

# DEVELOPMENT OF A TOOL FOR INDIVIDUAL AQUATIC RISK MANAGEMENT AMONG CHILDREN OF 6-12 YEARS (IARM-C)

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### Funciones de los autores:

The first, second and third author were constructing and guiding the research plan and process. The second author gathered all the data and started with the interpretation of the results. The first author wrote the text and selected the topics to focus on. Authors four, five and six were member of the expert group and were critical during the development of the tool. The last author gave essential suggestions on the draft text.

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## Abstract

**Background:** When it comes to children's competence in, on and around water, their risk management also plays an important role. For an optimal and safe participation in aquatic recreation, there is a crucial need to communicate about a realistic perception of potential dangers in relation to one's own actual and perceived aquatic skills.

**Goals:** The aim of this study was to develop and validate a tool for Individual Aquatic Risk Management for Children (IARM-C) useful in both research and practice regarding water safety for elementary school children and their families, as offered in schools, by local communities and different (water) sport organisations.

**Method:** The IARM-C tool was developed and validated in three subsequent phases: (1) a selection of relevant aquatic situations with possible risks for children based on the literature and discussed with experts, resulting in 10 aquatic situations that were drawn, (2) a pilot study with 22 children to test content (face) validity, and (3) a cross-sectional study with 70 children (6-12 years, 35 girls and 35 boys, 8.9 ± 2.0 years) recruited via convenience sampling in different (swimming) schools in Brussel (Belgium) to test their risk perception, assessment and decision making in these 10 situations.

**Results:** For each of the 10 aquatic risk situations of the IARM-C, data collection was organised in a one-on-one interview in order to assist the child in completing the questionnaire. Six of the 10 pictures resulted in a correct risk perception for > 80% (range between 83-94%) of the children. For one drawn aquatic risk situation in the swimming pool context (i.e. falling on someone else), only 60% of the children gave a correct description of the situation. In the drawn open water aquatic risk situations, three pictures scored quite low (range between 49%-54%): warning flag at sea, dangerous objects and sandbank in the sea.

**Conclusions:** The IARM-C tool, showing pictures of aquatic risk situations followed by three categories of questions (risk perception, assessment and decision making), is a useful instrument for further research and education purposes, especially for the swimming pool cases.

**Keywords:** Water competence, aquatic skill, risky play, water recreation, swimming, swimming pool, open water.

## Desarrollo de una herramienta para la Gest3n individual del riesgo acuático entre los ni os de 6 a 12 a os (IARM-C)

### Resumen

**Antecedentes:** Cuando se trata de la competencia de los ni os en, sobre y alrededor del agua, su competencia de riesgo tambi3n juega un papel importante. Para una participaci3n 3ptima y segura en la recreaci3n acuática, existe una necesidad crucial de comunicar una percepci3n realista de los peligros potenciales en relaci3n con las propias habilidades acuáticas reales y percibidas.

**Objetivos:** El objetivo de este estudio fue desarrollar y validar una herramienta para la Gest3n Individual de Riesgos Acuáticos para Ni os (IARM-C) 3til tanto en la investigaci3n como en la pr3ctica en relaci3n con la seguridad en el agua para los ni os de la escuela primaria y sus familias, tal y como se ofrece en las escuelas, por las comunidades locales y diferentes organizaciones deportivas (acuáticas).

**M3todo:** La herramienta IARM-C se desarroll3 y valid3 en tres fases sucesivas: (1) una selecci3n de situaciones acuáticas relevantes con posibles riesgos para los ni os, basada en la literatura y discutida con expertos, lo que dio como resultado 10 ilustraciones de situaciones acuáticas, (2) un estudio piloto con 22 ni os para comprobar la validez (aparente) del contenido, y (3) un estudio transversal con 70 ni os (35 ni os y 35 ni os, 6-12 a os, 8,9 ± 2,0 a os) seleccionados mediante muestreo de conveniencia en diferentes escuelas (de nataci3n) de Bruselas (B3lgica) para comprobar su percepci3n de los riesgos, su evaluaci3n y su toma de decisiones en estas 10 situaciones.

**Resultados:** Para cada una de las 10 situaciones de riesgo acuático del IARM-C, la recogida de datos se organiz3 en una entrevista individual para ayudar al ni o a rellenar el cuestionario. Seis de los 10 dibujos dieron lugar a una percepci3n de riesgo correcta para m3s del 80% (rango entre 83-94%) de los ni os. En una de las situaciones de riesgo acuático dibujadas en el contexto de la piscina (es decir, la ca3da sobre otra persona), s3lo el 60% de los ni os dio una descripci3n correcta de la situaci3n. En las situaciones de riesgo acuático dibujadas en aguas abiertas, tres im3genes obtuvieron una puntuaci3n bastante baja (entre el 49% y el 54%): bandera de advertencia en el mar, objetos peligrosos y banco de arena en el mar.

**Conclusiones:** La herramienta IARM-C, que muestra im3genes de situaciones de riesgo acuático seguidas de tres categor3as de preguntas (percepci3n del riesgo, evaluaci3n y toma de decisiones), es un instrumento 3til para seguir investigando y educando, especialmente para los casos de piscinas.

**Palabras clave:** Competencia acuática, habilidad acuática, juego de riesgo, recreaci3n acuática, nataci3n, piscina, aguas abiertas.

## Desenvolvimento de ferramentas para a Gest3o de risco Aquático com crianç as entre os 6 e os 12 anos de idade (IARM-C)

### Resumo

**Introduç3o:** No que toca às compet3ncias de uma crianç a dentro, fora ou à volta de àgua, as suas compet3ncias de risco desempenham um grande papel. Para uma participaç3o segura em atividades aquáticas recreativas, existe uma necessidade crucial de comunicaç3o para a perceç3o de potenciais perigos, em relaç3o à perceç3o do pr3prio, relativamente às habilidades aquáticas.

**Objetivos:** O objectivo deste estudo é de desenvolver e validar uma ferramenta para Controlo e Gest3o de Riscos Individuais em Crianç as (IARM-C) 3til tanto em procura como pr3tica independentemente da seguranç a das àguas de escolas do ensino b3sico, tal como respectivas famílias, assim como as oferecidas nas escolas, por comunidades locais, e diferentes organizaç3es de modalidades aquáticas.

**M3todo:** A ferramenta IARM-C foi desenvolvida e validada sob tr3s fases: (1) um seleç3o de situaç3es aquáticas relevantes com poss3veis riscos para crianç as baseadas em documentaç3o e discutida por profissionais, resultando em 10 situaç3es que foram desenhadas, (2) um estudo piloto com 22 crianç as para teste de conte3do, e (3) um estudo com p3blico de 70 crianç as de ambos os sexos e v3rias idades (35 raparigas e 35 rapazes entre os 6 e 12 anos de idade, idade M3dia 8,9 ± 2 anos) solicitados para amostra em diferentes escolas (de nataç3o) em Bruxelas (B3lgica) para testar a perceç3o ao risco, an3lise e tomada de decis3es perante estas 10 situaç3es

**Resultados:** Por cada uma das 10 situaç3es de risco do IARM-C, a informaç3o recolhida foi organizada numa entrevista de um para um, de modo a que a crianç a conseguisse completar o question3rio. Seis das 10 imagens resultaram numa assertiva resposta perante o perigo por >80% (vari3vel entre 83% e 94%) entre as crianç as. Por exemplo, em contexto de piscina (ex: escorregar e cair em cima de algu3m), apenas 60% das crianç as deram uma descriç3o correcta da situaç3o. J3 no desenho de risco em situaç3es de àguas abertas, tr3s imagens tiveram um resultado mais baixo (entre 49%-54%): bandeiras de aviso no mar, objectos perigosos, bancos de areia no mar.

**Conclus3o:** A ferramenta IARM-C, mostra imagens de situaç3es aquáticas de perigo, seguido de tr3s categor3as question3veis (perceç3o de riscos, avaliaç3o e tomada de decis3es), é uma ferramenta 3til para futuras pesquisas, e quest3es educativas, especialmente em casos envolvendo piscinas

**Palavras-Chave:** Compet3ncias Aquáticas, Habilidades Aquáticas, Mediç3o de riscos, Recreatividade aquática, nataç3o, piscinas, àguas abertas.

## Introduction

In water recreation, adult supervision is necessary to protect (young) children against drowning. In addition, in the prevention of drowning, teaching school-aged children basic swimming, water safety and safe rescue skills are emphasized as cost-effective community-based actions (WHO, 2014).

Understanding water competency includes, amongst others, ‘coping with risk competence’ in an aquatic environment (Stallman et al., 2017). Risk competence or management is built on three major pillars which are (1) perception, (2) assessment and (3) decision making (Kaulich et al., 2016). The first step is **risk perception** or identifying risks and is understood as the recognition of a threat, with its elements and sources, description, and classification. The next stage of individual risk management is the **assessment** and involves estimating the probability of risk and the extent of adverse consequences that may follow (Wiesner & Rejman, 2014). This assessment or analysis is followed by a **decision making** or strategic planning, in order to develop an effective way of reducing risk. Risk can be managed by teaching sound aquatic risk management strategies as a part of swimming/water safety education, starting with risk perception (Asher et al. 1995; McCool et al. 2009; Turgut et al. 2016; Wiesner & Rejman, 2014). According to Moran (2006), the role of individual risk management in relation to drowning in children is poorly understood.

In education, a broad view of risk (outdoor and indoor, not only physical, innovative practices for the benefit of children and society), encompassing a wide range of risk experiences for both children and educators, is necessary (Cooke et al., 2019). Interestingly, in Cookes’ work the focus lies on ‘beneficial risk’, which means engaging in experiences that take persons outside of their comfort zone, including outcomes that may be beneficial to learning, development and life satisfaction. After all, the question is how people develop into more competent, confident, and motivated participants in an aquatic environment (Dudley, 2019). Too much restrictions and no chances to explore the different activities in aquatic surroundings will lead to constraints regarding their autonomy and opportunities to learn more about themselves and the environment. In addition, childhood represent a particular time window for increasing levels of independence and autonomy as well as learning (how) to manage risk (Lester & Russell, 2010). Children can learn which risks are to be considered safe or unsafe (Kennair et al. 2018). Observation and education are the premise and guarantee of protecting children and understanding children’s intrinsic motivation to play (Liu & Birkeland, 2022). Moreover, the feeling of a child can have emotional benefits in learning to swim (Amelia, 2012) for optimal motivation.

In land-based risk competence, a risk perception test (reaction time: how fast a child saw the change from a neutral to dangerous situation) was used with children (3-8 years) (Lavrysen et al. 2017). Yurt & Keles (2021) developed 12 drawings based on the most commonly causes of injury in early childhood. Three drawings of four distinct categories of risky play (great heights, high speed, dangerous elements, and dangerous tools) were presented to children (4-5 years). In a semi-structured interview, the child was asked which of the three levels of risk he/she preferred, each presented in a separate drawing. Based on the provided answers, depending on choice of drawing, the child’s response was coded as ‘low risk level’ (code 0), ‘average risk level’ (code 1) or ‘high risk level’ (code 2) (Yurt & Keles, 2021). The authors indicate only three levels of risk perception was a limitation.

Picture-based surveys for children also exists in studying perceived motor competence. ‘Perceived motor competence’ is used to refer to one’s perception (i.e., the personal identification and interpretation of information) of the own actual motor competence level (De Meester et al., 2020; Estevan & Barnett, 2018). Recently the perceived aquatic skills are studied, using a pictorial scale of perceived water

competencies (D’Hondt et al., 2021; Moreno-Murcia et al., 2020; Morgado et al., 2020; De Pasquale et al., 2021). In these visual tools, the focus is on a child’s aquatic skills without integration of aquatic risk competence related to different aquatic environments.

To our knowledge, there is no published research concerning a tool for children’ (perceived) risk competence in, on and around water to date. For an optimal and safe participation in aquatic recreation, however, there is the need to communicate about realistic perceptions, assessment, and decisions in case of potential dangers in relation to one’s own experiences and competences an aquatic environment. Accordingly, the goal of this study is to develop and validate a tool for individual aquatic risk management for elementary school children (6-12 years), being useful for both research and practice in water recreation.

In this contribution, an answer will be given to three research questions:

- What are the most relevant potential risky situations for a child in an aquatic environment during leisure time?
- Is a child able to describe the risk in the pictures (**‘risk perception’**)?
- How is the **‘risk assessment’**: (a) What about the feelings of a child when it is in the same situation as drawn in the pictures? (b) What is the likelihood those situations happen to a child?

The questions concerning **‘decision making’** (own actions of a child when in trouble, expectation from peers to react, and expectations from adults to react) are out of the scope of this contribution. These open questions with qualitative data will be described in a separate contribution, taking into account the amount of information. A risk response plan can be extensive to explain, with a double-sided approach of (a) prevention of drowning by risk avoidance and (b) freedom of individuals making choices and bear responsibility for their actions.

## Methods

The IARM-C tool was developed and validated in three phases.

During the first design phase, a literature study resulted in an overview of the most common elements in risky aquatic situations for children. In this overview the three contributing factors (i.e. individual, environment and activity/task) as described by Newell (1986) and Langendorfer (2015), were indicated in a table presented to the experts, in order to check the diversity in risky aquatic situations. Moreover, the different activities should be linked to one or more of the categories of risky play by Sandseter (2007), being high speed, great heights, dangerous tools, dangerous elements, rough-and-tumble play, disappear/get lost. This information from the literature overview, relevant for the age group 6-12 years, was presented to experts in the field of swimming and water safety (7 experts from Belgium and 3 from the Netherlands). These experts were all active in the domain of swimming and/or lifesaving/prevention of drowning. The first idea was to come to 20 situations, 10 indoor and 10 open water to send to an artist for making the drawings. After discussion with the experts, a selection of 5 swimming pool and 5 open water situations was made. In open water situations ‘playing in the sea with high waves and yellow flag’ was combined with ‘ignoring safety signs’. When there was not enough international relevance, for example swimming in a canal is not known in the USA, the aquatic risk situation was not included. Those situations where the external threat was caused by an adult (eg. a lifeguard or parent who is inattentive) or the accommodation (lack of barrier or unclear communication about depth) were also not taken into account. After all, the focus is on the children’s capacity to recognize risks and their ability to reflect on how they would tackle that situation.

**Table 1.** Aquatic risky situations in a swimming pool  
(in grey those selected with experts)

Swimming pool (Indoor/outdoor)	References
Water slide with accelerations	(Chalmers et al., 2003; Cunningham, 2019)
Risky play with a ball (like water polo)	(Langendorfer, 2011)
Diving board (bad diving in water or diving from to high)	(Peden et al., 2020)
Indoor play castle (floating devices)	(Peden & Franklin, 2020)
Jumping on each other (slip and not paying attention)	(Peden & Franklin, 2020)
Supervision by parent/friend(s)	(Morrongiello et al., 2013; Stanley & Moran, 2017)
Lifeguards inattentive	(Pelletier et al., 2011; Schwebel et al. 2007)
Absence of barriers (fences)	(Hamilton et al. 2019, Raman et al., 2021)
Peer pressure	(Willcox-Pidgeon et al., 2020)
Unexpected depth change	(Peden et al., 2020)

**Table 2.** Aquatic risky situations in an open water environment  
(in grey those selected with experts)

Open water (river, lake, sea ...)	References
Cold water temperature (cramps)	(Stallman et al., 2008)
Canoeing in river (not wearing life jacket)	(Peden & Franklin, 2020; Willcox-Pidgeon et al., 2020)
Playing in sea, high waves & yellow flag to warn	(Peden & Franklin, 2020; Stallman et al., 2008)
Bumping head against a large object in open water (pontoon)	(Peden & Franklin, 2020)
Sandbank/sandbar in the sea	(Hatfield et al., 2012; Moran & Webber, 2014)
Incident light reflecting off the water	(experts' input)
Depth indication	(Stallman et al., 2008)
Filthy water & loose material (stuck in mud)	(Connolly, 2014)
Ignoring safety signs	(Williamsen, 2010)
Swimming in a canal/river	(Peden et al., 2020)

In the second, more experimental phase, the tool was tested in a small group of children (n= 22) to check content (face) validity. Thinking out loud was used as method, and remarks of the children were written down for the 10 selected aquatic risk situations. Throughout the process of the instrument developing, changes were made to the drawing and the description based on the feedback of the children in this pilot phase. These experiences were discussed in the research group and communicated with the artist to adapt the pictures. Examples of reasons to change a picture were: unclear what was going on exactly, the importance of the depth of the water, confusion about which character in the picture to look at. Inspired by other pictorial studies where the leading character in each picture was identified by wearing the same clothes (Döring et al., 2010), the swim clothes of our central figure was made similar (orange cap) in when there were different children in the picture to look at. The child was asked looking at the child in the picture with the orange cap and hereby imagine that he/she was that child. In drawings with only one child (e.g. aquatic risk situation N° 6), this did not matter and the swimming cap was not per se orange.

During the third phase, 70 children were recruited in different (swimming) schools in Brussel using convenience sampling.

They agreed to participate, and their parents/guardian gave written informed consent. The children themselves were explained orally what

the procedure (10 pictures showing aquatic situation with questions on risk competence) was, stressing the fact they could stop during the data collection. The sample of these elementary school children comprised 35 boys (50%) and 35 girls (50%) with a mean age of  $8.9 \pm 2.0$  years. The age of the children was distributed approximately equally: 6 years (n=10), 7 years (n=12), 8 years (n=9), 9 years (n=10), 10 years (n=10), 11 years (n=10), and 12 years (n=9).

#### Procedure and data collection

The 10 aquatic situations were presented one by one to a child, by showing these pictures as a comic strip without text, followed by an interview. This was standardised and administered by the same researcher (second author) using the pictures in the same order. Children could not listen to eachothers' answers. For the **risk perception** the researcher asked the following open question: "What do you see in the drawing?" The answers were written down, and clustered in those answers matching the aim of the picture (elements of correct description was predefined and listed by the research team) and other answers (wrong). The amount of children who gave the corresponding description were counted (absolute) and the percentage was calculated. For **risk assessment** the 5-point Likert scale was replaced by smileys and flags (after the pilot), respectively for expression of feelings ("How do you feel when this happens with you?") and the likelihood the risky situation happens ("What is the likelihood this happens to you?") (cf table 5).

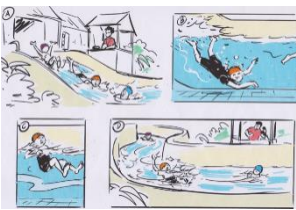


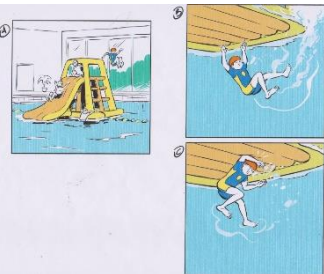
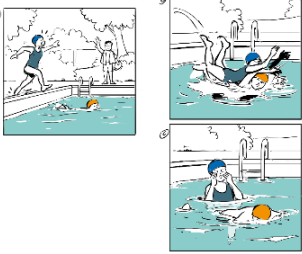
The answers for **decision making** were divided in three subcategories, about the personal characteristics (solution by the child itself), the expected anticipation of peers and expected anticipation of adults. Because of the size of the data, this qualitative part on decision making will not be presented in this paper.

Ethical approval was obtained from the Ethical Commission Human Sciences of the Vrije Universiteit Brussel (VUB), reference number ECHW\_271.02.

#### Results

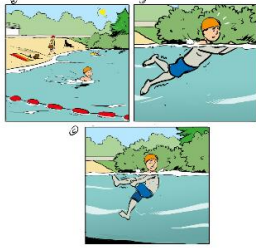
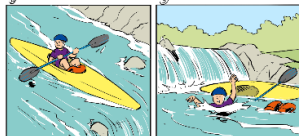

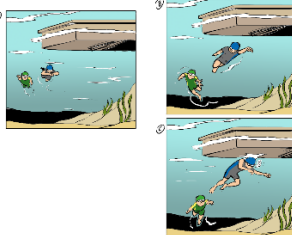
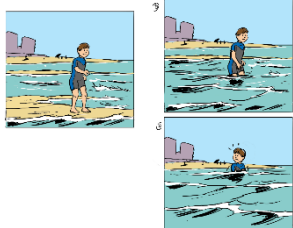
The most relevant potential risky situations for a child in an aquatic environment during leisure time in countries such as Belgium and the Netherlands were translated into 10 (series of) pictures. Tabel 3 gives an overview of the five aquatic risk situations in the swimming pool context and Table 4 is a summary of five outdoor aquatic risk situations. Next to the drawing, the first question in relation to **risk perception** is answered concerning the situation presented in the picture, also displaying the % of correct interpretations made by the participating children.

**Table 3:** Drawings, description and % of children with a correct interpretation regarding aquatic risk perception in a swimming pool

Aquatic risk situation	Description drawing <i>What do you see?</i> Correct risk perception in %
<b>1. Water slide with rapids</b> 	The child (with the orange cap) plays in water slide with 2 other children, falls in water/dives on belly, swallows up water & chokes when coming back up (panic).  86%
<b>2. Risky ball play</b> 	The child (with the orange cap) plays with the ball, another child tries to steal it, resulting in being pushed under water & getting troubles with breathing  83%
<b>3. Diving board</b> 	The child (with the orange cap) tries to dive (wrongly), hurts belly, and has stomach pain  94%
<b>4. Indoor playing castle</b> 	The child (with the orange cap) jumps off floatable playing castle & gets under it, bumps, and hurts head, gets troubles with breathing  89%
<b>5. Falling on someone</b> 	The child runs without paying attention to the pool, falls into the water on another child (with the orange cap) who falls unconscious  60%

With the exception of aquatic risk situation N° 5 (risk perception score of 60%), most of the swimming pool cases were clear for the children. Based on what they see in the drawings, they recognized what the possible danger can be.

**Table 4:** Drawings, description and % of children with a correct interpretation regarding aquatic risk perception in open water recreation











Aquatic risk situation	Description drawing <i>What do you see?</i> Correct risk perception in %
<b>6. Cold water immersion</b> 	The child (with the orange cap) holds his leg, gets cramps, back of leg muscles hurt, cold, deep water, child almost drowns  86%
<b>7. Canoeing without life jacket</b> 	The child is canoeing, does not pay attention, boat tilts, lot of current, not wearing life jacket  81%
<b>8. Warning (yellow) flag</b> 	The child (with the orange cap) sees a child playing in the sea not expecting high waves, putting pressure to come in the water too, another child is afraid, yellow flag as warning  50%
<b>9. Dangerous object</b> 	The child is swimming in open water, racing against another child, not looking well ahead, bumping head against something big (e.g., boat, ponton)  49%
<b>10. Sandbank in the sea</b> 	Sea, sand, water is not deep, but becomes deeper because of the tide (current) & fast change of water level  54%

Only two of the five aquatic risk situations in the open water context get a high score on the risk perception and correct interpretation by the children (86% for N° 6 cold water immersion and 81% for N° 7 canoeing without life jacket). For the following three open water cases the score was rather low, which means the drawings represented an unknown or unclear situation for the participants: the warning (yellow) flag at sea (50%), dangerous object in open water (49%) and the sandbank in the sea (54%).

In Table 5, the distribution of children's answers (in %) regarding the two questions about risk assessment per aquatic situation is presented.



**Table 5:** Risk assessment of children in the 10 aquatic risk situations (i.e. 1-5 in the swimming pool vs. 6-10 in open water).

Aquatic risk situation	How do you feel when this happens to you? (in %)					What is the likelihood this happens to you? (in %)				
	 1. Very bad	 2. Bad	 3. Not good, not bad	 4. Good	 5. Very good	 1. Never	 2. Almost never	 3. Sometimes	 4. Often	 5. Always
1.	30	49	20	0	1	14	43	34	9	0
2.	43	49	9	0	0	37	13	26	24	0
3.	19	33	49	0	0	13	21	43	23	0
4.	44	51	4	0	0	29	46	26	0	0
5.	59	23	19	0	0	29	44	26	1	0
6.	9	33	59	0	0	34	34	31	0	0
7.	23	43	34	0	0	30	27	37	6	0
8.	10	17	54	13	6	40	24	21	14	0
9.	41	40	19	0	0	33	61	3	3	0
10.	26	36	36	0	3	17	41	27	14	0

In most of the risky situations (children indicated they would feel bad or very bad when this would happen to them (N° 1 water slide with rapids, N° 2 risky ball play, N° 4 indoor playing castle, N° 5 falling on someone, N° 7 canoeing without life jacket, N° 9 dangerous object, N° 10 sandbank). In the following aquatic risk situations nearly 50% of the children indicated a neutral feeling (not good, not bad): diving board (N° 3), cold water immersion (N° 6), warning (yellow) flag (N° 8).

Looking at the perceived likelihood of the aquatic risk situation to happen to the children themselves, Table 5 shows they have the idea there is not much chance ('never' or 'almost never') these situations would happen to them, which was especially the case for the playing castle (N° 4), falling on someone (N° 5), cold water immersion (N° 6), and dangerous object (N° 9). On the other hand, in most of the situations, the mid score (meaning 'sometimes') was indicated by one third of the respondents, with the exception of aquatic risk situation N° 9 (dangerous object) being estimated to be highly unlikely to happen to them (94% score never or almost never). The following aquatic risk situations are perceived by more than 10% of the children as quite possible this could happen to them (indication 'often'): risky ball play (N° 2), diving board (N° 3), warning (yellow) flag at sea (N° 8) and sandbank in the sea (N° 10).

## Discussion

The first research question "What are the most relevant potential risky situations for a child in an aquatic environment during leisure time?" was answered during the process of literature review and expert discussions. A selection of 10 aquatic situations (taking into account individual, environment, activity/task), being evenly distributed over a swimming pool and an open water context, was discussed among the experts and adapted for the most suitable drawing, as validated by 22 children in the pilot. The second research question on the *capability of children to describe the risk in the drawings (risk perception)* was about gathering information on children's competence of observing and interpreting the potential risks in the 10 different aquatic situations. The five swimming pool situations scored good in terms of the correct perception, and better when compared with the open water situations. N° 5 falling on someone scored the lowest (60% correct answers). Three open water risk situations score low on correct recognition: N° 8 warning flag, N° 9 dangerous object and N° 10 sandbank in the sea.

For the third research question on **risk assessment** information on the 'feelings' experienced when the aquatic risk situation should happen and the 'likelihood' of these cases to happen to the child were collected. Usually, children indicated they would feel bad or very bad when

they would be exposed to such aquatic risk situations themselves. Yet there were situations for which children indicated a more neutral feeling. This can be an indication of them to accept the inherent possibility of being hurt, trying out a certain activity such as jumping from the diving board. However, the question remains, even if the majority of the children recognised the risk (e.g. case N° 6, representing cold conditions in open water, with a 86% prevalence of correct interpretation), whether they fully understood the individual risk related to their own aquatic skills and risk handling capacities/abilities. Concerning the 'likelihood', the participating children had the idea there was not much chance ('never' or 'almost never') the pictured aquatic risk situations would happen to them.

Presenting and asking questions about aquatic situations using the IARM-C tool is a start, but definitely insufficient. Wiggins et al. (2019) has shown that familiarity with water environments improves a person's ability to identify water safety cues. As constraints can change rapidly, especially in an open water context, apparently competent individuals may find themselves in difficulties if they lack awareness or knowledge of the environment (Baker, 2019; Button et al., 2020, Kjendie et al., 2013). Sharing risky situations in, on and around water can be the start of interaction and discussion within family, school or sport club settings. Children can express their risk competence and learn more about water safety (Ariaza-Alba et al., 2021) in combination with their expression of fun and attraction towards aquatic activities. Open water recreation provides a much greater variety of aquatic experiences compared with those in an indoor swimming pool (Wiesner & Rejman, 2014).

In further research, the difference in risk perception and assessment according to sex and age of the child can be studied. This is because cognitive-based factors form the basis of the difference between boys' and girls' risk-taking behavior, in some way explaining why boys are taking more risks than girls (Morronegiello et al. 1998). In addition to possible sex differences, the age of the child is another key factor that must be examined since children's risky play changes by growing older (Sandseter et al., 2021; Coster & Gleave, 2008). Therefore, an expansion of this newly developed tool's validation and the associated data collection among adolescents would be utmost interesting. In further research, this IARM-C instrument can be used to look for possible differences according to (a) country/culture and (b) specific minority groups (with health problems, low SES families, subcultural differences...), to increase the target population for water safety data and education.

The individual risk management of parents, and the link between child-parent perceptions and assessments could be topic of future studies. The question there is whether parents' assessment and decisions about their children's risk in water recreation and the opinion of children themselves is comparable and to what extent there are sex and/or age differences here. It could also be interesting to study dyads of children and their parents/guardians, taking into account the importance of parental support and supervision with regard to safe water recreation. The link between child-parent could stimulate a more educational approach. Organisations offering swimming courses (f.e. school, clubs, private initiatives, ...) could use the IARM-C tool to ameliorate the understanding and communication on aquatic risks. Education is always balancing between the risk concern avoiding injuries and drowning and recognize the need to learn to manage potential risk in children's increasing expertise and participation in aquatic recreation. Moreover, using moving or interactive drawings (e.g. Stop motion), video's and/or virtual reality can be considered in future research to make the tool more realistic.

## Contribution (strengths), practical implementations and limitations

Both the theoretical and practical importance of this research area on aquatic risk competence among children is promising and relevant to

ensure lifelong safe aquatic recreation all over the world. The IARM-C helps to identify and raise awareness of the potential risks associated with specific actions in the water. It is the task of the local community, including schools, families, and sport clubs, to enhance the water competence of children stimulating them mastering a realistic and balanced risk management, including making the right decisions, in addition to learning fundamental aquatic skills. To reach this goal, a wide range of water related activities in a safe but sufficiently challenging environment is the course of action.

The newly developed and validated IARM-C tool for individual risk aquatic risk management among children is considered helpful in the search for strategies to balance risk-taking and safety in water recreation. Thanks to the visualisation by using pictures instead of a classic questionnaire, there is a great(er) accessibility to families from culturally and linguistic diverse communities.

The tool can be validated in a more international group of experts, using a more systematic approach in the data gathering (e.g. Delphi rounds) to confirm the selected swimming pool and open water situations or to expand the aquatic risk situations chosen in this study.

Using convenience sampling and recruiting children from specific (swimming) schools yields selection bias, limiting the external validity of our results. Because of the cross-sectional study design, the presented results only provide a snapshot of 6- to 12-year-old children's aquatic risk competence without being aware of their individual background and experiences in swimming and/or water recreation. Therefore, gathering more details about their aquatic relatedness and their actual and perceived aquatic skills is useful.

Amongst the children who were unable to give a correct description of what happened in the presented pictures, it is unclear whether they were unfamiliar with the specific environment and activity or whether the way it was drawn and presented was still unclear for them. Therefore next data collection needs an extra question: Are you familiar with this environment or activity happening?

It would be valuable to replicate this study with larger sample, reaching a more representative population using randomized sampling techniques. Adaptations in the selection of open water cases and studying corresponding familiarity with aquatic environmental conditions and activities according to age and sex, is recommended for a broader implementation in different countries. Mastering the skills of risk management has also to be studied in youth population and adults, in particular those involved in the educational process (i.e. parents, teachers, instructors, lifeguards).

In this article the pictures (in table 3 and 4) were presented as they were shown to the children as it is a report on the development and validation of the tool. The IARM-C can still be improved in presentation of the drawings in one line or animations, supported by a short text or voice explaining what is happening. When writing our IARM-C manual the last drawn version of all 10 situations will be used and presented conform (horizontal A-B-...).

## Conclusions

There is a limited amount of studies in which a child's perception, reflection and reaction is assessed concerning risk management in recreational activities in general and in an aquatic context in particular. Regarding drowning prevention, it is important that children notice and understand the risk in certain situations, both in the indoor (i.e., swimming pool) and in the outdoor (i.e., open water) context (McCool et al. 2008; Wiesner & Rejman, 2014).

It is the first time that this kind of research has been performed regarding children's individual risk management in aquatic recreation, using pictures followed by questions to check their accompanying feelings and cognitive reasoning ability. The findings of this pilot study already provide us with some insight on two of the three distinct pillars of aquatic risk competence among children (perception, assessment) and can be used in further research. The approach in our sample to unravel children's risk perception and assessment is a start to study risk competence more in detail. Especially the reflections and arguments to understand their decision making (third pillar) as reaction on pictures and if possible, in real-life aquatic situations, need to be described in detail. Our preliminary data on this third pillar will be published in another article. The IARM-C tool is a crucial step forward to ensure lifelong water competent participants in water recreation, starting with educating children and their close social network.

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