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The C-Zones Framework

John Connolly

Lifesavers often discuss and analyze rescue and drowning incidents. The C-Zones Framework was designed to serve as an aid to such discussions. It is constituted by a number of zones (i.e., C_1-concern, C_2-crisis, C_3-critical, C_4-cardio-pulmonary resuscitation (CPR), C_5-coma, C_6-conclusion) and is simple enough to be easily remembered and quickly drawn on a piece of paper yet sufficiently detailed to be a serious analytical tool. The use of multicolored or different style lines permits the comparison of numerous casualty variations and outcomes on the one framework. The standard framework has a 20 min time limit describing the progress of an incident from its beginning to conclusion, but other versions of the framework are possible by adjusting the timing. Overall, this framework can serve as a teaching aid and useful feedback tool offering a visual overview of rescue options and their potential or likely consequences at various stages in the drowning process. This information can be valuable to lifesavers, lifeguards, professional rescuers, lawyers, expert witnesses, and judges.

Keywords: lifesaving, water safety, drowning, lifeguarding, water safety methods.

Drowning is a social and health problem globally with limited related theories, models, and frameworks dedicated to prevention or rescue. For example, Pia (1970) introduced the term "Instinctive Drowning Response" that described the pattern and the features of a drowning nonswimmer. The same author also established the RID factor as a cause of drowning where "R" stands for the lifeguards' failure to *recognize* the classic symptoms of a drowning victim. "I" stands for their *intrusion* by being engaged in other duties and "D" stands for their distraction by people of the opposite gender (Pia, 1984). Ellis and White (1994) introduced the Protection Rule 10/20 that recommended a 10-s time limit to scan and identify a person in distress and a 20-s limit for approaching and contacting the drowning victim. Later, Griffiths (2000) introduced the 5-min scanning strategy. According to this strategy, lifeguards should change their position, scanning and posture every five minutes to remain vigilant and effective.

Recently, others established and published the 4W model of drowning that identified the rescuer, the casualty, the place, and the circumstances of occurrence as the main determinants of the outcome of a drowning incident (Avramidis, 2009; Avramidis, Butterly & Llewellyn, 2007, 2009a, 2009b, 2009c, 2009d; Avramidis, McKenna, Long, Butterly, & Llewellyn, 2010). Similarly, Avramidis and

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McKenna (2010) applied the Haddon Matrix to suggest a preevent, in-event, and postevent approach for examining a drowning episode. Moreover, Avramidis and McKenna (2010) took one step beyond this by merging the preexisting 4W model and the Haddon Matrix resulting in a new educational aid that aimed to increase understanding of the drowning phenomenon in terms of prevention, rescue, and treatment. Because some of these theories and models, especially those in the first paragraph, were not scientifically validated, their effectiveness has been questioned (see DeRosa, 2008; Ellis and Associates & Poseidon Technologies, 2001; Pia, 2007).

A study of the previous empirical and research-based published work revealed the need for a framework usable as an aid to water safety-related discussions and as a tool to visually overview the various stages of the drowning and rescue process. Particularly, there is a lack of a tool simple enough to be easily remembered and quickly drawn on a piece of paper yet sufficiently detailed to be a serious analytical tool in explaining the drowning and lifesaving process. In addition, there is a need for a teaching aid that would offer a visual overview of rescue options and their potential or likely consequences at various stages in the drowning process. The aim of this educational article is to introduce a theoretical framework of drowning-related, interlinked C-Zones that might suggest practical applications for enhancing drowning prevention, rescue, treatment, policy making, risk management, and risk assessment.

Overview

To better describe the C-Zones model, there is a need to explain its constituent "building blocks." These building blocks include

- the lines that are drawn to show the progress of an event,
- the zones that delineate different stages in a drowning incident,
- the timing, and
- the key points involved in each emergency episode.

After describing each of these building blocks, I reassemble them to formulate the C-Zones framework (see Figure 1a).

Lines

The first building block of the C-Zones model is the lines representing relationships and connections. Vertical, horizontal, and diagonal lines are drawn on a framework of five connected rectangular zones numbered C_1 to C_5, on X (deterioration of situation into increased seriousness) and Y (elapsed time) axes. Colored lines or broken/wave lines are used to model the progress of an incident from its beginning to its conclusion. In addition, these lines permit the comparison of numerous casualty variations and outcomes on a single framework (examples in Figures 3 & 4).

Zones

The second building block in the model is the zones themselves. There are seven zones (Figure 1a), five connected numbered C_1 to C_5 and two C_0 and C_6 relating

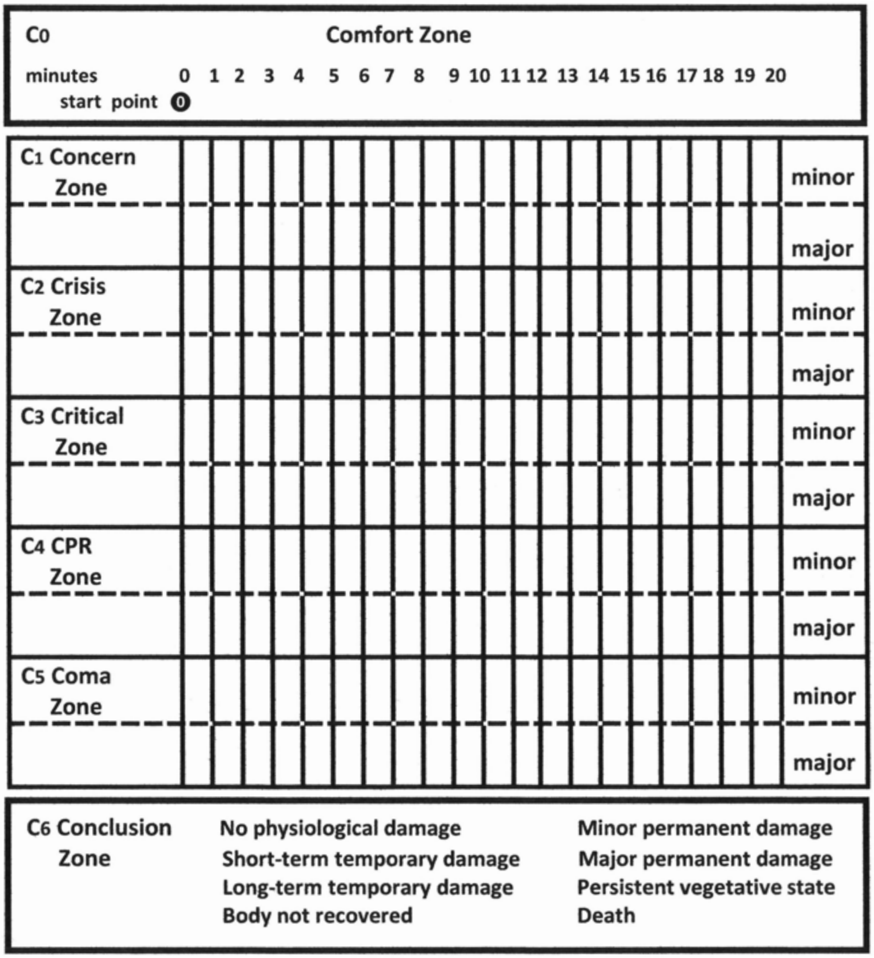

Figure 1a — C-Zones standard framework. The framework can be used to understand and evaluate a drowning incident.

to events before and after an incident. Before an event (to entering the framework) a person feels comfortable and nonthreatened in, on, or near water and is in the *Comfort Zone* (C_0). The *Concern Zone* (C_1) describes the situation where an event changes the person's feeling from being comfortable to being concerned (e.g., a fall into deep water). The *Crisis Zone* (C_2) describes the situation when the person believes that his or her life is threatened. The *Critical Zone* (C_3), describes the situation of a person who is close to exhaustion and who is losing the ability to self-help or to help a rescuer and may be about to panic or is already panicky, a point at which seconds count if the person is to survive. The CPR or *Cardio-Pulmonary Resuscitation Zone* (C4) depicts an unconscious, nonbreathing person with no heart beat in need of immediate life support. The *Coma Zone* (C_5) portrays

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a person who has fallen into a coma. At the conclusion of an event, the *Conclusion Zone* C_6, a casualty exits the framework in one of a number of possible physical states. Based on the International Life Saving drowning classification, the person is classified as either a fatal or nonfatal drowning. The working zones consist of C_1 to C_5 (Figure 1b).

Each of the zones is divided into two subareas called *minor* and *major* to illustrate different degrees (or a deepening progression) within each zone. For example, in the Critical Zone (C_3) *minor,* the person is close to unconsciousness but has not yet panicked; in Critical Zone (C_3) *major,* the person is in a state of panic. This brief outline of the zones is expanded with examples later.

Timing

The third building block in the C-Zones framework is the crucial factor of timing that can be affected by numerous variables and can vary in duration. A typical framework has a 20 min time duration describing the progress of an incident from its beginning to the removal of a casualty from the water and possible transfer to hospital. Research has shown that timing in a drowning episode is dependent on the rescuer (e.g., to attempt an early response that requires a rescuer to remain alert,

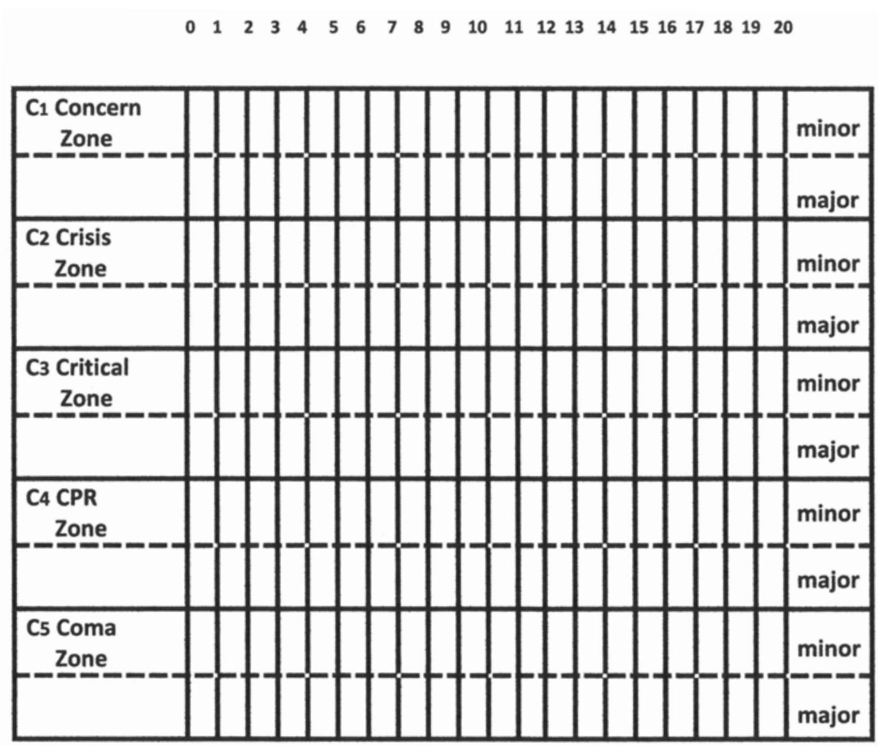

Figure 1b — C-Zones working framework.

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detect the casualty, run and swim toward the victim, implement life support knowledge and equipment), the casualty (e.g., swimming ability, casualty type, physical fitness, age, gender, previous experience and training), the place (e.g., water depth and salinity, distance from safety) and the circumstances (e.g., distance from safety, alone or while in presence of others, length of struggle for survival) of occurrence of this particular event (Avramidis, 2009; Avramidis et al., 2007, 2009a, 2009b, 2009c, 2009d, 2010). These variables are so many and their interrelationship so complicated that almost every case could be considered as a unique event. Many versions of the framework are possible by adjusting the timing. Single 1 min units can be doubled to make a 40 min framework or increased to 5 or 10 min units to make 100 or 200 min frameworks, respectively.

The importance of timing for the outcome of drowning is better understood when we consider that a fast rescue followed by fast resuscitation improves the probability of survival because drowning is based on progressive hypoxia (see Venema, Grootthoff, & Bierens, 2010). Table 1 refers to estimated timings for a clothed swimmer falling unexpectedly into cold, deep water. Adding the longest time periods together suggests that unless removal and resuscitation take place within 20 min of immersion, a casualty has a much reduced chance of surviving a drowning incident. A casualty also has a poorer prognosis of making a full recovery after a 10 min submersion compared with shorter submersions. Physiologically speaking, shorter submersions are associated with more positive outcomes (Bierens, 2006). An unconscious person falling into water will probably take less than 15 min to die. Seconds are very important when dealing with nonswimmers (a buoyant aid given within seconds will enable him or her to breathe and prevent a fast drop into the lower zones).

Table 1 The Timings and Outcomes of a Drowning Incident Occurring to a Clothed Swimmer Who Falls Unexpectedly Into Cold Deep Water

Timing (min)	Outcome
0-3	The effects of cold shock last up to 3 minutes immediately following immersion in cold water.
1-2	If a person chooses to swim in cold water while experiencing serious breathing difficulty, they will experience total swim failure within 2 minutes. It does not apply to persons who float face-up while experiencing cold shock and who commence swimming after the effects wear off.
1-3	A casualty will lose consciousness within 3 minutes following the inhalation of water.
2-5	A casualty will experience cardiac arrest within 5 minutes following the inhalation of water.
5-10	Irreversible biological death will begin about 5 minutes after cardiac arrest. It has been estimated that the immersion time for human death is between 3 and 10 minutes.

Note. Adapted from Golden & Tipton, 2002; Pearn, (1985); Connolly & Golden, 2005.

Points

The fourth building block of the C-Zones framework involves the two key points. The first point is called the *Point of Intervention,* presuming intervention occurs. It is symbolized with an "I." It is the point (place and time) at which help is made available to a casualty. A Point of Intervention may be a success or failure or not occur at all. It cannot necessarily be assumed that the later the intervention the more complicated or extensive the intervention required. For example, a reaching rescue may be sufficient to rescue a casualty in the Critical Zone Major. Similarly, basic CPR may only be needed in some cases but if the person has been submerged in the water for a very long period, physiological changes will have taken place and a casualty will need advanced life support. It may be that the longer it takes to rescue a person the greater the medical or technical lifesaving knowledge needed to keep them in a neurologically salvageable condition. If it is a successful intervention, the casualty will either remain stationary or will rise back up through the zones. If it is a failure, the casualty will continue to drop down through the zones unless another successful intervention occurs. A small rescuer, faced with a large casualty in a state of panic might choose to allow him or her to drop from the Critical Zone into the mild CPR Zone (to fall unconscious) before intervening.

The second key point is called the *Point of Panic.* It is symbolized with a "P" in the framework. It is the point at which the person panics. At this point a person loses the ability to self-help or to assist a rescuer and becomes a serious danger to potential rescuers. Progress downward through the zones is accelerated (close to vertical) after this point to the CPR Zone at which point the person loses consciousness. A drowning person has difficulty breathing and a person in a panic can have a heart beat rate between 145–175 beats per minute (bpm) instead of a normal 60–80 bpm, which speeds up their arrival at an anoxic state. Thrashing about in water accelerates the loss of buoyant air from clothing and the tensing of muscles and hyperventilation associated with panic will result in a loss of natural buoyancy. Figure 2 illustrates one hypothetic outcome for a lone nonswimmer who falls into deep water.

Progressing Down Through the Zones

Having explained the constituent building blocks of the framework, I now consider how a victim might progress down through the zones during a hypothetical drowning episode, considering what could happen in the Concern Zone (C1), the Crisis Zone (C_2), the Critical Zone (C_3), the CPR Zone (C_4), the Coma Zone (C_5), and the Conclusion Zone (C_6).

The Comfort Zone is a person's normal nonthreatened state in aquatic environments. The person is typically going about their business and does not act as if any danger or risk exists to their health or welfare. The person appears to feel comfortable and may be walking near the water, swimming, on board a vessel, scuba diving, or engaging in any number of activities in or near water. For the person to leave this state something must happen to change the person's feelings from being comfortable to being concerned (e.g., a fall into water).

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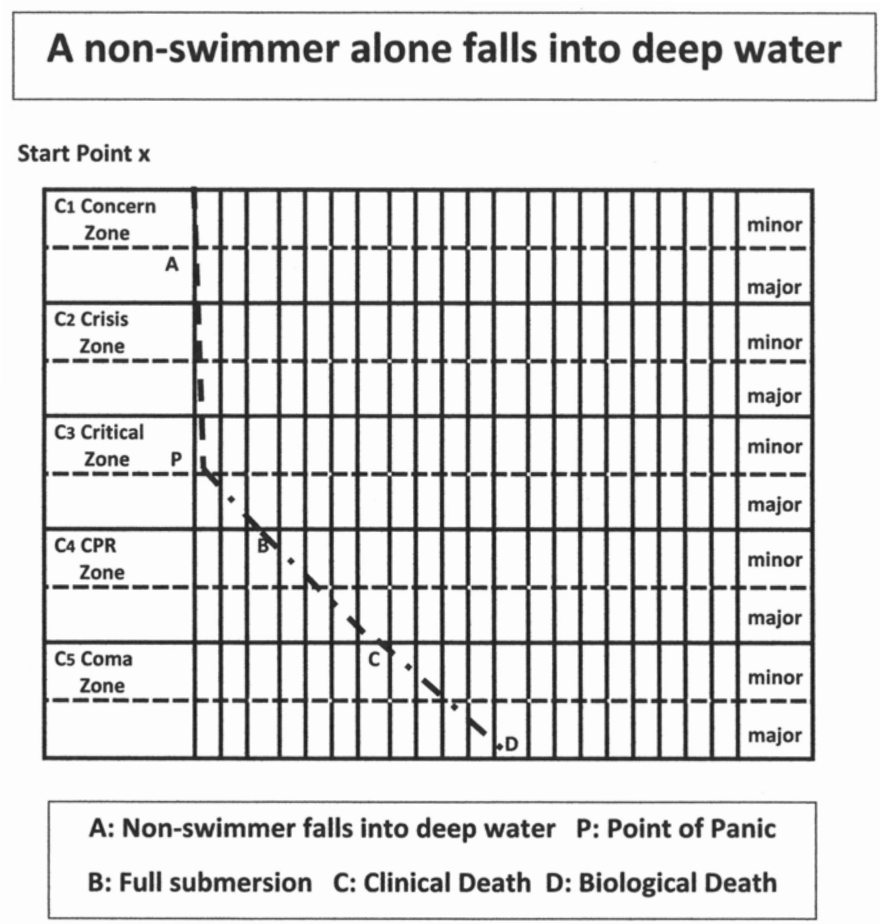

Figure 2 — A non-swimmer alone falls into deep water.

C_1: The Concern Zone

The second C-Zone (C_1) is titled the *Concern Zone*. A person's feelings have changed from being comfortable to being concerned. The new feeling can range from a minor concern (i.e., *Concern Zone Minor*, e.g., a strong swimmer trips and falls into a harbor and is simply annoyed at getting their clothes wet) to a major concern (i.e., *Concern Zone Major*, e.g., a weak swimmer falls into a harbor, is having difficulty swimming and breathing, but still thinks that they can swim the short distance to safety). Some action, such as self-help, external help, or a combination of both, is needed to restore one to a comfortable feeling. A person in the Concern Zone is not demonstrating panic and does not believe their life to be in imminent or terminal danger of death.

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C_2: Crisis Zone

The third C-Zone is titled the *Crisis Zone* and in it a person realizes that their life is threatened. In the *Crisis Zone Minor*, a person is aware that there is a serious problem that could end in their death but this is not felt to be the most likely outcome. It could be a weak swimmer who thought that she could swim to safety and now realizes that she cannot easily do so. She realizes that she has some alternatives such as being able to remove some of her outer clothing, swimming to a nearby mooring rope, and waiting for help while holding on to it. In a short period of time she has moved from the Comfort Zone through the Concern Zone and into the Crisis Zone (see Figure 3). In the *Crisis Zone Major* the victim believes that unless something

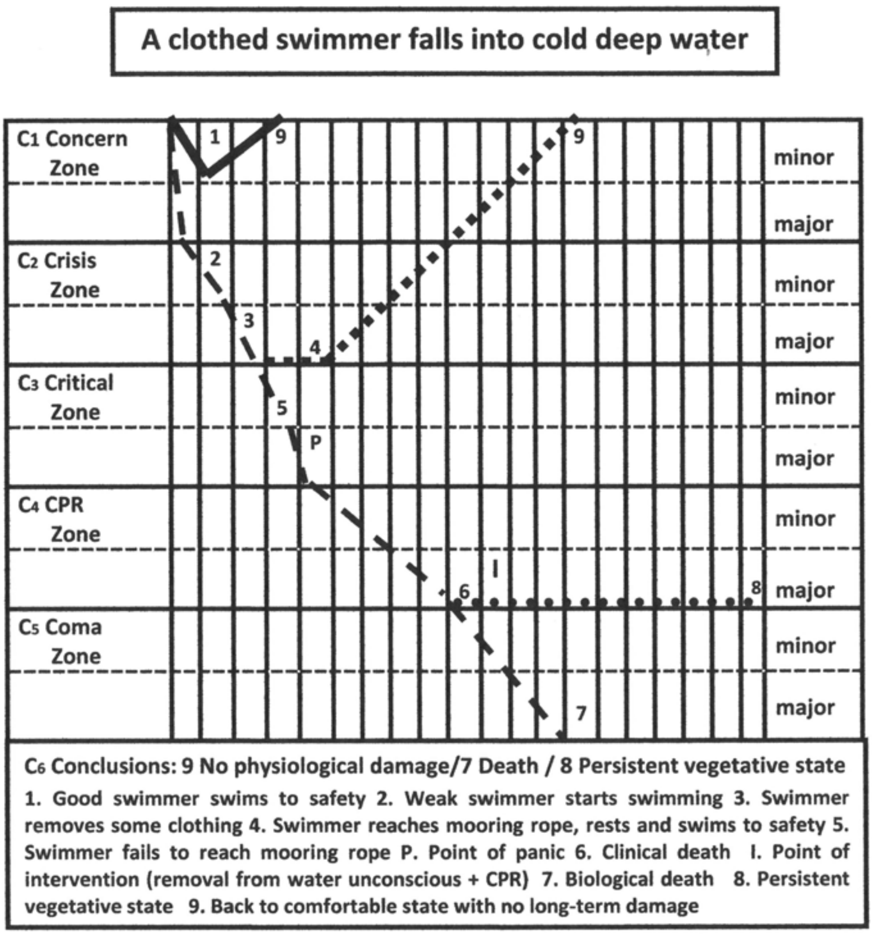

Figure 3 — A clothed swimmer falls into cold deep water.

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positive happens immediately they will die. Nonswimmers unexpectedly falling into deep water would drop straight through the Concern Zone into the Crisis Zone Major. The weak swimmer, in Crisis Zone Minor, may successfully remove some outer clothing but inhale water in the process, consequently experiencing difficulty in breathing, is close to total swim failure, and has therefore entered the Crisis Zone Major. Should the swimmer reach the rope and hold on to it while gradually restoring her breathing, she might rise up to and plateau in Crisis Zone Minor while awaiting rescue. After a period of rest and acclimatization, she might even complete the swim unaided, thereby eventually concluding the incident successfully through self-help.

C_3: Critical Zone

The fourth C-Zone is titled the *Critical Zone*. Within this zone the person is losing the ability to self-help because she is physically exhausted and may be close to a state of panic or is already there. Survival time may now be measured in seconds or minutes. In *Critical Zone Minor* the victim is not yet in a state of paralyzing panic and may have enough energy for one last survival effort. In *Critical Zone Major* the victim is in a state of full panic, making her unable to self-help or help a rescuer. The weak swimmer in the Crisis Zone fails to reach the mooring rope and consequently submerges. Any person in the Critical Zone level is in need of immediate rescue or they quickly will lose consciousness. This is the last zone during which self-help is possible.

C_4: CPR Zone

The fifth C-Zone is titled the *CPR Zone*. A drowning person can submerge within 1 min and become unconscious within 3 min or less of the initial submersion (Pearn, 2009). A person in C_4 CPR Zone is in need of immediate minor or major life support. *CPR Zone Minor* is defined within this zone as requiring immediate removal from the water followed by the performance of rescue breathing only. Without such immediate intervention, subsequent advanced life support techniques appear to be of little value in almost all drowning cases (Wiggington, Pepe, Mann, Persse, & Sirbaugh, 2006). *CPR Zone Major* is defined as the administration of advanced life support (e.g., cardio-pulmonary resuscitation combined with the use of resuscitation equipment, oxygen, and drugs). Several factors influence how long it will take a person to move through this zone, from falling unconscious to clinical death (respiratory and cardiac arrest) and finally biological death. For example, these factors may include length of submersion before resuscitation, water type and temperature, and victim's body size and age (Nemiroff & Pepe, 2006; Pepe & Bierens, 2006).

C_5: Coma Zone

The sixth C-Zone is titled the *Coma Zone*. Coma is defined as a "state of unconsciousness in which a person's responses to stimuli are absent or reduced" (British

Medical Association, BMA, 2005, p. 474). It can be a prolonged state from which a casualty does not recover consciousness spontaneously. This zone normally begins within 2–5 min following the total submersion of a casualty. In the early stages, casualties may move their eyes or cough and are therefore placed in the *Coma Zone Minor*, but casualties in a deep coma lose their physiological defense reflexes, such as the gag reflex, and will not respond to verbal or painful stimuli. Such people can be considered to be in the *Coma Zone Major (BMA, 2005)*. An airway that has been closed by a spasm of the vocal chords that serves to protect the lungs will relax and allow water into the lungs if the person is still submerged. Clinically dead casualties are in the Coma Zone. Underwater in this state, within 5–10 min, irreversible biological death will occur and if rescued the outcome typically is very poor unless the casualty is very young and the water temperature very cold.

C_6: Conclusion Zone

The seventh C-Zone is the *Conclusion Zone*. The conclusion or outcome of a drowning episode depends upon several factors and varies in different cases. Generally speaking, age, gender, submersion duration, water temperature, and the presence or absence of hypothermia, salt vs. fresh water, and immediacy and quality of rescue and cardio-pulmonary resuscitative care are all major factors influencing the probability of survival after drowning in icy water (Avramidis & Butterly, 2008; Nemiroff & Pepe, 2006). For example, a young victim experiencing a short submersion in cold water, with no injuries and an unintentional clear water entry, would have a more positive prognosis following maximal resuscitative efforts (Bierens, 2006). Similarly, in longer salt-water immersions, survival rates for children are as high or higher than those encountered in fresh-water immersions and can approach 70% (Pearn, 2008).

The long-term consequences for survivors of a drowning incident can be both psychological and physiological in nature. Particularly, serious psychological consequences may include family conflicts and even divorce among couples whose child has fatally drowned, as well as posttraumatic stress disorder expressed by stressful dreams, the unintentional flashback to the emergency situation, antisocial behavior, anxiety, panic, insomnia, memory problems, and lack of attention or focus for rescuers and surviving casualties (Borta, 1991; Jones, 1985; Shepherd & Hodgkinson, 1990; Grosse, 2001; Goleman, 1995; Howsepian, 1998; Hidalgo & Davidson, 2000; Shannon, 1991; Avramidis & McKenna, 2010). On the other hand, in terms of physiological consequences a nonfatal drowning victim may experience major permanent damage, persistent vegetative state, mental subnormality, minimal cerebral dysfunction, spastic quadriplegia, extrapyramidal syndromes, optic and cerebral atrophy, peripheral neuro-muscular damage leading to pulmonary interstitial fibrosis, loss of motor functioning, reduced visual and special abilities, reduced cognition, loss of mood stability, and personality disorder (Pearn, 2008). Approximately 1–2% of all drowning survivors, and perhaps 20–30% of those requiring prolonged artificial ventilation, exist in a persistent or permanent vegetative state (Pearn, 1985, p. 150; Crowe et al., 2003).

Example Drowning Episode Depiction Using the C-Zones Framework

Having broken down the C-Zones framework into its basic building blocks and outlined how a victim might hypothetically progress through them, it is time to explain how the framework works in practice. To achieve this, an example scenario with two possible options for a skilled male swimmer (e.g., capable of swimming at a speed of 2 m/sec in pool water) is presented (Figure 4). This swimmer falls into a harbor in winter, fully clothed with a water temperature between 5–10 °C and attempts to swim 500 m to safety to steps or a ladder at a pier.

The first scenario consists of eight phases. First, the swimmer immediately experiences cold shock that includes breathing difficulty and chest pain. Second, he decides to swim to safety as quickly as he can. Due to the clothing, his swim

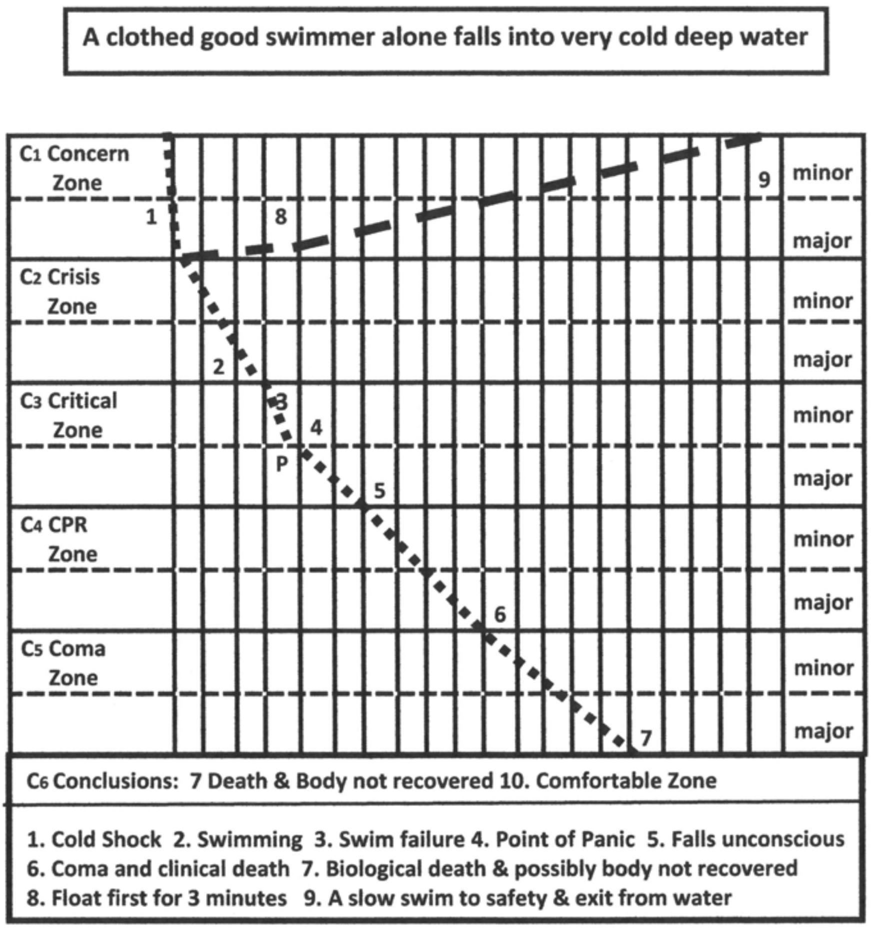

Figure 4 — A clothed good swimmer alone falls into very cold deep water.

speed is halved and due to the chilling of his arm and leg muscles, his swim speed is halved again (i.e., 1/4 in total or in other words only .5 m/second). In a pool he could swim the 500 m in 4 min 10 s but now it will take him approximately 16 min 40 s to do so. Third, after 2 min he experiences swim failure due to cold and decreased ventilation. His trunk and legs become almost vertical in the water and his progress has slowed almost to a stop. Blaming this on his clothing he decides to remove some of the clothing and treads water to do so. His fingers have lost all feeling and he fumbles with the clothing. He is now struggling to keep his head above the surface and begins to inhale water. Fourth, he starts to panic. Fifth, he falls unconscious and submerges fully. Sixth, within 4 min his heart stops beating and he is in a coma. Seventh, after 5 min his brain cells begin to die of anoxia. The conclusion is death with a possibility that his body may never be recovered.

The second option depicted consists of two phases. First, when the casualty experiences cold shock, he floats face up for 3 min until the cold water effects pass. Second, he actually manages to swim to safety and exits the water, although severely chilled and in need of medical help.

Applications of the C-Zones Framework

This educational study aimed to establish and overview the C-Zones framework, as a potential water safety aid with at least a double application. It has two applications with important advantages for those engaged or involved with a drowning episode (e.g., lifeguards, professional rescuers, general public). These applications and advantages are discussed here.

The first application of the framework is its use as a water safety educational tool. Water safety and lifesaving organizations can instruct lifeguards and other rescue professionals in the antecedents and outcomes of each stage in a drowning episode (e.g., how, when, where it happened and how it progressed). In a similar way, water safety instructors could use the same framework as a valuable educational aid for the general public in water safety related seminars, courses, and conversations regardless of the age group and the educational background of those using it.

The second application of the C-Zones is its use as an analytical tool offering visual feedback about the causes of drowning. More specifically, the framework may assist the identification of what went right or wrong at specific stages in an aquatic emergency. This information can be very valuable for the debriefing of a lifeguard team or other rescue team. Other professional services, such as court services, could use it while evaluating an incident from a legal point of view in cases of litigation by lawyers, judges, and expert witnesses.

Despite its applications and advantages, the C-Zones framework is subject to a number of different sources of potential limitations. The framework was established theoretically and therefore, its content or construct validity needs to be tested in a more quantitatively and qualitatively scientific way. There is a need to identify whether it can indeed be used as a teaching aid to people of all age groups (i.e., from adults down to young children) regardless of their educational backgrounds (i.e., how well will it be understandable to graduates of primary or secondary schools or higher education). Finally, there is a need to identify whether its constituent building blocks are adequate and wide enough to describe every drowning episode regardless of the potential combinations and interrelationships that might take place within it. The degree to which the C-Zones framework generalizes is also a topic for future research.

Conclusion

The C-Zones framework should heighten rescuers' awareness of the importance of recording times and temperatures as these are very important to decisions that will be taken in emergency departments post rescue. Water safety organizations and professionals can use the framework as a new educational and risk-assessment aid to support their drowning prevention and safety promotion efforts. Overall, the C-Zones framework is offered as an additional contribution to the existing list of drowning prevention theories and models that are currently available in the lifesaving and drowning prevention literature.

Acknowledgments

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