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Primary and Secondary Drowning Interventions: The American Red Cross Circle of Drowning Prevention and Chain of Drowning Survival

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Creating awareness about primary and secondary interventions that can be used in situations involving drowning is an important prevention strategy. Consistent among reports from almost all countries is that drowning injury steals life from young children, followed by youth, and then young adults. As a result of the ongoing need to reduce these types of statistics, the American Red Cross Scientific Advisory Council–Aquatic Subcouncil established two intervention programs to address both sides of drowning events. Content of this manuscript is based on work by members of the Aquatic Subcouncil. It focuses on describing and providing scientific rationale for two educational programs designed to approach the issue of drowning from both a primary and secondary intervention perspective. Presented are the Circle of Drowning Prevention and the Chain of Drowning Survival along with the thought processes and foundational research that brought them into existence. Both intervention programs are currently being used in educational materials and marketing efforts within American Red Cross water safety materials.

Keywords: aquatics, swimming, drowning, water safety, intervention, drowning prevention

Unintentional trauma is the major cause of death for those 1–44 years of age in the United States (Centers for Disease Control, 2010a). How drownings rank among causes of injury death varies by country; in some countries, drowning is the first cause of injury death for children less than 20 years of age. What is consistent among reports from almost all countries is that drowning injury steals life from the young, followed by youth, and then young adults. In the United States, drowning is the first cause of unintentional injury death among those 1–4 years of age, second cause among those 5–9 years of age, third for those 10–19 years of age, and fourth for those 20–44 years of age (Centers for Disease Control, 2010b). Reported fatal drowning rates in the highest risk age group, 1–4 years of age, range from less than 1 per 100,000 in Sweden (in contrast to almost all other countries,

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its drowning death rates increase with age) to 86 per 100,000 for those under 18 years of age in Bangladesh (Ahlm, Saveman & Björnstig, 2013; International Drowning Research Centre, 2010). These very high rates of drowning as a cause of death become more astounding when they are translated into actual numbers of lives lost. Globally, in 2004, 388,000 people died of drowning (World Health Organization, 2012). These astonishing numbers of deaths underscore the need to focus on drowning prevention and rescue.

Creating this focus is a challenge for drowning prevention because of the multifaceted nature of the problem. Drowning prevention must address multiple age groups (involved in a wide variety of activities on or near the water) and multiple aquatic environments. The challenge is to find the commonalities among drowning prevention approaches and establish consistent messaging to develop educated communities capable of addressing this public health issue.

The injury prevention perspective provides a useful approach. Prevention strategies are considered primary when the injury event can be completely avoided. These strategies include but are not limited to (a) learning to swim; (b) using lifejackets in, on, and around the water; (c) swimming only where lifeguard supervision is provided; (d) fencing pools on all four sides; (e) using pool alarms, pool or container covers, and signage to limit access to hazardous waters; and (f) educating the public on topics such as water safety practices and supervision. Secondary prevention strategies include those that mitigate the extent of injury after it has already occurred. These include (a) teaching basic water safety techniques that do not put the rescuer at risk; (b) teaching first aid and cardiopulmonary resuscitation (CPR) to supervisors and guardians; and (c) trying to improve early recognition and early response as well as early emergency medical services (EMS). Most organizations involved in promoting safe participation in aquatic activities—including swimming, boating, and water recreation—address both primary and secondary prevention to varying degrees. To decrease the "Tower of Babel" confusion surrounding the topic of drowning prevention, one international effort sought to develop a list of key interventions and the messaging around them (Quan, Moran, & Bennett, 2010). The resultant list was a combination of primary and secondary prevention interventions.

The purpose of this paper is to describe a set of processes and associated representative icons that highlight effective, evidence-based primary and secondary drowning prevention interventions. The Aquatic Subcouncil of the American Red Cross Scientific Advisory Council (SAC) sought to visually consolidate the primary prevention interventions within the Circle of Drowning Prevention and the secondary prevention interventions within the Chain of Drowning Survival. Both were developed for use in American Red Cross swimming and water safety programs as well as to help other organizations' aquatic safety programs, authorized providers, safety and risk management leaders, and the general public to recognize and respond at an individual, family, organizational, community, and policy level to decrease the risk of drowning and its consequences.

Primary Drowning Intervention: Circle of Drowning Prevention

Tremendous progress has been made in drowning prevention in the past 20 years. Many risk factors for drowning have been identified but only five active

interventions have been studied and shown to be associated with decreased risk of drowning. They are (a) providing four-sided fencing around swimming pools, (b) training lifeguards to supervise swimming areas, (c) using life jackets (referred to as United States Coast Guard approved personal flotation devices [PFDs]), (d) actively supervising swimmers, and (e) providing swimming lessons especially for children and nonswimmers. We chose to present these five interventions as a circle (see Figure 1) to promote the concept that all are important, that they must all be present, all should surround the person at risk for drowning to provide the most protection, and that any break in the circle makes a person or persons vulnerable to risk of drowning. The following sections provide evidence supporting each of the chosen interventions.

Fence Pools and Spas With Adequate Barriers Including Four-Sided Fencing

This icon focuses on swimming pools because they are the major cause of home drowning deaths in children less than 5 years of age in the United States (Centers for Disease Control, 2010a; Centers for Disease Control, 2010b). Moreover, pool fencing is the most studied intervention of all drowning prevention efforts. Studies from Australia, New Zealand, and the U.S. show that pool fencing can decrease

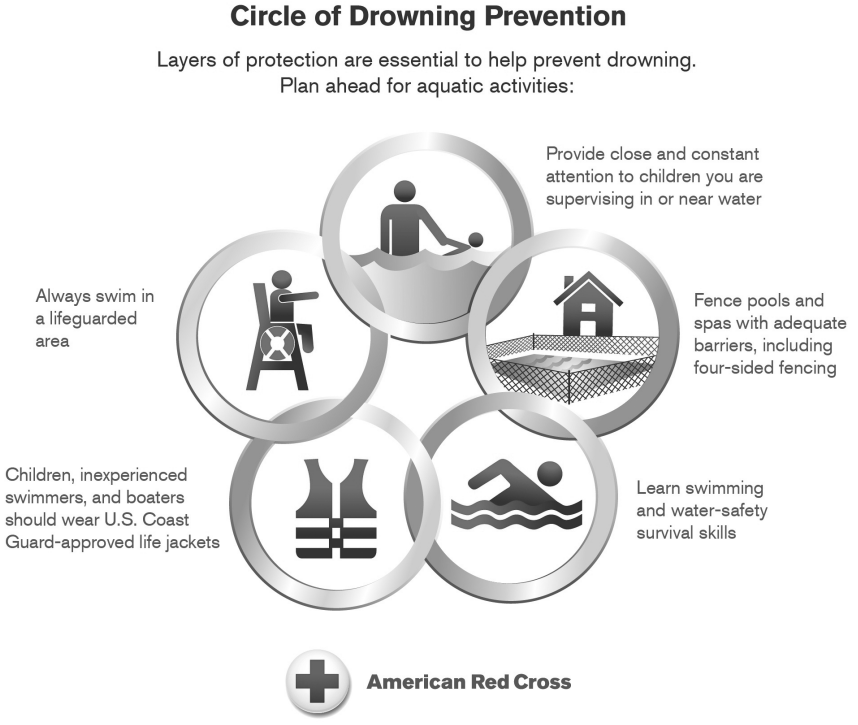

Figure 1 — Circle of Drowning Prevention diagram.

preschoolers' drowning deaths in residential pools by 50% (Thompson & Rivara, 2000). To be effective, a barrier must be a four-sided, intact, nonclimbable fence with a self-closing, self-latching gate that completely surrounds the pool. The limited effectiveness of the intervention (50%) is due to families' failure to comply with enacted laws. This, in turn, relates to lack of enforcement. Thus, an effective intervention that addresses the highest risk, most vulnerable population in the United States (i.e., 1–5-year-old preschoolers living in homes with residential pools), has been identified but still needs to be mandated widely, legislated, and then adequately enforced.

Children, Inexperienced Swimmers, and All Boaters Wear U.S. Coast Guard-Approved Life Jackets

Wearing a life jacket was recently associated with a 50% decreased risk of drowning death among boaters who wore them compared with those who did not in a large, national study of U.S. boating-related drownings (Cummings, Mueller, & Quan, 2011). More recently, wearing a life jacket also was associated with a 48% reduced likelihood of death among boaters involved in a boating incident (Stempski, Schiff, & Quan, 2014). National organizations in the U.S. and other countries have promoted life jacket use among boaters, but compliance has not increased (Mangione, Chow, & Nguyen, 2012). Boaters' use of life jackets varies by the type of boat (e.g., greatest among those in sailboats and kayaks), and age (e.g., children and teens). The very high wear rates (83–95%) among groups required to wear them (e.g., those on personal water craft, those being towed, and children) suggest that life jacket laws can effectively increase wear rates (Mangione, 2010; Chung, Quan, Bennett, Kernic, & Ebel, 2014). Survey and focus group research of boaters revealed that their refusal to wear life jackets was based on (a) beliefs of invulnerability, (b) misinformation that boating drowning deaths happen during bad weather and water conditions, and (c) lack of legal mandates for life jacket wear (Quistberg, Bennett, Quan & Ebel, 2014). Increasing life jacket wear requires consistent messaging, reaching reticent groups, and promoting public policy that mandates life jacket wear.

The Aquatic Subcouncil chose to focus on an expanded set of indications for life jacket use because their use holds promise for decreasing the risk of drowning among those near water. Vietnam, Alaska, and Washington State (U.S.) have promoted this intervention among children, while both Australia and New Zealand have focused on rock fishermen. An intervention by the U.S. Army Corps of Engineers required life jacket wear among those not only on the water, but also by or swimming in their waters and led to a marked decrease in drowning deaths (Mangione & Chow, 2014). Wearing of life jackets by children less than 5 years of age also has been shown to decrease the risk of drowning death when playing by or near water (Yang, Nong, Li, Feng & Lo, 2007). Effectiveness of this expanded use of life jackets needs further confirmation.

Learning Swimming and Water Safety Skills

Swim programs assume that learning to swim confers some primary protection, but only recently has involvement in swim lessons been shown to decrease drowning

risk in certain populations. Surprisingly, the effectiveness of swimming lessons in decreasing drowning death has only been documented through research in children less than 5 years of age (Yang et al., 2007; Brenner, Taneja, Haynie, Trumble, Qian, Klinger, et al., 2009). Brenner et al. (2009) showed swimming lessons decreased drowning risk among school age children, but the effect was not significant, perhaps due to the small number of school age children studied. No studies of the protective effect of swimming skills or swim lessons have been conducted among adults.

Interestingly, it is not clear what aspect of participating in swimming lessons may provide protection. Further, there is little consensus among the water safety community as to what specific skills and knowledge provide an adequate level of protection or comprise acquisition of sufficient water competency. In a Bangladesh study (Rahman, Bose, Linnan, Rahman, Mashreky, Haaland, et al., 2012), a comprehensive program involving multiple community and individual based interventions, including extensive efforts to teach school-aged children to swim, markedly decreased pediatric drowning deaths. While this study lends support to swimming lessons as a primary intervention, the study also did not identify the specific contribution that learning to swim provided in preventing drowning deaths.

Always Swim in a Lifeguarded Area

Lifeguards routinely provide primary prevention of drowning events by controlling risk-taking behaviors. Lifeguards also practice secondary prevention by performing rescues and resuscitation of victims. More than 95% of swimmers rescued by a lifeguard do not require transport for further medical attention, suggesting that most lifeguard rescues occur in a timely manner preventing serious hypoxic injury and need for further care (Harada, Goto, & Nathanson, 2011). Remarkably, although lifeguard data are routinely collected by local agencies, they have rarely been analyzed. While studies report drowning deaths do occur despite lifeguard supervision, the risk of drowning is very low when in a lifeguarded setting (Pelletier & Gilchrist, 2011; United States Lifesaving Association, 2010; Harada et al., 2011). Unfortunately, lifeguard effectiveness in providing secondary prevention rarely has been evaluated so there are no data on which to base conclusions (Fenner, Harrison, Williamson & Williamson, 1995).

Provide Close and Constant Attention to Children You Are Supervising in or Near Water

Supervision is the least studied of the primary prevention interventions. Existing studies define a lack of supervision as a contributing cause in 71–85% of pediatric drowning deaths. Preliminary definitions of what adequate supervision consists include three key components: (a) closeness, (b) attentiveness, and (c) constant supervision (Petrass, Blitvich & Finch, 2009). Attentiveness needs to be defined as well as being unimpaired by alcohol, drugs, or distractions (Petrass, Blitvich & Finch, 2011). In addition, the supervisor who performs surveillance must also be able to act and intervene. These needs were documented through a study in China where supervision by grandparents was discovered to be associated with increased risk of drowning in young children (Yang et al., 2007). Safekids USA has

promoted a program to improve supervision of children around water but has yet to be formally evaluated for efficacy. Despite the lack of studies documenting the effectiveness of supervision in reducing drowning risk, members of the Aquatics Subcouncil believed the need to provide and improve supervision was compelling.

Other Drowning Prevention Interventions

The Circle of Drowning Prevention is not meant to exclude other interventions. For example, "Never go in the water after drinking alcohol" is a key message because alcohol has been shown to be a definite risk factor for drowning death. Reducing or abolishing alcohol use was not included within the Circle because there are no published studies of interventions aimed at decreasing alcohol use to decrease fatal or nonfatal drowning rates. Other interventions may have been tried locally and successfully but may not have been evaluated and reported in the literature. Other efforts may have been studied but their effectiveness was statistically difficult to prove. Hopefully, evidence supporting the effectiveness of other drowning prevention efforts will be found and lead to expansion of the Circle of Drowning Prevention.

Secondary Prevention: Chain of Drowning Survival

Developed as a subsequent step to the Circle of Drowning Prevention, the Chain of Drowning Survival (Figure 2) was created to provide an easily understood series of actions that rescuers can take to mitigate the result of an aquatic accident or event involving a possible drowning. Research provides evidence that factors such as early recognition and early response can make a significant difference in the eventual outcome of emergency situations (Claesson, Svensson, Silfverstolpe, & Herlitz, 2008). In a specific example, a study by Quan and Kinder (1992) revealed that drowning victims whose submersion was limited

Figure 2 — Chain of Drowning Survival diagram.

to less than 5 minutes had better survival rates when compared with those with submersions longer than 10 minutes. The power of early intervention has also long been documented in the emergency response for cardiac arrest (Kloeck, Cummins, Chamberlain, Bossaert, Callanan, Carli, & Steen, 1997). Although prevention should always be seen as the antecedent to rescue, even with best efforts and practices for prevention, accidents/incidents will occur. In the event that primary prevention falls short, the next course of action is to employ secondary prevention actions to solve and mitigate possible negative outcomes, which can include catastrophic long-term medical consequences or death. Training and education that informs individuals about the actions that can be taken to reduce the number of negative outcomes is a key factor.

The American Red Cross Chain of Drowning Survival was designed by the Aquatic Subcouncil as an educational intervention guide to be employed at the onset of a drowning incident or aquatic emergency. In developing the sequencing for the model, the group decided on using the symbolism and imagery of a single chain for several reasons.

The first reason involved a desire to represent the strength that is acquired by learning this process, in addition to visually showing that one action is linked directly to the next in an order of importance when taking action. Action-based intervention processes generally begin with a phase in which a person must consciously recognize and acknowledge that someone is having difficulties (Quan, Moran & Bennett, 2010). The links of the chain were designed to connect the subsequent action steps in an ordered sequence from early invention by rescue and removal from the water to actions made to secure more advanced medical help, assessment, and delivery of first-aid (including use of CPR and an automated external defibrillator [AED], if needed), and concluding with final steps to relegate the victim to advanced medical care when necessary. In the order presented in the chain, an individual attempting to intervene will have the best chances of providing effective assistance and early care and limiting secondary injury following an aquatic accident or injury. The following sections provide the evidence supporting each of the five representative icons and corresponding actions that collectively make up the Chain of Drowning Survival. They include: (a) recognition of a drowning event, (b) rescue and removal from the water, (c) activate the EMS, (d) beginning rescue breathing and CPR, and (e) use of an AED and transfer to advanced life support. Each of these links in the chain is ordered to create a sequential picture that when employed in order can increase the probability of a successful outcome for a drowning emergency.

Recognition of a Drowning Event

This icon and action represents the need for a bystander to identify when a person is in the stages of drowning. According to Pia (1974), drowning can be either in a passive or active state. In a passive state, the victim slips under the water with little to no movement, while with an active victim the event is characterized by a person who stays mainly vertical in the water, no longer makes forward motion, struggles using an instinctive arm action (arms moving laterally up and down as well as the head tilted back in an attempt to maintain breath), and is unable to call for help. The active drowning victim may also repeatedly submerge and return to

the surface for a period of time. Once an active victim reaches this stage, they have 30–60 seconds before final submersion occurs. Thus, early recognition of a drowning victim is critical. Education on recognition of aquatic emergencies is provided through avenues for lay persons such as in American Red Cross "Learn-to-Swim" and "Water Safety and Home Pool Safety" programs.

Rescue and Removal From the Water

The second icon of a ring buoy illustrates the need to initiate a safe rescue. The 30–60 seconds of time wherein a drowning victim is still near the water surface requires immediate bystander response. First, the bystander needs to locate rescue equipment on site and then initiate a safe rescue while staying out of the water. This icon emphasizes the importance of teaching bystanders how to perform drowning rescues just as Citizen CPR enhanced the CPR response and improved outcomes of victims of cardiac arrest.

Two methods of bystander rescue have traditionally involved reaching for the victim with a long object or throwing something that will float to the victim. The reach rescue requires that the victim be near and keeps the rescuer from getting overwhelmed by the drowning victim. The throw technique requires a floating device that can be thrown easily while providing a victim some flotation. These devices can include ring buoys, rescue tubes, plastic bottles, and items that may be found in recreational settings such as sealable coolers, kickboards, or even spare tires. The SAC Aquatic Subcouncil chose to depict the throw object as the commonly recognized ring buoy because it is installed widely at waterside aquatic venues and accepted by some state and local codes as a required piece of lifesaving equipment. Members of the Subcouncil also recognized that there is currently little or no empirical evidence identifying the ideal object to be used in a throwing rescue or the advantages and disadvantages of commonly thrown objects. In somewhat related research, a study (Franklin and Pearn, 2011) studied the difficulty of throwing a rescue line and identified the need to practice this rescue technique. Unfortunately, despite their use in swim programs, none of the traditional, much less homemade, readily available and inexpensive throw objects have been studied for ease of use, ease of learning, or effectiveness. Importantly, the rescuer is at risk for drowning, usually by the victim; in some surveillance systems, as many as 10% of unintentional drowning deaths are of would-be rescuers (Franklin & Pearn, 2010).

Activate Emergency Medical Services

The third icon represents a cell phone call for help. When a drowning occurs, bystanders have two critical tasks: (1) to help the victim and stop the drowning process of ongoing anoxia and (2) to get help. Both are time-consuming actions that cannot be done simultaneously unless there are two or more bystanders at the scene. When more than one bystander is at the scene, one bystander should attempt rescue and another bystander should make the call for help. The Aquatics Subcouncil reasoned that, when possible, a bystander should delegate someone to call for help so that help is called without compromising rescue and resuscitation of the victim.

The call for help, especially in an open water setting, can be very time intensive. It requires: (a) making contact with a person within shouting distance, (b) finding

one's cell phone or the facility's emergency phone, (c) connecting and placing the call, (d) getting to the dispatcher which can require multiple telephone transfers within some EMS phone triage systems, (e) providing the dispatcher the patient identification and location, and (f) describing the situation to dispatch which includes recounting the history and the scene. Delays in these steps would also delay rescue and resuscitation until the arrival of EMS. Moreover, most drownings occur in rural settings wherein EMS arrival time is lengthy. Studies show that EMS arrival time is a key predictor of outcome (Claesson, Svensson, Silfverstolpe, & Herlitz, 2008). During this time period, which usually involves minutes, the drowning victim can become anoxic and may submerge out of sight.

For the purpose of this educational campaign, the Subcouncil decided to take the position that the bystander acting out the Chain of Drowning Survival would not be alone which would make the action of "calling for help" primary to the process. If the bystander was alone with a potential drowning victim, a critical caveat is included in the text portion below the chain icon.

Beginning Rescue Breathing and Cardiopulmonary Resuscitation

The fourth icon represents providing the victim rescue breathing ventilations plus CPR as needed. Rescue breathing and CPR are the vital link in the survival chain because it stops ongoing anoxic injury. The primary injury and the degree of anoxic injury inflicted during a drowning event is usually measured as: (a) the submersion duration, (b) the period of time the victim is under water, and (c) length of time that the victim has been unable to breathe. Secondary injury, the ongoing period of anoxia once the victim is no longer submerged, can be even longer than the initial submersion period if ventilations and oxygenation are delayed.

The delay in beginning rescue breathing and CPR occurs as a result of any difficulty locating the victim underwater and moving the victim to water's edge and then out of the water onto land or boat where ventilations and CPR can be started. These steps all require time and significant effort. In drowning rescue simulations at a beach with trained surf lifeguards, time intervals to the start of ventilations in the water have been recorded between 155–258 seconds until the start of CPR (Claesson, Karlsson, Thorén, & Herlitz, 2011). Moreover, further delay may occur awaiting the arrival of persons trained in CPR. In 250 drowning cardiac arrest emergency calls in Sweden, the time interval from cardiac arrest to call was 4 min and the interval to ambulance arrival was 11 min. Together, this time represents an average total delay of 15 min with an overall range 8–23 min. Thus, CPR cannot be delayed until the arrival of EMS. Bystanders must initiate rescue breathing and CPR as soon as possible.

CPR for the drowning victim requires ventilation to reinstitute blood oxygenation. Early intervention before arrival of EMS, and CPR provided by bystanders improves outcomes (Kyriacou, Arcinue, Peek & Kraus, 1994). The American Red Cross teaches the rescuer to assess the need for CPR by opening the victim's airway and checking for breathing, then providing two rescue breaths for the drowning victim. This provision of positive pressure should overcome alveolar collapse due to surfactant washout and hypoventilation following a submersion incident and force any fluid in the lungs into the pulmonary vascular bed.

Doing compressions first has been promoted to get more lay public to provide CPR. Studies show that bystanders are more likely to give mouth to mouth ventilations to drowning victims than cardiac arrest victims (Venema, Groothoff & Bierens, 2010). There is, however, no evidence on which to promote compressions first versus ventilations first for the drowning victim (American Heart Association, American Red Cross, 2012).

Use of Automated External Defibrillator and Transfer to Advanced Life Support

Rarely is an AED needed for the drowning victim; the incidence of "shockable" rhythms is low, less than 5%, in drowning victims of cardiac arrest (Claesson, Svensson, Silfverstolpe, & Herlitz, 2008). For a small percentage of drowning victims, however, a cardiac etiology with ventricular arrhythmia causing cardiac arrest may be the initial injury and drowning the second injury. Examples are the adult who has a cardiac ischemic event while swimming or in the bath tub or the child/adolescent with a channelopathy triggered by swimming.

The icon depicting an electrocardiogram represents Advanced Cardiac Life Support (ACLS), the augmentation of Basic Life Support (BLS), and further medical care. ACLS includes, but is not limited to, the clinical interventions of airway management and ventilation, recognition and treatment of cardiac rhythms, electrical defibrillation, intravenous fluid administration, drug administration, and the correction of metabolic changes as a result of the drowning process. ACLS started in the field setting by specially trained individuals (e.g., paramedics, critical nurses, and flight medical teams) dramatically improves outcome and success of further resuscitation efforts at ACLS capable facilities. Survival rates of 10–20% following cardiac arrest are better than survival rates of victims of nondrowning related cardiac arrest despite the low incidence of shockable rhythms (Claesson et al., 2008). Of survivors, 30–50% are normal (Graf, Cummings, Quan, & Brutocao, 1995; Quan & Kinder, 1992; Suominen & Vahatalo, 2012; Claesson et al., 2008; Claesson, Lindqvist, Ortenwall, & Herlitz, 2012; Youn, Choi, Yim, & Park, 2009). Others survive with severe neurological sequelae, spastic quadriplegia, inability perform self-help activities, or inability to communicate verbally. While most survivors with good outcomes are initially thought to be normal, some have major impairments on further follow up and long-term evaluation. Long-term outcome studies of drowning victims are few.

Studies of hospital care of drowning victims show medical care has little effect on outcomes. One such study showed no change in outcomes over two decades related to medical care (Cummings & Quan, 1999). A 2012 evidence-based consensus was that current treatment of drowning injury remains nonspecific, involving restoration and maintenance of normal physiology (Topjian et al., 2012). While there are increasing numbers of anecdotal reports of good outcomes following therapeutic hypothermia and extracorporeal resuscitation, these reports do not provide the level of evidence to support use of these treatment modalities. Their use requires rigorous evaluation because therapeutic hypothermia was once the national standard of care for children hospitalized after a significant drowning event and ceased because various centers in the U.S. and Canada showed no improvement in outcome (Bohn, Biggar, Smith, Conn & Barker, 1986).

Our goal is to inculcate the prevention messages and concepts of both the Circle of Drowning Prevention and the Drowning Response Chain with instructors and participants in American Red Cross programs. To accomplish this, the created visuals have been distributed to more than 1,200 aquatic facilities nationally, posted on the American Red Cross website (available for free use), and used in marketing and press releases. In addition, they are currently in the process of becoming integrated into the American Red Cross's "Learn-to-Swim" programs and water safety materials which includes the newly developed Red Cross aquatics app for smartphones and computer tablets. Essentially, these resources will help emphasize that water safety and drowning prevention form the foundation for activities in, on, and around the water.

We anticipate that the Drowning Response chain will stimulate further efforts by agencies and organizations to focus on the various links of the chain, but just as important, to work together to ensure a coordinated process. In the early stages of development for the Cardiac Chain of Survival, the role of the bystander materialized, and organizations focused on increasing the number of laypersons who know how to respond to a collapse and provide CPR, thus increasing availability and ease of use of EMS services with implementation of 911 systems, increasing expertise about cardiac arrest thru dispatcher training, and making widespread public availability of technical aids, such as AEDs. Similarly, the Drowning Response Chain will require widespread education on recognition of drowning, safe rescue practices, the appropriate CPR for drowning, and needs assessments of equipment available to potential lay rescuers. EMS systems, dispatchers, as well as laypersons need to recognize the special actions and skills needed to provide optimal response to a drowning situation.

Full implementation of the Drowning Response Chain will require capable systems in place to respond along with community commitment and policies that support them. These systems and others need to recognize that the most efficient approach however will be primary prevention, those proven prevention interventions captured within the Circle of Drowning Prevention. Community commitment and policies to promote drowning prevention and overall water safety will save many more lives and promote safe, healthy participation in water related activities.

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