| Eastern Mediterranean         | 21                           | 3                                                           | 14.3                                                | 5.8                                   | 7                 | 0                                   | 1 8 8.4 4 (6.7%) 5 (8.3%) 1 (1.7%) 0 (0%) |
| Europe                        | 53                           | 19                                                          | 35.8                                                | 36.5                                  | 7                 | 3                                   | 1 11 11.6 5 (8.3%) 3 (5%) 2 (3.3%) 1 (1.7%) |
| Africa                        | 47                           | 6                                                           | 12.8                                                | 11.5                                  | 9                 | 3                                   | 0 12 12.6 7 (11.7%) 7 (11.7%) 4 (6.7%) 0 (0%) |
| Americas                      | 35                           | 16                                                          | 45.7                                                | 30.8                                  | 3                 | 0                                   | 2 5 5.3 1 (1.7%) 2 (3.3%) 0 (0%) 0 (0%) |
| Total                         | 194                          | 52                                                          | 45.7                                                | 30.8                                  | 3                 | 0                                   | 2 5 5.3 1 (1.7%) 2 (3.3%) 0 (0%) 0 (0%) |

Cenderadewi et al.: Scientific Literature Review Unintentional Drowning
Published by ScholarWorks@BGSU, 2020
| World Bank's income groups |  |  |  |  |  |  |  |  |  |
|----------------------------|---|---|---|---|---|---|---|---|---|
| Low income                 | 31 | 4 | 12.9 | 7.7 | 4 | 1 | 0 | 5 | 4 (6.7%) | 3 (5%) | 1 (1.7%) | 0 (0%) |
| Lower middle income        | 52 | 16 | 30.8 | 30.8 | 28 | 12 | 3 | 43 | 45.3 | 15 (25%) | 17 (28.3%) | 5 (8.3%) | 1 (1.7%) |
| Upper middle income        | 56 | 32 | 57.1 | 61.5 | 28 | 12 | 7 | 47 | 49.5 | 13 (21.7%) | 15 (25%) | 10 (16.7%) | 4 (6.7%) |
| Total                      | 139 | 52 | 60 | 25 | 10 | 32 (53.3%) | 35 (58.3%) | 16 (26.7%) | 5 (8.3%) |
### Table 3
Drowning rates for each World Health Organization region

| WHO region          | Income level of countries | Drowning rate range (per 100,000) |
|---------------------|---------------------------|----------------------------------|
| Western Pacific     | Lower middle income       | 3.5                              |
|                     | Upper middle income       | 1.1 - 10                         |
| South-East Asia     | Lower middle income       | 6.4 – 104.8                      |
|                     | Upper middle income       | 7.0                              |
| Eastern Mediterranean| Lower middle income       | 1.5                              |
|                     | Upper middle income       | 1.5                              |
| Europe              | Lower middle income       | 5.5 - 21                         |
|                     | Upper middle income       | 0.1 - 37                         |
| Africa              | Low income                | 4.4                              |
|                     | Upper middle income       | 2.5                              |
| The Americas        | Lower middle income       | 1.0 – 3.2                        |
|                     | Upper middle income       | 1.3 – 9.2                        |

### Table 4
Data source of unintentional drowning mortality and morbidity in LMICs

| Data Source                        | Number of studies |
|------------------------------------|-------------------|
| **Primary data**                   |                   |
| Health/demographic surveillance data | 14                |
| Police/fire department/ambulance service records | 7            |
| Emergency Department records        | 4                 |
| Hospital admission records          | 1                 |
| Death registry                       | 6                 |
| Medico-legal/autopsy records        | 12                |
| Survey data                         | 6                 |
| Injury surveillance system          | 3                 |
| Online news                         | 5                 |
| Questionnaires                      | 6                 |
| **Secondary data**                  |                   |
| WHO mortality database              | 2                 |
| National health report              | 3                 |

**Risk Factors of Unintentional Drowning in LMICs**

Of 25 studies investigating contributing factors to unintentional drowning across LMICs, several key factors were identified (Figure 3): 1) Sociodemographic characteristics, including gender, age, parental characteristics (parent’s educational level, parent’s occupation, parent’s marital status), living in urban or rural area, number of children, and socio-economic status; 2) child-care practices, including child’s attendant and parental...
supervisory behaviour; 3) survival skills, knowledge, and practice, including swimming skill levels, evacuation practices (in relation to cataclysms), rescue skills, the use of flotation device, knowledge on drowning prevention, and perceived vulnerability for drowning, 4) environmental factors, such as home injury hazards and living in close proximity with water bodies, and meteorological and oceanographic factors, and 5) risky behaviour, including alcohol consumption, diving into unknown water without supervision, and personality type. Only one study (Mateen et al., 2012) identified underlying medical conditions and its association with drowning risk (Figure 3).

**Figure 3**
Summary of studies investigating risk factors of unintentional drowning across LMICs

Despite the importance of providing an understanding of risk factors for drowning across LMICs, most of these factors were not explored thoroughly. Of 25 studies reviewed, only 11 studies (Abdullah & Flora, 2013; Beydilli et al., 2017; Chasimpha et al., 2015; Ching et al., 2015; Chowdhury & Gulshan, 2016; Fang et al., 2014; Hossain et al., 2015; Mateen et al., 2012; Rahman et al., 2012; Zhu et al., 2015a; Zhu et al., 2015b) (n=11, 44.0%) reported RR or OR of risk factors of interest in association to fatal or non-fatal drowning incidents. Further details on risk factors of drowning studied in LMICs can be found in Appendix 3 that appears at the end of this review.

**Drowning Prevention in LMICs**
Analysis of the application of the health promotion framework across the 10 studies on drowning preventive interventions identified in this review revealed that most strategies utilised downstream individual approaches with a focus on education to build knowledge and skills. The interventions included: 1) household level educational programmes aimed to increase parents’ (Cao et al., 2015; Hossain et al., 2016; Rahman et al., 2012; Silva et al., 2016) and children’s (Rahman et al., 2012; Solomon et al., 2013; Turgut et al., 2016) water and
household safety knowledge; 2) school-based educational packages, preparing teachers and students to be ‘agents of change’ to disseminate knowledge on drowning prevention to local communities (Sansiritaweesook & Kanato, 2015); 3) basic swimming, water safety, and safe rescue skills training packages for children (Rahman et al., 2012), 4) healthcare worker education to enhance health professional-led water safety education (Guevarra et al., 2015); basic resuscitation training (Davoudi-Kiakalayeh et al., 2013) for the community; and 5) community-based education sessions (Guevarra et al., 2015; Rahman et al., 2012). Limited publications on prevention interventions were based on community participation and advocated for supportive environments with four (Davoudi-Kiakalayeh et al., 2013; Guevarra et al., 2015; Rahman et al., 2012; Sansiritaweesook & Kanato, 2015) and three (Davoudi-Kiakalayeh et al., 2013; Guevarra et al., 2015; Sansiritaweesook & Kanato, 2015) studies, respectively (Table 5).

In evaluating health outcomes related to drowning prevention strategies, it is essential to determine studies reporting final health outcomes. In this case it refers to changes in drowning mortality and or morbidity and intermediate outcomes of drowning such as knowledge and practices for water safety and community participation (Figure 4).

**Figure 4**
Summary of studies investigating intermediate outcomes and health outcomes of drowning prevention interventions in LMICs
Table 5
The relationships among preventive interventions investigated and health promotion

| Study                        | Population investigated | Study design                      | Intervention method                                      | Prevention aspect investigated in relation to Health Promotion Framework | Relevant findings                                                                 |
|------------------------------|-------------------------|-----------------------------------|----------------------------------------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Cao et al., 2015             | Rural school-aged children | Pre-test, post-test study design   | Educational programme for parents/guardians               | HE                                                                       | No significant increase on drowning knowledge in the intervention group          |
| Davoudi-Kiakalayeh et al., 2013 | Residents and tourists near coastline | Quasi-experimental study          | Modification of environmental factors (removal of water reservoirs), health information dissemination, and increasing supervision | HI, SD, CP, SE                                                            | Fatal drowning rate amongst resident population significantly decreased post-intervention The risk of death significantly lower in the intervention areas during the |
| Study                        | Research Participants | Research Design/Methodology | Objective                                                                 | Implementation Period |
|------------------------------|-----------------------|------------------------------|---------------------------------------------------------------------------|------------------------|
| Guevarra et al., 2015        | Village leaders and community residents’ | Community-based, participatory action research | Community education, community engagement (by establishing village drowning prevention committee), and modification of environmental factors (wells reconstruction, providing playpens and other physical barriers for households) | HI CP, SE | Demonstrated the importance of community engagement Need to assess the sustainability and community acceptance in the long term |
| Hossain et al., 2016         | Parents of children who had drowned and community leaders | Community-based, participatory action research | FGD | HE | Suggestions for preventive measures: mobile phone-based safety education programme |
| Study Authors                  | Study Participants | Study Design          | Study Intervention                                                                 | RR for a drowning death was significantly lower in the exposed group | Very cost effective (based on World Health Organization criteria) |
|-------------------------------|--------------------|-----------------------|------------------------------------------------------------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------|
| Rahman et al., 2012           | Households         | Retrospective cohort study | Health education, training on basic swimming, water safety, and safe rescue skills | HI, HE, SD, CP                                                      |                                                                 |
| Sansiritaweesook & Kanato, 2015 | Informants, villagers | Quasi-experimental study | Community participation-based drowning surveillance system                          | HI, HE, SD, CP, SE                                                  | The incidence rate in the comparison areas was significantly higher than in the target areas |
| Shen et al., 2015             | Children           | RCT                   | Drowning prevention video                                                          | HI                                                                  | Significantly improved safety knowledge in the intervention group |
| Researcher et al., Year | Population | Study Design | Intervention | HE | SD | CP | SE | LT | Note |
|-------------------------|------------|--------------|--------------|----|----|----|----|----|------|
| Silva et al., 2016      | Mothers    | Quasi-experimental study | Educational programme | HE |    |    |    |    | No significant difference on perceived vulnerability between the interventions and controls |
| Solomon et al., 2013    | Primary school children | One group, pre-test, post-test study design) | Educational programme | HE |    |    |    |    | Significant difference on the knowledge on drowning prevention |
| Turgut et al., 2016     | Secondary school students | One group, pre-test, post-test stud, 17, 18y design) | Water safety educational programme and LT training | HE, SD |    |    |    |    | A significant increase in knowledge (32 %) and in LT skills post-intervention |

Note: HE=health education; HI=health information; SD=skill development; CP=community participation; SE=advocating for supportive environment; LT=lifeline throw
A majority of the studies reviewed analysed the intermediate outcomes of drowning prevention interventions. Four studies (Shen et al., 2015; Silva et al., 2016; Solomon et al., 2013; Turgut et al., 2016) reported a significant increase on the levels of knowledge on water safety, one study (Turgut et al., 2016) reported a significant increase in lifeline throw skills, and two studies (Guevarra et al., 2015; Sansiritaweesook & Kanato, 2015) demonstrated the potential of enhancing community participation in planning and implementation of drowning prevention programmes. Significant changes in drowning rates as the health outcome of interest were only reported in two studies on prevention interventions applied in Iran (Davoudi-Kiakalayeh et al., 2013) and Thailand (Sansiritaweesook & Kanato, 2015). Davoudi-Kiakalayeh et al. (2013) reported a decrease in the fatal drowning rate in the studied population of residents along the Caspian Sea coastline of Iran, from 4.2 per 100,000 populations in the pre-observation stage to 3.0 per 100,000 following the implementation of a drowning intervention package consisting of modification of environmental factors, health information dissemination, and increased supervision. The value of community participation for preventing drowning cases was confirmed by Sansiritaweesook and Kanato (2015) when they described a 23.3 times higher drowning incidence rate ratio (95% CI: 3.1-176.6, p<0.05) in the control areas in comparison to the study areas in a year after a community-based drowning surveillance system was implemented in north-eastern Thailand.

Discussion
Limited publications on drowning rates, risk factors, and prevention of drowning have been published focusing on samples and populations within LMICs. Most of unintentional drowning epidemiological studies in LMICs originated from lower and upper middle-income countries, while a disproportionately lower proportion were from low middle-income countries. The lack of information on drowning rates amongst the most-populous LMICs was noted. Several socio-demographic characteristics, child-care practices, survival skills and practice, and living close to open water sources were identified as important predictors in unintentional drowning fatalities. The lack of publications on the upstream level of drowning prevention emphasises the under-exploration of the concept of the socio-ecological approach of health promotion related to drowning.

The Distribution of Unintentional Drowning Rates across LMICs: The Disparity on Data Availability
A key finding of this review outlines the limited availability of drowning data across LMICs. Of 140 LMICs listed by the World Bank, mortality and morbidity rates of unintentional drowning were only reported for 48 countries. The discrepancy of drowning data availability across regions and countries favored those geographically situated in Europe (n=19; 36.5%) and South America (n=16; 30.8%), whereas there were only four countries each from the Southeast Asia and Western Pacific regions, and three from the Eastern
Mediterranean (Table 2). Five countries, including India (n=10 studies; 16.7%), China (n=9, 15.0%), Bangladesh (n=6; 10.0%), and Pakistan (n=5; 8.3%) from these regions, as well as Turkey (n=6; 10.0%), an upper-middle income European country, were noted to be the most important contributors of publications on the rates of unintentional drowning in LMICs (Appendix 2).

The prominent role of Southeast Asia for unintentional drowning epidemiological research was recognised in a previous study on the epidemiology of unintentional drowning in LMICs by Tyler et al. (2017), who noted that Bangladesh, a Southeast Asian nation, has provided the highest number of publications on drowning epidemiology in comparison to any LMICs. The wide array of epidemiological studies produced in the Southeast Asia region affirmed the finding of the current review of the evidently high drowning rates amongst lower middle countries of the region, which varied between 6.4/100,000 and 104.8/100,000 (Table 2). These studies delineated drowning as a substantial public health problem in the areas, hence the high number of publications originating from the region. This result confirmed the validity of the 2014 WHO’s Global Report on Drowning which documented that a third of global drowning cases occurred in the Southeast Asia region (World Health Organization, 2014).

The potential under-reported drowning rates in LMICs were observed in this review. The availability of publications on drowning rates across LMICs in the Western Pacific, Eastern Mediterranean, and Africa were at low proportions in comparison to the actual number of countries in the region (14.8% of Western Pacific, 14.3% of Eastern Mediterranean and 12.8% of African countries) (Table 2). A disproportionately lower proportion of studies also reported on drowning in low income countries, with 12.9% of all countries classified within the low-income group, in comparison to 57.1% of all upper middle-income countries and 30.8% of lower middle-income countries reporting their drowning rates (Table 2). Interestingly, although several studies were reporting drowning rates in some of the most populous nations including China and India, the world’s first and second most populated countries, less was reported for Brazil (#5), Nigeria (#7), and Russia (#9), and none reported drowning rates for Indonesia (#4), the largest archipelagic state in the world with high numbers of meteorological and hydrological disasters and water transport-related injuries (Farhan & Lim, 2011; United States Census Bureau).

Although reliable estimates of the burden of drowning in LMICs were essential for the planning, implementation, and evaluation of drowning prevention strategies, ascertaining the actual drowning rates was difficult particularly among countries with limited resources and weak surveillance system. As illustrated in a study by Armour-Marshall et al. (2012) on paediatric drowning deaths in European nations, the gap in the drowning mortality data collection was observed between Western European nations and countries in
East Europe. On the other hand, South Africa had a nation-wide injury mortality surveillance system (NIMSS) via urban mortuaries which was most helpful in the investigation of unintentional drowning within the country. The reliance on medico-legal reports meant that this surveillance system may have missed drowning-related injuries occurring in and around the home (Donson & Van Niekerk, 2013; Matzopoulos, 2002; Matzopoulos & Seedat, 2005; Pretorius & Van Niekerk, 2015). Differences in health resources and infrastructure, performance of injury surveillance, national data collection schemes, and the country’s economic and political stability may contribute to the discrepancy in injury data availability and quality among countries, thus underlining the need to build public health system capacity, develop standardised national data collection and reporting frameworks, strengthen injury surveillance systems (including for drowning), enhance multi-sectoral collaboration, and advocate for political and financial investment for drowning prevention in each developing nation (Junaid Abdul Razzak et al., 2012; Reynolds et al., 2013; Schuurman et al., 2011).

Drowning Risk Factors in LMICs: Informing the Appropriate Preventive Measure for the Resource-Limited Setting of Developing Nations

The review identifies the under-investigated measurement of associations among various exposures that had been proposed as risk factors for drowning in high income countries and the health outcome of fatal or non-fatal drowning incidents in LMICs. The lack of assessment potentially hindered the development of prevention interventions needed in LMICs which may not necessarily be similar to prevention interventions demonstrated to be effective in high income countries (Bennett & Linnan, 2014; R. Franklin & Scarr, 2014; Hyder et al., 2014; Linnan, Scarr, & Linnan, 2014). Despite this under-exploration, parents’ educational level, overcrowding, lack of supervision, survival skills and practice, and living close to open water bodies still were identified as risk factors for fatal unintentional drowning in LMICS, particularly among children.

Socio-Demographic Characteristics

Mothers’ educational level and the socioeconomic status (SES) background of the family were important predictors of the risk of drowning in children in LMICs (Abdullah & Flora, 2013; Hossain et al., 2015). Abdullah and Flora (2013) reported that higher mothers’ educational level (grade 5 and above) had a protective effect in drowning incidents of children, which was supported by the finding of a case-control study by Hossain et al. (2015) that children who died from drowning were 1.7 times more likely to have illiterate mothers (95% CI: 1.0–2.8, \(p<0.05\)) (see Appendix 3). The correlation between fatal and non-fatal unintentional injury and parents’ educational level had previously been reported in high income countries. For example, on a study by Beiki, Karimi, and Mohammadi (2014) who performed a large-scale, 46-year retrospective cohort study on unintentional childhood injuries in Sweden, described
statistically significant 1.5 times (95% CI: 1.2-1.8) higher likelihood for children with the lowest parental educational levels (9 years or less of study) to experience fatal and non-fatal hospitalised unintentional injuries in comparison of children of parents with higher educational level. In addition, the evidence of the significant association between unintentional drowning and low socio-economic status has been observed worldwide in this review with several studies (Abdullah & Flora, 2013; Chowdhury & Gulshan, 2016; Fang et al., 2014) from Bangladesh and China reporting the higher odds of paediatric drowning victims to come from a lower SES background (Appendix 3). This finding underlined the importance of addressing socio-economic inequities in order to ensure the effectiveness of a drowning prevention programme.

This review also highlighted the higher risk for drowning was due to less parental supervision. Children who drowned were 9.2 times more likely to have mothers with single marital status (95% CI: 2.3–37.2, p<0.001) (Abdullah & Flora, 2013). Children who drowned were 3.7 times more likely to live in a household with 3 children (95%CI: 1.6–8.5, p<0.001), or 19.6 times more likely for living in a household of more than 3 children (95% CI: 6.6–58.4), p<0.001) (Abdullah & Flora, 2013) (see Appendix 3).

Although commonly cited as risk factors for drowning, the evidence for the strength of association between age and gender with drowning has not been extensively investigated. Out of 9 studies that explored age as a risk factor for drowning, only 3 studies (Ching et al., 2015; Hossain et al., 2015; Zhu et al., 2015a) reported OR for the association between age and drowning with the nation-wide Bangladesh study by Hossain et al. (2015) as the only study affirming the higher odds of fatal drowning victims in general populations to come from age group 5 years or less (OR 2.9 (95% CI: 1.9–3.1), p<0.05) (Appendix 3). A similar situation was observed for the association of gender and drowning incidents in LMICs Of 7 studies claiming gender as an important predictor for drowning identified in this review, only one study (Hossain et al., 2015) provided evidence for the positive association between being male and fatal drowning (OR 1.5 (95% CI: 1.3–1.8), p<0.05) (see Appendix 3).

Child-Care Practices
This review confirmed parental supervisory behaviour was a substantial protective factor in preventing drowning fatalities in LMICs. Hossain et al. (2015) described the positive association between drowning fatalities and the attention by people other than mother or main caregiver (OR 25.4 (95% CI: 14.4–45.3), p<0.05) (Appendix 3). Interestingly, Abdullah and Flora (2013) reported that non-fatal paediatric drowning victims were 5.7 more likely to have a mother as main caregiver (95% CI: 1.0–33.0), p<0.001) which supported the importance of attention from adults, especially by mothers, in preventing fatality in drowning cases by providing better supervision to children (Appendix 3). This finding affirmed a previous study on risk factors of drowning in
LMICs by Borse, Hyder, Streatfield, Arifeen, and Bishai (2011), reporting 70% of childhood drowning in Matlab, Bangladesh occurred while the mother was engrossed in doing household chores thus reducing the supervision of the child. Furthermore, a retrospective cohort by Rahman et al. (2012) affirmed that Bangladeshi children whose parents’ participated in the Anchal programme, a drowning preventive measure aimed to increase supervision by providing community-based crèches (child care centres) and an education programme for parents, were 0.2 time less likely to experience fatal drowning (95% CI: 0.1–0.6, p<0.05).

Survival Skills, Knowledge, and Practice
This review revealed the potential of swimming skill level as an effective drowning preventive measure in LMICs. A national-scale study in Bangladesh documented fatal drowning victims had 4.5 times higher odds for having lower levels of swimming skill than non-victims (95% CI: 1.3–19.4, p<0.05) (Appendix 3) (Hossain et al., 2015). Ching et al. (2015) also recognised the significance of swimming skill level as important survival skills in preventing drowning fatalities in a natural disaster setting (unable to swim OR 3.5, (95% CI: 1.9–6.5), p<0.001) (Appendix 3). The significance of having an effective swimming skill levels in preventing drowning incidence were presented by previous studies set in both LMICs (Borse, Hyder, Bishai, Baker, & Arifeen, 2011; Ma et al., 2010) and high income nations (Barss, Olsen, Hamilton, & Dalke, 2016; Vienola, Gudmundsson, & Heinonen, 2016) underlining the potential effectiveness of providing swimming lessons for preventing childhood drowning in both high income and developing nations. In addition, this potential was confirmed by a cost-effective analysis study by Rahman et al. (2012) who described the protective benefit of the SwimSafe programme in Bangladesh, a drowning intervention programme aimed to provide survival swimming skills training for children in Asian countries, with 0.1 (p<0.001) less likelihood of experiencing fatal drowning for the trained children along with the cost-effectiveness of the programme. Meanwhile, the protective benefit of wearing PFDs, a widely encouraged drowning preventive measure in developed nations had been under-explored in LMICs (Zhu et al., 2015b) hence stressing the insufficiency of scientific evidence for prioritising the wearing of PFDs as a drowning prevention strategy in the resource-limited setting of LMICs where various social determinants of health were more urgent to be managed.

In terms of disaster-related drowning events, this review identified the vital role of evacuation practices in preventing drowning fatalities. In a study conducted post-typhoon Haiyan in the Philippines, one of the most intense tropical cyclones in the Southeast Asian region, drowning death victims were 21.0 times more likely to not evacuate their residence before the cyclone hit (95% CI: 5.6–132.7, p<0.001) and 10.0 times more likely to not evacuate to the designated evacuation centres (95% CI: 3.8–29.1, p<0.001) (Ching et al., 2015). Providing education and training for disaster evacuation practices as well as
enhancing crisis communications, improving organisational capacity, and building appropriate infrastructure as a part of disaster preparedness plan in LMICs will be valuable for preventing drowning incidents due to cataclysmic events as natural and man-made disasters often took place in these LMIC countries (Czajkowski et al., 2011; Lumbroso & Di Mauro, 2008; Osti & Nakasu, 2016; Radosavljevic et al., 2017). The value of having basic rescue skills in preventing drowning fatalities amongst rescuers was outlined by Zhu et al. (2015b) who reported the lower odds of a first rescuer amongst drowning rescue events in mainland China in becoming a fatal drowning victim him/herself (OR 0.4, 95% CI: 0.2-0.9). This result was supported by a study by Slabe et al. (2016) that described the significance of being equipped with the knowledge and skills for rescuing drowning victims in reducing the number of drowning fatalities. These results recommended that the skills for rescuing drowning victims must be incorporated into the curriculum of medical education in order to encourage allied health professional-led interventions for providing similar training for a wider audience.

Environmental Factors
Living close to water bodies was identified as a predictor for drowning fatality with 2.8 times higher odds of paediatric drowning cases among those who resided in riverbank areas (95% CI: 1.6-4.9, p<0.01) (Chowdhury & Gulshan, 2016) and 3.9 times higher odds of becoming typhoon-related fatal drowning victims if they lived within 50 metres from the sea (95% CI: 2.1–7.3, p<0.001) (Ching et al., 2015). This was supported by a previous study by Ma et al. (2010) which reported 71.1% of childhood drownings in Guangdong Province of China, an upper middle-income country, took place in natural bodies of water with twice (95% CI: 1.2-3.7) the likelihood of drowning victims who played around natural waters. These findings outlined the need for customising preventive measures for LMICs especially because residential areas in LMICs frequently existed in close proximity with natural bodies of water which illustrated the higher risk of drowning associated with natural waters. This was dissimilar to the prevention interventions applied in high income nations which put more emphasis on the importance of regulating pool fencing at the household level because the majority of child drowning cases occurred in private pools (Franklin et al., 2012; Gámez de la Hoz & Padilla Fortes, 2016).

Risky Behaviour
Zhu et al. (2015a), who did a study on non-fatal drowning cases amongst migrant children in China, outlined several attributes of risky behaviour such as the willingness for children to dive into unknown water without supervision (OR 2.0 (95% CI: 1.3-3.0), p<0.01) or having an introvert type of personality (OR 1.8 (95% CI: 1.2-2.6), p<0.05) that contributed to drowning among children. Solid evidence of the correlation between excessive alcohol consumption and drowning cases had existed in developed nations such as Australia (Pajunen et al., 2017; Peden et al., 2016; 2017; Watt et al., 2012), New
Zealand (Croft & Button, 2015), and the United States of America (USA) (Ryan et al., 2016). Although two studies (Donson & Van Niekerk, 2013; Morris et al., 2016) in this review identified alcohol consumption as a risk factor for drowning across LMICs, no measure of association of excessive drinking and drowning was reported. Even though the association between risky behaviour and the incidence of fatal and non-fatal drowning had not been thoroughly explored globally, the correlation among risky behaviours and other types of unintentional injury has been widely investigated which affirmed the need for further research investigating psychological factors as predictors for unintentional drowning (Blows et al., 2005; Glass et al., 2014; Hasking, 2017; Maher et al., 2015; Mitchell et al., 2014; Olsen et al., 2013; Rusu et al., 2017; Thomson & Carlson, 2014; 2015).

**Understanding the Linkage between Drowning Prevention and the Health Promotion Framework**

**The Socio-Ecological Nature of Drowning in LMICs**

The disparity between the availability of publications investigating individual-focused, behavioural approaches and population-focused preventive measures across LMICs was apparent in this review. Using the Health Promotion Framework to analyse the socio-ecological approaches utilised the prevention of drowning in LMICs (Figure 2), this review identified the over-reliance on individual-focused, behaviour-based preventive measures, such as health education (Cao et al., 2015; Hossain et al., 2016; Rahman et al., 2012; Sansiritaweesook & Kanato, 2015; Shen et al., 2015; Solomon et al., 2013; Turgut et al., 2016) and health information (Davoudi-Kiakalayeh et al., 2013; Guevarra et al., 2015; Rahman et al., 2012; Sansiritaweesook & Kanato, 2015; Silva et al., 2016) in drowning prevention in LMICs (Table 5). Furthermore, the lack of emphasis on community capacity building (Davoudi-Kiakalayeh et al., 2013; Guevarra et al., 2015; Rahman et al., 2012; Sansiritaweesook & Kanato, 2015) and failure to initiate a supportive environment for water safety (Davoudi-Kiakalayeh et al., 2013; Guevarra et al., 2015; Sansiritaweesook & Kanato, 2015) were also evident across LMICs. In addition, none of the studies located in this review provided an in-depth examination of the development and availability of regulatory activities related to drowning prevention. This lack of studies left the research area of water-safety legislation in LMICs relatively neglected.

These findings contradicted the concept of the health promotion framework which suggested integrating educational, behavioural, socio-environmental, and regulatory approaches to ensure effective individual and community-level injury prevention (Denehy et al., 2016; Giles et al., 2017; Leavy et al., 2016; Stempinski et al., 2015; Stokols, 1992; Talbot & Verrinder, 2014; World Health Organization Regional Office for the Eastern Mediterranean, 2017). Indeed, the excessive dependence on individual-focused prevention interventions to reduce the risk of drowning in LMICs was
concerning because the lack of reliability of the effectiveness of prevention efforts that rely mostly on human behaviour and supervision in minimising risks of unintentional drowning had been widely recognised and reported in previous studies (Guo et al., 2010; Terzidis et al., 2007). In addition, the statistically significant reduction in drowning rates observed in Iran (Davoudi-Kiakalayeh et al., 2013), Bangladesh (Rahman et al., 2012), and Thailand (Sansiritaweesook & Kanato, 2015) following the implementation of community participation drowning intervention packages showed that they promoted safe environments. They outlined the reduction of risk of drowning based on the importance of community engagement in drowning prevention in LMICs.

In order to ensure the sustainability of a drowning prevention intervention in the resources-limited setting of LMICs, a comprehensive appraisal to contemplate the effectiveness of the prevention intervention and the economic investment and benefits of the investigated measure was essential. Only one study (Rahman et al., 2012) identified in this review assessed the relative costs and outcomes of a drowning prevention programme which affirmed the cost-effectiveness of the Prevention of Child Injuries through Social-Intervention and Education (PRECISE) programme in Bangladesh, along with its positive outcomes. The two components, Anchal and SwimSafe, showed protective benefits from fatal drowning: 1) Anchal participants were 0.2 \( (p<0.05) \) less likely to suffer drowning deaths, and 2) SwimSafe participants were 0.1 \( (p<0.001) \) less likely to experience fatal drowning. This programme informed the potential generalisability of the intervention programme to other LMICs which had similar socio-economical states with Bangladesh. Thus, an exhaustive evaluation to weigh the effectiveness of prevention interventions in reducing drowning mortality and morbidity rates, the economic costs and benefits, and the specific socio-cultural and environmental circumstances of each country, was needed to more fully understand the socio-ecological dimensions of drowning prevention in LMICs.

**Addressing Health Inequalities Through Upstream, Midstream, And Downstream Interventions for Drowning Prevention**

The population-focus of the socio-ecological approach of health promotion differed from the individual-focus of clinical and behavioural approaches and involved a variety of socio-environmental factors (Brownson et al., 2010b; Pettigrew et al., 2014). Interventions needed to operate at multiple levels across the upstream, midstream, and downstream continuum (Brownson et al., 2010b; Pettigrew et al., 2014). These downstream interventions were consistent with the findings of this review, in which most studies (Cao et al., 2015; Rahman et al., 2012; Shen et al., 2015; Solomon et al., 2013; Turgut et al., 2016) were focused on providing health education on drowning prevention and water-safety (Table 4).
Health inequities have been well-documented in LMICs (Boutayeb & Helmert, 2011; Reidpath & Allotey, 2007). The health discrepancies within these countries were then further complicated by a deficient health system, inefficient and ineffective governance, and poor research capacity, thus leading to inadequate development and implementation of evidence-based healthy public policy. The disproportionate availability of studies on water safety-related policy development across LMICs has resulted from these factors. (Bergstrom et al., 2015; Cotlear, 2016) The incongruity in evidence-based policy development in LMICs may also have been influenced by the way drowning prevention has been perceived by the public and politicians, who were more familiar with a ‘direct’ and recognisable link between illness and prevention, such as in communicable disease prevention, thereby resulting in less political and financial investment being allocated in LMICs to reduce the mortality and morbidity of drowning (Guevarra et al., 2015; Linnan et al., 2012; Linnan et al., 2013; World Health Organization, 2014). Ensuring the alignment of upstream, midstream, and downstream interventions, along with securing firm political and financial investments, were particularly important in reducing unintentional drowning mortalities and morbidities in developing nations.

Adapting the health promotion approach outlined by Howat and colleagues (2004) in the prevention of road-traffic injury attributable to excessive alcohol consumption could serve as a comparable context to the prevention of drowning because both are equivalent in numerous social determinants of health. Four pillars of health promotion are required to ensure the congruence of upstream, midstream, and downstream drowning prevention and its inter-connection with water safety promotion: 1) adequate political and economic investment; 2) well-developed organisational capacity and effective governance; 3) provision of health education; and 4) continuous evidence-based policy development. The strengthening of the four pillars of health promotion are required to ensure the sustainability of drowning prevention efforts to be applied in the resource-scarce context of LMICs, where providing one prevention programme might mean forgoing one alternative of managing another equally important health issue.

This review has met its aims, including providing analysis on the rates, risk factors, and the availability of studies reporting prevention strategies of unintentional drowning across LMICs, within a socio-ecological health promotion framework. Several strengths contributed to the robustness of this review included studies on cataclysmic-related and water transport-related drowning incidents in LMICs. This literature review also included studies which reported both unintentional and intentional drowning, extracting the unintentional drowning events to ensure this study only represented unintentional drowning burden among LMICs.
Limitations
Several major limitations were associated with this scientific literature review. First of all, while the authors believed that the systematic search on multiple databases helped to ensure the comprehensiveness of this review, it is possible that not all studies exploring unintentional drowning in LMICs were located and therefore were not included in this review. In addition, the inconsistency in data collection and reporting in several countries hindered the comparison of age-specific, gender-specific, drowning rates among articles. Moreover, the exclusion of grey literature, including government reports, policy statements, issues papers, and theses, also possibly overlooked essential information on unintentional drowning in LMICS, particularly regarding the rates and prevention interventions.

Recommendations for Further Research
While we believe that this review achieved its aims, we have noted several highlights for future research with particular focus on examining and developing relevant upstream, population-focused, socio-ecological approaches of drowning prevention and water safety promotion in LMICs. First, the performance of injury surveillance within each LMIC needs to be examined to ensure the availability of similar drowning mortality and morbidity data across regions and countries. Second, studies investigating measures of association among socio-demographic characteristics, childcare practices, survival skills, environmental factors, and risky behaviours, and the incidence of fatal and non-fatal unintentional drowning are essential to inform appropriate preventive variables for LMICs. In addition, analysing the cost-effectiveness of drowning preventive strategies is beneficial to appraise the generalisability of the strategies in the resource-scarce context of developing nations. Furthermore, providing the evidence of the effectiveness in strengthening upstream and midstream prevention interventions in reducing fatalities and disabilities due to drowning is important in LMICs, where the discrepancy between behavioural approaches and socio-ecological approaches is particularly apparent. It is also important to investigate the availability of water safety regulations across LMICs to provide preliminary data for studies on evidence-based policy development in these countries. In addition, it is also vital to investigate the effort of each LMICs government to strengthen all four pillars of health promotion, to ensure the congruence of upstream, midstream, and downstream drowning prevention and its inter-connection with water safety promotion.

Conclusions
Despite that more than 90% of drowning fatalities occurred in LMICs, limited publications on drowning rates, risk factors, and prevention of drowning have been published within these countries. The Southeast Asian region had the highest drowning rates across all LMICs, hence the critical need to study countries in this region, particularly India and Bangladesh in order to understand and report on unintentional drowning. The SES of the family, overcrowding,
inattention by parents, especially mothers, and living close to water bodies proved to be important predictors for paediatric drowning in LMICs. Swimming skill levels and evacuation practices were valuable in preventing drowning in natural disasters. The over-reliance on individual-focused, behaviour-based (i.e., downstream) preventive measures was observed in LMICs with an apparent under-development of the socio-ecological approach of health promotion (i.e., upstream). Future studies investigating the effectiveness of prevention strategies in reducing fatalities and disabilities due to drowning in LMICs along with the economic costs and benefits are urgently needed to ensure the sustainability of drowning prevention efforts to be applied in the resource-scarce context of developing economics. Further research on unintentional drowning in LMICs should be focused on developing relevant upstream, population-focused, socio-ecological approaches of drowning prevention and water safety promotion.

References
Abdullah, S., & Flora, M. (2013). Risk factors for nonfatal drowning in children in rural Bangladesh: A community-based case-control study. *WHO South-East Asia Journal of Public Health*, 2(2), 88-95. [https://doi.org/10.4103/2224-3151.122939]

Adewole, Fadeyibi, I. O., Kayode, Giwa, S. O., Shoga, M. O., Adejumo, A. O., & Ademiluyi, S. A. (2012). Ambulance services of Lagos State, Nigeria: A six-year (2001-2006) audit. *West African Journal of Medicine*, 31(1), 3-7.

Ae-Ngibise, K. A., Masanja, H., Kellerman, R., & Owusu-Agyei, S. (2012). Risk factors for injury mortality in rural Tanzania: A secondary data analysis. *BMJ Open*, 2(6). [https://doi.org/10.1136/bmjopen-2012-001721]

Ambade, V. N., Kukde, H. G., Malani, A., Tumram, N. K., Borkar, J. L., Batra, A. K., & Meshram, S. K. (2013). Decomposed and non-decomposed bodies retrieved from water: A comparative approach. *Medicine, science, and the law*, 53(1), 12-18.

An, N. T. (2012). Children and drowning in Vietnam. *Injury Prevention*, 18(Suppl 1), A68-A69. [https://doi.org/10.1136/injuryprev-2012-040580f.26]

Armour-Marshall, J., Wolfe, I., Richardson, E., Karanikolos, M., & McKee, M. (2012). Childhood deaths from injuries: Trends and inequalities in Europe. *European Journal of Public Health*, 22(1), 61-65.

Arun Kumar, S. V. V., & Prasad, K. V. S. R. (2014). Rip current-related fatalities in India: A new predictive risk scale for forecasting rip currents. *Natural Hazards*, 70(1), 313-335. [https://doi.org/10.1007/s11069-013-0812-x]

Banerjee, S., Paul, B., Dasgupta, A., & Bandyopadhyay, K. (2016). Domestic unintentional injury of 1 to 5-year-old children in a rural area of West Bengal, India: A cross-sectional survey. *International Journal of Aquatic Research and Education*, 12(2), 6. [https://scholarworks.bgsu.edu/ijare/vol12/iss2/6] DOI: [https://doi.org/10.25035/ijare.12.02.06]
Bengal, India: A community-based study. *Tanzania Journal of Health Research, 18*(3). https://doi.org/10.4314/thrb.v18i3.6

Barlas, B., & Beji, S. (2016). Rip current fatalities on the Black Sea beaches of Istanbul and effects of cultural aspects in shaping the incidents. *Natural Hazards, 80*(2), 811-821. https://doi.org/10.1007/s11069-015-1998-x

Barss, P., Olsen, K., Hamilton, J., & Dalke, S. (2016). 828 Non-wearing of flotation devices and swimming ability of boating immersion victims in Canada. *Injury Prevention, 22*. https://doi.org/10.1136/injuryprev-2016-042156.828

Beiki, O., Karimi, N., & Mohammadi, R. (2014). Parental educational level and injury incidence and mortality among foreign-born children: A cohort study with 46 years follow-up. *Journal of Injury and Violence Research, 6*(1), 37-43.

Bennett, E., & Linnan, M. (2014). Physical barriers. In J. J. L. M. Bierens (Ed.), *Drowning: Prevention, Rescue, Treatment* (pp. 181-185). Springer.

Bergstrom, A., Skeen, S., Duc, D. M., Elmer Zelaya, B., Estabrooks, C., Gustavsson, P., . . . Squires, J. E. (2015). Health system context and implementation of evidence-based practices-development and validation of the Context Assessment for Community Health (COACH) tool for low- and middle-income settings. *Implementation Science, 10*.

Beydilli, I., Sönmez, B. M., Yılmaz, F., Ararat, E., Karaca, A., Güven, R., & Kozaci, N. (2017). Mortality across drowning in the view of the meteorological parameters: Relative humidity and sea wavelength. *Biomedical Research (India), 28*(1), 61-65.

Blows, S., Ameratunga, S., Ivers, R. Q., Lo, S. K., & Norton, R. (2005). Risky driving habits and motor vehicle driver injury. *Accident Analysis and Prevention, 37*(4), 619-624. https://doi.org/10.1016/j.aap.2005.03.003

Borse, N. N., Hyder, A. A., Bishai, D., Baker, T., & Arifeen, S. E. (2011). Potential Risk Estimation Drowning Index for Children (PREDIC): A pilot study from Matlab, Bangladesh. *Accident Analysis and Prevention, 43*(6), 1901-1906. https://doi.org/10.1016/j.aap.2011.04.029

Borse, N. N., Hyder, A. A., Streatfield, P. K., Arifeen, S. E., & Bishai, D. (2011). Childhood drowning and traditional rescue measures: Case study from Matlab, Bangladesh. *Archives of Disease in Childhood, 96*(7), 675. https://doi.org/10.1136/adc.2010.202010

Boutayeb, A., & Helmert, U. (2011). Social inequalities, regional disparities and health inequity in North African countries. *International Journal for Equity in Health, 10*(1), 23. https://doi.org/10.1186/1475-9276-10-23

Brownson, R. C., Seiler, R., & Eyler, A. A. (2010a). Measuring the Impact of Public Health Policy. *Preventing Chronic Disease, 7*(A77).
Brownson, R. C., Seiler, R., & Eyler, A. A. (2010b). Measuring the impact of public health policies. Preventing Chronic Disease, 7(4), A77.

Cao, B. L., Shi, X. Q., Qi, Y. H., Hui, Y., Yang, H. J., Shi, S. P., . . . Yang, Y. P. (2015). Effect of a multi-level education intervention model on knowledge and attitudes of accidental injuries in rural children in Zunyi, Southwest China. International Journal of Environmental Research and Public Health, 12(4), 3903-3914. https://doi.org/10.3390/ijerph120403903

Chasimpha, S., McLean, E., Chihana, M., Kachiwanda, L., Koole, O., Tafatatha, T., . . . Glynn, J. R. (2015). Patterns and risk factors for deaths from external causes in rural Malawi over 10 years: A prospective population-based study. BMC Public Health, 15, 1036.

Chattopadhyay, S., Shee, B., & Sukul, B. (2013). Unidentified bodies in autopsy—A disaster in disguise. Egyptian Journal of Forensic Sciences, 3(4), 112-115. https://doi.org/10.1016/j.ejfs.2013.05.003

Ching, P. K., de los Reyes, V. C., Sucaldito, M. N., & Tayag, E. (2015). An assessment of disaster-related mortality post-Haiyan in Tacloban City. Western Pacific Surveillance and Response Journal: WPSAR, 6 Suppl 1, 34-38.

Chowdhury, F., & Gulshan, J. (2016). Drowning of under 18 children in Bangladesh: Analysis of risk factors using MICS 2006 data. Dhaka University Journal of Science, 64(1), 21-24. https://doi.org/10.3329/dujs.v64i1.28519

Cotlear, D. (2016). Policies to mitigate health inequity: A comparison of Israel and 24 developing countries. Israel Journal of Health Policy Research, 5. https://doi.org/10.1186/s13584-016-0105-4

Crawford, G., Leavy, J., Portsmouth, L., Jancey, J., Leaversuch, F., Nimmo, L., . . . Hills, E. (2014). Development of a systematic review of public health interventions to prevent children drowning. Open Journal of Preventive Medicine, 4, 100-106. https://doi.org/10.4236/ojpm.2014.43014

Croft, J. L., & Button, C. (2015). Interacting factors associated with adult male drowning in New Zealand. PloS One, 10(6), e0130545. https://doi.org/10.1371/journal.pone.0130545

Czajkowski, J., Simmons, K., & Sutter, D. (2011). An analysis of coastal and inland fatalities in landfalling US hurricanes. Natural Hazards, 59(3), 1513-1531. https://doi.org/10.1007/s11069-011-9849-x

Dai, D., Zhang, Y., Lynch, C. A., Miller, T., & Shakir, M. (2013). Childhood drowning in Georgia: A geographic information system analysis. Applied Geography, 37, 11-22. https://doi.org/10.1016/j.apgeog.2012.10.006

Davoudi-Kiakalayeh, A., Mohammadi, R., Yousefzade-Chabok, S., & Jansson, B. (2013). Evaluation of a community-based drowning prevention programme in northern Islamic Republic of Iran. Eastern Mediterranean Health Journal, 19(7), 629.
Denehy, M., Crawford, G., Leavy, J., Nimmo, L., & Jancey, J. (2016). Formative research to develop theory-based messages for a Western Australian child drowning prevention television campaign: Study protocol. *BMJ Open, 6*(5).

Dirlik, M., & Bostancıoğlu, B. (2015). Child drowning deaths in Aydin province, western Turkey, 2002–2012. *European Journal of Trauma and Emergency Surgery, 41*(6), 683-688. https://doi.org/10.1007/s00068-015-0493-0

Donson, H., & Van Niekerk, A. (2013). Unintentional drowning in urban South Africa: A retrospective investigation, 2001-2005. *International Journal of Injury Control and Safety Promotion, 20*(3), 218-226.

Fang, X., Jing, R., Zeng, G., Linnan, H. W., Zhu, X., & Linnan, M. (2014). Socioeconomic status and the incidence of child injuries in China. *Social Science and Medicine, 102*, 33-40. https://doi.org/10.1016/j.socscimed.2013.11.022

Farhan, A. R., & Lim, S. (2011). Resilience assessment on coastline changes and urban settlements: A case study in Seribu Islands, Indonesia. *Ocean & Coastal Management, 54*(5), 391-400. https://doi.org/10.1016/j.ocecoaman.2010.12.003

Ferretti, E., De Angelis, S., Donati, G., & Torre, M. (2014). Fatal and non-fatal unintentional drownings in swimming pools in Italy: Epidemiological data derived from the public press in 2008–2012. *Microchemical Journal, 113*, 64-68. https://doi.org/10.1016/j.microp.2013.11.009

Forjuoh, S. N. (2013). Water safety and drowning prevention. *International Journal of Injury Control and Safety Promotion, 20*(3), 207-208. https://doi.org/10.1080/17457300.2013.822634

Franklin, R., & Scarr, J. (2014). A Framework for Prevention. In J. J. L. M. Bierens (Ed.), *Drowning: Prevention, Rescue, Treatment* (pp. 153-163). Springer.

Franklin, R. C., Peden, A., Watt, K., & Peter, P. L. (2012). Pool fencing—Can Australia go much further? *Injury Prevention, 18*. https://doi.org/10.1136/injuryprev-2012-040590h.13

Gámez de la Hoz, J. J., & Padilla Fortes, A. (2016). Drownings associated with swimming pools concerned in judicial cases from Spain, 2000-2015. *Revista Andaluza de Medicina del Deporte*. https://doi.org/10.1016/j.ramde.2016.07.005

Giles, A. R., Brooks-Cleator, L. A., & Glass, C. T. R. (2017). Barriers to sustainable health promotion and injury prevention in the Northwest Territories, Canada. In G. Fondahl & G. N. Wilson (Eds.), *Northern Sustainabilities: Understanding and Addressing Change in the Circumpolar World* (pp. 151-162). Springer International Publishing.

Glass, N. E., Frangos, S. G., Simon, R. J., Bholat, O. S., Todd, S. R., Wilson, C., . . . Levine, D. A. (2014). Risky behaviors associated with pediatric pedestrians and bicyclists struck by motor vehicles. *Pediatric*
Guevarra, J. P., Franklin, R. C., Basilio, J. A., Orbillo, L. L., & Go, J. J. L. (2015). Child drowning prevention in the Philippines: The beginning of a conversation. *International Journal of Injury Control and Safety Promotion, 22*(3), 243-253. https://doi.org/10.1080/17457300.2014.912235

Guo, Q.-z., Ma, W.-j., Xu, H.-f., Nie, S.-p., Xu, Y.-j., Song, X.-l., & Li, H.-k. (2010). Evaluation on the health education program regarding prevention of non-fatal drowning among school-aged children in Lianping county, Guangdong province. *Zhonghua liu xing bing xue za zhi = Zhonghua liuxingbingxue zazhi, 31*(1), 22-26.

Guzel, A., Duran, L., Paksu, S., Akdemir, H. U., Paksu, M. S., Kati, C., . . . Murat, N. (2013). Drowning and near-drowning: Experience of a university hospital in the Black Sea region. *The Turkish Journal of Pediatrics, 55*(6), 620-627.

Halawa, E. F., Barakat, A., Rizk, H. I. I., & Moawad, E. M. I. (2015). Epidemiology of non-fatal injuries among Egyptian children: A community-based cross-sectional survey. *BMC Public Health, 15*(1). https://doi.org/10.1186/s12889-015-2613-5

Hanifi, S. M. A., Mahmood, S. S., & Bhuinya, A. (2014). Cause-specific mortality and socioeconomic status in Chakaria, Bangladesh. *Global Health Action, 7*(1). https://doi.org/10.3402/gha.v7.25473

Hasking, P. (2017). Differentiating non-suicidal self-injury and risky drinking: A role for outcome expectancies and self-efficacy beliefs. *Prevention Science, 18*(6), 694-703. https://doi.org/10.1007/s11121-017-0755-7

Hassan Md Abdullah, S. A., & Flora, M. S. (2014). Risk factors for nonfatal drowning in children in rural Bangladesh: A community-based case-control study. *Annals of Epidemiology, 24*(9), 691-692. https://doi.org/10.1016/j.annepidem.2014.06.049

He, S., Lunnen, J. C., Zia, N., Khan, U., Shamim, K., & Hyde, A. A. (2015). Pattern of presenting complaints recorded as near-drowning events in emergency departments: A national surveillance study from Pakistan. *BMC Emergency Medicine, 15 Suppl 2, S4.*

Hossain, M., Mani, K. K. C., Mohd Sidik, S., & Kadir Shahar, H. (2016). The development of an intervention package to prevent children under five years old drowning in rural Bangladesh. *Acta Paediatrica, International Journal of Paediatrics, 105*(8), e373-e378. https://doi.org/10.1111/apa.13447

Hossain, M., Mani, K. K. C., Sidik, S. M., Hayati, K. S., & Rahman, A. K. M. F. (2015). Socio-demographic, environmental and caring risk factors for childhood drowning deaths in Bangladesh. *BMC Pediatrics, 15,* 114.

Howat, P., Sleet, D., Elder, R., & Maycock, B. (2004). Preventing alcohol-related traffic injury: A health promotion approach. *Traffic Injury...
Prevention, 5(3), 208-219. 
https://doi.org/10.1080/15389580490465238

Hss, A. S., Tan, P. S., & Hashim, L. (2014). Childhood drowning in Malaysia. 
International Journal of Injury Control and Safety Promotion, 21(1), 75-80. 
https://doi.org/10.1080/17457300.2013.792284

Hyder, A. A., Alonge, O., He, S., Wadhwaniya, S., Rahman, F., Rahman, A., & Arifeen, S. E. (2014). A framework for addressing implementation gap in global drowning prevention interventions: Experiences from Bangladesh. Journal of Health, Population, and Nutrition, 32(4), 564-576.

Jagnoor, J., Suraweera, W., Keay, L., Ivers, R. Q., Thakur, J., Jha, P., & Million Death Study, C. (2012). Unintentional injury mortality in India, 2005: Nationally representative mortality survey of 1.1 million homes. BMC Public Health, 12, 487.

Kanchan, T., & Monteiro, F. N. P. (2012). An analysis of accidental drowning fatalities in Manipal, South India. Injury Prevention, 18. 
https://doi.org/10.1136/injuryprev-2012-040590b.1

Kitulwatte, I. D., & Edirisinghe, P. A. S. (2014). Study on unnatural childhood deaths presented to North Colombo Teaching Hospital, Sri Lanka. Medicine, Science and the Law, 54(2), 74-77. 
https://doi.org/10.1177/0025802413491249

Kuchewar, S. V., Meshram, R. D., Gadge, S. J., & Khetre, R. R. (2013). Epidemiological study of drowning in Yavatmal. Medico-Legal Update, 13(1), 102-105.

Kumar, S., Verma, A. K., Ahmad, I., Ali, W., & Singh, U. S. (2013). Profile of unnatural deaths- A study of autopsies at Mortuary of King George's Medical University, Lucknow, India. Medico-Legal Update, 13(2), 113-118. 
https://doi.org/10.5958/j.0974-1283.13.2.028

Laosee, O., Khiewyoo, J., & Somrongthong, R. (2014). Drowning risk perceptions among rural guardians of Thailand: A community-based household survey. Journal of Child Health Care, 18(2), 168-177. 
https://doi.org/10.1177/1367493513485477

Lapa, T. Y., Turgut, A., & Turgut, T. (2012). Deaths by drowning incidents during recreational boating and similar activities. World Applied Sciences Journal, 17(2), 233-238.

Leaning , J., & Guha-Sapir, D. (2013). Natural disasters, armed conflict, and public health. New England Journal of Medicine, 369(19), 1836-1842. 
https://doi.org/10.1056/NEJMra1109877

Leavy, J. E., Crawford, G., Leaversuch, F., Nimmo, L., McCausland, K., & Jancey, J. (2016). A review of drowning prevention interventions for children and young people in high, low and middle income countries. Journal of Community Health, 41(2), 424-441. 
https://doi.org/10.1007/s10900-015-0105-2

Leavy, J. E., Crawford, G., Portsmouth, L., Jancey, J., Leaversuch, F., Nimmo, L., & Hunt, K. (2015). Recreational drowning prevention interventions
for adults, 1990–2012: A review. *Journal of Community Health*, 40(4), 725-735. https://doi.org/10.1007/s10900-015-9991-6

Lili, X., Jian, H., Liping, L., Zhiyu, L., & Hua, W. (2017). Epidemiology of injury-related death in children under 5 years of age in Hunan province, China, 2009-2014. *PLoS ONE [Electronic Resource], 12*(1). https://doi.org/10.1371/journal.pone.0168524

Lin, C.-Y., Wang, Y.-F., Lu, T.-H., & Kawach, I. (2015a). Unintentional drowning mortality, by age and body of water: an analysis of 60 countries. *Injury Prevention*, 21(e1). https://doi.org/10.1136/injuryprev-2013-041110

Lin, C.-Y., Wang, Y.-F., Lu, T.-H., & Kawach, I. (2015b). Unintentional drowning mortality, by age and body of water: An analysis of 60 countries. *Injury Prevention: Journal of the International Society for Child and Adolescent Injury Prevention*, 21(e1), e43-50.

Lin, G., Zhang, X., Dong, H., Shen, J., Li, K., & Zhou, Q. (2016). Excessive fatal injury among migrant children in China: Inequities in safety. *Injury Prevention: Journal of the International Society for Child and Adolescent Injury Prevention*, 22(1), 68-71.

Linnan, M., Rahman, A., Scarr, J., Reinten-Reynolds, T., Linnan, H., Rui-wei, J., . . . Finkelstein, E. (2012). Child drowning: Evidence for a newly recognized cause of child mortality in low and middle income countries in Asia. *UNICEF Office of Research, Florence.* https://www.unicef-irc.org/publications/pdf/drowning.pdf

Linnan, M., Scarr, J., & Giersing, M. (2013). Toward a world where children do not drown. *JAMA Pediatrics, 167*(2), 110-111. https://doi.org/10.1001/jamapediatrics.2013.948

Linnan, M., Scarr, J., & Linnan, H. (2014). Drowning prevention in low- and middle-income countries versus high-income countries. In J. J. L. M. Bierens (Ed.), *Drowning: Prevention, Rescue, Treatment* (pp. 165-173). Springer.

Liu, Q., Zhang, L., Li, J., Zuo, D., Kong, D., Shen, X., . . . Zhang, Q. (2012). The gap in injury mortality rates between urban and rural residents of Hubei Province, China. *BMC Public Health, 12*, 180.

Lumbroso, D., & Di Mauro, M. (2008). Recent developments in loss of life and evacuation modelling for flood event management in the UK. *WIT Transactions on Ecology and the Environment, 118*, 263-272. https://doi.org/10.2495/FRIAR080251

Ma, W. J., Nie, S. P., Xu, H. F., Xu, Y. J., Song, X. L., Guo, Q. Z., & Zhang, Y. R. (2010). An analysis of risk factors of non-fatal drowning among children in rural areas of Guangdong Province, China: A case-control study. *BMC Public Health, 10*(1), 156. https://doi.org/10.1186/1471-2458-10-156

Maher, A. M., Thomson, C. J., & Carlson, S. R. (2015). Risk-taking and impulsive personality traits in proficient downhill sports enthusiasts.
Personality and Individual Differences, 79, 20-24. 
https://doi.org/10.1016/j.paid.2015.01.041

Mamady, K., Yao, H., Zhang, X., Xiang, H., Tan, H., & Hu, G. (2012). The injury mortality burden in Guinea. BMC Public Health, 12, 733.

Martinez, R. E., Go, J. J., & Guevarra, J. (2016). Epidemiology of drowning deaths in the Philippines, 1980–2011. Western Pacific Surveillance and Response, 7(4).

Martins, C. B. G., & de Mello-Jorge, M. H. P. (2013). Circumstances and factors associated with accidental deaths among children, adolescents and young adults in Cuiabá, Brazil. Sao Paulo Medical Journal, 131(4), 228-237. https://doi.org/10.1590/1516-3180.2013.1314459

Mateen, F. J., Shinohara, R. T., Alam, N., Black, R. E., & Streatfield, P. K. (2012). Injury deaths among people with epilepsy in rural Bangladesh: A retrospective population-based study. Epilepsy & Behavior, 23(3), 291-293. https://doi.org/10.1016/j.yebeh.2011.11.028

Matthews, B., Birch, R., Jayawardena, M., Mathew, D., Nanayakkara, A., Wiyayaratne, S., & Dharmaratne, S. D. (2016). The burden of drowning in Sri Lanka: 2001 to 2006 and 2009. Injury Prevention, 22. https://doi.org/10.1136/injuryprev-2016-042156.825

Matzopoulos, R. (2002). The national injury mortality surveillance system : A profile of fatal injuries in South Africa, 2000. Injury and Safety Monitor, 1(1), 3.

Matzopoulos, R., & Seedat, M. (2005). National Injury Mortality Surveillance System-a call for city-level injury prevention. South African Medical Journal-Cape Town-Medical Association of South Africa-, 95(10), 708.

Mecrow, T. S., Rahman, A., Linnan, M., Scarr, J., Mashreky, S. R., Talab, A., & Rahman, A. K. M. F. (2015). Children reporting rescuing other children drowning in rural Bangladesh: A descriptive study. Injury prevention : journal of the International Society for Child and Adolescent Injury Prevention, 21(e1), e51-55.

Mitchell, R. J., Bambach, M. R., & Friswell, R. (2014). Work and non-work-related vehicle crashes: The contribution of risky driving practices. Safety Science, 68, 65-72. https://doi.org/10.1016/j.ssci.2014.02.025

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. BMJ, 339(7716), 332-336.

Morris, N. K., du Toit-Prinsloo, L., & Saayman, G. (2016). Drowning in Pretoria, South Africa: A 10-year review. Journal of Forensic and Legal Medicine, 37, 66-70.

Mtaweh, H., Kochanek, P. M., Carcillo, J. A., Bell, M. J., & Fink, E. L. (2015). Patterns of multiorgan dysfunction after pediatric drowning. Resuscitation, 90, 91-96. https://doi.org/10.1016/j.resuscitation.2015.02.005

Murray, K., & Carter, P. (2017). Fatal drownings in Fiji: An effective parsimonious model that can explain the number of cases from January
2012 to April 2015. Asia Pacific Journal of Public Health, 29(1), 28-34. https://doi.org/10.1177/1010539516685610

National Institute of Population Research and Training Dhaka Bangladesh. (2012, April 2012 ). Bangladesh demographic health survey 2011. The Demographic and Health Surveys (DHS) Program. http://www.dhsprogram.com/pubs/pdf/FR265/FR265.pdf

Olsen, E. O. m., Shults, R. A., & Eaton, D. K. (2013). Texting while driving and other risky motor vehicle behaviors among US high school students. Pediatrics, 131(6), e1708-e1715. https://doi.org/10.1542/peds.2012-3462

Osti, R., & Nakasu, T. (2016). Lessons learned from southern and eastern Asian urban floods: from a local perspective. Journal of Flood Risk Management, 9(1), 22-35. https://doi.org/10.1111/jfr3.12107

Pajunen, T., Vuori, E., Vincenzi, F. F., Lillsunde, P., Smith, G., & Lunetta, P. (2017). Unintentional drowning: Role of medicinal drugs and alcohol. BMC Public Health, 17. https://doi.org/10.1186/s12889-017-4306-8

Paul, B., Mahanta, P., & Tamuli, R. P. (2013). A statistical analysis of death victims brought for medico-legal autopsy. Medico-Legal Update, 13(2), 97-101. https://doi.org/10.5958/j.0974-1283.13.2.024

Peden, A. E., Franklin, R. C., & Leggat, P. A. (2016). Fatal river drowning: The identification of research gaps through a systematic literature review. Injury Prevention, 22(3), 202. https://doi.org/10.1136/injuryprev-2015-041750

Peden, A. E., Franklin, R. C., & Leggat, P. A. (2017). Alcohol and its contributory role in fatal drowning in Australian rivers, 2002–2012. Accident Analysis and Prevention, 98, 259-265. https://doi.org/10.1016/j.aap.2016.10.009

Pereira, B. M., Morales, W., Cardoso, R. G., Fiorelli, R., Fraga, G. P., & Briggs, S. M. (2013). Lessons learned from a landslide catastrophe in Rio de Janeiro, Brazil. American Journal of Disaster Medicine, 8(4), 253-258.

Pettigrew, S., Borys, J. M., du Plessis, H. R., Walter, L., Huang, T. T.-K., Levi, J., & Vinck, J. (2014). Process evaluation outcomes from a global child obesity prevention intervention. BMC Public Health, 14(1), 757. https://doi.org/10.1186/1471-2458-14-757

Plitponkarnpim, A., & Chinapa, M. (2014). Trend of child injury and drowning in Thailand, and child safety promotion initiative. Southeast Asian Journal of Tropical Medicine and Public Health, 45(Suppl 1), 50-52.

Prameprart, M., Lim, A., & Tongkumchum, P. (2015). Modeling unintentional drowning mortality rates in Thailand, 2000-2009. Asia-Pacific Journal of Public Health, 27(2), NP2471-NP2479. https://doi.org/10.1177/1010539513488796

Pretorius, K., & Van Niekerk, A. (2015). Childhood psychosocial development and fatal injuries in Gauteng, South Africa. Child Care,
Quan, L., Bierens, J. J. L. M., Lis, R., Rowhani-Rahbar, A., Morley, P., & Perkins, G. D. (2016). Predicting outcome of drowning at the scene: A systematic review and meta-analyses. Resuscitation, 104, 63-75. https://doi.org/10.1016/j.resuscitation.2016.04.006

Quan, L. D., Mack, C. D., & Schiff, M. A. (2014). Association of water temperature and submersion duration and drowning outcome. Resuscitation, 85(6), 790-794. https://doi.org/10.1016/j.resuscitation.2014.02.024

Radosavljevic, V., Belojevic, G., & Pavlovic, N. (2017). Tool for decision-making regarding general evacuation during a rapid river flood. Public Health, 146, 134-139. https://doi.org/10.1016/j.puhe.2017.01.025

Raghavendra Babu, Y. P., Joseph, N., & Kadur, K. (2012). Mortality among homeless and unclaimed bodies in Mangalore city - An insight. Journal of Forensic and Legal Medicine, 19(6), 321-323.

Rahman, A., Linnan, M., Mashreky, S. R., Hossein, M. J., & Rahman, F. (2014). The prevalence of naturally acquired swimming ability among children in Bangladesh: A cross sectional survey. BMC Public Health, 14, 404-404. https://doi.org/10.1186/1471-2458-14-404

Rahman, F., Bose, S., Linnan, M., Rahman, A., Mashreky, S., Haaland, B., & Finkelstein, E. (2012). Cost-effectiveness of an injury and drowning prevention program in Bangladesh. Pediatrics, 130(6), e1621-1628.

Rahman, M., Sohel, N., Hore, S. K., Yunus, M., Bhuiya, A., & Streatfield, P. K. (2015). Prenatal arsenic exposure and drowning among children in Bangladesh. Global Health Action, 8, 28702.

Razzak, J. A., Khan, U. R., Zia, N., & Azam, I. (2013). A child an hour: Burden of injury deaths among children under 5 in Pakistan. Archives of Disease in Childhood, 98(11), 867-871. https://doi.org/10.1136/archdischild-2013-303654

Razzak, J. A., Shamim, M. S., Mehmood, A., Hussain, S. A., Ali, M. S., & Jooma, R. (2012). A successful model of road traffic injury surveillance in a developing country: Process and lessons learnt. BMC Public Health, 12(1), 357. https://doi.org/10.1186/1471-2458-12-357

Reidpath, D. D., & Allotey, P. (2007). Measuring global health inequity. International Journal for Equity in Health, 6(1), 16. https://doi.org/10.1186/1475-9276-6-16

Reynolds, T. A., Bisanzo, M., Dworkis, D., Hansoti, B., Obermeyer, Z., Seidenberg, P., . . . Mowafi, H. (2013). Research priorities for data collection and management within global acute and emergency care systems. Academic Emergency Medicine, 20(12), 1246-1250. https://doi.org/10.1111/acem.12261

Rusu, A., Sârbescu, P., Moza, D., & Stancu, A. (2017). Implicit attitudes towards risky driving: Development and validation of an affect
misattribution procedure for speeding. *Accident Analysis and Prevention, 100*, 15-22. https://doi.org/10.1016/j.aap.2016.12.022

Ryan, K. M., Nathanson, A. T., Baird, J., & Wheelhouse, J. (2016). Injuries and fatalities on sailboats in the United States 2000–2011: An analysis of US coast guard data. *Wilderness and Environmental Medicine, 27*(1), 10-18. https://doi.org/10.1016/j.wem.2015.09.022

Samaneh, A., Samaneh, A., Hamid, S., Ardeshir, K., & Khosro, G. (2012). Years of potential life lost due to unintentional drowning mortality in Mazandaran province, Iran. *World Applied Sciences Journal, 20*(10), 1433-1438. https://doi.org/10.5829/idosi.wasj.2012.20.10.2070

Sansiritaweesook, G., & Kanato, M. (2015). Development of the model for local drowning surveillance system in northeastern Thailand. *Journal of the Medical Association of Thailand, 98*, S1-S9.

Schuurman, N., Cinnamon, J., Matzopoulos, R., Fawcett, V., Nicol, A., & Hameed, S. M. (2011). Collecting injury surveillance data in low- and middle-income countries: The Cape Town Trauma Registry pilot. *Global Public Health, 6*(8), 874-889. https://doi.org/10.1080/17441692.2010.516268

Seleye-Fubara, D., Nicholas, E. E., & Esse, I. (2012). Drowning in the Niger Delta region of Nigeria: An autopsy study of 85 cases. *The Nigerian Postgraduate Medical Journal, 19*(2), 111-114.

Shaikh, M. A. (2014). Risks of drowning and safety concerns at the beaches of Karachi—Perspective from lifeguards. *JPMA. The Journal of the Pakistan Medical Association, 64*(5), 576-578.

Shaikh, M. A. (2016). Epidemiology of drowning and near drowning at Karachi beaches from 2012 to 2014. *JPMA. The Journal of the Pakistan Medical Association, 66*(5), 602-605.

Shen, J., Pang, S., & Schwebel, D. C. (2015). Evaluation of a drowning prevention program based on testimonial videos: A randomized controlled trial. *Journal of Pediatric Psychology, jsv104*. https://doi.org/10.1093/jpepsy/jsv104

Shen, J., Pang, S., & Schwebel, D. C. (2016). Cognitive and behavioral risk factors for unintentional drowning among rural Chinese children. *International Journal of Behavioral Medicine, 23*(2), 243-250. https://doi.org/10.1007/s12529-015-9518-7

Silva, E. C. S., Fernandes, M. N. F., Sá, M. C. S., de Souza, L. M., Gordon, A. S. A., Costa, A. C. P. J., . . . Vieira, N. F. C. (2016). The effect of educational intervention regarding the knowledge of mothers on prevention of accidents in childhood. *Open Nursing Journal, 10*, 113-121. https://doi.org/10.2174/1874434601610010113

Slabe, D., Dolenc, E., Sazonov, A., & Hiti, N. (2016, 01/01). The introduction of practical exercises of rescuing a drowning person within the subject of basic clinic medicine and first aid for students of health sciences as a challenge for interdisciplinary cooperation. SHS Web of Conferences, 31, 01021. https://doi.org/10.1051/shsconf/20163101021
Solomon, R., Giganti, M. J., Weiner, A., & Akpinar-Elci, M. (2013). Water safety education among primary school children in Grenada. *International Journal of Injury Control and Safety Promotion, 20*(3), 266-270.

Srinivas, J., Chand Basha, V., & Sudhakar Reddy, K. (2012). A comprehensive medico-legal analysis of paediatric deaths at Osmania General Hospital Hyderabad. *Indian Journal of Forensic Medicine and Toxicology, 6*(2), 40-43.

State Government of Victoria, A. (2017). School policy and advisory guide: Swimming instruction and water safety. *State Government of Victoria, Australia,* [http://www.education.vic.gov.au/school/principals/spag/curriculum/Pages/swimming.aspx](http://www.education.vic.gov.au/school/principals/spag/curriculum/Pages/swimming.aspx)

Stempski, S., Liu, L., Grow, H. M., Pomietto, M., Chung, C., Shumann, A., & Bennett, E. (2015). Everyone swims. *Health Education and Behavior, 42*(1_suppl), 106S-114S. [https://doi.org/10.1177/1090198115570047](https://doi.org/10.1177/1090198115570047)

Stokols, D. (1992). Establishing and maintaining healthy environments: Toward a social ecology of health promotion. *American Psychologist, 47*(1), 6. [https://doi.org/10.1037/0003-066X.47.1.6](https://doi.org/10.1037/0003-066X.47.1.6)

Sultana, F., Malik, S. A., Amir, S., Khan, M. M., Qadir, I., & Ishaq, K. (2016). Medico legal autopsies of mechanical asphyxial deaths carried out in Allama Iqbal Medical College Lahore during the year 2013: A retrospective study. *Pakistan Journal of Medical and Health Sciences, 10*(2), 392-395.

Suominen, P. K., & Vähätalo, R. (2012). Neurologic long term outcome after drowning in children. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 20*(1), 55. [https://doi.org/10.1186/1757-7241-20-55](https://doi.org/10.1186/1757-7241-20-55)

Talbot, L., & Verrinder, G. (2014). *Promoting health: The primary health care approach* (5th ed.). Elsevier Australia.

Terzidis, A., Koutroumpa, A., Skalkidis, I., Matzavakis, I., Malliori, M., Frangakis, C. E., . . . Petridou, E. T. (2007). Water safety: Age-specific changes in knowledge and attitudes following a school-based intervention. *Injury Prevention, 13*(2), 120. [https://doi.org/10.1136/ijp.2006.014316](https://doi.org/10.1136/ijp.2006.014316)

Thakar, M. K., & Guleria, P. (2015). Tracking drowning trends in Himachal Pradesh during 2006-2010. *Anil Aggrawal's Internet Journal of Forensic Medicine and Toxicology, 16*(1).

Thomson, C. J., & Carlson, S. R. (2014). Personality and risky downhill sports: Associations with impulsivity dimensions. *Personality and Individual Differences, 60*, 67-72. [https://doi.org/10.1016/j.paid.2013.12.022](https://doi.org/10.1016/j.paid.2013.12.022)

Thomson, C. J., & Carlson, S. R. (2015). Increased patterns of risky behaviours among helmet wearers in skiing and snowboarding.
Accident Analysis and Prevention, 75, 179-183.  
https://doi.org/10.1016/j.aap.2014.11.024

Turgut, T., Yaman, M., & Turgut, A. (2016). Educating Children on Water Safety for Drowning Prevention. Social Indicators Research, 129(2), 787-801.  
https://doi.org/10.1007/s11205-015-1109-0

Tyler, M. D., Richards, D. B., Reske-Nielsen, C., Saghafi, O., Morse, E. A., Carey, R., & Jacquet, G. A. (2017). The epidemiology of drowning in low- and middle-income countries: A systematic review. BMC Public Health, 17.  
https://doi.org/10.1186/s12889-017-4239-2

United Nations. (2019). Sustainable Development Goals - Goal 3: Ensure healthy lives and promote well-being for all at all ages United Nations.  
http://www.un.org/sustainabledevelopment/health/

United States Census Bureau. (03 October 2017). World population - Top 10 most populous countries. United States Census Bureau.  
https://www.census.gov/popclock/print.php?component=counter

Vienola, R., Gudmundsson, H. B., & Heinonen, K. (2016). 266 Swimming ability and drowning prevention – Do they have something in common? A Nordic case study. Injury Prevention, 22(Suppl 2), A97-A97.  
https://doi.org/10.1136/injuryprev-2016-042156.266

Wallis, B. A., Watt, K., Franklin, R. C., Nixon, J. W., & Kimble, R. M. (2015). Drowning mortality and morbidity rates in children and adolescents 0-19 years: A population-based study in Queensland, Australia. PloS One, 10(2), e0117948.  
https://doi.org/10.1371/journal.pone.0117948

Wallis, B. A., Watt, K., Franklin, R. C., Nixon, J. W., & Kimble, R. M. (2015). Where children and adolescents drown in Queensland: A population-based study. BMJ Open, 5(11), e008959.  
https://doi.org/10.1136/bmjopen-2015-008959

Wang, Y., He, C., Li, X., Miao, L., Zhu, J., & Liang, J. (2014). Nationwide study of injury-related deaths among children aged 1-4 years in China, 2000-2008. Journal of Paediatrics and Child Health, 50(10), E94-E101.  
https://doi.org/10.1111/j.1440-1754.2012.02525.x

Watt, K., Applegarth, K., Fischer, J., Franklin, R., & Najman, J. (2012). Bingeing on the beach: An exploratory study of alcohol consumption, knowledge, attitudes and behaviour of young beachgoers. Injury Prevention, 18.  
https://doi.org/10.1136/injuryprev-2012-040580f.30

Weldearegawi, B., Ashebir, Y., Gebeye, E., Gebregziabiher, T., Yohannes, M., Musa, S., . . . Abebe, Z. (2013). Emerging chronic non-communicable diseases in rural communities of Northern Ethiopia: Evidence using population-based verbal autopsy method in Kilite Awlæelo surveillance site. Health Policy and Planning, 28(8), 891-898.  
https://doi.org/10.1093/heapol/czs135

Weraarchakul, W., Weraarchakul, W., Jetsrisuparb, A., Thepsuthammarat, K., & Sutra, S. (2012). Unintentional injury among Thai children and
adolescents in 2010. Journal of the Medical Association of Thailand = Chotmaihet thangphaet, 95 Suppl 7, S114-122.

World Bank. (2018) World Bank country and lending groups: Country classification. World Bank. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519

World Health Organization. (2017). Health statistics and information systems: Definition of regional groupings. World Health Organization. http://www.who.int/healthinfo/global_burden_disease/definition_regions/en/

World Health Organization. (2014). Global report on drowning: Preventing a leading killer. World Health Organization. http://apps.who.int/iris/bitstream/10665/143893/1/9789241564786_eng.pdf?ua=1&ua=1&ua=1&ua=1

World Health Organization. (2016). Global health estimates 2015: Deaths by cause, age, sex, by country and by region, 2000-2015. World Health Organization. http://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html

World Health Organization. (2017). Global top 10 causes of death, 2015. World Health Organization. http://www.who.int/gho/mortality_burden_disease/causes_death/top_10/en/

World Health Organization Regional Office for the Eastern Mediterranean. (2017). Health promotion and disease prevention through population-based interventions, including action to address social determinants and health inequity. World Health Organization. http://www.emro.who.int/about-who/public-health-functions/health-promotion-disease-prevention.html

Yang, B., Lee, J., Hwang, J. S., Kweon, H. M., & Lee, J. L. (2014). Quantitative risk assessment for beach drowning management. Journal of Coastal Research, SI(72), 117-121.

Yin, Z., Wu, J., Luo, J., Pak, A. W. P., Choi, B. C. K., & Liang, X. (2015). Burden and trend analysis of injury mortality in China among children aged 0-14 years from 2004 to 2011. BMJ Open, 5(7), e007307.

Zhu, Y., Jiang, X., Li, H., Li, F., & Chen, J. (2015a). Mortality among drowning rescuers in China, 2013: A review of 225 rescue incidents from the press. BMC Public Health, 15, 631.

Zhu, Y., Xu, G., Li, H., Huang, Y., Ding, K., & Chen, J. (2015b). Epidemiology and risk factors for nonfatal drowning in the migrant children. The Southeast Asian Journal of Tropical Medicine and Public Health, 46(6), 1112-1123.
### Appendix 1. Database searching

| Databases | Aspects investigated                     | Search strings                                                                 |
|-----------|------------------------------------------|--------------------------------------------------------------------------------|
| Ovid      | Epidemiology of drowning                 | exp Drowning/ep, mo [Epidemiology, Mortality] OR exp Near Drowning/ep, mo [Epidemiology, Mortality] |
| MEDLINE   |                                          |                                                                                  |
| CINAHL    | Epidemiology of drowning                 |                                                                                  |

Including:

- Drowning in water transport incidents
  - exp Drowning/ OR exp Near Drowning/) AND exp Transportation/

- Drowning in disasters
  - exp Drowning/ OR exp Near Drowning/) AND exp Disasters

- Risk factors of drowning
  - exp Drowning/pc [Prevention & Control] OR exp Near Drowning/pc [Prevention & Control]

- Prevention of drowning
  - exp Drowning/pc [Prevention & Control] OR exp Near Drowning/pc [Prevention & Control]

Note: other similar search string brought more limited results:

- exp Drowning OR exp Near Drowning) AND exp epidemiology

- exp Drowning/ OR exp Near Drowning/) AND exp Transportation/

- exp Drowning/ OR exp Near Drowning/) AND exp Disasters

- exp Drowning/pc [Prevention & Control] OR exp Near Drowning/pc [Prevention & Control]

Note: other similar search strings brought more limited results:

- exp Drowning/pc [Prevention & Control] OR exp Near Drowning/pc [Prevention & Control]

- exp Drowning/pc [Prevention & Control] OR exp Near Drowning/pc [Prevention & Control]) AND exp Preventive Health Services

- exp Drowning/pc [Prevention & Control] OR exp Near Drowning/pc [Prevention & Control]) AND exp Preventive Health Services ((MH "Drowning+") OR (MM "Near Drowning")) AND (MH “EPIDEMIOLOGY+"
Including:
- Drowning in water transport incidents ((MH "Drowning+") OR (MM "Near Drowning")) AND (MH "Transportation+")
- Drowning in disasters ((MH "Drowning+") OR (MM "Near Drowning")) AND (MM "Natural Disasters")
- Risk factors of drowning ((MH "Drowning+") OR (MM "Near Drowning")) AND (MM “Risk Factors”)
- Prevention of drowning ((MH "Drowning+") OR (MM "Near Drowning")) AND (MH "Preventive Health Care+")

Informit health databases

Epidemiology of drowning (SU="DROWNING") AND (SU="EPIDEMIOLOGY")

Including:
- Drowning in water transport incidents (SU="DROWNING") AND (SU="TRANSPORTATION")
- Drowning in disasters (SU="DROWNING") AND disasters
- Risk factors of drowning (SU="DROWNING") AND (SU="RISK FACTORS")
- Prevention of drowning subject="Drowning--Prevention"

PsycINFO (ProQuest)

Epidemiology of drowning (drowning OR ("near drowning")) AND epidemiology

Including:
- Drowning in water transport incidents (drowning OR ("near drowning") AND SU.EXACT.EXPLODE("Water Transportation")
- Drowning in disasters (drowning OR ("near drowning") AND (SU.EXACT.EXPLODE("Natural Disasters") OR SU.EXACT.EXPLODE("Disasters")))
| Source        | Query                                                                 |
|--------------|----------------------------------------------------------------------|
| Risk factors of drowning | (drowning OR ("near drowning")) AND SU.EXACT.EXPLODE("Risk Factors") |
| Prevention of drowning     | (drowning OR ("near drowning")) AND (SU.EXACT.EXPLODE("Accident Prevention") OR SU.EXACT.EXPLODE("Prevention")) |
| SCOPUS       | Epidemiology of drowning                                             |
|              | (((drowning OR ("near drowning"))) AND (epidemiology))               |
|              | Including:                                                           |
|              | - Drowning in water transport incidents                             |
|              |   (((drowning OR ("near drowning"))) AND (transportation))           |
|              | - Drowning in disasters                                              |
|              |   (((drowning OR ("near drowning"))) AND (disaster*))                |
|              | Risk factors of drowning                                             |
|              |   (((drowning OR ("near drowning"))) AND ("risk factors"))          |
|              | Prevention of drowning                                              |
|              |   (((drowning OR ("near drowning"))) AND (prevention))              |
| SafetyLit    | Epidemiology of drowning                                             |
|              | (drowning OR ("near drowning")) AND epidemiology                    |
|              | Including:                                                           |
|              | - Drowning in water transport incidents                             |
|              |   (drowning OR (near drowning)) AND “water transportation”          |
|              | - Drowning in disasters                                              |
|              |   (drowning OR (near drowning)) AND “disasters”                      |
|              | Risk factors of drowning                                             |
|              |   (drowning OR ("near drowning") AND “risk factors”)                |
|              | Prevention of drowning                                              |
|              |   (drowning OR ("near drowning") AND “prevention”)                  |
| Google Scholar | Epidemiology of drowning                                             |
|               | allintitle: drowning AND "epidemiology"                              |
|               | Including:                                                           |
|               | - Drowning in water transport incidents                             |
|               |   allintitle: drowning AND "transportation"                         |

https://scholarworks.bgsu.edu/ijare/vol12/iss2/6
DOI: https://doi.org/10.25035/ijare.12.02.06
| BioMed Central | Epidemiology of drowning |
|----------------|--------------------------|
| - Drowning in disasters | allintitle: drowning AND "disaster" |
| Risk factors of drowning | allintitle: drowning AND "risk factors" |
| Prevention of drowning | allintitle: drowning AND "prevention" |

Including:

| - Drowning in water transport incidents | ((drowning OR ("near drowning")) AND (transport*) NOT australia NOT USA not US not canada NOT "new zealand" NOT france NOT sweden NOT japan) |
| - Drowning in disasters | ((drowning OR ("near drowning")) AND (disaster*) NOT australia NOT USA not US not canada NOT "new zealand" NOT france NOT sweden NOT japan) |
| Risk factors of drowning | ((drowning OR ("near drowning")) AND "risk factors") NOT australia NOT USA not US not canada NOT "new zealand" NOT france NOT sweden NOT japan |
| Prevention of drowning | ((drowning OR ("near drowning")) AND (prevent*) NOT australia NOT USA not US not canada NOT "new zealand" NOT france NOT sweden NOT japan) |
### Appendix 2. Unintentional drowning rates across LMICs

| Countries | WHO region | World Bank level of income | Number and proportion of studies (vs. all studies on mortality and morbidity of drowning) | Reported unintentional drowning rate/rates | Population included for the rate/rates reported | Provided drowning location for the rate/rates reported |
|-----------|------------|-----------------------------|--------------------------------------------------------------------------------------------|-------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Albania (Armour-Marshall et al., 2012) | Europe | Upper middle income | 1 (1.7%) | 19/100,000 | Children (aged 1-14 years) | No |
| Argentina (Lin et al., 2015b) | The Americas | Upper middle income | 1 (1.7%) | 1.3/100,000 | All ages | No |
| Armenia (Armour-Marshall et al., 2012) | Europe | Lower middle income | 1 (1.7%) | 9/100,000 | Children (aged 1-14 years) | No |
| Azerbaijan (Armour-Marshall et al., 2012) | Europe | Upper middle income | 1 (1.7%) | 10/100,000 | Children (aged 1-14 years) | No |
| Bangladesh (Abdullah & Flora, 2013; Chowdhury & Gulshan, 2016; | South-East Asia | Lower middle income | 6 (10.0%) | 104.8/100,000 | Children (aged 0-17 years) | No |
| Region        | Income Level | Rate (per 100,000) | Age Group          | Available Data                                      |
|---------------|--------------|--------------------|--------------------|----------------------------------------------------|
| Belarus       | Europe       | 2 (3.3%)           | 8.6/100,000        | All ages                                           |
|               |              |                    | 15/100,000         | Children (aged 1-14 years)                         |
| Brazil        | The Americas | 3 (5.0%)           | 3.0/100,000        | All ages                                           |
|               |              |                    | 10/100,000         |                                                   |
| Bulgaria      | Europe       | 2 (3.3%)           | 1.7/100,000        | All ages                                           |
|               |              |                    | 10/100,000         | Children (aged 1-14 years)                         |
| China         | Western Pacific | 9 (15.0%)     | 6.9/100,000        | All ages                                           |
|               |              |                    | 10/100,000         | Children (aged 0-14 years)                         |
et al., 2014; Yin et al., 2015; Zhu et al., 2015a; Zhu et al., 2015b)

| Country                  | Region          | Income Level    | Year | Case Rate | Age Group | Source Details                                                                 |
|--------------------------|-----------------|-----------------|------|-----------|-----------|-------------------------------------------------------------------------------|
| Colombia (Lin et al., 2015b) | The Americas     | Upper middle income | 1 (1.7%) | 2.2/100,000 | All ages | No                                                                            |
| Costa Rica (Lin et al., 2015b) | The Americas     | Upper middle income | 1 (1.7%) | 2.5/100,000 | All ages | No                                                                            |
| Cuba (Lin et al., 2015b)    | The Americas     | Upper middle income | 1 (1.7%) | 2.0/100,000 | All ages | No                                                                            |
| Ecuador (Lin et al., 2015b)   | The Americas     | Upper middle income | 1 (1.7%) | 3.0/100,000 | All ages | No                                                                            |
| Egypt (Halawa et al., 2015; Lin et al., 2015b) | Eastern Mediterranean | Lower middle income | 2 (3.3%) | 1.5/100,000 | All ages | No                                                                            |
| El Salvador (Lin et al., 2015b) | The Americas     | Lower middle income | 1 (1.7%) | 4.1/100,000 | All ages | No                                                                            |
| Ethiopia (Weldearegawi et al., 2013) | Africa          | Low income      | 1 (1.7%) | Not reported | No      | No                                                                            |
| Fiji (Murray & Carter, 2017) | Western Pacific | Upper middle income | 1 (1.7%) | 6.3/100,000 | All ages | Yes (river, creek, drains, ocean, ponds, swimming pools)                     |
| Europe                   |                 |                 | 2 (3.3%) | 1.2/100,000 | All ages | No                                                                            |
| Country                  | Region                | Income Level           | Cases (Percentage) | Rate/100,000 | Age Group          | Details |
|--------------------------|-----------------------|------------------------|--------------------|--------------|--------------------|---------|
| Georgia (Armour-Marshall et al., 2012; Lin et al., 2015b) | Upper middle income | 5/100,000              | Children (aged 1-14 years) |
| Guatemala (Lin et al., 2015b) | The Americas Lower middle income | 1 (1.7%) 1.0/100,000 | All ages No |
| Guinea (Mamady et al., 2012) | Africa Low income | 1 (1.7%) 4.4/100,000 | All ages No |
| Guyana (Lin et al., 2015b) | The Americas Upper middle income | 1 (1.7%) 9.2/100,000 | All ages No |
| India (Ambade et al., 2013; Arun Kumar & Prasad, 2014; Chattopadhyay et al., 2013; Jagnoor et al., 2012; Kuchewar et al., 2013; Kumar et al., 2013; Paul et al., 2013; Raghavendra Babu et al., 2012; Srinivas et al., 2012; | South-East Asia Lower middle income | 10 (16.7%) 6.4/100,000 | All ages No |
| Country                          | Region          | Income Level       | Number (%) | Rate per 100,000 | Age Group                           | Protection Area                                                                 |
|---------------------------------|-----------------|--------------------|-------------|------------------|-------------------------------------|--------------------------------------------------------------------------------|
| Iran (Samaneh et al., 2012)     | Eastern Mediterranean | Upper middle income | 1 (1.7%)   | 3.3             | All ages                            | Yes (the protected area of the sea, the unprotected area of the sea, river).     |
| Kazakhstan (Armour-Marshall et al., 2012; Lin et al., 2015b) | Europe          | Upper middle income | 2 (3.3%)    | 6.2/100,000      | All ages                            | No                                                                              |
| Kyrgyz Republic (Armour-Marshall et al., 2012; Lin et al., 2015b) | Europe          | Lower middle income | 2 (3.3%)    | 5.5/100,000      | All ages                            | No                                                                              |
| Macedonia former Yugoslav Republic (Armour-Marshall et al., 2012) | Europe          | Upper middle income | 1 (1.7%)    | 7.5/100,000      | Children (aged 1-14 years)          | No                                                                              |
| Malawi (Chasimpha et al., 2015) | Africa          | Low income         | 1 (1.7%)    | 8.6             | All ages                            | Yes (lake, rivers/streams, drain, basin).                                     |
| Country              | Region            | Income Group       | Category                      | Total Rate | Age Group                     | Study References                                                                 |
|----------------------|-------------------|--------------------|-------------------------------|------------|------------------------------|---------------------------------------------------------------------------------|
| Malaysia (Hss et al., 2014; Lin et al., 2015b) | Western Pacific | Upper middle income | 2 (3.3%)                     | 1.1/100,000 | All ages                     | No                                                                               |
|                      |                   |                    |                               |            |                              |                                                                                  |
|                      |                   |                    |                               | 3.05/100,000 | Children (aged 0-17 years)    |                                                                                  |
| Mexico (Lin et al., 2015b) | The Americas      | Upper middle income | 1 (1.7%)                     | 2.1/100,000 | All ages                     | No                                                                               |
| Moldova (Armour-Marshall et al., 2012; Lin et al., 2015b) | Europe            | Lower middle income  | 2 (3.3%)                     | 6.0/100,000 | All ages                     | No                                                                               |
| Montenegro (Armour-Marshall et al., 2012) | Europe            | Upper middle income  | 1 (1.7%)                     | 1.6/100,000 | Children (aged 1-14 years)    | No                                                                               |
| Nicaragua (Lin et al., 2015b) | The Americas      | Lower middle income  | 1 (1.7%)                     | 3.2/100,000 | All ages                     | No                                                                               |
| Nigeria (Adewole et al., 2012; Seleye-Fubara et al., 2012) | Africa            | Lower middle income  | 2 (3.3%)                     | Not reported | No                            | No                                                                               |
| Pakistan (He et al., 2015; Razzak et al., 2013; Shaikh, | Eastern Mediterranean | Lower middle income  | 5 (8.3%)                     | Not reported | No                            | No                                                                               |
| Country                          | Region              | Income Level       | Unass. Rate | All ages | Children |
|---------------------------------|---------------------|--------------------|-------------|----------|----------|
| Panama (Lin et al., 2015b)      | The Americas        | Upper middle income| 1 (1.7%)    | 3.5/100,000 | No       |
| Paraguay (Lin et al., 2015b)    | The Americas        | Upper middle income| 1 (1.7%)    | 2.2/100,000 | No       |
| Peru (Lin et al., 2015b)        | The Americas        | Upper middle income| 1 (1.7%)    | 1.7/100,000 | No       |
| Philippines (Ching et al., 2015; Guevarra et al., 2015; Martinez et al., 2016) | Western Pacific | Lower middle income| 3 (5.0%)    | 3.5/100,000 | No       |
| Romania (Armour-Marshall et al., 2012; Lin et al., 2015b) | Europe            | Upper middle income| 2 (3.3%)    | 3.9/100,000 | No       |
| Russian Federation (Armour-Marshall et al., 2012; Lin et al., 2015b) | Europe            | Upper middle income| 2 (3.3%)    | 7.1/100,000 | No       |
| Country                        | Region            | Income Level      | Age Group          | Prevalence | No. of Deaths | Methodology |
|-------------------------------|-------------------|-------------------|--------------------|------------|---------------|-------------|
| Serbia                        | Europe            | Upper middle income | 3 (5.0%)          | 1.1/100,000 | 5/100,000     | Children (aged 1-14 years) |
| South Africa                  | Africa            | Upper middle income | 4 (6.7%)          | 2.5/100,000 |               | All ages     |
| Sri Lanka                     | South-East Asia   | Lower middle income | 1 (1.7%)          | Not reported |               | No          |
| Tajikistan                    | Europe            | Lower middle income | 1 (1.7%)          | 14/100,000  |               | Children (aged 1-14 years) |
| Tanzania                      | Africa            | Low income         | 1 (1.7%)          | Not reported |               | No          |
| Thailand                      | South-East Asia   | Upper middle income | 4 (6.7%)          | 7.0/100,000  |               | All ages     |

Note: The prevalence and number of deaths are estimated based on the available data from the referenced studies.
2014; Lin et al., 2015b; Prameprart et al., 2015; Weraarchakul et al., 2012)

| Country (Reference) | Region | Income | Cases (% Total) | Prevalence | Age Group | Presence |
|---------------------|--------|--------|-----------------|------------|-----------|----------|
| Turkey (Barlas & Beji, 2016; Beydilli et al., 2017; Dirlik & Bostancioğlu, 2015; Guzel et al., 2013; Lapa et al., 2012; Lin et al., 2015b) | Europe | Upper middle income | 6 (10.0%) | 0.1/100,000 | All ages | No |
| Turkmenistan (Armour-Marshall et al., 2012) | Europe | Upper middle income | 1 (1.7%) | 37/100,000 | Children (aged 1-14 years) | No |
| Ukraine (Armour-Marshall et al., 2012; Lin et al., 2015b) | Europe | Lower middle income | 2 (3.3%) | 6.1/100,000 | All ages | No |
| Uzbekistan (Armour- | Europe | Lower middle income | 1 (1.7%) | 21/100,000 | Children (aged 1-14 years) | No |
| Source                                      | Region          | Income Level     | Incidence Rate | Age Group   | Intervention Available |
|---------------------------------------------|-----------------|------------------|----------------|--------------|------------------------|
| Marshall et al., 2012                       | The Americas    | Upper middle     | 1 (1.7%)       | All ages     | No                     |
| Venezuela (Lin et al., 2015b)               |                 |                  | 2.1/100,000    |              |                        |
### Appendix 3. Studies on risk factors of unintentional drowning in LMICs

| Socio-demographic characteristic | Risk factors investigated | Relative Risk/Odds Ratio (95% CI) |
|--------------------------------|--------------------------|----------------------------------|
| **Age**                        | Age 55 years and above: OR 3.0 (1.7–6.0) *(p<0.001)* (Ching et al., 2015)  
Aged less than 5 years: OR 2.9 (1.9–3.1) *(p<0.05)* (Hossain et al., 2015)  
Older age OR 0.9 (0.9–1.0) *(p<0.01)* (Zhu et al., 2015b) |
| **Gender**                     | Male: OR 1.5 (1.3–1.8) *(p<0.05)* (Hossain et al., 2015) |
| **Mother’s educational level** | Up to grade 5 OR 0.2 (0.6–1.3), grade 6–10: 0.1 (0.02–0.3), above grade 10: 0.2 (0.04–1.0) *(p<0.001)* (Abdullah & Flora, 2013)  
Illiterate: OR 1.7 (1.0–2.8) *(p<0.05)* (Hossain et al., 2015) |
| **Mother’s age**               | Aged 25–29 years OR: 0.2 (0.1–0.5), 30–34 years 0.1 (0.1–0.3), and ≥ 35 years 0.02 (0.00–0.1) *(p<0.001)* (Abdullah & Flora, 2013) |
| **Father’s educational level** | Up to grade 5: OR 1.2 (0.6–2.6), grade 6–10: 1.3 (0.5–3.6), above grade 10: 0.6 (0.2–2.4) *(p<0.001)* (Abdullah & Flora, 2013) |
| **Father’s occupation**        | *p>0.05* (Abdullah & Flora, 2013) |
| **Parent’s marital status**    | Single mother OR 9.2 (2.3–37.2) *(p<0.001)* (Abdullah & Flora, 2013) |
| **Number of children**         | Three children OR 3.7 (1.6–8.5), more than 3 children 19.6 (6.6–58.4) *(p<0.001)* (Abdullah & Flora, 2013) |
| **Family expenditure (monthly)** | $US 60–120: OR 0.4 (0.2–1.0), $US 0.4 (0.1–1.7) *(p<0.001)* (Abdullah & Flora, 2013) |
| **Socioeconomic status**       | Poor OR 1.8 (0.6–5.2) *(p<0.001)* (Abdullah & Flora, 2013) |
| Child-care practices | Main caregiver | Parental supervisory behaviour | Childcare index | Swimming ability |
|---------------------|----------------|-------------------------------|-----------------|-----------------|
| Living in urban or rural areas | Wealthy OR 0.7 (0.6-0.9) ($p$<0.05) (Fang et al., 2014) | Living in urban areas and poor: OR 2.8 (0.9-8.6) ($p$<0.10) (Chowdhury & Gulshan, 2016) | Urban OR 0.7 (0.7–1.9) ($p$<0.05) (Hossain et al., 2015) | Cannot swim: OR 3.5 (1.9–6.5) ($p$<0.001) (Ching et al., 2015) |
| Child’s attendant | $p$>0.05 (Abdullah & Flora, 2013) | Others than mother/caregiver: OR 25.4 (14.4–45.3) ($p$<0.05) (Hossain et al., 2015) | Parents accompany child to school OR 0.7 (0.5-0.9) ($p$<0.05) (Zhu et al., 2015b) | Cannot swim: OR 4.5 (1.3–19.4) ($p$<0.05) (Hossain et al., 2015) |
| Parental supervisory behaviour | Anchal participants (intervention to increase supervision): RR 0.2 (0.1–0.6) ($p$< 0.05) (Rahman et al., 2012) | Second quartile: OR 0.5 (0.2–1.6), third quartile: 0.3 (0.1–1.0), fourth quartile: 0.2 (0.1–0.8) ($p$<0.001) (Abdullah & Flora, 2013) | SwimSafe participants (training for basic swimming, water safety, and safe rescue skills: RR 0.1 (0.02–0.3) ($p$<0.05) (Rahman et al., 2012) | SwimSafe participants (training for basic swimming, water safety, and safe rescue skills: RR 0.1 (0.02–0.3) ($p$<0.05) (Rahman et al., 2012) |
### Evacuation practices
- Exiting house during storm surge: OR 3.6 (1.9–6.8) (p<0.001) (Ching et al., 2015)
- Did not evacuate home before storm: 21.0 (5.6–132.7) (p<0.001) (Ching et al., 2015)
- Did not evacuate to the designated evacuation centre: 10.0 (3.8–29.1) (p<0.001) (Ching et al., 2015)

### Rescue skills
- Being a first rescuer OR 0.4 (0.2–0.9) (Zhu et al., 2015a)

### Intention to save others if they are drowning
- Yes OR 1.3 (1.0-1.6) (p<0.05) (Zhu et al., 2015b)

### Perceived vulnerability of swimming alone
- Yes OR 0.7 (0.5-1.0) (p<0.05) (Zhu et al., 2015b)

### Knowledge on drowning prevention
- OR 1.0 (0.98-0.99) (p<0.01) (Zhu et al., 2015b)

### The use of floatation device (in the water in the previous year)
- No OR 1.8 (1.4-2.3) (p<0.01) (Zhu et al., 2015b)

### Environmental factors
- **Home injury hazards**
  - No water source around the house OR 1.0 (0.4–2.4) (p<0.005) (Abdullah & Flora, 2013)

- **Living 45-48in close proximity with water bodies**
  - Living within 50 metres from sea/ocean: OR 3.9 (2.1–7.3) (p<0.001) (Ching et al., 2015)
  - Residing in riverbanks: OR 2.8 (1.6-4.9) (p<0.01) (Chowdhury & Gulshan, 2016)
### Meteorological and oceanographic factors

| Risky behaviour | Underlying medical conditions | Relative humidity OR 0.9 (0.9-1.0) ($p<0.001$) (Beydilli et al., 2017) | Dived into unknown water without supervision OR 2.0 (1.3-3.0) ($p<0.01$) (Zhu et al., 2015b) |
|-----------------|-------------------------------|-------------------------------------------------|-------------------------------------------------|
| Personality type | History of epilepsy | Being introvert: OR 1.8 (1.2-2.6) ($p<0.05$) (Zhu et al., 2015b) | RR 12.6 (7.7–20.7) ($p<0.0001$) (Mateen et al., 2012) |