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Learning from Incidents to Reduce the Risk of Drowning in Swimming Pools: Implementation of Experience-Based Feedback Regarding Near-Misses in Four Public Facilities in France

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Abstract

The prevention of sports accidents must rely on a detailed knowledge of accident circumstances and risk factors. Today, very few studies have investigated in depth non-fatal drowning incidents that have occurred in public swimming pools (PSP). Learning from incidents seems likely to advance the knowledge of accident scenarios. This research study aimed to capture minor incidents that might identify safety lessons and preventive measures. Incidents of minor and major aquatic events were collected from four PSPs that had hosted 700,000 bathers per year. About 800 incidents and 300 aquatic rescues performed by lifeguards were recorded within a time frame of two and one-half years. The analysis of results offered insights both in terms of managing risk and preventing drownings. Drowning risk management could directly benefit from the results of this study. Methodological recommendations also provided suggestions to ensure the proper collection of non-fatal drowning incidents in PSPs.

Keywords: public swimming pools, incidents, non-fatal drownings, aquatic rescues, injury prevention, risk analysis

Introduction

The effectiveness of the prevention of sports accidents[1] is usually addressed through informational issues related to clear statements and the adequate understanding of preventive messages. Historically, in-depth knowledge of the frequency of accidents, identification of risk factors, formulation of victim profiles, and accident scenarios were expected measures[2] (Bahr & Krosshaug, 2005, Rasmussen & Svedung, 2000).

Recent research on recreational sports practiced in hazardous environments such as mountainous areas (Vanpoulle, Vignac & Soulé, 2017) or aquatic settings (Vignac, Lebihain & Soulé, 2015) have highlighted that the factual knowledge of accidents has not been perfected. These findings raise an important issue regarding the possibility of building prevention campaigns on concrete elements about accident circumstances and scenarios (Bierens & Scapigliati, 2014; Idris, Berg, Bierens, Bossaert, Branche, Gabrielli, Graves, Handley, Hoelle, & Morley, 2003). Thus, the accidentology (i.e., scientific study of accidents, their causes and consequences) of sports practiced in risky environments could be improved in France.

We propose in this article an alternative means of advancing the knowledge of drowning sequences in public swimming pools (PSP): examining and learning from non-fatal drowning incidents[3] instead of merely relying on actual fatal drowning accidents. Closely examining feedback of problematic situations in terms of safety such as particular conditions which could have turned into an accident could be used to draw preventive lessons.[4] Incidentology has the advantage of skirting some persistent barriers to accessing accurate accident data. First, stakeholders don't have to face the same emotional, moral, and legal issues as in the case of a fatal drowning accident. Moreover, based on many situations,[5] the study of non-fatal drowning incidents shows promise thanks to the larger number of cases to be analyzed. After having detailed the conceptual and methodological frameworks of this approach, we have reported on a 32 month-long initiative concerning the risk of drowning in a convenience sample of French public swimming pools (PSP).

Background Theory

Accident causation is classically described as a complex process involving not only entire socio-technical systems (Rasmussen, 1997) but also interdependencies within systems of systems (Harvey & Stanton, 2014). It is consequently inappropriate to attribute a whole accident to a single error in decision-making, without considering all of the influences, mechanisms, and constraints that shaped that decision, and, more broadly speaking, human behaviour (Perrow, 2004; Leveson, 2004). Accidents usually proceed as the result of the interaction of various, sometimes scattered, causes or contributory factors (Lundberg, Rollenhagen, & Hollnagel, 2009) rooted in different time scales.

In Leveson's System Theoretic Accident Model and Processes (STAMP), systems are interrelated components kept in a state of dynamic equilibrium by feedback loops of information and control. According to Leveson's model, a system is a dynamic process that is continually adapting to achieve its ends and to react to changes in itself and its environment. This model can easily be transferred to aquatic environments such as PSP: to be kept in balance, the system constantly is adapted through safety control loops (e.g., supervision by lifeguards, swimming skill levels, specific attention of supervising staff to vulnerable users, contingent detection of a person in distress by a bather, computerized video system for drowning detection) (Rasmussen & Svedung, 2000; Vignac, Lebihain, & Soulé, 2016; 2018). If one (or more) of these control loops fails, or if the system's equilibrium is offset by the interaction of its components, the probability of the emergence of an accident scenario increases (whether the actual outcome is an accident or merely a close call).

When the weak hazard signals that incubate in a system (Turner & Pidgeon, 1978) are taken into account, it is more likely that they will not escalate into an actual accident sequence (Leveson, 2004). Weill-Fassina & Pastré (2004) stated that this way of thinking focuses on serious accidents as well as on less serious incidents and thus should serve as forerunner signals of hazards that must not be overlooked (Vaughan, 1996). Less serious incidents and near-misses actually result from mechanisms and underlying factors similar to those causing accidents (Harrald, Spahn, Van Dorp, Merrick, Shresta, & Grabowski, 1998). More and more frequently, feedback methods resulting from experience are applied to close calls, defined as "any situation in which a sequence of events was interrupted, preventing the occurrence of potentially serious consequences" (Van der Schaaf, 1991). When an incident occurs, one must keep in mind that slight circumstantial changes could have led to much more serious consequences (Gambino & Mallon, 1991). In fact, some accidents result from failures to learn from previous incidents (Hopkins, 2008); not learning from incidents is subsequently an incident to study in itself (Drupsteen & Hasle, 2014).

According to Mazaheri, Montewka, Nisula, and Kujala (2015), "both positive and negative experiences can be tracked" (p. 206). These include safety factors[6] that failed, but also decisions and actions that prevented the escalation to an accident. Instead of regarding spectacular or dramatic events occurring in extreme conditions, learning from minor incidents and weak signals (as defined by Drupsteen & Wybo, 2015) can help to grasp characteristics of ordinary accident sequences as they unfold in normal conditions (Plant & Stanton, 2012).

The sharing of incident accounts is based on the principle that it is everyone's responsibility to consult and eventually apply such "lessons" (Lukic, Margaryan, & Littlejohn, 2010). In this paper, we aimed to analyze a sample of the data gathered this way in order to make sense of this information and to enhance the knowledge and prevention of accident sequences (Lukic, Littlejohn, & Margaryan, 2012). Our intent was to emphasize the preventive value of near-miss sequences in PSP.

Method

The data collection was undertaken as part of a larger research project dealing with the prevention of drowning risk in four PSPs within an urban agglomeration of western France. These four PSPs had been built between 1966 and 1976, and their cumulative annual attendance was close to 700,000 visitors during the study period. The incident collection tool aimed to record all assistance and relief operations that occurred during the supervision of the pools by lifeguards, including those without medical consequences. It was designed to be participatory, and at the end of a short test period, the lifeguards were invited to make comments in order to improve and simplify the collection tool.

Lifeguards working in the four PSPs were invited to contribute, both through their supervisory hierarchy (i.e., management memo presenting the tool, the collection method, and its interest) and during an oral presentation by the researcher. During this presentation, the importance of systematically reporting interventions carried out during supervision was emphasized along with the preventive usefulness of comprehensive data gathering. Although the focus was on accident sequences that could lead to accidents or drownings, we also encouraged lifeguards to report mundane, apparently-innocuous events such as the treatment of minor injuries such as cuts and bruises or preventive advice provided to those vulnerable and at risk. In order for lifeguards to complete the survey without diverting them from their primary supervision mission, the collection tool (see Figure 1) had to be simple, quick to fill out (i.e., one minute at most), accessible, user-friendly, accurate, confidential, and perceived as useful (Sepeda, 2006; Yang & Maxwell, 2011).

For practical reasons, a notebook was made available in each facility with a single page dedicated to each incident. Most of the information in the pre-structured form simply needed to be circled or ticked (see Figure 1 and Table 1). The lower part of the form included an open field to let the lifeguards describe the cause(s) considered to be at the origin of the incident. Since this narrative field was the most time-consuming to complete on the reporting form, it was omitted in a number of cases (n=70).

According to Le Coze and Lim (2004), the regular collection of reported incidents, combined with feedback, can reinforce the staff's sense of usefulness. It is likely to increase its involvement in terms of data gathering. For this purpose, the reported incidents were collected on-site on a regular basis (each month), providing an additional opportunity to be supportive. This monthly collection has helped to counter decreases in the involvement due to forgetfulness or lack of time, that often happens after the novelty wears off. The quantitative data were then entered in an *Excel* matrix, then coded, and categorized to facilitate their analysis.

Table 1. Categories of the incident collection tool

Occurrence data	Demographic data	Context data	Incident data
Date, hour, day, place	Sex, age, type of public, swimming skills	Estimated frequency at the time of the incident, duration of the intervention, place of intervention	Type of intervention, causes and circumstances, type of detection, type of rescue

To understand how this initiative was perceived and to identify possible variations in terms of involvement, we conducted 30 semi-structured interviews in parallel with lifeguards engaged in the data collection. These interviews made it possible to identify 1) how the data collection tool was actually used and 2) the nature of the data effectively gathered (e.g., comprehensiveness, detail level).[7]

Figure 1. English version of the survey form

Contributor:
Day: M T W T F S S **Date :**
Time of the intervention : **Duration of the intervention :**

Frequenting:

Low	Average	High	Very high

Place of the incident :

Outdoor pool	Indoor pool	Pool beaches	Locker room	Shallow pool	Hall

Place of care:

On the spot	Supervision station	Infirmary

Victim: ☐ M ☐ F **Age :**

- 6 yo	+ 6 yo	10-19 yo	Adult	Senior

☐ **Swimmer** ☐ **Non swimmer**[1]

Type of user:

School	Free bather	Group	Lesson	Animation	Club

First aid intervention:

Minor injury	Nosebleed	Cut	Shock / bump	Other :
Injury	Type :			
Faintness	Type :			

Aquatic rescue:

Rescue	Pole	Jump	Third party	Other:
Detection	Direct (by myself)	Indirect (colleague, user, etc.)	Other:	
Main cause				

Follow-up given to the intervention:

Without continuation	Alone departure	Help departure	Sanitary evacuation

Circumstances *(main cause, secondary cause) :*

[1] Thank you for considering that a "non-swimmer" is unable to achieve 25 meters without support and/or flotation device (only for an aquatic rescue).

Results

Demographic Information

From July 2013 to January 2016 (i.e., over 32 months), 791 interventions were reported, including 282 (36%) aquatic rescues. An aquatic rescue was defined as the intervention of a lifeguard during an accident sequence. It could take different forms: a hand reached out, the use of a pole, or a dive into the water. In such cases, the absence of any lifeguard action could have led to a fatal drowning accident. This first result could either have been worrying (about the actual risk of drowning) or reassuring (in terms of supervision efficiency). The treatment of cuts and other minor injuries (e.g., nosebleeds, lacerations) accounted for the most frequent of the lifeguards' activities during supervision (n = 385; 49%). Matthews, Alister, & Franklin (2008) made a similar observation about lifeguards' activities. One hundred twenty-eight (128) interventions were initiated by cases of faintness, dispute, severe traumatic injury, or the delivery of preventive advice.

In the French PSPs studied, the care for bathers who suffer minor injuries was an integral part of the lifeguards' missions. This part of the job had not been clearly anticipated in terms of global safety management. For example, temporary absences of a lifeguard due to the treatment of bruises were often not compensated by other staff in support. As a consequence, adequate pool supervision was frequently impaired (Vignac, Lebihain & Soulé, 2016). It is important for readers to realize that the prevention of drowning cannot be understood in isolation from the daily operation of a PSP. For example, the RID factors (an acronym for failures of *recognition*, *intrusion*, and *distraction*) stressed that lifeguards who are distracted by intrusions into their supervisory routines were less prone to catch a person in distress (Pia, 1984).

A substantial majority of incidents required more than 3 minutes (n = 437 versus 307 incidents necessitating less than 3 minutes) with a proportion of interventions lasting more than 6 minutes (n=177). It is worth mentioning that on the physiopathological timeline used in anoxia and drowning, the average survival rate seems to drop to 25% after 3 minutes of immersion while it is still 75% between 1- and 3-minute immersions (Mathon, Aymard, Kretyl & Levraut, 2011).

Aquatic Rescues and the Potentiality for Drowning Accidents.

Males were slightly more likely to be rescued than females (n=153 *versus* 110) with no significant difference. Of course, it is important to realize that historically males have represented more than 75% of drowning victims across all ages. Harada, Goto & Nathanson (2011) and Pitt (1994) reached the same conclusions. Adolescents (10-19 years old according to WHO), adults and seniors are rarely or very rarely helped (n=37). On the other hand, as Hunsucker and Davidson (2011) found, the under-6-year-olds (n=112) and the 6-9-year-olds (n = 130) required, by far, the greatest number of aquatic rescues.

Nevertheless, belonging to the category of "non-swimmers" constituted the most discriminating variable in predicting a need for a rescue (n=233 aquatic rescues); moreover, no "swimmer" aged 6 years or younger required aquatic rescues. Since no precise definition was available, we considered for this study that a "non-swimmer" was unable to achieve 25 meters without support and/or flotation device. Among "non-swimmers" older than 6 years old, the number of aquatic rescues was significant (n=103), but it remained slightly lower than for "non-swimmers" younger than 6 years (n=105).

Aquatic rescues occurred mainly during periods of average (n = 119) and low (n = 115) attendance (*versus* 39 and 7 in periods of high and very high attendance, respectively). Even if off-peak periods were often described as lending themselves to decreased lifeguard vigilance, these results confirmed the importance of the co-supervision phenomenon: in periods of high attendance when pools were saturated with users, apparently the risk of drowning without being seen (especially by another bather) was reduced. According to Harrell and Boisvert (2003), lifeguards' supervisory observations were stimulated during peak periods, mitigating the actual risk of drowning. On the other hand, Vittone and Pia (2006), Avramidis, Butterly, & Llewellyn (2007), and Griffiths (2002) explained that in most cases, drownings occurred under the eyes of users who didn't realize and/or perceive what was happening, perhaps because they felt the risk was low.

A proportion of aquatic rescues were reported to have occurred to "free bathers" (n=158). We can hypothesize that other types of aquatic activity (e.g., training, learning, recreating) benefitted from dedicated coaching or instructional activities which likely interrupted earlier accidental sequences (Pitt, 1994). The situation regarding schoolchildren was a peculiar one: learning to swim and getting familiar with the aquatic environment necessitates controlled and limited risk-taking for pedagogical purposes. Because flotation devices were contextually prohibited outside instructional settings, a number of rescues (n=67) occurred among this novice population.

When all ages were combined, the majority of aquatic rescues occurred in shallower pool depths (n=195) versus in deeper areas of pools (n = 83) where the victims necessarily could not touch the bottom. Adolescents, adults, and seniors needed assistance in the large pools (n = 31) while rescue operations were launched for children (ages 9 or younger) in shallower depth pools (n=192). Both Wendling Vogelsong, Wuensch and Ammirati (2007) and Hunsucker & Davidson (2011) previously had highlighted similar results. In most cases, lifeguards themselves detected the drowning process that lead to rescues (n=174). Detections by a third party (e.g., non-lifeguard staff,[viii] teachers, animators, caregivers, or other bathers) were mentioned in only a small number of occasions (n = 21).

The majority of aquatic pool rescues in this study were extension rescues, that is, carried out using a pole (n=130). Direct intervention in the pool accounted for 67 cases, while in 46 circumstances, a third party intervened. Lifeguards who detected an emergency situation sometimes involved a third party nearby. In only 18 cases, the interventions were limited to assisting the victim by stretching out the hand (i.e., a “reaching” rescue). The reasons for the origins of each rescue were often described through a short narrative of the situation.

Supervision deficiencies (resulting on the part of non-lifeguards) (n=97) and overestimation of swimming capabilities (n=31) were the two main causes reported. This finding was of particular concern because supervision deficiencies were cited mostly for rescues of children under 6 (n = 56) and 6 to 9 years old (n = 41) who have been reported as the most vulnerable (Kemp & Sibert, 1992). The overestimation of swimming capabilities was mainly attributed to rescues of 6-9-year-old children (n = 22), especially during the learning phase of swimming including when they lost their flotation device (n=10). This kind of event has been considered the cause of a number of drownings (Stallman, Junge & Blixt, 2008). The compilation of 1) the causes reported by lifeguards, and 2) the swimming capabilities of rescued bathers, designated as "non-swimmers" were the main victims of supervision deficiencies according to reports by parents, animators, or teachers (n = 96). A related finding that corroborated these findings had been reported by Petrass and Blitvich (2012).

Discussion

In some facilities, interventions seemed to have been frequent, while they were quite rare in other ones. Different levels of commitment from one PSP facility to another by the staff were noted by the researchers, as well as from one lifeguard to another within the same PSP. Numerous lifeguards acknowledged being very conscientious about filling out forms.

Data collected echoed the single-loop learning process (Lukic et al., 2010), that mostly aimed to correct superficial dimensions of safety problems (through technical advice or skills training, for instance). In doing so, this system somewhat overlooked the systemic origin of mishaps, although fragments of underlying causes were also mentioned. This type of approach must therefore be complemented by more in-depth organizational and systemic analyses based, for example, on individual semi-directive interviews to help to foster the double-loop learning process, which could reveal the root causes of failures as well as the influence of organizational values and culture (Lukic et al., 2010). These systemic and organizational approaches were encouraged by Le Coze (2016) in the industry but also with respect to risky physical activities by Soulé (2009), Lebihain (2000), and more recently, by Vignac et al. (2018) in French PSP.

Near-misses and close calls comprise most, if not all, of the ingredients of an accident sequence without the heavy physical and emotional consequences for the party involved. Thus, they make the testimonials easier and lessen some of the blocks to accident reporting. However, the implementation of a valid, reliable, and objective collection system was time-consuming for many stakeholders. It could even detract lifeguards from their most important tasks. On the other hand, in the long term, the analysis of gathered data made it possible to better treat reasonably foreseeable accidents. This innovative approach constituted an organizational change in terms of risk management. Furthermore, the French NF-15288 standard encouraged detailed risk analysis approaches (Cranga, 2009). Our study also highlighted how difficult it was to mobilize and motivate the lifeguard teams and to set up this type of participatory approach in a sustainable fashion, in spite of the initial interest that lifeguards and PSP managers had shown. We still are unable to answer the question about how to make sure that these professionals reported as systematically as possible the incidents they encountered. Like in many innovations, the challenge raised here was above all that of the adaptation and improvement of the approach.

Recommendations

Although it is important to be cautious about the validity and reliability of these results (since we do not know exactly which events were reported and which were not), we can infer some ideas for prevention:

- If it is not anticipated in an organizational plan, the management of minor injuries may negatively impact the supervision process (for a duration range of 3 to 10 minutes in a majority of reported cases). These tasks could usefully be delegated to the non-lifeguard staff in the facility in order not to impair lifeguard supervision;
- It is important for the lifeguards not to slacken their supervision efforts during off-peak periods since most reported rescues happened under in such context;
- Children under 6 years-old (especially "non-swimmers") require special attention since 1) they are particularly vulnerable, and 2) supervision failures are frequent on the part of their companions and caregivers;
- Though they may seem innocuous, shallower pools (or areas of pools) proved to be quite dangerous; diligent supervision should not be neglected in these areas.

Limitations

Our descriptive data probably underestimates the actual occurrence of incidents. As a matter of fact, several interviewed lifeguards stated that during peak periods, they were more focused on supervision (rightfully) than on maintaining the consistently of completing forms. As a consequence, an unspecified number of aquatic rescues were not reported, especially for incidents occurring during periods that required constant alertness such as during teaching times. The other limits drawn from the qualitative and descriptive analyses of interviews were synthesized in the table below.

Table 2. Interview anecdotes from actual reporting of non-fatal drowning incidents

Limits unveiled	Interviews excerpts
Incompleteness of interventions and reported incidents (events perceived as harmless, mundane)	*« Sometimes we do not have the motivation to record minor injuries, for example, a small cut, even if it should be noted »* *« It's so innocuous and constant that we often forget, after a school session, to note that we assisted kids two or three times with the rod »*
Wearisome effect a couple of months after the initial period of eagerness	*« Initially I was very enthusiastic, but then… It requires an administrative rigorousness that the lifeguard doesn't really have (...) Either we forget, or we do not have the willingness to keep playing »* *« I have not been a very good boy regarding this form. I probably filled out 2 or 3 times, while I am performing at least 2 to 3 aquatic rescues a week (...) lack of time, and laziness a little bit »*
Impairing of the supervision, prioritization of monitoring tasks	*« It's true that it forces you to skip to a degraded supervision, which bothers me a little bit »* *« This summer I noticed a lot of risky situations. We went up to 4 interventions in 15 minutes! In such circumstances, you cannot write in the notebook, you cannot leave the supervision… »*

Conclusions

Close calls, much more frequent in PSP than accidents, may provide an important source of data to comprehend accident scenarios. While it is to be used with some caution, the methodology introduced in this study offered interesting opportunities in terms of training and prevention. It showed that "things happen" during supervision, making the constant presence of the lifeguard essential to maintain the operation of a swimming pool in an accident-free state (Leveson, 2004).

Our results showed that a safe PSP is not a facility where no accident or incident occurs, but a facility where almost every near-miss is reported in order to avoid further escalation into a more serious accident or fatal drowning. In this regard, our work encouraged and pushed us to develop an alternative way of considering drowning accidents in PSP.

This initiative posed a risk of oversimplifying the complexity of drowning incident sequences. In a way, it was prone to the “root cause seduction” (Cooke & Rohleder, 2006), since most reports tend to mention one and only one contributing factor in the event of an aquatic incident. The main finding from this experience feedback was actually of a different nature: it enhanced the knowledge of 1) the number of interventions, and 2) the duration of lifeguards' solicitations (especially those interfering with their observational supervision of the pools). Such data made it possible to estimate the importance of such intrusions in the supervision system, potentially hindering the capacity to detect in time an actual drowning sequence, and incidentally, the quality of supervision.

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Endnotes

[1] Actualization of a danger, an accident is a sudden and involuntary event which causes bodily injury, in addition to possible material damage.
[2] Accidental scenarios or trajectories consist of multiple factors (e.g., initiating events, particular contexts, decisions made at different levels) whose combination has contributed to transforming a risky situation into an accident.
[3] Unexpected and sudden event affecting at least one person without entailing bodily injury. Example: an aquatic rescue without medical consequences. In this article, we will not differentiate between incidents and near-misses (when an accident was narrowly avoided according to Vincent, Ennis & Audley (1993).
[4] Analysis of accidents or incidents to make them safety learning materials.
[5] According to Bird's Pyramid (Bird, Cecchi, Tilche & Mata-Alvarez, 1974), based on accident statistics in the North American industry in 1969, the probability of a serious accident occurring increases when the number of previous near-misses is large. The underlying idea is that every serious accident is associated with hundreds of minor incidents that occurred prior to it; this suggests that the number of precursors could act as an alarm or a learning system.
[6] Safety factors (SFs) are functions likely to contribute to safe operations (Mazaheri,et al., 2015). Their positive nature helps to identify measures likely to stop the situation to become an accident.
[7] The interviews conducted focused on the general theme of security in organizational way. A sub-theme of the interviews was dedicated to the feedback of experience (REX) and more specifically to the process of collecting incidents that are the subject of this article. The following questions were addressed to the interviewee: How are you involved in this process? When and how do you inquire? What do you think about this approach? Are there any incidents which are not recorded? If yes, why, for what reasons? What should be done to improve collection?
[viii] Teacher, animator, caregiver, etc.