



DESCRIPTIVE MANUSCRIPT

# Systemic Drowning Prevention – A Theoretical Framework for the Development of Evidence-Based Interventions

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AQUATICS SERIES: This series aims to explore the diverse aspects of water safety, including the prevention and management of water-related injuries; the education of rescuers and the lay public; and the development of safety equipment and protocols across different levels of training, scopes of practice, and contexts. Together the *International Journal of First Aid Education* and the *International Journal of Aquatic Research* invite you into the unique needs and competencies required for safety in aquatic environments.

## ABSTRACT

**Problem:** Drowning is a multifactorial, systemic problem. To enable evidence-based, effective decisions and policies, an overarching theoretical framework is necessary that can describe the complexity of this issue.

**Process:** This paper describes a systemic drowning prevention framework based on the main tenets of Luhmann's systemic theory (Luhmann, 1995; Hafen, 2020). Previous work by Hafen (2020) is advanced by integrating systems theory, evidence-based practice, and insight from recent drowning prevention research.

**Submitted:** 16 October 2024

**Accepted:** 24 February 2025

**Published:** 20 March 2025

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**Outcomes/Implications:** With respect to four different levels on which drowning prevention can be viewed, (i.e., population, impact factors, target systems, and methods) we describe theory-driven methods for acquiring information, flag potential challenges, and outline how the application of this theory can be combined with the process of evidence-based practice. This framework presents the basic principles that a practitioner or governing body might use to decide on evidence-based drowning prevention actions.

**Keywords:** Public health; evidence-based practice; systems theory; aquatic; water safety

## ZUSAMMENFASSUNG

**Problem:** Ertrinken stellt ein komplexes und systemisches Problem dar, welches durch eine Vielzahl von Akteur:innen und Maßnahmen geprägt wird. Um evidenzbasierte, wirksame Entscheidungen und Richtlinien zu ermöglichen, ist ein übergreifendes theoretisches Konzept erforderlich, der die Komplexität dieses Problems beschreiben kann.

**Prozess:** Dieses Doppelt Papier stellt ein systemisches Konzept für die Ertrinkungsprävention vor, welches auf den Grundprinzipien der systemischen Theorie von Luhmann (Luhmann, 1995; Hafen, 2020) basiert. Aufbauend auf früheren Arbeiten von Hafen (2020) werden Systemtheorie, evidenzbasierte Praxis und aktuelle Forschungsergebnisse integriert.

**Ergebnisse/Auswirkungen:** Das hier beschriebene theoretische Konzept betrachtet Ertrinkungsprävention auf vier verschiedenen Ebenen: derjenigen des Problems, der Einflussfaktoren, der Zielsysteme, und der Massnahmen/Methoden. Wir beschreiben theoriegeleitete Methoden zur Informationsbeschaffung, weisen auf potenzielle Herausforderungen hin und skizzieren, wie die Anwendung dieser Theorie mit dem Prozess der evidenzbasierten Praxis kombiniert werden kann. Praktiker:innen und Leitungsgremien können die hier beschriebenen Grundprinzipien anwenden, wenn sie über evidenzbasierte Ertrinkungspräventionsmaßnahmen entscheiden.

**Schlüsselwörter:** Öffentliche Gesundheit; evidenzbasierte Praxis; Systemtheorie; aquatisch; Wassersicherheit

## RESUMO

**Problema:** O afogamento é multifatorial e sistêmico. Para permitir decisões e políticas eficazes e baseadas em evidências, é necessário um quadro teórico abrangente que possa descrever a complexidade desta questão.

**Processo:** Este artigo descreve uma estrutura sistêmica de prevenção do afogamento baseada nos princípios essenciais da teoria sistêmica de Luhmann (Luhmann, 1995; Hafen, 2020). O trabalho anterior de Hafen (2020) avança ao integrar a teoria dos sistemas, a prática baseada em evidências e os insights de pesquisas recentes sobre prevenção de afogamento.

**Resultados/Implicações:** No que diz respeito a quatro níveis diferentes em que a prevenção do afogamento (isto é, população, fatores de impacto, sistemas-alvo e métodos) pode ser vista, descrevemos métodos baseados na teoria para adquirir informação, sinalizamos desafios potenciais e delineamos como a aplicação desta teoria pode ser combinada com o processo de prática baseada em evidências. Este quadro apresenta os princípios básicos que um profissional ou órgão governamental pode usar para decidir sobre ações de prevenção do afogamento baseadas em evidências.

**Palavras-chave:** Saúde pública; prática baseada em evidências; teoria de sistemas aquáticos; segurança hídrica

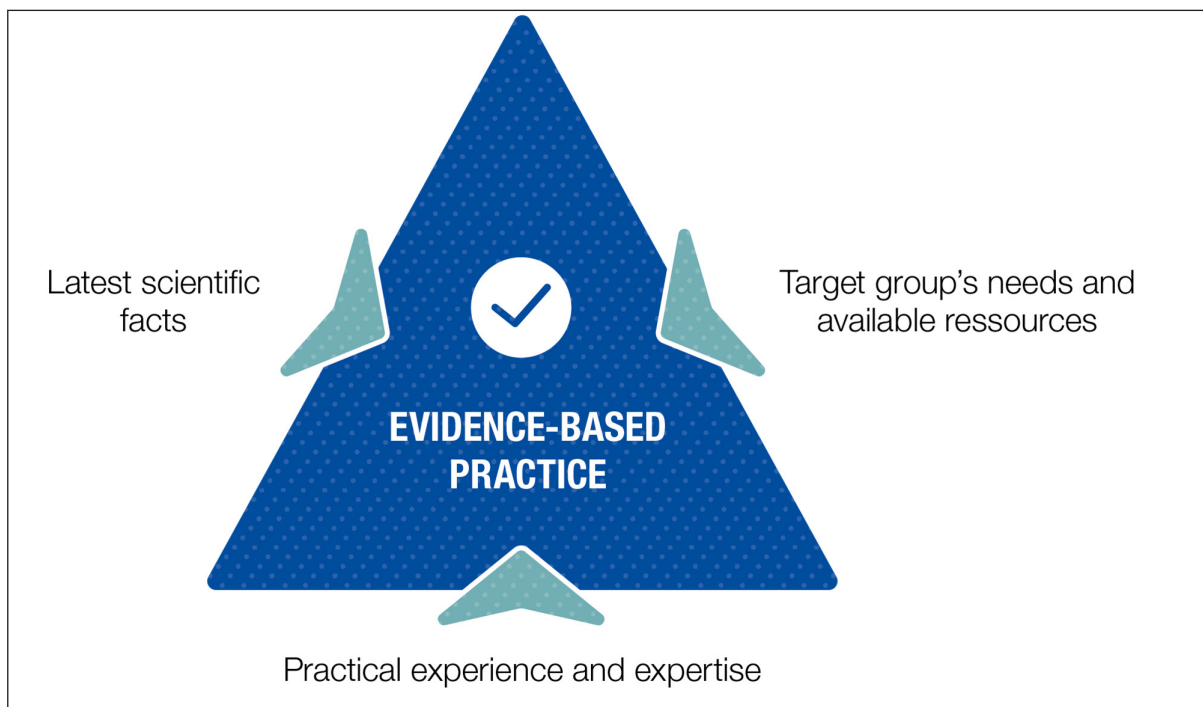
## PROBLEM: EVIDENCE-BASED DROWNING PREVENTION NEEDS A FRAMEWORK

Drowning is one of the ten leading causes of death for people aged 1–24 years in every region of the world (World Health Organization, 2014). The World Health Organization (2021) has made drowning prevention a priority for the next century and produced the first set of guidelines on specific prevention measures. All over the world, increased efforts to systematize and improve prevention actions are being instigated and scientifically tested (Hafen, 2015). Historically, action-led organizations such as coastguard agencies and non-governmental organizations (NGOs) have been making the decisions, relying mostly on tacit knowledge or experience (Ryan, 2018). Although practical knowledge is an important pillar of evidence-based practice, there is also a need for a foundation on scientific evidence. To inform evidence-based practice in the future, organizations need to understand how to integrate its three principles: current scientific facts, practical experience, and the needs and available resources of the targeted system (Sackett & Rosenberg, 1995; see [Figure 1](#)).

Only a fraction of the existing studies on drowning prevention methods refer to theories or use a theoretical framework for the evaluation of their measures (Leavy et al., 2016). Existing theoretical models, such as the Drowning Chain of Survival (Szpilman et al., 2014) are a useful start, but these are either superficial or are focused on a small sub-part of prevention. As we will lay out in this paper, drowning is an extremely complex and systemic problem (Hafen, 2020). If we want all recommendations and interventions to be evidence-based, we need a novel theoretical framework that addresses the full scope and multidisciplinary nature of drowning.

## PURPOSE AND SIGNIFICANCE OF DEVELOPING A DROWNING PREVENTION FRAMEWORK

The development of a theoretical framework for drowning prevention is essential for advancing research and practical efforts in the field. Such a framework provides a structured approach to understanding the multifaceted and systemic nature of drowning and allows researchers and practitioners to work and communicate more effectively. Based on the Chain of Survival Behaviors,



**Figure 1** Activity model based on the principles of evidence-based practice (Sackett & Rosenberg, 1995). Reprinted with permission from the Swiss Lifesaving Society.

the problem of drowning can be tackled ‘through several domains prevention, early recognition, access to help and first aid, and early recovery/medical care (International Federation of Red Cross/Red Crescent Societies, 2016). The framework we describe focuses on the first element in the chain, which has enormous potential for affecting outcomes.

Hafen’s (2005, 2013) systemic prevention framework, based on the systems theory by the German sociologist Niklas Luhmann (1995, 1997), serves as a valuable model for an overarching drowning prevention theory. Systems theory emphasizes the interconnectedness and interdependence of components within a complex system, making it particularly well-suited for addressing the multifactorial and systemic nature of drowning.

This framework will allow researchers and practitioners to define and consistently use common terminology. Further, it provides a common analytical toolbox that can capture the full range of drowning prevention topics, from individual risk behaviors and community-level interventions to broader policy measures. Lastly, a theoretical framework may help to identify parallels to other prevention fields such as injury prevention, disaster management, and public health, which makes the transfer of learning from these fields to the drowning context easier.

## **OUTLINE AND STRUCTURE OF THIS PAPER**

We first summarize the main assumptions of systems theory and Hafen’s systemic prevention theory (2005, 2013). We describe how the systemic drowning prevention framework was built on these core concepts and apply them to practical examples. We then briefly explain what we can learn from this theory for evidence-based drowning prevention and discuss limitations and future research opportunities.

We will not provide specific recommendations on drowning prevention interventions. Instead, this will serve as a toolbox: it presents the basic principles that a practitioner or governing body might use to decide on evidence-based drowning prevention actions.

## **THEORETICAL BACKGROUND: DROWNING PREVENTION FROM A SYSTEMIC PERSPECTIVE**

During an international consensus procedure in 2002, researchers and policymakers agreed on a common definition for drowning: “drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid” (van Beeck et al., 2005, p. 854). Drowning outcomes are classified as fatal or non-fatal. Many efforts may be wrongly termed “prevention measures” – for example first aid, rescue and resuscitation. These measures are only initiated once a person drowns (IFRC, 2016). They aim to prevent death by drowning (which is a consequence of drowning).

Drowning is extremely dynamic. A possible drowning incident can result from the interaction of social factors (e.g., peer pressure), psychological processes (e.g., the need to be perceived in a certain way, risk disposition), physical conditions (e.g., the effect of alcohol on the brain), and physical circumstances (e.g., the flow of a river). These different systems each operate according to their own logic and constraints and are structurally coupled, meaning that changes in one domain (e.g., social norms around risk-taking) can influence another (e.g., individual decision-making in aquatic environments). Furthermore, society shapes its understanding of drowning prevention through self-referential processes, for example, the framing of risk in the media, or through cultural narratives around water. These factors mean that interventions must account for the non-linear changes and emergent properties of these systems rather than working in a linear cause-and-effect manner (Button et al., 2022).

## **ORIGINS AND KEY CONCEPTS OF SYSTEMS THEORY**

Systems theory addresses this multifactorial nature of drowning prevention neatly, as it enables people to think of the different entities to which drowning prevention applies, as autonomous, self-perpetuating systems (Luhmann, 1984). It also captures the difficulty of influencing a system (e.g., a person, family, or political

system), in an attempt to change its structure or behavior – one of the main problems that drowning prevention has to address.

Systems theory sees humans as part of the continuous interplay of physical, mental, and social systems and their environments. The term “system” in Luhmann’s systems theory denotes a self-organized unit, such as a brain (a biological system), a family, a peer group, an organization, or a country (all social systems). Although self-organized, a system is not a completely independent entity but is rather seen as the difference between the system and its environment. To make this definition easier to understand, take as an analogy a hole: the edge of a hole is not part of the hole. But still, if you remove the edge, the hole disappears (Hafen, 2013). Equally, a system and its environment are inseparably connected. We cannot understand a system unless we try to understand its relevant environment.

Systems contain individual structures (i.e., stable patterns of relations within each system) and interact with their environment through operations (i.e., the fundamental processes through which a system maintains itself (see [Table 1](#)). Systems theory assumes that all systems are operationally closed, meaning that no system can operate beyond its system boundaries. Therefore, it is impossible to directly influence a system by “operating into it.” Consequently, influence is only possible through the environment. Systems theory suggests that a successful intervention needs to be based on a dynamic, closed, and self-generating understanding of all involved systems (Hafen, 2015).

## MODEL DEVELOPMENT PROCESS

Based on Luhmann’s systemic theory, Hafen (2005) derived a general framework for the broad field of prevention. This model was adequate to address societal issues such as addiction prevention (Hafen, 2006, 2015, 2017). Later, Hafen (2020) explored the application of the theory to drowning prevention in a white paper published in German. For the present paper, we integrated these models and worked out examples and considerations for research and practice. In developing the systemic drowning prevention framework, we used the basic tenets of Luhmann’s systems theory – dynamic, self-organized, autopoietic, and operationally closed systems – as a standpoint from which to view drowning prevention.

Additionally, in light of recent calls for stronger integration of evidence-based practice in drowning prevention, cross-links to the evidence-based practice framework (Sackett & Rosenberg, 1995) were mapped out. This paper is the first to provide guidelines for application by non-scientifically trained practitioners.

## THE SYSTEMIC DROWNING PREVENTION FRAMEWORK

Based on the assumptions of systems theory, the systemic prevention model helps us understand the complexity of drowning prevention and allows a view of the higher- and lower-level issues at the same time (Hafen, 2005, 2013, 2020). The goal of prevention is to change the structures of a target system (e.g., in the form of improved water literacy, better swimming technique,

Concept	Examples from biological, mental, and social systems		
Systems	Biological: brain, body	Mental: mind, consciousness, belief system	Social: organization, country, family, peer group
Structures	Neural pathways, nerve cells, muscles, skeletal structure	Mental structures (e.g. self-consciousness, intelligence, courage)	Hierarchy, organizational structures, values, social address of a person (role and other expectations toward people)
Operations	Electrical and chemical operations, cellular operations	Thoughts, perceptions, decisions, movement	Communication (verbal and nonverbal)

**Table 1** Key concepts of systems theory (based on Hafen, 2005).

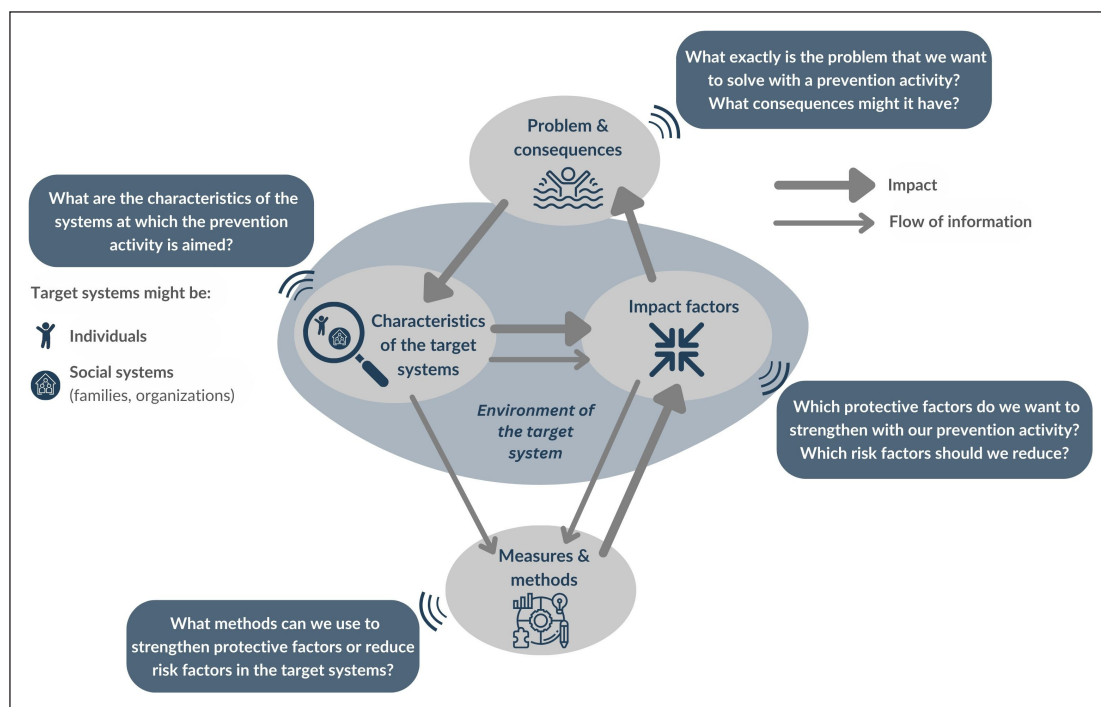
and greater knowledge of a river's behavior). However, the defining characteristics of self-organizing systems (e.g., operational closedness) prompt the question of how anyone can ever influence the behavior of a system. For example, how can swim instructors (system A) influence the minds of the children they are teaching (system B), or their motor skills? Based on systems theory, all the instructors can do is attempt to make a difference in the children's environment, via instructions and exercises. The children themselves decide (consciously or unconsciously) which of these environmental affordances inform their learning processes (Button et al., 2022). Because the mind of each child is structured differently by socialization and physical training, different children may not respond to instructions and exercises in the same way. This is termed the "self-organization" of autopoietic (self-generating) systems.

Due to their self-organized nature, the relevant systems in drowning prevention are structured very differently from each other (e.g., they include social, biological, and mental systems). For this reason, no "one size fits all" approach can be used on them. Fixed structures such

as the hierarchy of an organization, the buildup of a schooling system, or the habits of an adult are difficult to change, as often the "identity" of a system is built on these. Prevention measures often struggle to achieve change on the level of existing, fixed structures and therefore tend to target more fluid aspects (such as, for example, the motor skills of a child). An intervention may use different forms of communication to learn about and interact with its target systems: education and information, motivation, appellations, commands, or laws (Luhmann, 2002). For effective prevention interventions, it is essential to understand how these attributes influence the behaviors of target systems and to tailor interventions to a specific level.

### Drowning prevention levels

According to the systemic drowning prevention framework that is proposed here, drowning prevention takes effect on four different levels, which impact and circularly inform each other (see [Figure 2](#)): The level of the problem and its consequences, the level of impact factors, the level of target systems and the level of measures and methods (Hafen, 2020).



**Figure 2** Schematic of the systemic drowning prevention framework.

Note: although the term "level" referred to in the text may suggest a hierarchical structure, the different levels (i.e., problem, impact factors, target systems and measures) influence and inform one another in a circular relationship.

### Level of the problem

All prevention efforts ultimately aim at the reduction of unintentional drownings and the resulting consequences (i.e., medical problems or death). The attainment of such goals is assessed based on drowning statistics, such as the number of drowning incidents and their consequences. When the number of drowning incidents rises, the pressure on authorities to invest more in drowning prevention increases. Yet, evaluating the success of interventions concerning this goal is challenging for several reasons (Peden et al., 2018):

- The causality is often unclear, i.e., we cannot make a direct link between a specific intervention and a change in drowning statistics.
- It is challenging to measure outcomes in the population: Reliable and consistent data collection systems may not be in place across regions or countries, and tracking long-term changes in population-level drowning rates requires sustained data collection.
- Other factors (e.g., increased exposure during the COVID-19 pandemic during summer) can influence results independently of prevention measures.
- While deaths may be easy to track, non-fatal drowning events – which also carry societal costs – are often overlooked.
- It is easier to measure the outcomes on the next level – the level of impact factors.

However, evaluating the outcome of an intervention on this level is crucial for the development of the field. Since such an impact measurement is not possible in all cases, it is all the more important to use the evidence already available for planning, implementation and anchoring of preventive measures.

### Level of impact factors

Prevention interventions are aimed at reducing the probability of drowning events – and this can only be done by manipulating the factors that influence the risk of drowning. Therefore, a broad evidence base around possible impact factors is needed (Denny et al.,

2019; Peden et al., 2016; Peden, 2019). Impact factors are differentiated into risk factors, which increase the probability that a problem will occur, and protective factors that reduce this probability (Hafen, 2012, 2013). For example, a lack of attention in adults while supervising young children represents a risk factor for child drowning (Moran, 2009), while access restrictions to bodies of water in private and public spaces act as protective factors (Quan et al., 2020). We can further separate the impact factors along the dimensions of body, psyche, social and physical environment (Hafen, 2005). Examples of key impact factors in drowning prevention are presented in [Table 2](#).

The goal of preventive activities at the level of impact factors is to reduce key risk factors that strongly predict drowning and to strengthen the protective factors. The starting point of any drowning prevention measure must therefore be an analysis of the impact factors in an environment, which vary across cultures, regions, and populations. Prevention efforts should also consider how multiple factors may interact within a specific setting (e.g., within a particular community). For example, it is well-known that males are more likely to die due to drowning (Peden et al., 2018). The mechanism for that may involve higher risk affinity (psychological) and higher alcohol consumption (sociocultural), both of which can be targeted better with initiatives than the impact factor gender (Peden et al., 2017). An organization or policymaker planning a new intervention must survey the etiological literature and research the fields of mental, physical, and social sciences to understand the interactions of different factors.

A next step is to prioritize interventions focusing on impact factors that are easy to change: Some factors can be directly affected by an intervention (such as barriers, supervision, etc.) and some cannot (e.g., gender, weather). Finally, an intervention should also be assessed to determine its effectiveness. Even if an effect of an intervention on the impact factor level can be shown, this is not the same as showing that the initiative worked on the level of the problem: effective reduction of risk factors does not directly reduce drowning tolls!

	<b>Problem</b>	<b>Impact factors</b>	<b>Target systems</b>	<b>Measures and methods</b>
Examples	Drowning incidence	Protective factors, risk factors - Bodily (age <sup>1</sup> , sex <sup>2</sup> , health conditions <sup>3</sup> ) - Mental (e.g., attitudes, risk disposition, water safety skills <sup>4</sup> , self-efficacy) - Social (e.g., peer pressure, regulations <sup>5</sup> , child supervision) - Physical/biological (e.g., tide, water temperature <sup>6</sup> , pool barriers <sup>7</sup> )	Individuals (with their bodies and minds) Social systems (families, organizations)	Programs (e.g., water safety skills program), laws (e.g., pool fencing), awareness campaigns Behavioral (individual) vs. environmentally focused interventions
Where do we get knowledge of this level?	Empirical and theoretical research into the problem (drowning) and its development over time (i.e., epidemiology) Experts' perspective on evolution of the problem Target group's perception of the problem	Scientific knowledge (empirical and theoretical) about etiology of the problem Practical knowledge and experience	Theoretical models and empirical knowledge about structures and operations of systems: Neurobiology, psychology, sociology, psycho-sociology etc. Practical knowledge and experience System knowledge of the target systems	Theories Research studies on efficacy of programs More general methodology principles Practitioners' (often implicit) knowledge of "what works" in target group
What are our outcome goals on this level?	Reduction of the problem (drowning) Reduction of the consequences (deaths) Prevention of harmful side effects	Strengthening of protective factors Reduction of risk factors	Sustainable strengthening of protective and reduction of risk factors within the targeted system This requires a change in structures of the system	Consistent and high-quality implementation of measures and methods
How can we measure the impact on this level?	Randomized controlled trials with long-term follow-up assessments Very challenging	Measurement of factors pre- and post-intervention, as well as after a delay	Measurement of factors pre- and post-intervention, as well as after a delay	Process evaluation (i.e., not outcome but the actual process of the intervention is in the focus)

**Table 2** Summary and drowning-related examples of the systemic prevention framework by Hafen (2017, 2020).

Note: Evidence supporting risk and protective factors: 1) Davey et al., 2019; 2) Peden et al., 2018; 3) Peden et al., 2022; 4) Stallman et al., 2017; 5) Quan et al., 2020; 6) Datta & Tipton, 2006; 7) Thompson & Rivara, 1998.



### Level of target systems

Systems are distinguished by their structures, shaped over time through interactions with the environment (Luhmann, 1984). Understanding the specific characteristics of the systems we target with our prevention efforts is essential for effective interventions. Each risk or protective factor operates across multiple systems (e.g., a parent's attention while supervising their child near a pool is part of a mental system and influenced by social and situational factors). Drowning prevention involves identifying the structures within a system (e.g., distractions in a caregiver's environment), and determining how to influence them. This requires drawing on evidence from relevant disciplines, such as neurobiology, behavioral economics, developmental psychology, organizational psychology, or systems theory (Hafen, 2020). In our example, one would have to study cognitive psychology, specifically literature that focuses on attention control. Target group factors such as age, sex and gender, socio-economic status, or migration background are also important because they contain information about the structuring of the target systems (e.g., see Cenderadewi et al., 2020, for socio-ecological factors in drowning).

Human beings are included in social systems, where they are a part of the social structure. This means there are specific expectations associated with a role (e.g., as a swimming instructor or student) or other personal attributes (i.e., gender, ethnicity, age, migration background). A thorough understanding of how such attributes influence expectations and behavior is useful for tailoring measures to target systems. Target systems or populations are not homogenous, so fine-tuning prevention measures greatly enhances the effect and cost-efficiency of an intervention.

### Level of measures and methods

Once a thorough understanding of the target systems and their specific structures has been achieved, it becomes easier to answer the question of how – with which measures and methods – the target system can best be encouraged to change. Under the assumption that our target systems are operationally closed and cannot be directly influenced, intervention measures need to become a part of their relevant environment. The more

complex a system is, the more challenging it becomes to bring about a desired change.

Operationally closed systems can only be influenced through communication, which allows for the exchange of information without directly altering the system's internal processes. Empirical findings and theories from impact research should be considered to determine optimal methods of communication (i.e., which methods have worked, where, and why). Communication methods are usually most efficient if they are as follows (World Health Organization, 2017):

- Integrated into multi-strategic programs that consist of different, coordinated actions
- Interactive and include personally relevant messages
- Designed with a long-term plan and financing
- Professionally designed (also visually)
- Making use of the whole range of mass media, especially the Internet
- Adapted to the cultural circumstances of the target persons
- Able to trigger emotional responses

### MODEL APPLICATION: HOW CAN THE FRAMEWORK BE USED TO INFORM EVIDENCE-BASED DROWNING PREVENTION MEASURES?

The World Health Organization (2017) calls for evidence-based development and monitoring of prevention programs. Decisions about preventive measures should be made according to the three principles of evidence-based practice, i.e., integrating practical and scientific knowledge with information on the needs of the target system (Sackett & Rosenberg, 1995; see [Figure 1](#) earlier in the manuscript). Many organizations have already anchored this principle in their mission statement, but its application is not often described. Below, we describe the main steps of an evidence-based process for designing and implementing a drowning prevention intervention, touching on each of the four levels of the systemic drowning prevention framework.

On the level of the problem, we can gain scientific information on the overall problem of “drowning” by

considering drowning tolls, epidemiological research, and incidence reports. Assessing the effect of specific interventions on this level would require very rigorous and holistic, randomized controlled trials where all factors apart from the intervention are matched and controlled. In regional and local contexts, professionals' assessment of the evolution of the problem can be a complementary resource. It is also important to know the target systems' perception of the problem. Cultural norms, differences in knowledge, priorities, and the complexity of social systems can shape how problems are perceived, therefore what is seen as a problem from a scientific point of view is not necessarily seen as a problem by the target systems.

On the level of the impact factors, it makes sense to collect scientific knowledge (empirical and theoretical) about the etiology of the problem of drowning as well as any research that establishes causal connections between impact factors and the incidence of unintentional drowning. Also, the interaction between various impact factors should be investigated.

On the level of the target systems, involving experts with deep knowledge of the target group is essential. Early engagement of local experts in planning allows their specific insights to shape the intervention. Reviewing theoretical literature and research on the structures and operations of the systems can help identify the best communicative strategies. For stakeholders in organizations or politics, understanding organizational theory and political science is beneficial. Drowning prevention efforts must be tailored to the unique contexts of different groups (e.g., drowning prevention for young men in India might be substantially different from drowning prevention in Australian rivers), making knowledge of the target system's structure and environment crucial. Lastly, securing buy-in from the target system early in the process, e.g., by including representatives in the decision-making process from an early stage, is key to the success of an intervention measure.

When designing, conducting, and evaluating methods, it is important to consider existing impact research (e.g., the usefulness of video-based learning in a water safety course), as well as broader pedagogic and behavioral research studies, to assess the effectiveness of specific approaches. Practical knowledge of subject matter experts

is crucial, and because it is often implicit and unwritten, including experts in decision-making is more effective than simply seeking their advice. [Table 2](#) summarizes the systemic drowning prevention framework (Hafen 2020) and connects it to the principles of evidence-based practice.

## DISCUSSION

### Strengths and limitations of the systemic drowning prevention framework

The systemic drowning prevention framework is the first to capture the complexity of the problem of drowning. While maintaining the overview of the overall issue, the framework breaks the problem into manageable factors for research and intervention. The framework further provides a consistent terminology and "way of thinking" that may bridge the gaps between different public health fields, thus enabling the transfer of insights across fields, as well as within the drowning prevention scene.

Luhmann's Systems theory has been criticized for its high level of conceptual abstraction (Kunczik & Zipfel, 2005). The present paper attempts to make these theoretical concepts more accessible and provide specific examples that are actionable. To further refine the model in the future, deeper integration with other frameworks such as the Chain of Survival Behaviors (IFRC, 2016) or theoretical models such as ecological dynamics (Warren, 2006) may be useful for certain perspectives, and may also account for individual agency. However, the elegance in the present framework is that it transcends all research disciplines and stands alongside (without contradicting or subsuming) other theories.

### Indications for drowning prevention-related research

Prevention deals with events that have not happened yet. This is a bit tricky, as we have to work with probabilities rather than given facts. Instead of tackling the problem head-on, all we can directly influence are factors that make this event more or less likely (see subchapter "Impact factors"). This also relates to an assessment of outcomes in research studies. Given the complexity and interactive nature of target systems, multi-disciplinary study designs are needed to evaluate

multi-strategic interventions (United Nations General Assembly, 2021).

Continued research at all levels is essential to generate new insights that may inform evidence-based practice. Solid data on the development of drowning accidents, on the most important risk and protective factors and their interaction, and on the systems whose structures are to be changed are necessary to enable future practitioners to make evidence-based decisions. Finally, more impact research is needed to enable us to distinguish effective from ineffective preventive interventions and to ensure optimal use of resources.

### Practical implications

We have outlined the importance of having an evidence-based approach in the planning and implementation of drowning prevention measures. We also provide a guide on how one might go about achieving this: The section “model application” may be used when designing methods and approaches, to ensure the connections, complexities, and challenges at each level are taken into account. The paper can be used for small to large problems, from everyday lesson planning, instruction approaches, or communication to large-scale intervention programs, policy-making, and political decisions. However, the framework does not provide specific solutions to problems. Every stakeholder still needs to consider what is best for their drowning problem and target population.

The framework underlines the importance of gaining as much knowledge as possible about the systems targeted by a prevention effort, including their interaction with the environment and each other. If one carefully considers the levels on which an intervention should work, combines scientific knowledge on that level with the experiential knowledge of practitioners in the relevant fields and if one also includes the target systems appropriately, then one has the necessary knowledge for the planning and implementation of effective measures with manageable effort.

### CONCLUSION

Drowning is a complex, multifactorial issue that requires a systemic approach for effective prevention. This

paper introduced a theoretical framework grounded in Luhmann’s systemic theory, advancing previous work by integrating systems theory, evidence-based practice, and recent research. By structuring drowning prevention across four levels – population, impact factors, target systems, and methods – the framework breaks down the complexity of the issue into manageable components and establishes a shared terminology.

The framework is also a tool for researchers, practitioners, and policymakers, providing a structured way to acquire information, identify challenges, and support evidence-based decision-making. The presented framework thus sets a foundation that will drive evidence-based decision-making in the field of drowning prevention.

### ACKNOWLEDGMENTS

The authors provided the abstract in German, and Dr David Szpilman translated the abstract into Portuguese.

### FUNDING INFORMATION

This research was funded by the Swiss Lifesaving Society (SLRG).

### COMPETING INTERESTS

The authors have no competing interests to declare.

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