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

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

Cover Page Footnote

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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-Sapir 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 & Vähätalo, 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 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 (Plitponkarnpim & 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 Meditteranean, 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

Search Strategy

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

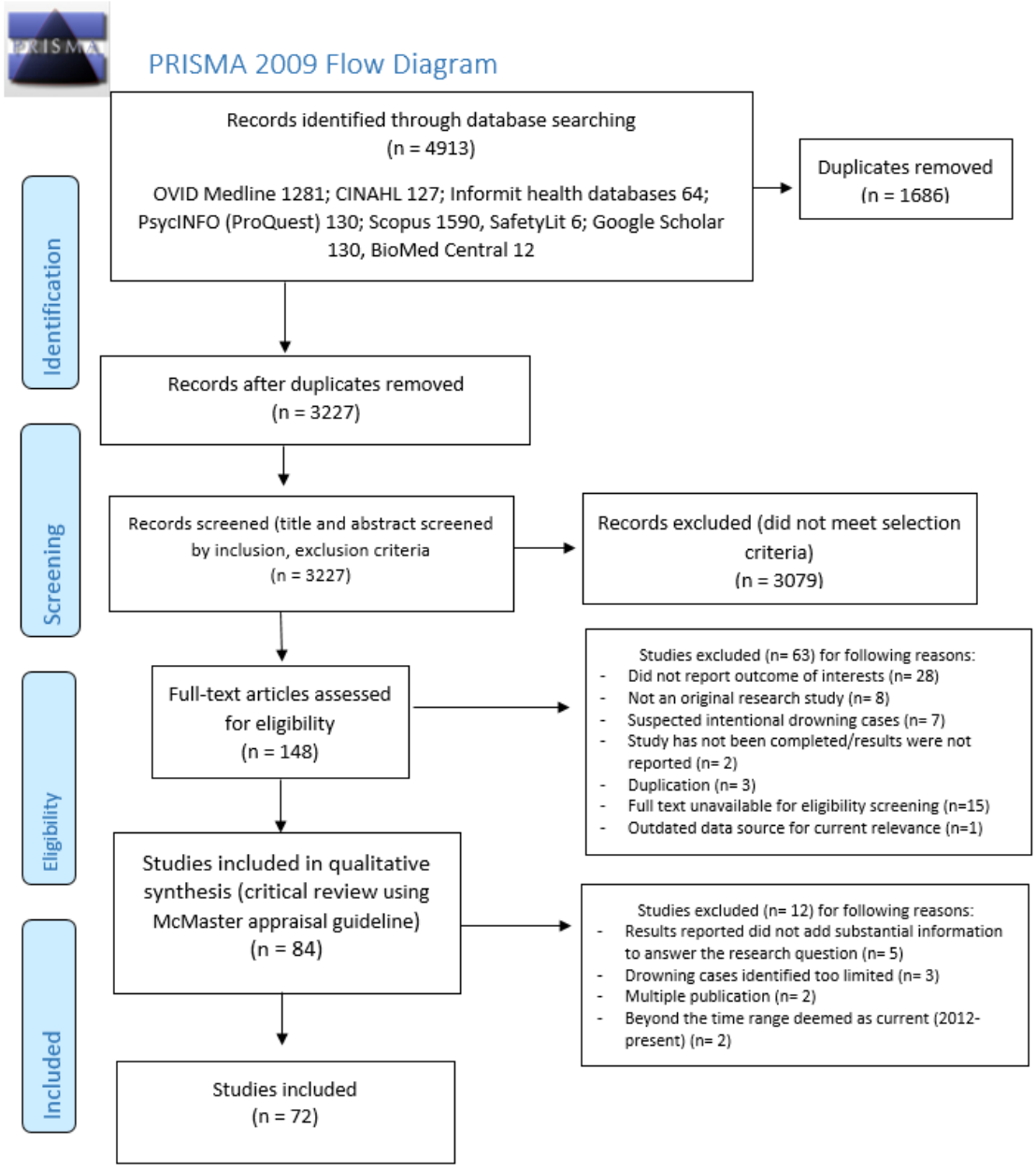
The following data were abstracted from the studies: authors, year of study and publication, country and region, data source, study design, scale of study, manner of drowning cases, relevant findings on the mortality and morbidity rate, risk factors, and prevention of drowning. The classification of 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 • Peer-reviewed journal articles • Original research paper • 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	• Non peer-reviewed journal articles, other types of publications • Comprehensive scientific reviews, meta-analysis, statements of clinical standards, case reports, opinion pieces • Only includes intentional drowning cases, without investigating unintentional drowning incidents

Figure 1

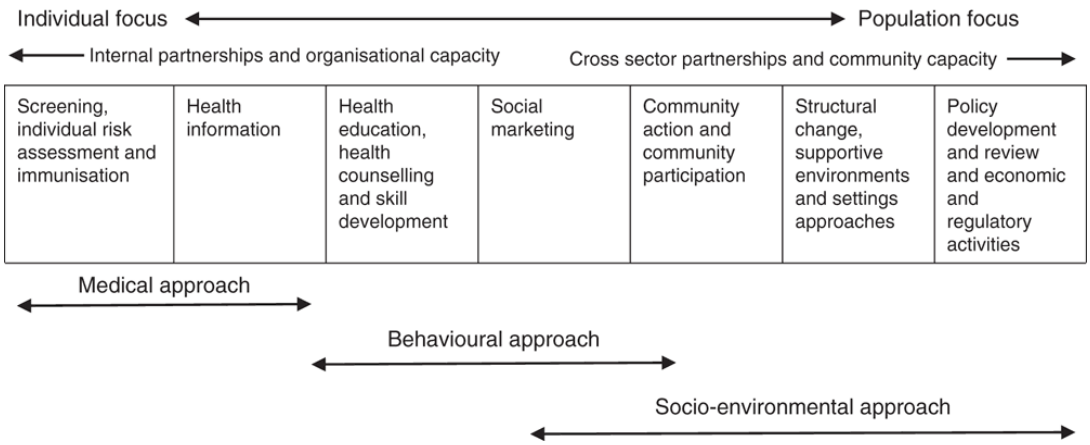
PRISMA flow diagram of the study selection process



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; Chattopadhyay 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; Thakar & 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; 2016; 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					The proportion of epidemiological studies			
					Epidemi-ology	Risk factors	Preven-tion	Total	Proportion of studies in review (%)	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			60	25	10			32 (53.3%)	35 (58.3%)	16 (26.7%)	5 (8.3%)

World Bank's income groups													
Low income	31	4	12.9	7.7	4	1	0	5	5.3	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

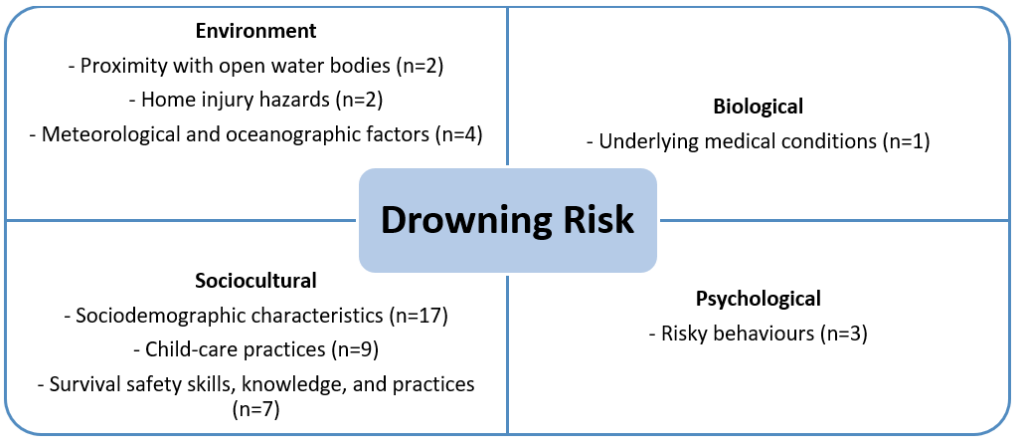
Data Source	Number of studies
Primary data	
Health/demographic surveillance data	14
Police/fire department/ambulance service records	7
Emergency Department records	4
Hospital admission records	1
Death registry	6
Medico-legal/autopsy records	12
Survey data	6
Injury surveillance system	3
Online news	5
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

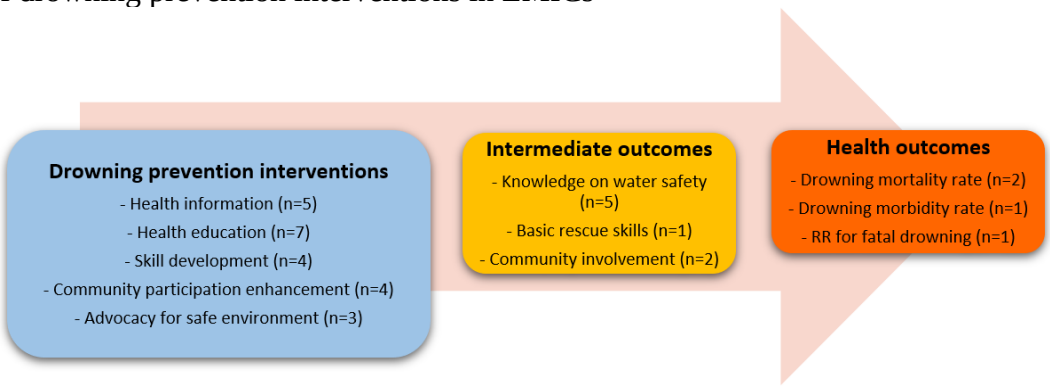


Table 5
The relationships among preventive interventions investigated and health promotion

Study	Population investigated	Study design	Intervention method	Prevention aspect investigated in relation to Health Promotion Framework			Relevant findings
				Medical/ Individual approach	Behavioural approach	Socio-environmental approach	
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

						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

Rahman et al., 2012	Households	Retrospective cohort study	Health education, training on basic swimming, water safety, and safe rescue skills	HI	HE, SD	CP	RR for a drowning death was significantly lower in the exposed group
							Very cost effective (based on World Health Organization criteria)
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
							Community participation improved
Shen et al., 2015	Children	RCT	Drowning prevention video	HI			Significantly improved safety knowledge in the intervention group

					No significant difference on perceived vulnerability between the interventions and controls
Silva et al., 2016	Mothers	Quasi-experimental study	Educational programme	HE	Significant difference on the knowledge on drowning prevention
Solomon et al., 2013	Primary school children	One group, pre-test, post-test study design)	Educational programme	HE	Significant increase on water safety knowledge
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 Quangdong 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; Stempski et al., 2015; Stokols, 1992; Talbot & Verrinder, 2014; World Health Organization Regional Office for the Eastern Meditteranean, 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.(Rahman et al., 2012) 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.

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Appendix 1. Database searching

Databases	Aspects investigated	Search strings
Ovid MEDLINE	Epidemiology of drowning	exp Drowning/ep, mo [Epidemiology, Mortality] OR exp Near Drowning/ep, mo [Epidemiology, Mortality] Note: other similar search string brought more limited results - exp Drowning OR exp Near Drowning) AND exp epidemiology
	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/ OR exp Near Drowning/) AND exp Risk Factors/
	Prevention of drowning	exp Drowning/pc [Prevention & Control] OR exp Near Drowning/pc [Prevention & Control] Note: other similar search strings brought more limited results: - Drowning/pc [Prevention & Control] OR Near Drowning/pc [Prevention & Control] - Drowning/pc [Prevention & Control] OR Near Drowning/pc [Prevention & Control]) AND exp Preventive Health Services - exp Drowning OR exp Near Drowning) AND exp Preventive Health Services
CINAHL	Epidemiology of drowning	((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"))

	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"

	- Drowning in disasters	allintitle: drowning AND "disaster"
	Risk factors of drowning	allintitle: drowning AND "risk factors"
	Prevention of drowning	allintitle: drowning AND "prevention"
BioMed Central	Epidemiology of drowning Including:	((drowning OR (“near drowning”)) AND epidemiology) NOT australia NOT USA not US not canada NOT "new zealand" NOT france NOT sweden NOT japan
	- 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

Hanifi et al., 2014; Hossain et al., 2015; Mateen et al., 2012; Mecrow et al., 2015)						
Belarus (Armour-Marshall et al., 2012; Lin et al., 2015b)	Europe	Upper middle income	2 (3.3%)	8.6/100,000 15/100,000	All ages Children (aged 1-14 years)	No
Brazil (Lin et al., 2015b; Martins & de Mello-Jorge, 2013; Pereira et al., 2013)	The Americas	Upper middle income	3 (5.0%)	3.0/100,000	All ages	No
Bulgaria (Armour-Marshall et al., 2012; Lin et al., 2015b)	Europe	Upper middle income	2 (3.3%)	1.7/100,000 10/100,000	All ages Children (aged 1-14 years)	No
China (Fang et al., 2014; Lili et al., 2017; Lin et al., 2016; Liu et al., 2012; Shenet al., 2015; Wang	Western Pacific	Upper middle income	9 (15.0%)	6.9/100,000 10/100,000	All ages Children (aged 0-14 years)	No

et al., 2014; Yin et al., 2015; Zhu et al., 2015a; Zhu et al., 2015b)						
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

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

Thakar & Guleria, 2015)						
Iran (Samaneh et al., 2012)	Eastern Mediterranean	Upper middle income	1 (1.7%)	3.3 per 100,000	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 25/100,000	All ages Children (aged 1-14 years)	No
Kyrgyz Republic (Armour-Marshall et al., 2012; Lin et al., 2015b)	Europe	Lower middle income	2 (3.3%)	5.5/100,000 24/100,000	All ages Children (aged 1-14 years)	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 per 100,000	All ages	Yes (lake, rivers/streams, drain, basin)

Malaysia (Hss et al., 2014; Lin et al., 2015b)	Western Pacific	Upper middle income	2 (3.3%)	1.1/100,000 3.05/100,000	All ages Children (aged 0-17 years)	No
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 17.5/100,000	All ages Children (aged 1-14 years)	No
Montenegro (Armour-Marshall et al., 2012)	Europe	Upper middle income	1 (1.7%)	1.6/100.000 (as cumulative rate of South East Europe region)	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

2014, 2016; Sultana et al., 2016)						
Panama (Lin et al., 2015b)	The Americas	Upper middle income	1 (1.7%)	3.5/100,000	All ages	No
Paraguay (Lin et al., 2015b)	The Americas	Upper middle income	1 (1.7%)	2.2/100,000	All ages	No
Peru (Lin et al., 2015b)	The Americas	Upper middle income	1 (1.7%)	1.7/100,000	All ages	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	All ages	No
Romania (Armour-Marshall et al., 2012; Lin et al., 2015b)	Europe	Upper middle income	2 (3.3%)	3.9/100,000 15/100,000	All ages Children (aged 1-14 years)	No
Russian Federation (Armour-Marshall et al., 2012; Lin et al., 2015b)	Europe	Upper middle income	2 (3.3%)	7.1/100,000 23/100,000	All ages Children (aged 1-14 years)	No

Serbia (Armour-Marshall et al., 2012; Lin et al., 2015b; Radosavljevic et al., 2017)	Europe	Upper middle income	3 (5.0%)	1.1/100,000 5/100,000	All ages Children (aged 1-14 years)	No
South Africa (Donson & Van Niekerk, 2013; Lin et al., 2015b; Morris et al., 2016; Pretorius & Van Niekerk, 2015)	Africa	Upper middle income	4 (6.7%)	2.5/100,000	All ages	No
Sri Lanka (Kitulwatte & Edirisinghe, 2014)	South-East Asia	Lower middle income	1 (1.7%)	Not reported	No	No
Tajikistan (Armour-Marshall et al., 2012)	Europe	Lower middle income	1 (1.7%)	14/100,000	Children (aged 1-14 years)	No
Tanzania (Ae-Ngibise et al., 2012)	Africa	Low income	1 (1.7%)	Not reported	No	No
Thailand (Laosee et al.,	South-East Asia	Upper middle income	4 (6.7%)	7.0/100,000	All ages	No

2014; Lin et al., 2015b; Prameprart et al., 2015; Weraarchakul et al., 2012)						
Turkey (Barlas & Beji, 2016; Beydilli et al., 2017; Dirlik & Bostancıoğlu, 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 19/100,000	All ages Children (aged 1-14 years)	No
Uzbekistan (Armour-	Europe	Lower middle income	1 (1.7%)	21/100,000	Children (aged 1-14 years)	No

Marshall et al., 2012)						
Venezuela (Lin et al., 2015b)	The Americas	Upper middle income	1 (1.7%)	2.1/100,000	All ages	No

Appendix 3. Studies on risk factors of unintentional drowning in LMICs

Risk factors investigated		Relative Risk/Odds Ratio (95% CI)
Socio-demographic characteristic	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)

		Wealthy OR 0.7 (0.6-0.9) (p<0.05) (Fang et al., 2014)
	Living in urban or rural areas	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)
Child-care practices	Main caregiver	Mother OR 5.7 (1.0–33.0) (p<0.001) (Abdullah & Flora, 2013)
	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)
	Parental supervisory behaviour	Anchal participants (intervention to increase supervision): RR 0.2 (0.1–0.6) (p< 0.05) (Rahman et al., 2012)
	Childcare index	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)
Survival skills, knowledge, and practice	Swimming ability	Cannot swim: OR 3.5 (1.9–6.5) (p<0.001) (Ching et al., 2015) Cannot swim: OR 4.5 (1.3–19.4) (p<0.05) (Hossain et al., 2015) 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	Relative humidity OR 0.9 (0.9-1.0) (p<0.001) (Beydilli et al., 2017)
Risky behaviour	Dived into unknown water without supervision	OR 2.0 (1.3-3.0) (p<0.01) (Zhu et al., 2015b)
	Personality type	Being introvert: OR 1.8 (1.2-2.6) (p<0.05) (Zhu et al., 2015b)
Underlying medical conditions	History of epilepsy	RR 12.6 (7.7–20.7) (p<0.0001) (Mateen et al., 2012)