Systemic Drowning Prevention

A theoretical framework for the development of evidence-based regulations, interventions and decisions in the public and policy-making domain

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Abstract

Drowning is a multifactorial, systemic issue. In order to enable evidence-based, widely justifiable decisions and policies, an overarching theoretical framework is necessary that is capable of describing the complexity of this issue. This paper describes a systemic drowning prevention framework based on the main tenets of Luhmann's systemic theory (Luhmann, 1995; Hafen, 2005). With respect to four different levels on which drowning prevention can be viewed (i.e., population level, impact factors level, target systems level and methods level), the paper describes theory-driven methods for acquiring information, flags potential challenges and outlines how the application of this theory can be combined with the process of evidence-based practice. This framework presents, in an organized manner, the basic principles which a practitioner or governing body might use to reach a decision about evidence-based drowning prevention actions.

Keywords: Public health, evidence-based practice, intervention, systems theory, Luhmann.

Introduction

Background and importance

Drowning has been the cause of over 236'000 deaths a year, which is more than those caused by hepatitis and close to the number dying of malnutrition (UN General Assembly, 2021; World Health Organisation, 2022). In many of the settings where drownings occur, surveillance systems are underdeveloped, so the real injury burden may be up to twice as high in low-income countries. Drowning is one of the 10 leading causes of death for people aged 1–24 years in every region of the world.

The World Health Organisation (World Health Organisation, 2021) has made drowning prevention a priority for the next century and produced a first set of evidence-based guidelines on specific prevention measures. All over the world, increased efforts to systematize and improve prevention actions are being instigated. Providing clear recommendations for evidence-based drowning prevention is complex, not the least because the evidence-base on drowning is still weak.

Evidence-based drowning prevention needs a theory

Prevention naturally lies between science and professionalized praxis. Increasing professionalization (as seen in recent years) means that the connection to scientific evidence needs to be strengthened, and that the impact of prevention interventions is increasingly tested according to scientific standards (Hafen, 2015). The gap between research and practice is exceptionally large in drowning prevention (Ryan, 2018). Historically, practical organisations have been making the decisions, relying mostly on tacit knowledge or experience. Although this expert knowledge is a very important pillar of evidence-based practice, there is also need for a foundation on scientific evidence, which in turn consists of empirical insights (e.g., new knowledge found in research studies) and theoretical concepts. In recent years, funding bodies have increasingly made a connection to scientific evidence a requirement for their support.

So far, the evidence-base of drowning prevention can be safely described as "weak". In a literature review, Leavy et al. (2016) criticised that 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. Various

theoretical models exist, but they are usually focused on a small sub-part of prevention, such as the chain of survival (Szpilman et al., 2014).

If we want all recommendations and interventions to be evidence-based, we need a theoretical framework. This serves two purposes: Firstly, to be able to define and consistently use terminology, and secondly to have a common toolbox that can capture and deal with all the various aspects of drowning prevention. Furthermore, a theoretical framework may help to identify parallels and overlaps to other prevention fields. A theory usually bears a high degree of abstraction, which means it does not provide direct recommendations to practice but is widely applicable to the whole field. Sometimes, some translation is needed to make the aspects of a theoretical framework easier to understand for practitioners. To be able to encompass all levels of drowning and its prevention, a sufficiently abstract general theory is useful. Such a theory is found in Hafen's (Hafen, 2005, 2013) systemic prevention framework, based on the systems theory by the German sociologist Niklas Luhmann (Luhmann, 1997, 1995).

How this paper should be used

This paper summarizes the main points and assumptions of Hafen's systemic prevention theory (2005, 2013) and briefly explains what we can learn from this theory for evidence-based drowning prevention. It is based on a whitepaper written in German by Martin Hafen (Hafen, 2020), which explores the application of the theory to drowning prevention in depth. The white paper was commissioned by the Swiss Lifesaving Society and funded by the Swiss Red Cross Humanitarian Foundation.

The present paper will not provide specific recommendations on drowning prevention interventions. Instead, it will serve as a toolbox: it presents the basic principles which a practitioner or governing body might use to reach a decision about evidence-based drowning prevention actions. Additionally, this model makes the transfer of learnings from other public health-problems to the drowning context easier.

Drowning prevention from a systemic perspective

Drowning can be seen a multifactorial, systemic issue

Drowning is extremely dynamic. A possible drowning incident is influenced by different interdependent factors. It 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). The problem «drowning» can be tackled with three different approaches of intervention: prevention, early recognition, and treatment. It is important to differentiate between these three approaches when thinking about implementing new measures.

Based on constructivism, Luhmann's systems theory suggests that events differ from their observation. Different observers may observe the same thing differently. This means that it matters how things are described – we need consistent terminology if we want to make sure we are all speaking of the same thing.

During an international consensus procedure in 2002, research and policy-makers 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 nonfatal. Many efforts may be wrongly termed "prevention measures" – for example first aid, rescue, and resuscitation. These measures are only initiated once a person drowns. Their aim is to prevent death by drowning (which is a consequence of drowning), but they can't prevent the actual event "drowning" as defined above. Being very clear about the limits of the problem is important to derive a clear and concise theory.

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"). And about these factors, as you may have guessed, we can only learn from scientific evidence: psychology, sociology, political studies, aquatic knowledge, and many more fields.

Basics of systems theory

Humans are part of the continuous interplay of physical, mental and social systems and their environments. The term “system” in Luhmann’s systems theory denotes the self-organized unit, such as a brain, a mental system, a family, a peer group, an organization, or a country and also to its relevant environment. 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. Equally, a system and its environment are inseparably connected. And it is the common paradigm of all “systemic” approaches (be it systemic social work, systemic health care or systemic psychotherapy) that you cannot understand a system unless you try to understand it’s relevant environment. Systems theory assumes that all systems are operationally closed, and self-perpetuating. For example, in a mental system, thoughts and perceptions are followed by thoughts and perceptions as communications follow communications in social systems. No system can operate beyond its system boundaries. Therefore, it is impossible to directly influence a system by “operating into it” or transferring information into it; information is always generated by the system itself. Consequently, influence is only possible through the environment (i.e., a source of information can be brought into the relevant environment of the system, which may decide to consider it – or not). Of note, it is the system that determines by which aspects of its environment it allows itself to be influenced. This feat is a defining characteristic of self-organizing systems.

In terms of drowning prevention, these components of the theory prompt the question of whether, and how anyone can ever influence the structures or behaviour of a system. For example, how can a swim instructor influence the mind of the children they are teaching, or their motor skills? Based on the theory, all the instructor 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 they use as a trigger for 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 “self-organisation” of autopoietic (self-generating) systems.

Due to their self-organised nature, the relevant systems in drowning prevention are structured very differently from each other. This suggests that no “one size fits all” approach can be used on them. Fixed structures are difficult to change, as often the “identity” of a system is built on these. This means that prevention measures often struggle to achieve change on the level of existing, fixed structures and therefore target more fluid aspects. 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.

Human beings are included as persons in social systems, where they have a social address (Fuchs 1997). Social address is therefore not a set of propertiesof a person, but a social structure. It expresses the expectations that are directed at a person in the social system. These can be 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 behaviour is useful for tailoring measures to target systems (individuals / organisations). When the effect of these attributes on on behaviours of target system are properly understood, the goal of prevention - changing the structures of a target system (e.g., in the form of improved water literacy, better swimming technique, greater knowledge of a river’s behavior) - can be achieved more efficiently.

Table 1 Examples of different concepts of systems theory

Concept	Examples		
Dimension	Biological	Psychological / mental	Social
Systems	Brain, body	Mental systems, mind	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)

Systemic drowning prevention framework: drowning prevention takes effect on four levels

Based on the assumptions of systems theory, the systemic prevention model (Hafen, 2017, 2020) helps us understand the complexity of drowning prevention. According to the model, drowning prevention takes effect on four different levels, which impact and inform each other in a circular fashion (see Figure 1).[1]

Drowning prevention levels

- The level of the problem and its consequences: what exactly is the problem that we want to solve with a certain prevention activity and what consequences might it have?
- The level of impact factors: Which protective factors do we want to strengthen with our prevention activities and which risk factors should we reduce?
- Level of target systems: what are the structural characteristics and specifics of the systems at which the prevention activity is aimed?
- Level of measures and methods: Which measures and methods can we use to promote the desired strengthening of protective factors or reduction of risk factors in the target systems?

[1] Note: although the term “level” may suggest a hierarchical structure, the different levels influence and inform one-another in more of a circular relationship.

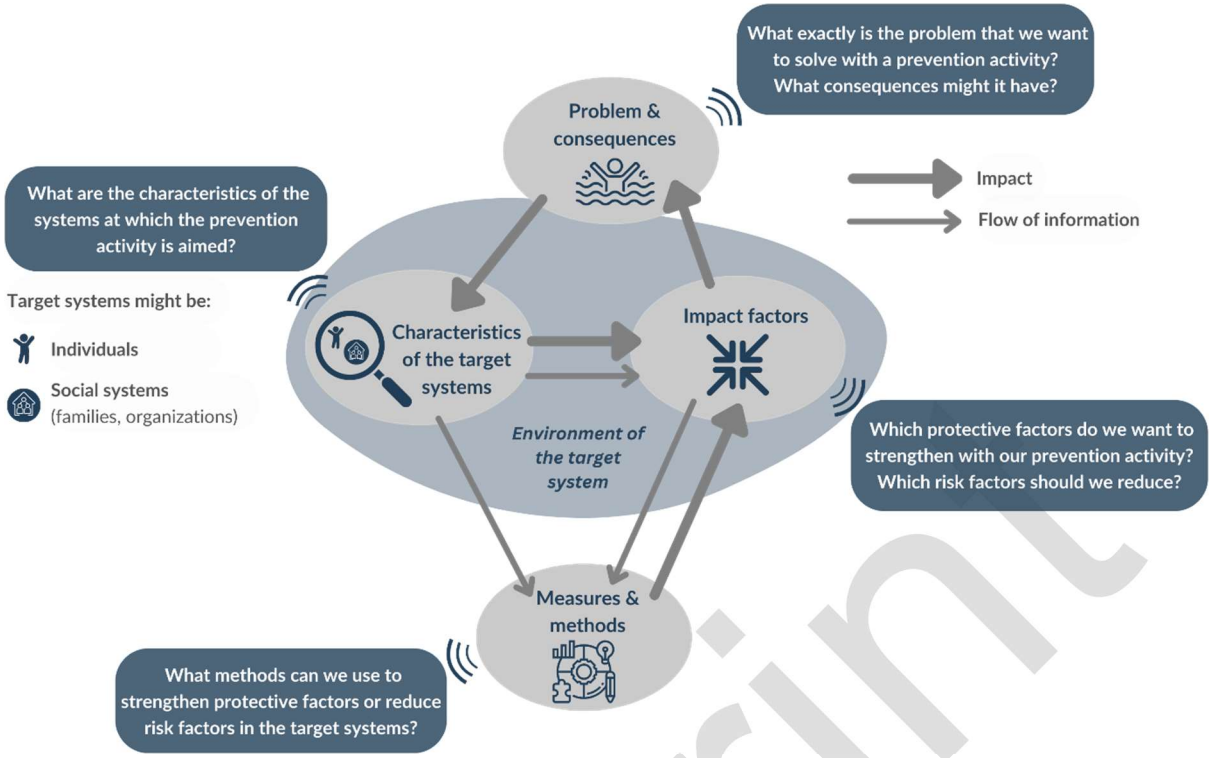

Figure 1 - Schematic of the systemic drowning prevention framework (Note, a professionally designed image is in production and will be provided before publication)

Level of the problem

The goal we aim for on this level is a reduction of unintentional drownings and the resulting consequences (i.e., medical problems or death). All prevention efforts ultimately aim at this overarching goal. The attainment of such goals is assessed based on drowning statistics, such as the number of drowning accidents and their consequences. When the number of drowning accidents rises, the pressure on authorities to invest more in drowning prevention increases. Yet, how can we evaluate whether the interventions are successful with regards to this ultimate goal? Assessing this is actually really difficult, for several reasons:

- The causality is often unclear, i.e., we can't make a direct link between a specific intervention and a change in drowning statistics.
- It is close to impossible to measure outcomes in a whole population.
- It is difficult to prevent all other potential factors from varying or from influencing the outcome (for example, during the COVID-19 -pandemic, many more people went bathing in rivers, which increased the overall exposure but was unrelated to any prevention measure).

- Deaths may be easy to measure, but the impact on a society may also be seen in nonfatal drowning events (which lead to injuries, costs, etc.) this is relevant information that we often fail to obtain.
- 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

Since prevention does not start with the problem - in our case with drowning - but tries to prevent the development of the problem in the first place, its 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, 2019; Peden et al., 2016)

Impact factors are differentiated into protective factors and risk factors. Risk factors actively increase the probability that a problem will occur, while protective factors reduce this probability (Hafen, 2013, 2014). For example, a lack of attention from 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. We can further separate the impact factors along the dimensions of body, psyche, social and physical environment.

Thus, the starting point of any drowning prevention measure has to be an analysis of the impact factors. However, many of these factors differ greatly between cultures, regions and even groups of people. They also are often connected to one-another. When deciding on prevention measures in a community or region (or country), it is important to assess the main protective and risk factors that exist, and how they influence one-another. In this sense, a prevention measure should never focus on solely improving one factor – it always needs to be aware of, and possibly take into account, the others.

Some factors can be directly affected by an intervention (such as barriers, supervision, etc.) and some cannot (e.g., gender, weather). Logically, it makes more sense to attempt to change those factors that are easy to change.

What are the most important impact factors?

Bodily factors: Most bodily factors (i.e. physical, biomedical factors related to physique, anthropometry, and physical movement health) are fixed and cannot be changed, though it is important to understand how they interplay with other factors in the mental and social domain. Among the bodily factors are illnesses, especially in older people: heart problems, dementia, depression, epilepsy, and Parkinson's Disease are the main illnesses that influence drowning risk. Swimming can trigger or exacerbate the illnesses, while the illness may cause falls into the water or impair the movements that are necessary to exit or remain on the surface. Age, sex and gender might be categorized as "bodily" as well. Depending on the region, young children, teenagers or middle-aged people might be at a higher risk of drowning. In most regions, males drown more often. Though these factors cannot be changed by interventions, useful prevention points normally correlate with age and/or gender (e.g., alcohol consumption and its combination with mental factors such as risk disposition, risk awareness, normative beliefs, locus of control).

Mental factors such as risk disposition, inattention (e.g., in those supervising small children) and other aspects of attitudes and behaviours can often be impacted with interventions. Self-efficacy (Bandura, 1997) is a mental factor that may be either protective or detrimental: for example, although self-efficacy is often linked to better motor performance such as swimming, if someone has a high self-efficacy related to their own water safety skills, they might attempt a rescue and put themselves at risk. Knowledge of water safety can be considered a mental factor which can be targeted fairly well through education and information (Leavy et al 2016). Water competency includes aquatic movement skills that help prevent drowning, as well as the associated water safety knowledge, attitudes and behaviors (Moran 2013, p.4). Stallman et al. (2017) have listed 17 separate competencies that are either bodily (motor) or mental (cognitive) skills (see Figure 2). Often, mental and bodily aspects both play a role in the same competency: for example, "breathing control" may be affected by a state of panic or stress, as well as by the motor skill of floating.

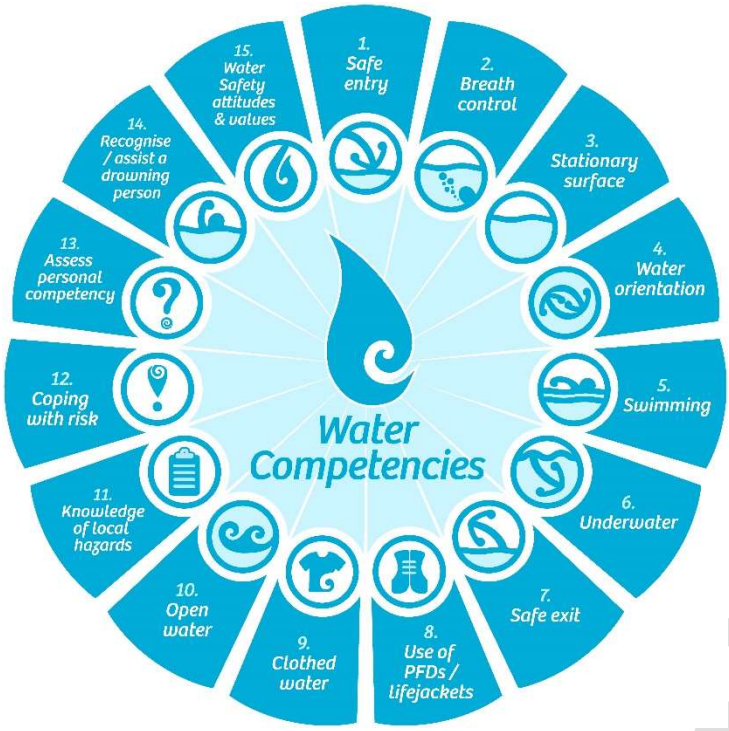

Figure 2 - Water competencies as developed by Stallman et al., 2017 (printed with permission from Drowning Prevention Auckland)

Social factors: Regulations around bodies of open water are an important sociocultural factor. There are five forms of evidence-based regulations that positively impact drowning risk: the deployment of lifeguards, water quality, the availability of rescue equipment, warning signals, and tracking, planning, and reporting measures (Quan et al., 2020). If all five measures are in place, there is a 3-fold reduction of drowning in young people compared to a location where none are in place. Other protective factors include water safety guidelines and supervision of small children (Rahman et al., 2012; Davey et al., 2019). Peer pressure is a social factor that affects behaviour in social contexts, especially in boys and men. Social factors also include income and education level: ethnic minorities, aboriginal people and migrants tend to have a lower socio-economic status and are more often affected by drowning. Interventions that aim at improving socio-economic balance in a population may in fact improve drowning risk as well.

Physical/biological factors refer to the material environment of individuals and social systems: Light, air, temperature, weather, building-related aspects, other human-made artifacts, and elements of nature and water bodies are included here. Temperature of the water is often an important factor, as it may

often decide which behaviours are required in a drowning incident (e.g., knowledge of cold-water shock). In different regions of the world, the main causes of drowning differ greatly, and therefore the impacting factors that are involved in the causation may be completely different. Physical artifacts that are often seen as protective factors include barriers that limit access to pools, ponds and springs, as well as the political decision to make them compulsory.

What are the challenges on the level of impact factors?

The goal of preventive activities on the level of impact factors is to reduce the most important risk factors and strengthen the protective factors. For example, one might choose water competency as a protective factor. In that case, one could approach this factor systematically in a program to increase water competency. The program should be designed to cover and strengthen all sub-competencies and also address potential factors that may hamper the successful application of this new knowledge or competency – for example, by including opportunities for skill transfer to cold and moving water.

The success of an initiative must be assessed with respect to the goal. In the water competency example, a pre-test of competencies of the learners before starting the program, as well as a post-test and a delayed retention test need to be conducted. Ideally, a control group should be included that completes the same pre- and post-tests to ensure that other factors that change over time (e.g., children getting stronger, hours spent playing at the beach in their free time, getting used to the test items and getting better at answering questions) are not confounding the findings. This is a significant effort, but it is not impossible (see for example Button et al., 2020; van Duijn et al., 2022). Even if an effect of an intervention on the impact factors-level can be shown, this is not the same as showing that the initiative worked on the level of the problem: we have not (yet) proven that drowning tolls were reduced due to the program!

Determining the most important impact factors is difficult. Scientific evidence in this field is weak and only specific to regions and groups of people. Any person planning a new intervention must comb the etiological literature and research the fields of mental, physical and social sciences to understand the action and interaction of these different factors. In this context, having expert knowledge at hand can be very beneficial: a person that understands the target group and situation in depth might be able to ensure that nothing big is missing.

Due to the interactive nature of impact factors, it might be tricky to tease them apart. For example, it is well-known that males are more likely to die due to drowning than females. 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 gender. As another example, socioeconomic status and age are mediators for several factors which are more likely to cause drowning than socio-economic status alone (e.g., strength, flexibility, coordination ability, access to education, protected bodies of water near workplace, etc.).

Level of target systems

Systems can be distinguished from one-another by their structures, which have been established over time, through interaction with the environment. Understanding the characteristics and specifics of the systems at which the prevention activity is aimed is quintessential for successful interventions. Each protective or risk factor plays roles in several systems (e.g., attention is part of the mental system of a father supervising his daughter near a pool, and is at the same time dependent on the situation, social factors etc.). Drowning prevention has the task of getting to know the structures that operate within a system (e.g., to find out what it is in the environment of caregivers that distracts attention and how these distractions can be prevented). To achieve this, one needs to study the scientific evidence in the disciplines involved (e.g., neurobiology, behavioural economics, developmental psychology, organizational psychology, or systems theory). In our example, one would have to study cognitive psychology, specifically literature that focuses on attention control. In this context, 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.

Knowledge of a system's structures should then be used to tailor the approach of a prevention activity. This leads to a variety of possible measures and methods that can impact structures of a system.

Target systems or populations often exhibit microdiversity, i.e., they are not homogenous. Fine-tuning prevention measures to cater for these microdiversities greatly enhances the effect of an intervention and its cost-efficiency. However, this requires even more in-depth knowledge of the structures in the target system.

Situational vs. behavioral prevention

On this level, we also find the differentiation of individual-focused (behavioural) vs. setting-focused (situational) drowning prevention: individual-oriented prevention aims to change the behaviours of people (also peer groups, families, etc.), while setting-focused prevention aims to change the impact factors that operate in the context of social systems. Education is usually behavioural, aimed at mental systems and aiming at a change of attitudes and behaviours of individuals. Regulation of open water is a setting focused measure that aims at changing the structures in the social systems – usually in the context of formal organisations (e.g., towns, councils, etc.).

Level of measures and methods

Once a thorough understanding of the target systems and their specific structures has been achieved, it is easier to answer the question of how – with which measures and methods – the target system can best be encouraged to change. The theory of autopoietic, self-organizing systems assumes that systems are closed at the level of their operations and therefore cannot be directly influenced. To solve this issue, intervention measures need to become a part of the relevant environment of the target systems. This opens the possibility (but not the certainty) that the systems may adapt their structures in desired ways. The more complex a system is, the more challenging it becomes to bring about the desired change. This is especially the case when we think about influencing social systems such as the political system. Lobbying activities may be a way to attempt to influence the legislation, however, the success of such an activity depends on the specific political structures in the target state. Knowledge of the target system (in this case, knowing the political structures of the system “nation XY”) is crucial to design a successful intervention.

Communication is the central means of intervention. The “HOW” of communication, its methodology, is aimed at dealing efficiently with the operational closedness and self-organisation of its target systems.

Evidence-based prevention on the level of the methods is based on empirical findings from impact research and the theories that are developed from such knowledge. (i.e., which methods have worked, where, and why?). From research, we can summarize that communication intervention methods are usually most efficient if they are:

- Integrated into multi-strategic programs that consist of different, coordinated actions
- Personally communicative, interactive measures

- 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
- Triggering emotions and “nudging”-Strategies (WHO, 2017)

What does evidence-based prevention mean in the drowning prevention context?

As mentioned in the introduction, drowning prevention needs a stronger evidence-base. Decisions about preventive measures should be made with appropriate consideration of current scientific facts, practical experience and expertise as well as the needs and available resources of the targeted system (Sackett & Rosenberg, 1995). When we talk about scientific evidence, we usually don’t only refer to empirical insights (i.e., new knowledge found in research studies) but also theoretical concepts such as the systemic prevention theory and the four-levels framework. The three pillars of evidence-based practice are shown in Figure 4.

Many organisations have already anchored this principle in their mission statements. For example, the Swiss Lifesaving Foundation (SLRG) has integrated it into their 2017 activity model “evidence-based practice”, Figure 3 and uses this model to critically reflect on existing prevention measures and to develop new ones.

Figure 3 - Activity model based on the principles of evidence-based practice (Sackett & Rosenberg, 1995). Reprinted with permission from the Swiss Lifesaving Society.

In this paper, we have outlined how prevention activities could be seen through the lens of this theory. In the following, we present the main steps that evidence-based practice would indicate on each of the four levels of drowning prevention.

On the level of the problem, we can gain scientific information on the overall problem "drowning" by considering drowning tolls, epidemiological research and incidence reports. 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. 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 etiology of the problem of drowning as well as any research that makes clear causal connections between impact factors and the incidence of unintentional drowning. Also the connections between various impact factors should be investigated.

On the level of the target systems, it may make sense to involve experts who have experience with the target group and a deep understanding of how they function, what they respond to. Early

participation of the target systems in the planning of the activities makes it possible to bring in their specific system knowledge. Additionally, theoretical literature and research papers on the structures and operations of the systems should be perused to learn how the influential factors might best be targeted with communicative tools. For a stakeholder that deals with organizations or with politics it is helpful to have knowledge of organizational theories and political science. Similarly, drowning prevention for young men in India might be substantially different to drowning prevention in Australian rivers, so knowledge of the target system, its structures and environments is paramount. Lastly, buy-in from the target system is critical for success of an intervention measure. This might be achieved by e.g. including representatives in the decision-making process from an early stage.

When designing, conducting and evaluating methods, it is important to consider all existing impact research that has tested the efficacy of specific approaches (e.g., the usefulness of adding video-based classroom learning to a water safety course). Also more widely, pedagogic, methodological and behavioural research can inform about the efficacy of specific methods in a specific target system. Additionally, tapping expert knowledge is crucial on this level, as often experts have implicit knowledge about what works for a group of people, although it may not be written up and available publicly. Including experts in the decision-making process may be a better way to make use of this implicit knowledge than just asking for their advice. Table 1 summarizes the systemic drowning prevention framework (Hafen 2020) and connects it to evidence-based drowning prevention practice.

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

	Problem	Impact factors	Target systems	Measures and methods
Examples	Drowning incidence	Protective factors, risk factors - Bodily (WS skills) - Mental (e.g., risk disposition) - Social (e.g., peer pressure) - Physical/biological (e.g., tide)	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 about the problem (drowning) and it's development over time (i.e., epidemiology) Expert's perspective on evolution of the problem Target group's perception of the problem	Scientific knowledge (empirical and theoretical) about etiology of the problem Expert knowledge and experience	Theoretical models and empirical knowledge about structures and operations of systems: Neurobiology, psychology, sociology, psycho-sociology etc.) Expert knowledge and experience System knowledge of the target systems	Theories Research studies on efficacy of programs More general methodology principles Experts' (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?	RCT with long-term follow-up 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)

Discussion

Indications for drowning prevention-related research

The systemic drowning prevention framework is the first to capture the levels of complexity of the problem “drowning”. Assessing the impact of a program on the problem level is very challenging and only works if a massive effort on a large population is made. However, the framework also shows how the problem can be broken down into more manageable factors that research and prevention may tackle. The complexity and interactive nature of the target systems and influential factors do indicate that classic research, which tries to control all factors but a single, independent variable, may not be adequate to drive drowning prevention forward. Novel, multi-disciplinary study designs are needed that allow us to assess multistrategic interventions, in clearly defined target populations.

Nonetheless, it is essential that research continues at all levels, as it is the only way to provide new insights that will then have an impact in the context of evidence-based practice. We need solid data on the development of drowning accidents to expand preventive measures accordingly. Further research into the most important risk and protective factors and their interaction is also crucial for drowning prevention. Only with this knowledge can practitioners distinguish important from insignificant factors and thus design effective measures while minimising undesirable side effects. Further theoretical and empirical knowledge is also required on the systems whose structures are to be changed by drowning prevention.

Finally, increased efforts are necessary in the area of impact research. Impact research data enable us to distinguish effective from ineffective preventive interventions, ensuring that the financial resources are used wisely.

Practical implications

This paper has outlined the importance of having an evidence-based approach in the planning and implementation of drowning prevention measures.

The presented framework sets a foundation that will enable more rigorous and systematic research and policy efforts and drive evidence-based decision making in the field of drowning prevention. This may

be achieved by providing a consistent terminology and “way of thinking” that may bridge the gaps between different public health fields, thus enabling transfer of insights across fields, as well as within the drowning prevention scene.

The framework we have presented does not provide specific solutions to problems. It is there to help a person or provider understand the complexity of their problem and encourage them to see and address the problem on each level (or, if not, to make an informed decision not to do so). Every actor in this field still needs to think critically and make the best decision for their problem and target population – this paper here merely serves as a toolbox and “checklist” of things to consider.

One of the main tenets of Luhmann’s systems theory is the fact that every”thing” only exists through the eyes of the observer – there is no objective truth or reality. Translating this to drowning prevention, this means that no-one has the one, best perspective on any situation. Every person or entity involved, every actor or organization - in short, every system has a different reality, which an intervention may never completely capture. This underlines the importance of gaining as much knowledge and insight as possible into the systems that are targeted with a prevention effort. A second way to deal with this constructed reality is by involving the target group(s) in the design of methods wherever possible, and in maintaining an awareness that we may not have the complete picture.

Another hypothesis of Luhmann’s theory is that systems are closed and self-recreating. This means that we cannot operate into another system, i.e., we can’t directly cause a person to change their behaviour. All we can do is try to become a part of their relevant environment, and engage in the most effective forms of communication, to encourage them to change their structures and thereby their operations (or behaviour).

In drowning prevention practice, it is often not possible (for methodological or financial reasons) to measure the impact of a program on the whole population. This makes it all the more important to consult the existing scientific evidence on the four levels that are relevant for all prevention measures. If one combines this scientific knowledge with the experiential knowledge of experts in the field of drowning prevention 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.

The paper can be used at every level: from small to large problems, from everyday lesson planning, instruction approaches or communication to large-scale intervention programs, policy-making and political decisions. The paper, and especially Table 2 may be used a checklist or guideline when designing methods and approaches, to ensure each level as well as the connections and complexities and challenges at each levels are taken into account.

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