

Supplemental 1

Qualitative Analysis

Citation	Evidence Level*	Key Findings
Avramidis et al. (2009)	3B	Professional lifeguards and other rescuers reacted while bystanders failed to do so. Thus, demonstrating professional lifeguards' ability to do risk assessment and their willingness to take responsibility for the situation. A lack of response in untrained people is understandable and expected. Aquatic safety professionals and bystanders were unaware in most of the cases of the outward behavior of a drowning casualty. Even though most of the lifeguards remained alert while on duty, it was discouraging to note that only one-third were able to recognize someone who was drowning
Brander et al. (2011)	5	<p>Hypothetically, we can assign the following commonly observed reactions to distress in the water to the fight, flight, and freeze terminology:</p> <ul style="list-style-type: none"> • Lashing out in bursts of energy attempting to remain above water in primal movements such as “climbing the ladder” (fight); • Struggling toward an object that will help them stay afloat, including family or friends who may be in the rip current with them (flight); • Becoming overwhelmed with the situation and struggling on the spot, usually probing with their feet while sinking under water in their indecisiveness (freeze). <p>The instinctive reaction is to swim directly toward the shoreline. When this initial response to the stressor is ineffectual and the logical centers of the brain are shutting down, panic can set in which further limits effectual response.</p>
Carballo-Fazanes et al. (2020)	4	The visual drowning behaviour showed a broad range of behaviours. The pattern of drowning behaviour in children, who all drowned in pools, was much more homogenous than the pattern in adults, who drowned in various settings. A behaviour that matched the IDR was recognised by the observers as well as a modified version with “climbing ladder motion”. A typical behaviour recognized by observers was like one of the components of the IDR—the non-voluntary control movement consisting of extending the arms laterally and beginning to press down on the surface of the water to try to breathe—but was more forceful and with clear splashes of water while the arms were rotated fiercely backwards to keep the front of the head out of the water. There was no evidence in any of the videos of persons waving for help and there were no indications that any of the drowned persons tried to shout or scream.
Doyle & Webber (2007)	3B	The authors divided behaviours into five different classifications to create the SENTINEL model. We tested the application of the model on a category 8 (ABSAMP) rated beach. Each series of data (in water behaviour) was grouped and provided a status code from 1 to 5.
Fenner et al. (1999)	5	A distress situation involves a swimmer who is unable to return to safety without assistance, but because of their floating or swimming skills, is generally able to summon aid by waving, or calling out for help – i.e. they

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		<p>have voluntary control of their actions and could actually assist the rescuer.</p> <ul style="list-style-type: none"> • The passive victim slips under water without waving or calling out for help or struggling on the surface of the water - usually because of a sudden loss of consciousness. • The active conscious, drowning non-swimmer exhibits a struggling behavior that an attentive, properly trained lifeguard can detect. Importantly they characteristically flail their arms sideways in the water, extend their head backwards but, importantly, do not call for help.
Franklin et al. (2019)	3B	<p>Rescues are often performed when the rescuer is young and, in general, people only undertake one rescue in their lifetime, usually of a family member or loved one. Males were most likely to perform rescues at the beach, while females were more likely to perform rescues of young children at swimming pools. There is a need to train people early in their life on how to undertake a safe rescue and it would be useful to refresh these skills regularly, if supervising young children around water. Preventing rescuer drowning deaths will be an ongoing challenge due to the altruistic nature of the rescue attempt.</p>
Hunsucker & Davidson (2008)	5	<p>Recognizing drowning victims:</p> <ul style="list-style-type: none"> • On or near surface <ul style="list-style-type: none"> ○ Facial Express ○ Irregular motion including the absence of motion ○ Loss of body position ○ A head-back, nose-up posture ○ No leg kick • Victims on or near the bottom <ul style="list-style-type: none"> ○ Unexplained colour variation in pool ○ Elevated chest and drooping head ○ Lack of motion ○ Bubbles <p>Victims might exhibit some or none of the above characteristics. Guard training is essential for better recognition of drowning victims.</p>
Lanagan-Leitzel & Moore (2010)	3B	<p>The coverage of surveillance focuses on two basic processes—how to scan the zone of coverage and how to identify a drowning when it occurs. Proper scanning ensures that each swimmer is monitored and no swimmer is ignored. Yet, even with proper scanning, lifeguards must also be able to identify a drowning when it occurs and identify precursors that allow them to take preventative action to ensure that a drowning does not occur.</p> <p>A swimmer who is in distress is one who is struggling to stay afloat and may be cognizant enough to be able to call out for help and grab onto lane dividers, the pool edge, or rescue equipment. If unaided, a distressed swimmer could begin to panic and demonstrate a set of behaviors known collectively as the instinctive drowning response (Pia, 1974). This set of behaviors includes sinking very low in the water and frequent submerging, coupled with frantic efforts to keep the mouth and nose above the surface of the water (through flailing arms and a head that is tilted back). At this stage, the drowning person is devoting full attention to staying</p>

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		<p>above the surface of the water, so s/he may be unable to call out for help. This struggle only lasts as long as the patron's energy permits—a weak patron or a child may struggle for less than a minute before submerging. Once the patron slips underwater and can no longer breathe, critical body functions that require oxygen begin to shut down. The heart stops beating, preventing oxygen from reaching the brain. The longer a person is submerged without oxygen, the greater the risk of permanent brain damage, so lifeguards are taught the behaviors associated with each of these stages and are instructed to search for patrons exhibiting any of these behaviors.</p> <p>This analysis showed no large differences between lifeguards and non-lifeguards in monitoring behaviors consistent with drowning or distress. This suggests either that the behavior present in the video was salient enough to attract the attention of the non-lifeguards or that the lifeguards had modified their search strategy away from searching for specific behaviors they were taught in training.</p>
Lanagan-Leitzel (2012)	4	<p>Lifeguards are instructed to look for a specific set of behaviors that are thought to accompany drowning or distress. The most dangerous set of behaviors are splashing, frequent submersion, and a lack of progress through the water, such as what might occur during the instinctive drowning response (Pia, 1974). Lifeguards must also be vigilant for behaviors that indicate that a patron is distressed or soon may become so a patron who is moving slowly due to weakness, physical condition, or fatigue, or who is moving into water that is beyond their skill level.</p> <p>One problem with these definitions is that the behaviors described are not always indicative of drowning or distress—splashing and submersion happen very frequently in an aquatic environment, and even strong swimmers will slow down or stop eventually. An overreliance on these behaviors can result in surveillance that is haphazard and incomplete.</p> <p>One way that lifeguards could manage the task of surveillance is to search not for specific behaviors but for critical events. A critical event would be a specific event used by each individual lifeguard to determine attentional priority in a scene. Experienced lifeguard instructors, lifeguards, and non-lifeguards do not identify the same events as critical for a lifeguard to monitor. The non-lifeguards did surprisingly well at identifying many of the events that the lifeguard instructors had identified. They were especially good at identifying events where young children were performing dangerous activities, such as repeated submerging, horseplay, or going too far from shore</p>
Langendorfer (2011)	5	<p>Competence to swim surprisingly depends upon what kind of swimming I am intending to do and where. Individual characteristics illustrate the personal qualities that any human brings to aquatic endeavours. These include a person's size, body segment relative proportions, their force production capabilities, their body composition, the state of their nervous system including consciousness, and a host of other relevant abilities/disabilities.</p>

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McCool et al. (2008)	3B	<p>The findings identified considerable variability in self-estimated swimming competency among beachgoers. Perhaps it is not surprising that higher perceived swimming competency was associated with lower perception of risk, which raises the possibility that some individuals (especially young males) might be overly confident about their ability to manage risky situations through overestimation of their swimming skill. When associated with lower estimations of risk as indicated in this study, this combination of factors might prove to be potentially fatal.</p> <p>Indeed, past risky behavior was associated with lower risk perceptions, raising the possibility that a perceived invulnerability factor might override protective swimming skills and behaviors.</p>
Moran et al. (2017)	4	<p>Most respondents incorrectly thought that the waving of arms was a characteristic of a drowning person both pre- (incorrect response 72%) and post-intervention (incorrect response 60%). When asked about their rescue knowledge, levels of understanding varied considerably. While two-thirds of the respondents correctly agreed for the need to shout 'Are you okay?' to the person in the water, less than a quarter (23%) correctly disagreed that waving arms and shouting for help were normal signs of someone drowning. The persistence of the misconception that drowning people wave their arms and shout for help suggests that this is a strongly held belief that was not corrected by the intervention. Further emphasis on this</p> <p>critical factor of victim identification is strongly recommended in future bystander water safety programmes.</p>

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National Aquatics Safety Company (2017)	5	<p>Facial Expressions: Terror is many times exhibited through the expression on the face. Look for wide eyes with a lot of white showing. The face may be pinched and drawn. They may look as if they are over the edge of emotional control. They just look scared. All of these are signs that the victim is in an environment that they cannot control.</p> <p>Irregular Motion Including the Absence of Motion: What the victim is doing does not look like swimming. A flapping of the arms like a side-straddle-hop may occur. A pawing action is not uncommon. They may look as if they are trying to crawl or climb out of the water. Included in this symptom is the absence of motion. It is very difficult for even a trained swimmer to remain motionless in a floating position on the surface.</p> <p>Loss of Body Position: Most, but not all, victims drown in the vertical position. Once a swimmer goes vertical and starts fighting the water, they may become a victim. Remember though, some people who float can drown in the horizontal position.</p> <p>Head Back, Nose Up: Look at the nose of the victim. The position of the head controls the position of the body in the water. As the head goes back and the nose goes up, the victim goes to the vertical position. This may be the start of the drowning process. Watch children playing in chest deep water. Those that play with their nose pointed up are usually uncomfortable in the water. They don't like the water in their face. This is a dead giveaway of a potential victim.</p> <p>No Leg Kick: Swimmers kick. Victims usually don't. The absence of leg action implies that the person is using only their arms to keep themselves on or near the surface. If they can kick, they can swim.</p>
Page et al. (2011)	3B	<p>Cue extraction and integration are indicators of expertise rather than visual search per se. In addition to effective cue extraction, contextual knowledge is suggested to underpin decision making by influencing the categorisation and integration stages. There is also extensive literature documenting the differences between the knowledge of experts and novices. Lifeguards often must observe complex environments and extract relevant cues for long periods of time.</p>
Pascual-Gomez (2011)	4	<p>The aquatic incidents could be categorised as:</p> <ul style="list-style-type: none"> • Contacts and collisions between swimmers. This is a potential cause of disorientation and loss of breathing or movement. • Splashing from other swimmers or waves. This causes discomfort and activates the apnoea reflex. • Accidental water swallowing. This causes choking, cough, and apnoea reflex. • Being out on the deep or not reaching the edge or shore. This is a potential cause of fear and psychological distress. • Accidental falls, tiredness, discomfort, illness, stroke, or seizure. This may disturb or hamper the normal performance.

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Pascual-Gomez (2014)	3B	<p>The observations showed that the swimmers who have a considerable risk to lose control in the water can be recognised by their behaviour:</p> <ol style="list-style-type: none"> 1. Swimmers who do not know how to place their face, eyes or head under the water and do not use goggles to prevent eyes contacting water 2. Swimmers who do not know how to achieve apnoea or hold their breath underwater 3. Swimmers whose basic skills as floating, propulsion and breathing are weak or lack self-confidence, thus feeling insecure in water 4. Swimmers who increase supporting swimming movements with their hands and arms to keep afloat 5. Swimmers who are not able to tread water and not able to roll over their back or change strokes <p>Swimmers who demonstrate the first and second types of behaviour when involved into an incident will be unable to react properly and, when their head gets into the water, will easily get distressed or panic. Those who demonstrate the third and fourth types of behaviour will be frightened because they have the feeling that their abilities are too weak to keep them safe. These swimmers become psychologically distressed, lose control of their swimming movements, and submerge due to their inefficacy. Swimmers who demonstrate the fifth type of behaviour are highly handicapped. They lack the ability to keep their airway above the water surface.</p>
Pearn & Franklin (2012)	4	<p>The syndrome of the rescuer-who-drowns comprises a hitherto neglected and under-identified set of victims where preventive approaches are difficult. Rescuers who drown give their lives, involuntarily but altruistically</p>
Petrass & Blitvich (2017)	4	<p>Supervision is multifaceted and other factors that were consistently associated with the notion of lower levels of supervision and potential drowning risk in public pools included: the caregiver being responsible for multiple children (83%); the caregiver leaving the younger children under the supervision of older children (17%); and a busy pool environment (25%).</p>
Petrass & Blitvich (2018)	3B	<p>This study examined perceived ability of young adults to perform a rescue; determined the level of aquatic rescue knowledge; and measured the effect of an aquatic rescue intervention. Findings indicated that many young adults lacked both the physical capacity and knowledge required to safely perform a rescue, a factor that may place them at increased drowning risk if they attempt an aquatic rescue. Participants had a low level of rescue knowledge and the relationship between perceived rescue ability and practical rescue testing was weak. Post-intervention, ability to perform a contact tow demonstrated significant improvement and rescue knowledge also improved significantly, demonstrating a rescue-based intervention can significantly improve competency of young adults regardless of previous experience and/or qualifications.</p>

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Pia (1974)	5	<p>There are two types of water crises, distress situations and drowning situations. Distress situations are those in which swimmers with varying degrees of skill are unable, because of tidal conditions (surf or tip tides) or fatigue, to return to shore without some assistance.</p> <p>Drowning situations involve non-swimmers who, for a variety of reasons, suddenly find themselves in water above their heads. A non-swimmer is defined here as an individual who cannot support himself by swimming or floating. When drowning, the person:</p> <ul style="list-style-type: none"> • Rarely can call out for help. • Has instinctual arm movements which, unlike the hailing or waving of persons in distress, appear to push the victim upward in the water by thrashing the water with both arms partially extended from his sides. The arm movements of the non-swimmers are instinctive efforts to keep their heads above water and remain breathing. • Usually manages to turn toward shore, with his body in an upright position, with no apparent support kick. As the drowning progresses, the drowning person's head sinks lower in the water. His arm movements become less visible - and more feeble - until only the top of his head and grasping hands may be seen. The whole process may be as long as 60 seconds or as short as 20 seconds.
Pia (1984)	5	<p>The Instinctive Drowning Response.</p> <p>The person is rarely able to call out for help. This apparently odd fact becomes believable when one remembers that breathing, not speech, is one of the primary functions of the respiratory system. Therefore, in time of extreme peril in water, breathing must take precedence over speech. Accordingly, onlookers may be watching a person drown-unaware that he or she is drowning, because there has been no call for assistance.</p> <p>The person has instinctive arm movements, which appear to be an attempt to push the victim upward in the water by thrashing the water with both arms extended laterally. This type of arm movement cannot propel the person in any direction; it merely raises and lowers the person out of and into the water as he or she tries to breathe.</p> <p>The person usually manages to turn toward shore. The body is upright with no apparent supporting kick. The person's head sinks lower and lower in the water as the drowning progresses. The arm movements become less visible and feebler, until only the top of the head and grasping hands can be seen. The process can last for as long as 60 seconds or for as few as 20 seconds.</p>

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Pia (1997)	5	<p>Characteristics which differentiate distressed swimmers from a drowning person is that the distressed swimmer have voluntary control over their movements. Movements such as attempting to but not making any progress toward safety, trying to use another patron for support, or waving or calling out for help, all signal the lifeguard, and often other patrons, that help is needed.</p> <p>An active drowning person struggles on the surface of the water in a highly predictable, patterned, and to the trained eye, recognizable way. The Instinctive Drowning Response represents a person's attempts to avoid the actual or perceived suffocation in the water. The key concept in understanding a drowning person's behavior is to keep in mind that suffocation in water triggers a constellation of autonomic nervous system responses that result in external, unlearned, instinctive drowning movements.</p> <p>Characteristics of the Instinctive Drowning Response (IDR)</p> <ol style="list-style-type: none"> 1. Persons, except in very rare circumstances, are physiologically unable to call out for help. The respiratory system was designed for breathing; speech is the secondary or overlaid function. The second reason drowning persons cannot call out for help is their mouths alternately sink below and reappear above the surface of the water. When the drowning persons' mouths are above the surface, they exhale and inhale quickly as their mouths start to sink below the surface of the water. While their mouths are below the surface of the water drowning persons keeps them tightly closed to avoid swallowing water. 2. Drowning persons cannot wave for help. Immediately after drowning persons begins gasping for air, they are instinctively forced to extend their arms laterally and begin to press down on the surface of the water with their arms and hands. 3. Drowning persons cannot voluntarily control their arm movements. Physiologically, drowning persons who are struggling on the surface of the water cannot stop drowning and perform voluntary movements such as waving for help, moving toward a rescuer, or reaching out for a piece of rescue equipment. 4. Drowning persons' bodies are perpendicular in the water, and they are not able to move in a horizontal or diagonal direction. Also, there is no evidence of a supporting kick. 5. Drowning persons struggle on the surface of the water from 20 to 60 seconds

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Stallman et al. (2008)	5	<p>Whiting, noted expert in motor learning, characterized a person who can swim as “able to cope with an unexpected and involuntary submersion</p> <p>When considering the analyses of the drowning accident reports, the interviews of survivors and observation of simulated episodes together, several key elements constantly appeared. The list of these key elements include the following:</p> <ol style="list-style-type: none"> 1. The victim didn’t realize the danger. It looked safe to them (e.g., the victim did not know about the undertow). 2. The victim suffered an unexpected occurrence before or in conjunction with entering the water (e.g., fall from height, awkward landing, loss of breath, wind knocked out at landing). 3. The victim suffered an unexpected result or experience during submersion (e.g., deep submersion after fall, difficulty in regaining the surface, couldn’t see where I was going, water was cold, clothes heavy). 4. Following submersion, the victims skills were inadequate to survival (e.g., unable to turn back toward safety, unable to roll over and change strokes, couldn’t swim in waves, became quickly tired— couldn’t swim far, couldn’t stop and rest/float). <p>In too many cases, children are not taught what is necessary for them to cope with an unexpected submersion that could lead to drowning.</p>
Turgut & Turgut (2012)	3B	<p>Rescuers who died from drowning -in this study- weren't trained to perform in water rescues. People can be prepared to attempt such a high-risk activity with prior knowledge in water rescue training. MDIs are an important part of the drowning incident problem, and for that reason it is important for individuals to know how to identify drowning and how to properly help someone who is drowning.</p>
Webber (2012)	5	<p>The ability to recognise a victim in distress is a core lifeguarding skill. With junior and less experienced lifeguards, these skills may be lacking. Cognitive and developmental issues can also impact on a lifeguard’s ability to recognise a person in distress. Preliminary research suggests that detection rates in both groups can, however, be improved with training and experiential learning</p>

- Levels of evidence are based on the work of Burns, P. B., Rohrich, R. J., & Chung, K. C. (2011). The levels of evidence and their role in evidence-based medicine. *Plastic and reconstructive surgery*, 128(1), 305 and Centre for Evidence-Based Medicine, <http://www.cebm.net>.