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REVIEW

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A quest for an integrated management system of children following a drowning incident: A review of the literature

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Abstract

Purpose: Management of children following a drowning incident is based on specific interventions which are used in the prehospital environment, the emergency department (ED) and the Paediatric Intensive Care Unit (PICU). This paper presents a review of the literature to map and describe the management and interventions used by healthcare professionals when managing a child following a drowning incident. Of specific interest was to map, synthesise and describe the management and interventions according to the different clinical domains or practice areas of healthcare professionals.

Design and Methods: A traditional review of the literature was performed to appraise, map and describe information from 32 relevant articles. Four electronic databases were searched using search strings and the Boolean operators AND as well as OR. The included articles were all published in English between 2010 and 2022, as it comprised a timeline including current guidelines and practices necessary to describe management and interventions.

Results: Concepts and phrases from the literature were used as headings to form a picture or overview of the interventions used for managing a child following a drowning incident. Information extracted from the literature was mapped under management and interventions for prehospital, the ED and the PICU and a figure was constructed to display the findings. It was evident from the literature that management and interventions are well researched, evidence-informed and discussed, but no clear arguments or examples could be found to link the interventions for integrated management from the scene of drowning through to the PICU. Cooling and/or rewarming techniques and approaches and termination of resuscitation were found to be discussed as interventions, but no evidence of integration from prehospital to the ED and beyond was found. The review also highlighted the absence of parental involvement in the management of children following a drowning incident.

Practice Implications: Mapping the literature enables visualisation of management and interventions used for children following a drowning incident. Integration of these interventions can collaboratively be done by involving the healthcare practitioners to form a link or chain for integrated management from the scene of drowning through to the PICU.

KEYWORDS

child drowning, children, emergency department management, management of child drowning, paediatric, Paediatric Intensive Care Unit management, prehospital management, traditional review

WHAT IS CURRENTLY KNOWN?

Interventions and management of children following a drowning incident is focused on the prevention of the consequences of acidosis, hypoxia and hypercapnia resulting from respiratory inadequacy, hypothermia and cardiac arrest. These interventions and management strategies are clustered in clinical domains namely the prehospital environment, in the emergency department and the Paediatric Intensive Care Unit. This approach result in excellent care, but provided in silos or pockets of interventions with no evidence of integration of activities.

WHAT DOES THIS ARTICLE ADD?

A summary of the latest interventions used in the management of children following a drowning incident was drafted. The results depicted the interventions used in the different clinical domains and but no link or interrelationships between the interventions and the different domains could be found for mapping. The findings will enable organisation of interventions to present to health care practioners to assist in coconstructing an integrated management system for children following a drowning incident.

1 | INTRODUCTION

Drowning is regarded as a process which involves respiratory impairment that prevents breathing of air after immersion or submersion in a liquid (Van Beeck et al., 2005; Idris et al., 2003; Matthew et al., 2017). Immersion refers to a state where the head is up and out of the water or liquid, but the body is submerged—this may lead to aspiration of the liquid when it splashes over the face and result in drowning (Idris et al., 2017). Submersion is viewed as the most important aspect of drowning and occurs when the head and face of the child are underwater, the water (liquid) covers the nose and mouth and air is prevented from entering the lungs (Idris et al., 2017). Drowning outcomes can be fatal and result in death, nonfatal without morbidity (Szpilman et al., 2021; Thom et al., 2021) or with morbidity which is usually seen after survival and normally associated with permanent neurological impairment (Koon et al., 2021). In view of Idris et al. (2017), one should view drowning as a process if a child is involved in a drowning incident, irrespective of the drowning outcomes (World Health Organization [WHO], 2020).

Drowning accounts for 7% of all injury-related deaths and grades as the third leading cause of unintentional injury death worldwide (WHO, 2020). In children, drowning remains a global health concern as it is positioned as the number 5 cause of mortality in the age group 1–14 years (Cantwell, 2021; Schmidt et al., 2019). In South Africa, a low- and middle-income country, drowning accounts to more than 90% of unintentional drowning deaths, especially among children aged 1–4 years (Fortuin et al., 2022; Schmidt et al., 2019), followed by the age groups 5–9 years (WHO, 2020). Gauteng, the smallest of the nine provinces of South Africa, is an urban, highly-populated inland province that accounts for the third highest number of childhood drownings (Fortuin et al., 2022). This province is characterised by high levels of poverty, large areas of informal settlements, unemployment and social exclusion (GCRO, 2023). Childhood drownings in this province occur as fresh water drownings in dams, ditches, gully holes, mineshafts, stormwater pipes, streams, buckets or drums of water, septic tanks and toilets (Fortuin et al., 2022). Associated with unemployment and poverty in this province is the misuse of alcohol by parents and adults, which result in inadequate supervision of young children and the increased risk for drowning (Fortuin et al., 2022).

Following a drowning incident, children are usually managed at the scene of drowning, the emergency department (ED) and the Paediatric Intensive Care Unit (PICU). Understanding the drowning process and related pathophysiology provide a rationale for the management, treatment strategies and interventions that are followed when the child is managed following the drowning incident (Cantwell, 2021; Parenteau et al., 2018). Clear guidelines and protocols exist that directs postdrowning management in the different clinical areas (Cantwell, 2021; Parenteau et al., 2018; Widyantara et al., 2019) as well as clinical pathways for interventions, and managing the effects of the pathophysiological process of drowning (Kritz et al., 2018; Parenteau et al., 2018). However, after

exploring the above-mentioned guidelines, protocols and pathways, it was evident that silos or pockets in care approaches exist in the different clinical areas, the parents or family's inclusion during management is not clearly demarcated, and nor is withdrawing or withholding life sustaining treatment clearly linked between the different clinical areas.

There was a need to evaluate the management of the child postdrowning, focus on the interventions which are used in the different clinical areas and integrate these contextual interventions into an integrated management system to follow from the scene of drowning through to the PICU. The following section focuses on the process of drowning after submersion in water.

2 | THE PROCESS OF DROWNING

Drowning can occur at different aquatic scenes which include natural bodies of water such as coastal areas, ponds, lakes, quarries, rivers (Schmidt et al., 2019) and manmade sources including bathtubs, buckets, swimming pools and toilets (Idris et al., 2003). The salinity or osmotic gradient of the aspirated water is of little concern when focusing on the process of drowning (Van Beeck et al., 2005; Cantwell, 2021), although aspiration of heavy contaminated sources of water might result in chemical pneumonitis (McCallin et al., 2021) and other subsequent complications such as early onset postdrowning pneumonia (Thom et al., 2021) and sepsis (McCallin et al., 2021).

Drowning can occur in either cold or warm water (Cantwell, 2021; Schmidt et al., 2019). Household drownings happen in water with temperatures of 20°C and above while cold water drowning takes place in water temperatures less than 20°C (Cantwell, 2021). Water is thermally neutral for humans at temperatures of about 33–35°C (Bierens et al., 2016; Schmidt et al., 2019) to allow for a physiological balance between heat loss and heat production (Bierens et al., 2016). Although Cantwell (2021) is of opinion that it is necessary to find out what the temperature of the water was, conductive heat loss that occur during submersion overturn this view, as hypothermia is normally the outcome of drowning incidents, irrespective the temperature of the water. Evidence include that lower water temperatures do not necessarily have greater neuroprotective possibilities-better drowning outcomes relate to the sequence of the drowning event and the duration of submission and not necessarily the degree of cooling (Cantwell, 2021; Davidoff, 2021; Singer, 2021; Tipton & Montgomery, 2022). Because children have larger surface areas in relation to body volume ratios and limited subcutaneous body fat, cooling occurs quickly after cold-water submersion. Due to decreased breath-holding ability, aspiration occurs earlier during cold-water drowning which can further contribute to the cooling process (Bauman et al., 2021). Hypothermia may be an indication of extended submersion duration or a prolonged period of cardiac arrest (Szpilman et al., 2021). Hypothermia can be graded as mild, with a core body temperature less than 35°C, moderate between 30°C and 32°C, or severe when core body temperature is less than 30°C (Bauman et al., 2021). Hypothermia depresses the release of adrenaline and noradrenaline that results in a fall in endogenous production of insulin, inhibits the glucose carrier mechanism of the cell membrane and reduces glucose utilisation with resulting hyperglycaemia as consequence (Bierens et al., 2016). It, therefore, has become practice to continue resuscitation until the child achieve a core body temperature of 32–34°C (Kieboom et al., 2015).

Irrespective of the water temperature, submersion and consequently drowning is regarded as a process that is characterised by particular sequences on a continuum (Szpilman et al., 2021). Due to the sequence of events, drowning can be described according to a timeline that refers to the pathophysiologic changes which are experienced during the drowning process (Szpilman et al., 2021). The drowning event starts with fluid that initially enters the mouth and oropharynx, followed by an attempt to clear the airway which lasts for approximately 20–30 s and then followed by a period of conscious breath holding (Mott & Latimer, 2016; Szpilman et al., 2021; Widyantara et al., 2019). During the period of voluntary breath holding, which can last up to 60 s, the presence of fluid in the oropharynx and larynx triggers laryngospasm that causes a disability to breathe in air and results in oxygen depletion and carbon dioxide retention (Cantwell, 2021). The internal respiratory drive to breath together with a fall in arterial oxygen tension in the blood decreases the laryngospasm and the child will gasp, hyperventilate, inhale and aspirate fluid that contribute to further hypoxia (Cantwell, 2021; Mott & Latimer, 2016; Widyantara et al., 2019). Finally decreased lung compliance occurs with areas of very low to zero ventilation-perfusion, atelectasis, intrapulmonary shunting and acute lung injury (Cantwell, 2021; Widyantara et al., 2019). Aspiration of water into the lungs is followed by wash out and damage to surfactant that disrupts the alveolar capillary membrane and lead to alveolar oedema to develop, which further contributes to local acute respiratory distress syndrome (Widyantara et al., 2019). Hypoxaemia leads to acidotic changes in the acid–base balance and hypercarbia, loss of consciousness, apnoea and cardiac arrest follow. Prevention of hypoxia is therefore fundamental to prevent neurological and cardiorespiratory complications (Şik et al., 2021).

Drowning also results in severe cerebral hypoxia and anoxia with ischaemic brain injury that has an extensive effect on normal brain function and the central nervous system. The hypoxic-anoxic brain injuries are responsible for the neurological sequelae associated with drowning survival and are in most children irreversible, especially when rescue occurred after 4–6 min of submersion and prolonged cerebral hypoxia or ischaemia was present (Cantwell, 2021). Some of the neurological sequelae associated with ischaemic brain injury after drowning survival includes the development of seizures, autonomic instability manifesting as sympathetic nervous system hyperstimulation with tachycardia, hypertension, diaphoresis, agitation and muscle rigidity, ataxia, dysarthria and tetraplegia, learning difficulties and memory deficits (Cantwell, 2021; Nucci et al., 2017; Widyantara et al., 2019).

Limited evidence is available that reflect on the survival outcomes of children following a drowning incident (Ballestin

et al., 2021). Prognostic factors that project poor outcomes include children younger than 3 years of age, submersion duration longer than 5 min, delay longer than 10 min to start basic cardiopulmonary resuscitation (CPR), duration of resuscitation exceeding 20–25 min without return of spontaneous circulation, a Glasgow Coma score of 5 or less, persistent apnoea that requires CPR on hospital admission, an arterial blood pH of less than 7.10 on admission, need for the use of intravenous epinephrine at the scene of drowning and hyperglycaemia on admission (Davidoff, 2021; Salas Ballestín et al., 2021). The most robust factor that predict more favourable survival outcomes, according to Quan et al. (2016), is shorter submersion duration times as submersion duration seems to have biological credibility as the most direct indicator of anoxic injury of drowning according to Salas Ballestín et al. (2021).

In summary, drowning is the result of primary respiratory impairment following submersion in water, breath-holding and laryngospasm that results in hypercapnia, hypoxia and respiratory or cardiorespiratory arrest, if the process is prolonged (Salas Ballestín et al., 2021). Denny et al. (2019) state that the drowning process occurs on a continuum that can be interrupted by rescue at any point during the process and will result in a variety of sequelae from no symptoms to fatality.

A review of the literature was undertaken to appraise, map, group and describe the current health care practices and interventions used for the management of children following a drowning incident in the prehospital environment, the ED and the PICU. The research question that guided the review, was: What are the current practices find in literature that describe the management of children following a drowning incident? After mapping these findings the practices regarding management and interventions used in the different clinical areas were highlighted in Figure 1 to draw associations between management and interventions used for the management of children following a drowning incident.

3 | METHODS

A traditional review of the literature was conducted to appraise, describe and reflect on findings of previous research (Li & Wang, 2018) that focused on the management of children following a drowning incident. The initial search for relevant literature was conducted in October 2020. Four electronic databases were used, namely CINAHL, EBSCO, Science Direct and Web of Science. An information specialist of the University of Pretoria, South Africa was consulted to confirm that the search strings that were used, were focused enough to collect all relevant data. The information specialist also assisted in a combined search to narrow the specific articles required. A fourth and final search was conducted in the World Discovery data base to ensure that all relevant literature was searched and included. The search strings included management of a child after drowning and main concepts such as prehospital, scene of drowning, ED and PICU were included. The Boolean operators AND as well as OR were used to combine or separate concepts and key terms during the searches to ensure that all relevant literature were searched and included. Only articles published in English from 2010 were selected and reviewed. A 10-year time frame from 2010 to 2020 was deemed appropriate to search, extract and describe the current practices used by healthcare professionals when managing children following a drowning incident. Thesis and dissertations were excluded, but other grey literature was included. Primary citations were traced to original publications and included. Table 1 provides an overview of the strings that were used during the searches.

TABLE 1 Overview of search strings.

'management of children after drowning' OR 'managing child drowning'
AND
'prehospital' OR 'emergency department' OR emergency room' OR Paediatric Intensive Care Unit'
AND
'guidelines' OR 'policies' OR 'manuals'
AND
'interventions' OR 'strategies'

The researcher (primary author) conducted a secondary and broader search in Google Scholar in February 2022 with a time limit on publications from 2019 to 2022. Search keywords used were 'child drowning' OR 'management of child drowning' AND 'prehospital' OR 'emergency department' OR 'Pediatric Intensive Care' OR 'interventions'. The researcher reviewed all the articles. Only primary studies/research were selected and all articles that did not have a central focus on the management of children after drowning, were excluded.

3.1 | Process of review

The researcher developed a table with three columns that indicated prehospital, the ED and the PICU. Each article was then appraised for management and associated interventions that were discussed and findings were mapped in the appropriate column with the citation bracketed as a number. The use of a number ensured that tracking and listing could be done (Table 2). The citation lists of the selected articles were also scanned for possible original research that could be used as cross referencing. After mapping the articles under the respective headings, the researcher reviewed each one of the identified characteristics and developed a figure of the particular interventions to be included in the discussion of the management of children following a drowning incident (Figure 1). The researcher and C.M.M. independently screened the abstracts by title for inclusion or exclusion. A consultation meeting was held with C.M.M. and consensus was reached about the articles that were selected for inclusion.

TABLE 2 Articles cited as numbers to map management of and interventions used for children after a drowning incident for constructing Figure 1.

Number	Authors	Year of publication	Country	Design of the study
[1]	World Health Organization	(2020)	Switzerland	Report
[2]	Cantwell, G. P.	(2021)	United States of America	Review of clinical guidelines
[3]	Schmidt, A. C., Sempsrott, J. R., Hawkins, S. C., Arastu, A. S., Cushing, T. A., & Auerbach, P. S.	(2019)	United States of America	Consensus
[4]	Idris, A. H., Berg, R. A., Bierens, J., Bossaert, L., Branche, C. M., Gabrielli, A, Graves, S. A., Handley, A. J., Hoelle, R., Papa, L., Pepe, P. E., Quan, L., Szpilman, D., Wigginton, J. G., Modell, J. H., other contributors, Atkins, D., Gay, M., Kloeck, P. W., & Timmerman, S.	(2003)	United States of America	Consensus
[5]	Van Beeck, E. F., Branche, C. M., Szpilman, D., Modell, J. H., & Bierens, J. J. L.	(2005)	The Netherlands	Consensus
[6]	Matthew, J., Robertson, C., & Hofmeyr, R.	(2017)	South Africa	Review article
[7]	Mott, T. F., & Latimer, K. M.	(2016)	United States of America	Review article
[8]	Widyantara, W., Faridi, M. S., Ariswanda, I. G. A. G., & Widyadharma, I. P. E.	(2019)	Indonesia	Review article
[9]	Grmec, Š., Strnad, M., & Podgoršek, D.	(2009)	Slovenia	Retrospective comparative study
[10]	Nucci, M. P., Lukasova, K., Sato, J. R., & Amaro, E.	(2017)	Brazil	Retrospective comparative study
[11]	Denny, S. A., Quan, L., Gilchrist, J., McCallin, T., Shenoi R., Shabana, Y., Hoffman, B., Weiss, J., and Council on Injury, Violence, and Poison Prevention.	(2019)	United States of America	Consensus
[12]	Macintosh, I., & Austin, S.	(2017)	United Kingdom	Symposium presentation
[13]	Parenteau, M., Stockinger, Z., Hughes, S., Hickey, B., Mucciarone, J., Manganello, C., and Beeghly, A.	(2018)	United States of America	Clinical practice guidelines
[14]	Best, R. R., Harris, H. L., Walsh, J. L., & Manfield, T. M.	(2020)	United Kingdom	Literature review and Standing Operating Procedure
[15]	Topjian, A. A., Berg, R. A., Bierens, J. J. L. M., Branche, C. M., Clark, R. S., Friberg, H., Hoedemaekers, C. W. E., Holzer, M., Katz, L. M., Knape, J. T. A., Kochanek, P.M., Nadkarni, V., van der Hoeven, J. G., & Warner, D. S.	(2012)	United States of America	Consensus
[16]	Semple-Hess, J., Campwala, R., Quan, L., & Waltzman, M.	(2014)	United States of America	Review
[17]	De Villiers, F. P. R.	(2008)	South Africa	Practice guidelines
[18]	Jan, M. M.	(2013)	Saudi Arabia	Review article
[19]	Moore Shepherd, S.	(2011)	United Kingdom	Guidelines
[20]	Calvello, E., Reynolds, T., Hirshon, J. M., Buckle, C., Moresky, R., O'Neill, J., and Wallis, L. A.	(2013)	United States of America	Consensus
[21]	Kritz, D., Piantino, J., Fields, D., and Williams, C.	(2018)	United States of America	Case report and literature review
[22]	Curtis, K., Foster, K., Mitchell, R., and Van, C.	(2016)	Australia	Integrative review
[23]	Zuckerbraun, N. S., and Saladino, R. A.	(2005)	United States of America	Review article

(Continues)

TABLE 2 (Continued)

Number	Authors	Year of publication	Country	Design of the study
[24]	Steward, C.	(2006)	United States of America	Literature review
[25]	Szpilman, D., & Morgan, P. J.	(2021)	Brazil	Review article
[26]	Wati, D. K., Indrawan, I. G. de D. K., Kristianti, N. G. H., Wijaya, F. A., Arga, D. M. W., and Manggala, A. K.	(2021)	Indonesia	Case study
[27]	Topjian, A. A., de Caen, A., Wainwright, M. S., Abella, B. S., Abend, N. S., Atkins, D. L, Bembea, M. M., Fink, E. L., Guerguerian, A-M., Haskell, S. E., Kilgannon, J. H., Lasa, J. J., and Hazinski, M. F.	(2019)	United States of America	Consensus
[28]	Queensland Emergency Care Children Working Group	(2019)	Australia	Clinical practice guidelines
[29]	Perkins J.	(2021)	United Kingdom	Practice guideline
[30]	New South Wales: Emergency Care Institute.	(2021)	Australia	Clinical practice guidelines

3.2 | Results

The general search that was done, returned 370,469 articles. A refined search yielded 24,700 articles which were subjected to a combined search to exclude duplicate publications and generated 1022 articles, which were reviewed by the researcher for possible inclusion. Using a search string including 'management of child drowning' AND 'interventions' resulted in 30 articles. This ensured the inclusion of publications that focus on management of child drowning or interventions used for children following a drowning incident. From the review of the citation lists, 2 articles were selected as cross reference research articles and included, adding up to 32 articles that were reviewed and included in appraisal of the literature. During consultation with C.M.M., it was decided to exclude the two articles that were added from a citation list as the primary research publications were included. All articles originated from this search were marked with a short summary and kept for possible use. Figure 2 represents the search and selection of the articles.

3.3 | Data presentation of the management of children after a drowning incident

Taking into consideration the views of Denny et al. (2019), it is clear the approaches and considerations for management should start immediately on rescue by treating the main threat of hypoxia (Cantwell, 2021; Macintosh & Austin, 2017). Based on the resulting pathophysiological processes following the drowning incident, management of children should be focused on specific interventions and strategies (Cantwell, 2021; Denny et al., 2019; Macintosh & Austin, 2017; Schmidt et al., 2019). The commencement of treatment comprises of different approaches or phases including the rescue process, initial resuscitation at the scene of drowning initiated by the primary rescuers, advanced prehospital care and care in the ED and the PICU (Cantwell, 2021; Denny et al., 2019; Macintosh & Austin, 2017; Parenteau et al., 2018; Schmidt et al., 2019). The next section discusses interventions and strategies used by trained healthcare professionals in the prehospital environment, the ED and the PICU to manage children after a drowning incident. Citations referring to a rescue process and initial resuscitation in water at the scene were excluded as these processes were not regarded as inclusive for the aim of the review, irrespective the availability of protocols or guidelines.

3.3.1 | Prehospital management

Optimal care in the prehospital environment is regarded as an important factor to manage the principle danger of hypoxia and cardiac arrest (Best et al., 2020; Cantwell, 2021; Macintosh & Austin, 2017; Matthew et al., 2017; Mott & Latimer, 2016; Widyantara et al., 2019). Prehospital management is initiated at the scene of drowning or submersion site by bystanders or lay persons,

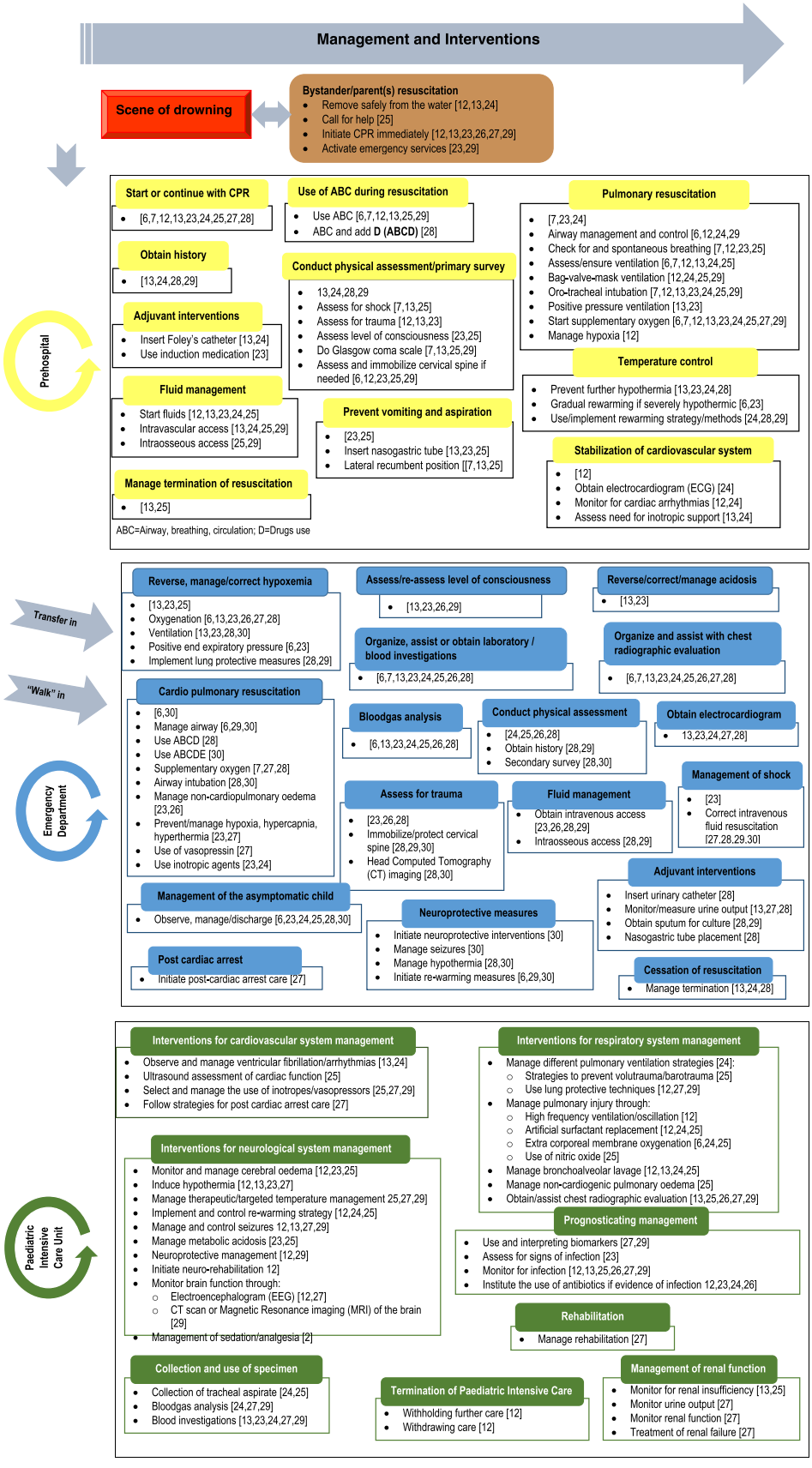

FIGURE 1 Summary of interventions used for the management of children following a drowning incident appraised and mapped from the literature reviewed. CPR, cardiopulmonary resuscitation.

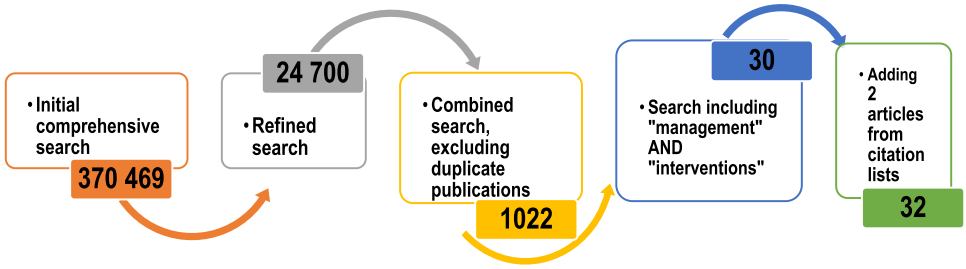

FIGURE 2 Search and selection of articles.

started before the arrival of paramedics on the scene (Denny et al., 2021) and continued by paramedics from the scene of drowning and during transfer to the ED. Efforts focus on implementing advanced life-saving techniques to secure the airway, reverse the state of hypoxia, prevent progression of the hypoxic-ischaemic injuries and establish return of respiration and circulation as quickly as possible, and early rewarming (Bauman et al., 2021). Management strategies and interventions include maintaining of the airway, breathing through bag-valve-ventilation with or without orotracheal intubation, administration of high flow oxygen, cardiac support and compressions, gastric decompression, intravenous access for administration of crystalloids in restricted volumes and use of passive and gradual rewarming techniques depending on the degree of hypothermia (Best et al., 2020; Cantwell, 2021; Macintosh & Austin, 2017; Matthew et al., 2017; Mott & Latimer, 2016; Parenteau et al., 2018; Widyantara et al., 2019).

It is recommended that a core temperature should be obtained before rewarming, and that rewarming should be done gradually by removing the wet clothes, drying and covering the child with blankets or dry clothes (Queensland Emergency Care Children Working Group: Children's Health Queensland Hospital and Health Service [CHQ-GDL], 2019; Evans et al., 2021). Strategies for passive external rewarming (core temperature above 30°C) include the use of interventions in the prehospital area such as removal of the wet clothes and use of warm blankets while a warm air system (Bair Hugger™) or heating blankets (Queensland Emergency Care Children Working Group: CHQ-GDL, 2019; Evans et al., 2021). No clear evidence could be found related to direct active core rewarming in the prehospital environment and the strategy will be explained under management in the ED.

Advanced prehospital activities might include history taking, physical assessment, obtaining of vital signs and results of Glasgow Coma Scale score (Parenteau et al., 2018), while Best et al. (2020 mentioned that adrenaline should only be used when the rectal temperature is above 30°C, monitoring of blood glucose and treatment of hypoglycaemia if necessary, and prealerting the PICU of pending admission (Best et al., 2020). Parenteau et al. (2018) pointed out that the use of Osmitrol^{R} (Mannitol), mechanical hyperventilation, diuretics and barbiturate induced coma in the prehospital management have not shown any benefit for brain resuscitation. After the management of immediate threats to life and initiating active CPR, the child should be transported to the hospital immediately (Matthew et al., 2017). Topjian et al. (2019) state that the literature provide no evidence on the transport of children, especially after cardiac arrest and that sicker children are inclined to develop instability during transport. The authors (Topjian et al., 2019) discussed the coordination of transport in the prehospital setting and mentioned that the child should be closely monitored to start timely interventions when changes during transport occur.

3.3.2 | ED management

Matthew et al. (2017) regarded management and interventions in the ED not different than the initial prehospital priorities, while Parenteau et al. (2018) reflect on ED management as improved oxygenation through a secured airway, stabilisation of circulation, gastric decompression and thermal protection, especially if these interventions were not done prehospital or during transfer (Matthew et al., 2017; Parenteau et al., 2018). The ED management is done by medical practitioners and professional nurses and the focus is on managing the child who present either asymptomatic or symptomatic with hypothermia, tachycardia, bradycardia (altered vital signs), having an anxious appearance, tachypnoea, hypoxia, dyspnoea, an altered level of consciousness, neurological deficit or had a cardiopulmonary arrest after the drowning incident (Mark, 2020). Management might include evaluation of chest X-rays, initiation of lung protected ventilation strategies, neurological assessment, monitoring of blood glucose, acid–base balance and electrolyte imbalances and takes place until transfer to the PICU (Cantwell, 2021; Matthew et al., 2017; Parenteau et al., 2018; Schmidt et al., 2019). Active rewarming is described by Evans et al. (2021) and the Children's Health Queensland Guideline (Queensland Emergency Care Children Working Group: CHQ-GDL-60013, 2019) as an activity that should be initiated with care in hospital, in the ED or PICU, while the process of re-establishing normothermia is commenced for the prehospital environment.

Strategies which are recommended for active rewarming include the use of warm intravenous fluids (39°C), warm ventilator gasses (42°C) and warm NaClO.9% (42°C) for bladder or gastric lavage (Queensland Emergency Care Children Working Group: CHQ-GDL-60013, 2019; Evans et al., 2021) while the Queensland Emergency Care Children Working Group: CHQ-GDL-60013 (2019) supports the use of extracorporeal blood rewarming, endovascular rewarming and

pleural or pericardial lavage, although evidence is unclear to which particular clinical setting from the scene of drowning these strategies are directed for implementation. No clear guideline for the use of therapeutic cooling could be found, although referral to targeted hypothermia occurs.

3.3.3 | Paediatric intensive care management

Management in the PICU is done by professional nurses and medical practitioners and is directed towards the prevention of secondary brain injury and maintenance of vital functions (Topjian et al., 2012). Some of the interventions are continuation of protected lung ventilation strategies using optimal recruitment methods such as extracorporeal membrane oxygenation, as well as treatment of acidosis, fluid depletion and electrolyte shifts, neuroprotection by ensuring a 30 degree head-up tilt, maintenance of normoglycaemic values and sodium chloride levels, treatment of seizures, as well as early identification and treatment of pneumonia, renal insufficiency and haemolysis (Cantwell, 2021; Parenteau et al., 2018; Topjian et al., 2012).

4 | RESULTS AND FINDINGS FROM LITERATURE

The following Figure 1 synthesises a summary of the interventions used for the management of a child following a drowning incident and provides information regarding the interventions used from the scene of drowning (prehospital environment), in the ED through to the PICU. The information is captured in Figure 1 with the key interventions grouped together and relevant citations added in bracketed numbers which is not a final reflection of the integrated management system for children following a drowning incident in each phase. The findings from the literature review form base line data which will be used in the next phase by healthcare practitioners to collaborately construct an integrated management system for children following a drowning incident.

5 | DISCUSSION

It is most likely that the severity of primary brain injury due to the process of drowning can be reduced by competent prehospital care, while secondary brain injury can be reduced or prevented in the ED and the PICU through integrated care (Topjian et al., 2012). The focus of prehospital management of children after a drowning incident is on life-saving interventions by paramedics guided by protocols (Cantwell, 2021; Matthew et al., 2017; Semple-Hess & Campwala, 2014), with the purpose of rescue, resuscitation and transport of the child.

In the ED the emphasis is placed on collection of baseline data and further stabilisation of the child, directed by guidelines (Best et al., 2020; Cantwell, 2021; Mott & Latimer, 2016; De Villiers, 2008) or prescriptive manuals (Jan, 2013). In the PICU interventions concentrate on restoration of normal physiological functions, prevention of secondary complications and further deterioration of physiological functions, commonly based on pulse oximetry (hypoxia), blood gas analysis (acidosis), electrocardiogram (arrhythmias), chest X-ray (acute lung injury) and computed tomography of the head (hypoxic brain injury) (Evans et al., 2021).

The approaches in the management and pathway of a child after drowning are fragmented in terms of the place and practise of interventions such as the use of hyperoxia, efforts to reverse hypothermia, rewarming/cooling down strategies and lung protective ventilation methods. Management of the child after drowning is complex while using evidence based interventions with the focus on strategies applicable to the clinical area where the child is at the particular phase of management (timeline). Currently no evidence could be found regarding inclusion of the parents or family during the management of the child following a drowning incident, despite research indicating the importance of parents to be present at the bedside of the critically ill child (Miller et al., 2022)], where they need to collaborate in decision-making about treatment and participate in care interventions (Terp et al., 2021).

Moore Shepherd (2011) and Topjian et al. (2012) reflected on interventions for children following a drowning incident as a 'chain of management' and place emphasis on the importance of evidence-based interventions that can link activities from the scene of drowning through to the PICU. The need is to evaluate the management, interventions and strategies used in the different clinical areas when managing a child following a drowning incident, integrate the interventions into a management system that will form a chain that ensure flowing of activities from the scene of drowning, is supported in the ED and continued in the PICU. This approach will ensure that activities such as cooling/rewarming based on evidence, will be started in the correct manner at the scene of drowning and followed through to the PICU.

In addition, a fragmented approach in the management of children following a drowning incident may influence the outcomes of these children negatively and to ensure integrated clinical guidelines might contribute to quality care in the management of children following a drowning incident (Calvello et al., 2013). Despite these recommendations, interventions are still focused on activities for management in the prehospital environment, followed by a set of actions for the ED and finally, supportive acute care procedures in the PICU and integrated guidelines are not available in the practice environment.

During acute illness of children and especially after drowning, the role of parents changes. Parents are normally responsible for the care and safety of their child and after drowning and admission to hospital, they become reliant on health care practitioners for saving their child and making decisions (Curtis et al., 2016). In many cases, the parents or family are left out during resuscitation and initial management following the drowning incident, and sometimes, may become involve in the care of the child in the PICU. No clear evidence is available on family inclusion in the management of the child postdrowning due to lack in information and consensus concerning practice and practice guidelines (Mark, 2020).

Acknowledging that pockets of excellence are present in the management of children following drowning incidents, there remains a quest, globally and in South Africa, to link the interventions during management in an integrated system from the scene of drowning through to the PICU. Debates between the involved healthcare practitioners who managed children following a drowning incident, reflection on interventions and strategies and opportunity to deliberate well-integrated interventions for the management of children after drowning can expedite best health outcomes, allow early involvement and continuous participation of parents and family in care interventions and shared-decision making. These may reduce length of stay in hospital and decrease readmission rates post discharge.

6 | LIMITATIONS

Some limitations were identified for this review. The selected literature for this review focused on management and interventions for children after a drowning incident and no particular assessment of the levels of evidence was done-this fact might influence the findings of the review.

The selection and inclusion of literature for the appraisal was based on the aim of the review, the search strings and Boolean operator combinations. It is possible that if the search were approached in a broader manner, more literature could be included.

The researcher was the reviewer who conducted the search, evaluated the articles for inclusion, appraised the articles critically, mapped the data and discussed the findings. The researcher was in consultation with CMM to reach consensus about article inclusion. The use of more reviewers may increase rigour and prevent bias during the review process.

7 | CONCLUSION

The aim of the article was to describe the management of children following a drowning incident by using literature to map the respective interventions. Interventions for the purpose of this article are perceived as actions that can be used by healthcare professionals prehospital, in the ED and the PICU to link and integrate the management of children following a drowning incident. Through visualising the interventions or strategies healthcare professionals can collaborate to horizontally integrate the management of children from the scene of drowning to the PICU.

8 | HOW MIGHT THIS INFORMATION AFFECT NURSING PRACTICE?

Using the mapped information of children after a drowning incident to align and link interventions into an integrated management system will ensure inclusion of all identified interventions. Collaborative involvement of healthcare practitioners from prehospital, the ED and PICU, will provide unique input to construct an integrated management system with inclusion of interventions or strategies for cooling and/or rewarming, termination of resuscitation and parental involvement. The possibility of providing an integrated management system would ensure that interventions and strategies could be initiated and used uniformly from the scene of drowning through to the PICU.

CONFLICT OF INTEREST STATEMENT

This article forms part of Phase 2 of a PhD study conducted by the corresponding author. The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed. All data cited are included in the reference list.

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