DROWNING

This is to certify that to the best of my knowledge, the content of this report is my own work. This report has not been submitted for any subject or for other purposes. I certify that the intellectual content of this report is the product of my own work and that all the assistance received in preparing this report and sources have been acknowledged.

Your name: Teresa Wang
Student number: n10611093
Date: 10/09/2023

How can wearable technology to enhance the safety of swimmers and reduce the risk of drowning?

TABLE OF CONTENT

ABSTRACT

In the list of major global public health concerns, drowning rank third, accounting for 8% of the global total of injuries and fatalities each year (WHO, 2019). Despite the World Health Organization's call for governments of all countries to promote and establish muti-sectoral drowning prevention efforts, the mortality rate has remained unchanged and has even shown sighs of increase over the past decade. However, there is currently no reliable method to effectively prevent drowning deaths of unknown cause, though WHO estimates that 40% of drowning incidents are preventable. This report investigates how wearable technology can enhance the safety of swimmers and reduce the risk of drowning. By employing a mixed-methods approach involving both quantitative and qualitative research, surveys and structured interviews were conducted with 35 individuals and 11 experts, respectively. The surveys findings reveal public behaviors in aquatic environments, insufficient safety awareness, and the potential of future technology in aquatic safety. Meaningful insights validate the necessity of wearable technology to prevent drowning incidents across various water bodies. Furthermore, design implications are drive, forming robust building blocks for the upcoming development phase.

Figure 1. Drowning

1.0 INTRODUCTION

Drowning occurrences are a multidimensional public health hazard, shaped by a variety of circumstances that change throughout a person's life. While swimming and diving are praised for their soft impact, making them desirable for both leisure and physical training, the aquatic environment provides unique problems.

Real-time monitoring systems provide up-to-the-minute insights into water conditions and empower individuals to make informed choices about the safety of their aquatic endeavors. Moreover, smart devices integrated with sophisticated algorithms can detect subtle shifts in currents, proactively alerting swimmers, and recreational enthusiasts to potential hazards before they escalate into life-threatening situations. Despite significant technological advancements, there is a notable gap in addressing the unique challenges presented by river environments. These challenges, including swift currents, poor visibility, and a lack of fixed technology infrastructure along riverbanks, have not been comprehensively addressed. While advances in drowning detection technologies, such as wearable sensors and smart lifebuoys, have been considered, their adaptation and efficacy in river scenarios have not been properly studied. Personal monitoring systems and coastal safety measures might not effectively cater to the complexities of river environments.

According to the Royal Life Saving Organization's research, inland waterways account for more than one-third of all drowning fatalities. Rivers were responsible for the most fatalities between 2011 and 2014, accounting for 20.3% of all unintentional fatal drownings from 2002 to 2007 (Royal Life Saving, 2016). The Australian Water Safety Council (AWSC) has classified inland waterways, including rivers, creeks, streams, lakes, dams, and lagoons, as a significant
concern, recognizing the seriousness of the situation. Their goal is to reduce national drowning deaths by half by 2030 through targeted initiatives (Australian Water Safety Council, 2023).

Figure 1. Drowning deaths by location (Royal Life Saving, 2022)

To bridge this gap, this research aims to develop a specialised AI-controlled safety buoy that can enhance safety along riverbanks and address the specific challenges posed by river settings. The research begins with a literature review to understand the factors causing river drowning. This is followed by a secondary study to understand the existing digital tools available to prevent water drowning. This research is further narrowed down to the use of lifebuoys and the integration of available digital technologies. Based on this literature study the research gap is identified which shall form the basis of the remaining parts of the capstone project. The project outline is shown in the Figure 2.

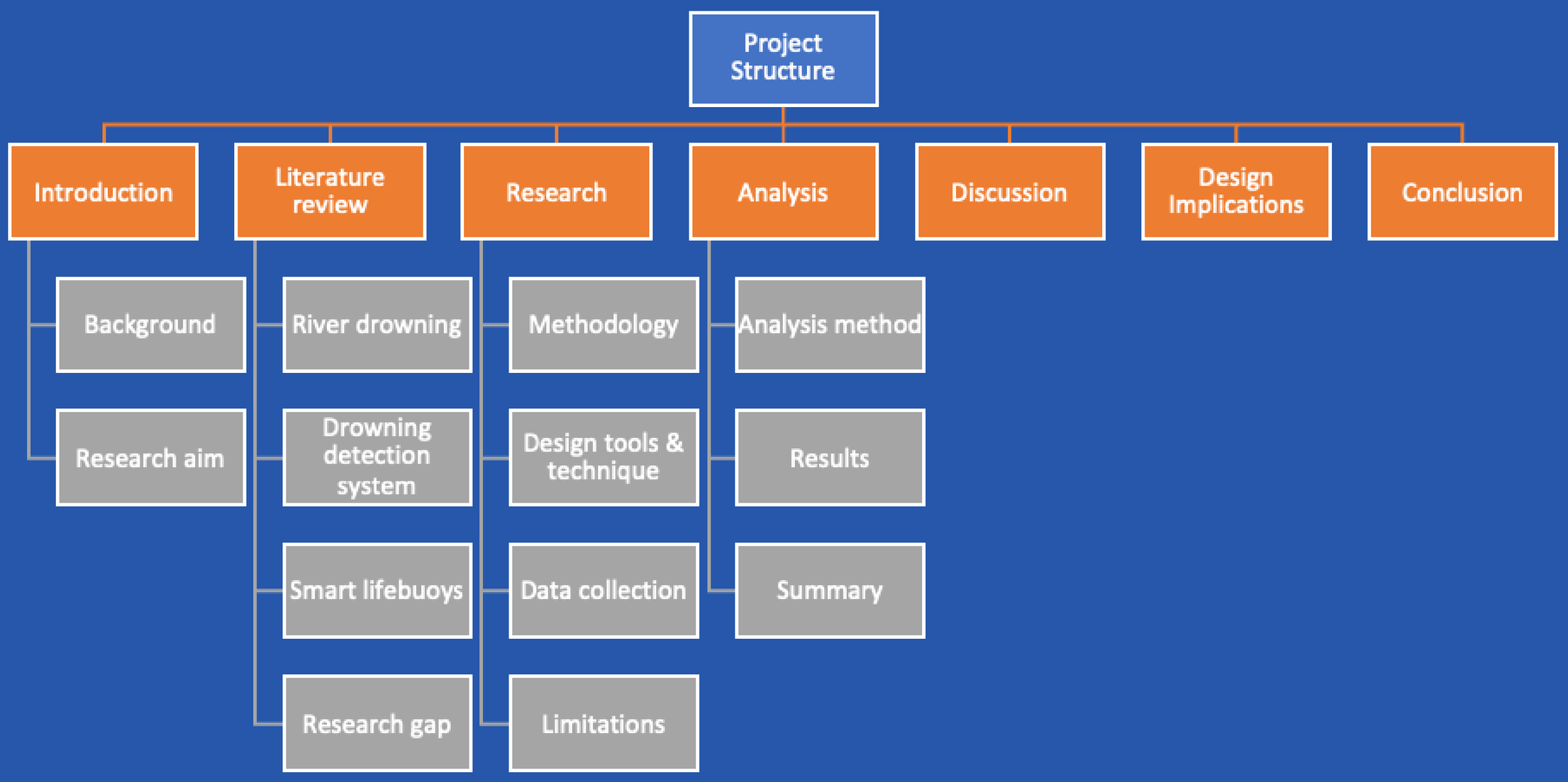


Figure 2. Project Structure

2.0 LITERATURE REVIEW

2.1 Drowning in Water Bodies

The Royal Life Saving Drowning reports a 15% increase in drowning-related deaths compared to the previous year. Inland waterways such as rivers and creeks account for the highest drowning-related incidents at 34% which is followed by beaches (21%), and oceans/harbours (13%). Drownings are caused by a lack of barriers restricting water access, insufficient adult supervision for young children, poor swimming skills, a lack of understanding of the dangers, alcohol consumption, and flooding-related disasters (Royal Life Saving, 2022). Community-centred efforts such as creating safe spaces for water activities using water barriers, lifeguards, etc., raising awareness about swimmers' vulnerability to drowning, implementing safe boating regulations, use of life jackets, patrolling water bodies, implementing flood risk mitigation measures are the strategies to prevent drownings. However, teenagers and young adults, particularly men, and their proclivity for risk-taking behaviours were repeatedly discovered in research publications as the prime cause of drowning incidents (Royal Life Saving, 2022). Poor swimming skills, underestimating river risks, local habitation, rural river settings, use of tree rope swings, and reluctance to utilise life jackets were all risk factors. The absence of adult supervision in water bodies increases the danger of drowning for children, albeit supervision may not be completely effective in certain circumstances. In most of the drowning cases in Australia, victims were not always alone when they drowned (Amy, Peden, Franklin, & Leggat, 2007).

The concerning rise in drowning incidents is mainly attributed to human behavior and requires the integration of engineering technology to prevent it. Present engineering solutions to limit access, such as grills and coverings, are poorly explained and may not be appropriate for open water situations such as rivers. Hence, there is a need to investigate the avenues of smart gears, remotely controlled life buoys, smart water barriers, AI-enabled cameras, life-saving drones, etc.

2.2 Drowning Detection System

Sensor-based systems and image-processing systems are the two broad groups of drowning detection systems. The former employs pressure, heartbeat, motion, and depth sensors, whilst the latter use algorithms to identify drowning by analysing live video data. Different drowning detection methods were examined in a study by Shehata et al. (2021) based on their accuracy levels, complexity, and prices. Sensor-based devices were discovered to be low to moderate in cost and complexity, whereas image-processing systems were identified for their complexity and cost (Shehata et al., 2021). Image processing systems sometimes necessitate the employment of drones to cover bigger regions, posing practical issues such as drone safety and battery charging. Image processing approaches outperform sensor-based systems in terms of accuracy. They do, however, have limits when drowning happens underwater in muddy waters with little visibility. Wearable sensor devices have been investigated by researchers to improve drowning detection. For example, Chaudhari et al. (2018) created a gadget that monitors the swimmer's heart rate and compares it to a predefined threshold value before transmitting the data over a 5–6-meter radio. For mobility, this device can be readily attached to the swimmer's head or hand (Chaudhari et al., 2018).

Recent advancements have resulted in the development of sensitive sensors with small fingerprints, which have the potential to be used in drowning detection systems (Rafeie et al., 2017). Wristbands, for example, have been built with microcontrollers and heart rate sensors with pre-defined high and low thresholds. When the heart rate reading exceeds specified limits, an alert is issued to the receiver. Ramdhan et al. (2018) introduce a three-module system comprised of monitoring, access point, and drowning detection segments to provide a more comprehensive solution to drowning detection. A microprocessor and a pulse sensor are used by the drowning detection module to measure the swimmer's heartbeat. In addition, it assesses data such as blood oxygenation levels, breathing patterns, and body submersion underwater using three sensors: an oxygen saturation level sensor, a respiration monitoring sensor, and a water sensor. These readings are analysed by a controller to identify warning signs of drowning. Aside from wearable gadgets, researchers have also investigated sensor systems combined with airbags. Ramani et al. (2019) developed an automatic drowning prevention system that combines a peripheral interface controller and an accelerometer. The device monitors the vitals of the swimmer in the water and compares them with certain benchmark values. If the data exceeds any of these thresholds, the wristband devices open a floatable which provides buoyancy to the swimmer.

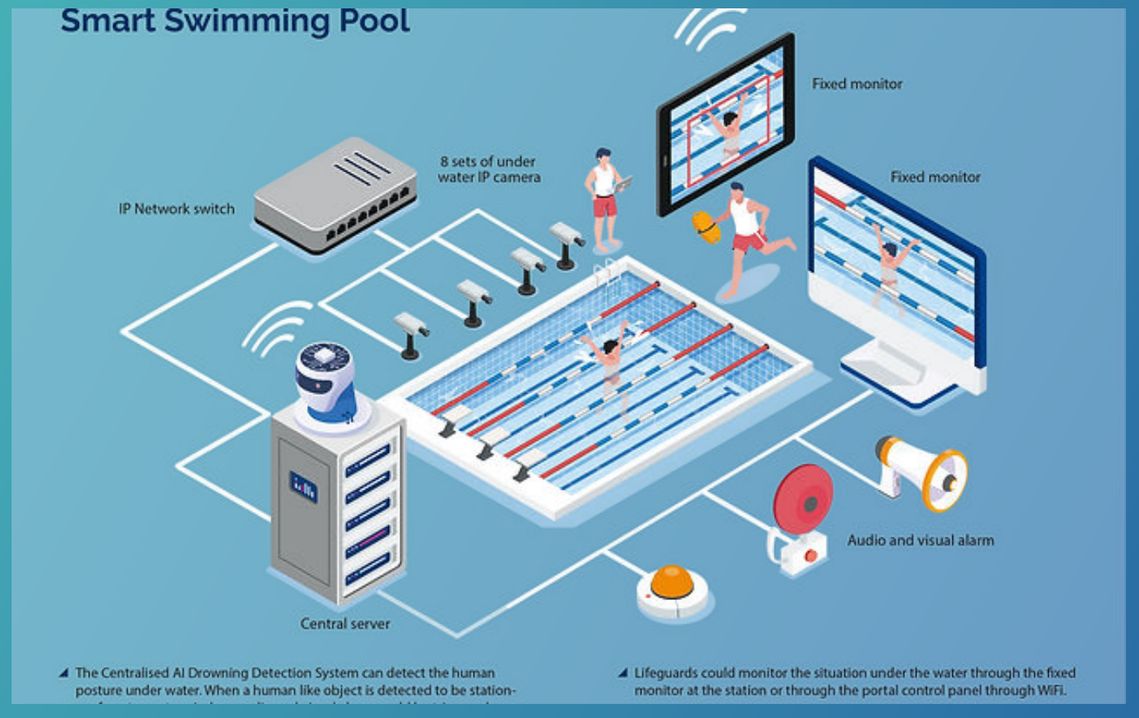


Figure 1. Drowning detection in swimming pool.

2.3 Existing Product – Smart lifebuoys

The advancement in technology has led to the development of smart lifebuoys to prevent drowning. They are U-shaped and can be controlled remotely. The lifebuoys have a thumb stick arrangement which allows lifeguards to control their trajectory from a safe position (Collins, 2023). It allows the lifeguards to carry out rescue operations swiftly over a larger area and reduces the risk from water.

However, the use of smart lifebuoys is hampered by concerns such as weight and complexity, making them difficult to use for women, children, and people with impairments. This could cause problems in emergency man-overboard situations. Recognizing the need for a lightweight and effective remote-control lifebuoy device, Badmasi (2014) used Arduino technology to prototype one. Arduino, an open-source electronics design platform, provides various advantages, including compactness, cost, usability, and diverse input-output capabilities (WatElectronics, 2021). The Arduino-enabled smart lifebuoy incorporates remote-control technology, a wireless power transmission system consisting of a transmitter and a receiver for signal communication (Terada et al., 2014). The transmitter unit is made up of a power transmission module and a communication module, whereas the receiver unit is made up of a power receiving unit that receives signals. The signal activates a water pump within the smart lifebuoy, which generates thrust via a pull-and-push mechanism. The resulting water flow drives the buoy, providing directional control based on remote controller impulses. Empirical evidence demonstrates the remote-control lifebuoy system's efficiency and effectiveness in rescue missions. It decreases the risk of jeopardising rescuers and speeds up response times, perhaps cutting the rescue process in half. The remote controller's user-friendliness makes it more accessible for use by anyone on land or aboard vessels. Finally, remote-controlled lifebuoys, also known as smart lifebuoys, outperform conventional lifebuoys in terms of better rescue capabilities and the potential to save lives (Thanakodi et al., 2021). Therefore, smart lifebuoys are one of the technology that can prevent swimmers from drowning.

Figure 2. Smart lifebuoy.

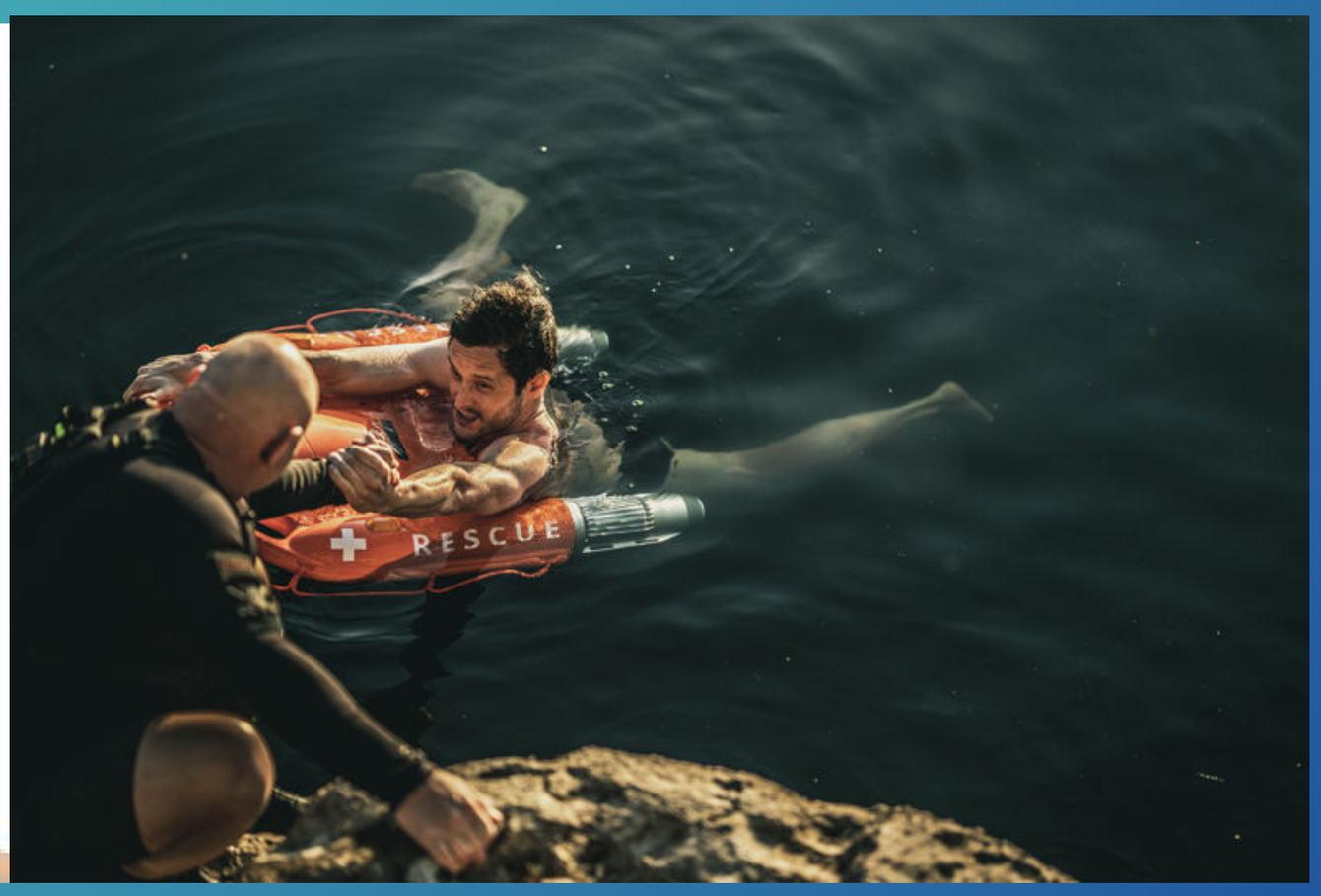


Figure 3. During the rescue, how does it work?

2.4 Research Gap

Current research focuses mostly on sensor-based and image-processing systems, as well as remote-controlled smart lifebuoys, but their applicability and performance in river situations, with their specific obstacles such as murky waters and changing depths, has not been properly investigated. As a result, there is an essential need to close this gap by developing specialised AI-controlled safety solutions that meet the unique dangers and conditions associated with river ecosystems. This study could lead to more effective drowning prevention techniques along riverbanks and help save lives in drowning emergencies.

3.0 RESEARCH

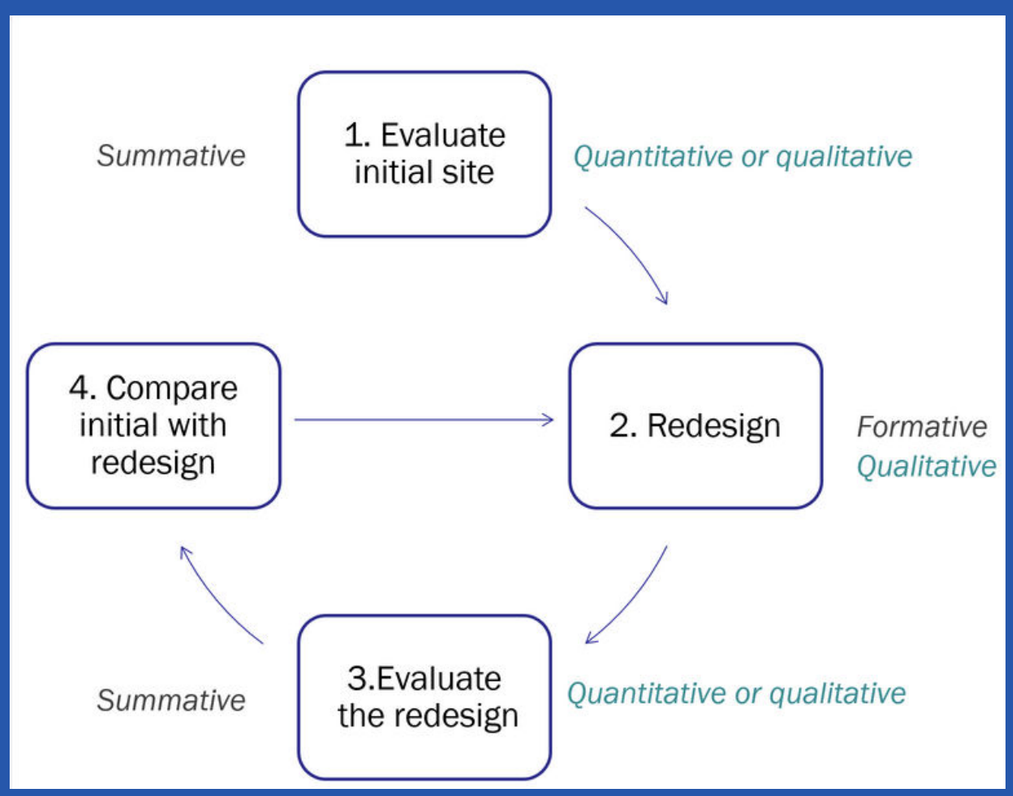


Figure 3. During the rescue, how does it work?

The research in this paper was divided into two cycles that used two separate approaches, a quantitative cycle and a qualitative cycle. The focus of this report centres around the phenomenon of drowning, a complex event influenced by various factors. Exploring this topic from multiple angles is crucial, as it enables a comprehensive understanding, akin to the approach proposed by Creswell (1999). Consequently, employing a mixed method strategy is advantageous, as it not only strengthens the quality and dependability of gathered data but also heightens the potential to draw causal inferences, as highlighted by the research of Abowitz and Toole (2010).

3.1 Survey Methods

The initial phase of the research was the quantitative cycle, which encompassed a 10-question multiple-choice survey. This survey was administered to a sample group of 35 individuals, chosen through a volunteer sampling method. The primary objective of this survey was to understand the public's awareness of the risk of drowning, their swimming skills, and water safety measures. The survey covered many aspects such as swimming frequency and location, whether you have received water safety education, and the understanding of life-saving techniques.

Some of the research question that the survey aims to address are:

- Have you ever been experienced in drowning before?
- Which waters do you think are most prone to drowning accidents?

- Do you wear a life jacket or other floating gear when participating in water activities?
- Under what circumstances do you think drowning accidents are most likely to occur?

After data accumulation, the acquired insights and findings were utilised to shape the interview questions for the subsequent phase of data collection involving expert interviews and 10 people selected from it who had experienced drowning incidents.

3.2 Interview Methods

The qualitative cycle of this report consisted of expert interviews from lifeguards and volunteers based on the survey were drawn from 10 people. By engaging with them, a comprehensive spectrum of insights emerges. These insights drive the development of holistic water safety strategies that combine immediate response expertise with preventive measures, ultimately contributing to a safe water environment and a reduction in drowning incidents.

Face-to-face interviews are not available due to their working hours and distance issues, only via email and phone. Phone call interviews lasted between 15 to 30 minutes, following approval, phone call enabled the capacity to record audios.

Themes were recorded and analysed visually in the quotes, the respondents' responses provide solid knowledge for research in this area (based on a literature review) and provide insight into the numerous challenges facing the general population and water safety education.

4.0 ANALYSIS & FINDINGS

The findings of people who have drowned shed light on many aspects of swimmer behavior that are areas of concern. It is also worth noting that some respondents said they had not received any training in water safety education. These results are still included in the analysis because they are a crucial part of the investigation.

4.1 Survey Data

CHART 1: HAVE YOU EVER EXPERIENCED ACTIVITIES IN DANGEROUS WATER ENVIRONMENTS

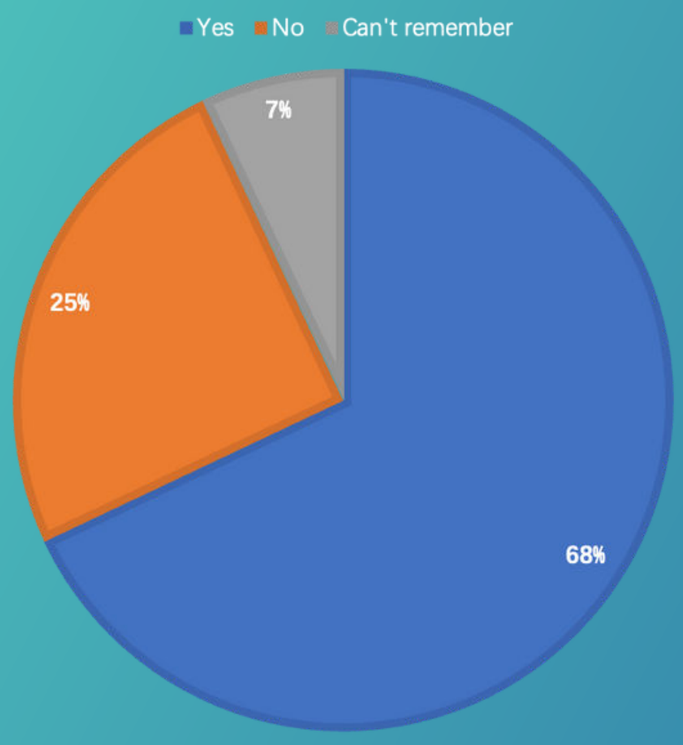


CHART 2: IF YOU ANSWER YES, HAVE YOU EVER EXPERIENCED DROWNING OR NEAR

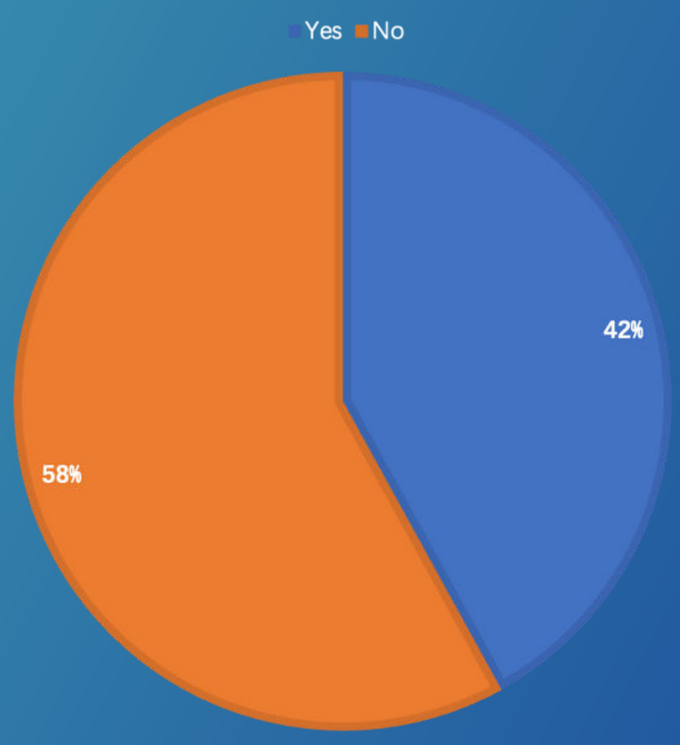


CHART 3: HAVE YOU EVER TAKEN ANY WATER SAFETY EDUCATION

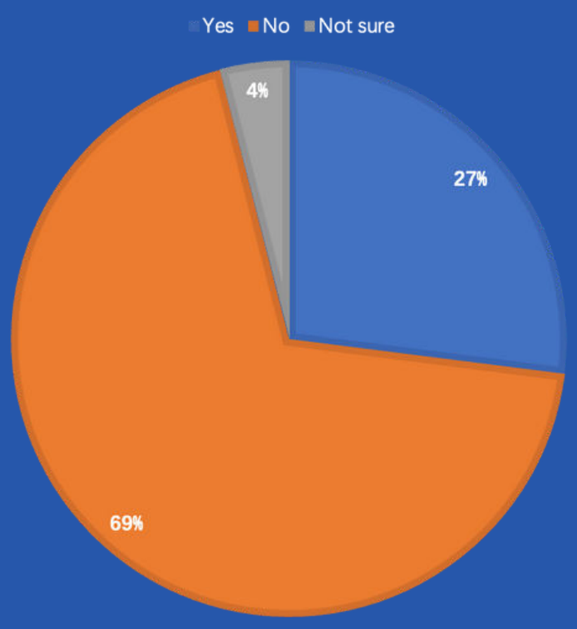
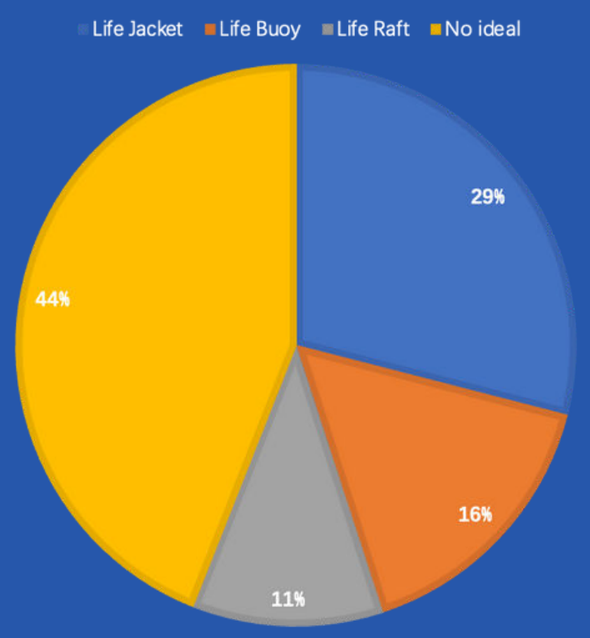


CHART 4: DO YOU KNOW ANY WATER SAFETY EQUIPMENT (COMMON ANSWER)



In this survey, chart 1 has showed that 68% of the respondents said they had experienced in dangerous water conditions, and 42% of them had experienced drowning or near-drowning in the water. While the majority of respondents were aware of the importance of water safety to some extent, only 27% said they had received any water safety education or training. This raises the challenge that even if future products are able to address the occurrence of drowning, without any water safety education, how to ensure that the public is truly prepared for sudden dangers? In addition, 56% of respondents knew they should use a life buoy or other floating gear, but only 39% were able to describe the correct safety code of conduct. There is still a significant percentage of people who do not take these critical safety measures during water activities. This may be related to some people's discomfort with safety equipment or not understanding how to use it properly.

CHART 5: THE MOST LIKELY LOCATIONS FOR WATER ACTIVITIES

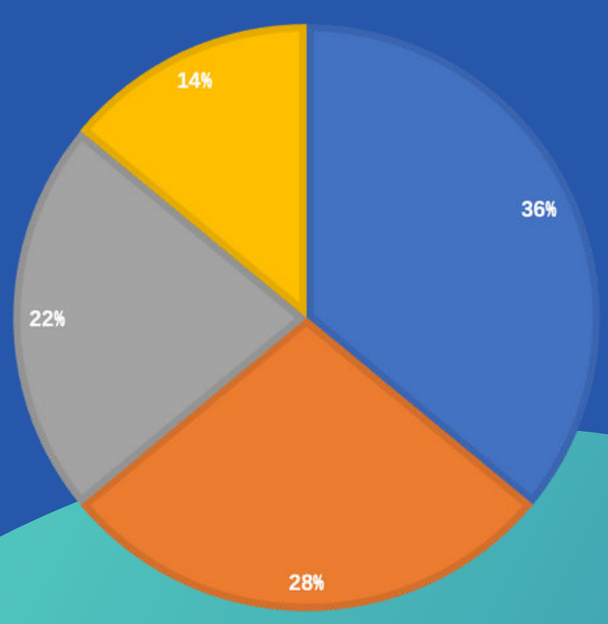
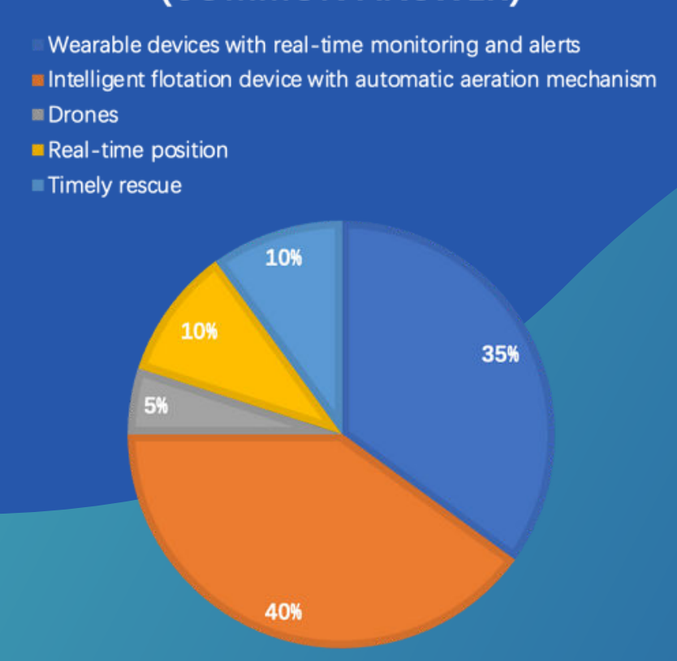


CHART 6: DO YOU THINK TECHNOLOGY CAN REDUCE DROWNING RATES?, IF SO, GIVE AN EXAMPLE (COMMON ANSWER)



In chart 5, the survey data revealed differences in perceptions and risk assessments across different waters. The most likely locations for water activities are : swimming pools (36%), beaches (28%), lakes (22%) and rivers (14%). This results indicates that because swimming pools are typically the most commonly visited bodies of water by people, it may be related to the greater prevalence of swimming pools in urban and community settings. However, the risk of drowning incidents also exists in open water bodies, but the respondents have a lower awareness of these risks.

Technological innovations have the potential to improve the safety of water activities. In chart 6, shows that the majority of respondents are positive about using technological innovations to improve the safety of water activities. This includes the use of smartphone apps, GPS systems, drones and other tools to provide more timely rescue and support. In the digital age, these tools can quickly spread alerts and provide accurate location information to help rescue workers respond more effectively to emergencies.

4.2 Interview Analysis

4.2.1 People who had experienced drowning

Table 1: Interview Themes and Example Quotations

Theme	Quote
Drowning Scenarios	‘I experienced a drowning incident at a family gathering in a pool, turning what should have been a joyful moment into a nightmare.’ – Happened in 7-years-old ‘That day, I was on a beach vacation, never expecting to be caught by a wave.’ – Happened in 18-years-old ‘I once swam in a mountain lake, and due to the cold temperature and the lake’s depth, the situation became very dangerous.’ – Happened in 57-years-old ‘I went to a less familiar swimming area with friends and ended up in treacherous currents.’ – Happened in 12-years-old ‘It was my first attempt at diving and i underestimated the challenges of deep water, nearly paying with my life.’ – Happened in 22-years-old
Safety Measures and Preparedness	“I rarely use survival gear, I know how to swim so I don’t think I need it.„ “To be honest, I never wear a survival vest. I find them uncomfortable, and I’ve gone swimming many times before and never had a problem, but after one experienced of drowning I now understand that it can be a dangerous decision.„ “We paddled on the lake and never carried any life-saving equipment. We always felt safe there.„ “I checked the speed and quality of the river carefully before swimming. I only go swimming when I am sure it’s sage to do so.„ “I will bring a aid kit with supplies and regular medicines. This is useful especially if you have a vacation away from medical facilities.„
During Drowning	“When i started to feel like i was drowning, i felt extreme fear and despair. I struggled as hard as i could but couldn’t seem to surface. Luckily, my friend noticed me and swam over in time to help to to shore.„ “I remember feeling like i couldn’t breathe, water was engulfing me. I tried to paddle with my arms and legs, but it seemed like i was sinking deeper. Eventually, a stranger tossed my a float, and i grabbed onto it.„ “Not really remember, but i know that because of my fear, i can not stay afloat and waiting for help.„ “I was so scared, and can’t remember anything, when i regained consciousness, i found myself in the hospital.„
Education and Action Post-Drowning	“I attended a water safety course once, and it truly changed my perspective.„ “I didn’t take any education after that, because i was too scared to touch water.„ “I now undergo swim skill training every year, I see it as a responsibility to protect myself and others.„ “My experience inspired me to become an educator, hoping to teach more people how to stay safe in the water.„ “I used to consider myself a strong swimmer, but the drowning incident taught me never to underestimate water safety, no matter how skilled you are.„
Future Technology	“I believe future technology can bring significant improvements to water safety. For instance, smart life jackets and underwater camera surveillance systems could become standard equipment, providing real-time monitoring and alerts to reduce drowning incidents.„ “I hope to see more applications and online tools that can provide people with safety information about local water bodies, including water currents and tide conditions, enabling swimmers to better plan their activities.„ “Future rescue technologies may become more efficient. For example, water drones could respond more rapidly to emergencies, providing rescue and support services. This will pay a crucial role in saving lives.„

The interview analysis identified In the interview, respondents described their drowning experiences. The majority of individuals mentioned incidents occurring in common water bodies such as swimming or beaches, often during swimming or recreational water activities. It is noteworthy that the age group with the highest frequency of drowning experiences fell within the 5–15 year-old range, and they reported the absence of clear warning signs during their incidents. Most respondents described their actions when drowning as attempting to struggle back to the shore or stay afloat while calling for help. However, respondents mentioned that fear and panic may have led to unwise behaviours, such as frantic struggling. Some of the interviewees received timely rescue efforts during their drowning incidents, with rescuers including nearby swimmers, lifeguards, and even strangers in the vicinity. Nonetheless, there were also reports of rescues not being sufficiently rapid or effective.

The majority of respondents experienced physical or psychological consequences following the drowning events. Physical consequences encompassed fatigue, nausea, and breathing difficulties, while included anxiety, fear, and a heightened apprehension towards water environments. Interviewees mentioned that this experience had altered their aquatic activity habits, rendering them more cautious and vigilant. Nearly all respondents expressed their willingness to learn and employ innovative technologies to enhance their safety during water-based activities, offering a plethora of practical recommendations in this regard.

4.2.2 Expert Interview-Lifeguard

According to lifeguard responses (in appendix), we can delve deeper into the issue of drowning and the significance of water safety. Firstly, lifeguard's job experience and professional training make them experts in water safety, enabling them to respond swiftly and effectively to drowning incidents. Secondly, the frequency of drowning incidents is a concerning matter, especially in cases involving swimmers who are unfamiliar with the water, disregard safety signage, or exhibit overconfidence. This underscores the importance of public awareness and education regarding water safety. Lifeguards emphasise that their role extends beyond life-saving to include prevention through patrols, signage placement, and educational outreach. In dealing with drowning incidents, lifeguards underscore the criticality of collaboration, necessitating organised teamwork with other rescue personnel to ensure swift and efficient responses. This highlights the professional competence of lifeguards and the importance of teamwork in handling emergencies.

Public education and awareness are pivotal factors in reducing drowning incidents. Lifeguards point out that regular water safety lectures and disseminating information about water safety can enhance swimmers' safety awareness. This reflects the importance of educating the public about water safety and how education can mitigate potential risks. Future technology and innovation are regarded by lifeguards as crucial factors in improving water safety. They mention technologies such as underwater monitoring systems, smart life saving equipment, and waterborne drones, which hold the potential to enhance rescue efficiency and waterbody monitoring capabilities

Lastly, lifeguards provide recommendations regarding water safety, including the necessity for everyone to receive basic water safety training, emphasising the importance of information dissemination. These recommendations underscore individual and collective responsibility in reducing drowning incidents.

5.0 DISCUSSION & DESIGN IMPLICATION

5.1 Discussion

Most of the research gaps were addressed after preliminary research with people who had experienced drowning and experts in rescue. Additionally, new information was discovered that further illuminates the context of the design problem.

5.1.1 Applicability of Drowning Detection Technologies in Different Water Environments

The examination of drowning detection technologies in various water environments emphasizes the urgent need for context-specific solution. The literature review highlights two main categories of drowning detection systems: sensor-based systems and image processing systems. Sensor-based systems utilize a range of sensors, including pressure, heartbeat, motion, and depth sensors. In contrast, image processing systems use algorithms to analyze real-time video data. The research emphasizes that the choice of technology depends on the specific water environment. Image processing systems excel inaccuracy, but their effectiveness can suffer in challenging conditions such as muddy waters with limited visibility. Conversely, sensor-based systems are more cost-effective and less complex, making them suitable for a variety of scenarios. However, rivers present unique challenges, such as swift currents and poor visibility, that necessitate specialized solutions. Existing technologies, while promising in controlled environments, might not fully address the complexities of river settings. This research responds to this critical gap by proposing a controlled safety buoy designed explicitly for river ecosystems.

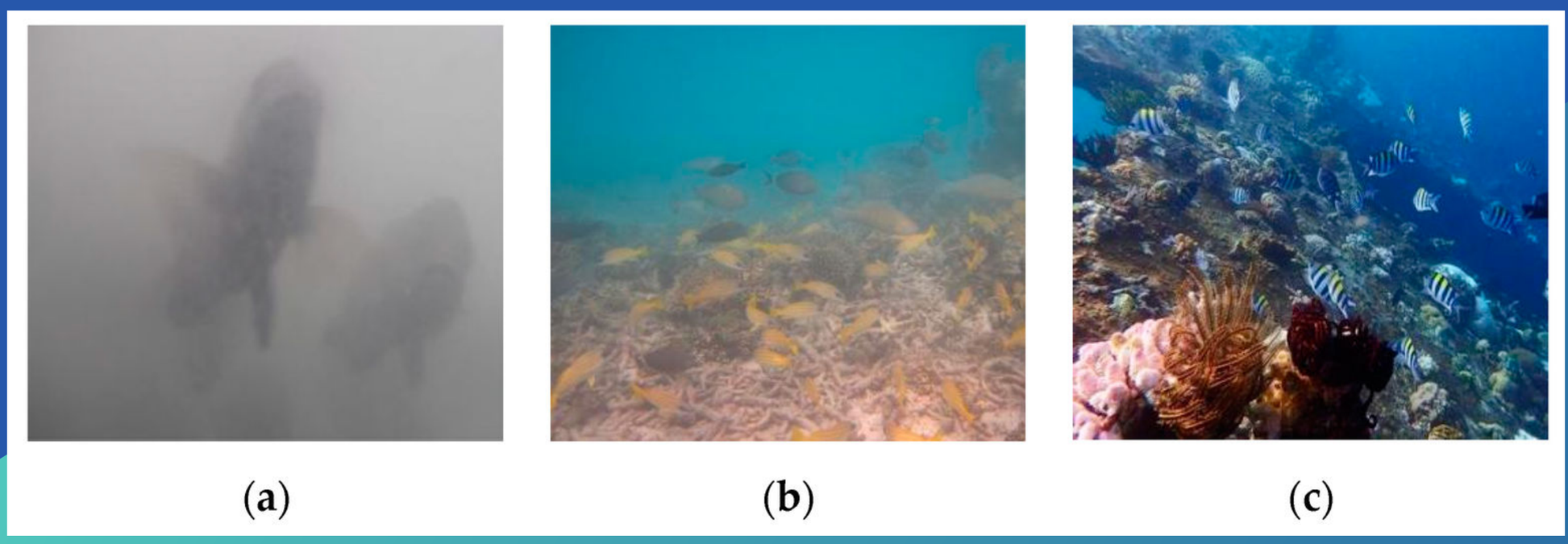


Figure 1. Use image processing system in different water bodies

5.1.2 Addressing the Education and Awareness Gap

The Findings from the survey and interviews indicated significant education and awareness gaps in drowning prevention. The survey shows that although most respondents are aware of the importance of water safety, a considerable number of them have not received formal water safety education or training. This gap in preparedness poses considerable challenges, as even advanced technologies are only effective when used by individuals with a good understanding of water safety. Interviews with individuals who have experienced drowning events highlight the consequences of insufficient education and awareness. Respondents described panic, fear and a lack of clear warning signs during their events. These experiences underscore the urgency of proactive safety measures and comprehensive education. Additionally, lifeguard interview highlighted the critical role of public education and awareness in reducing drowning incidents. They advocate holding water safety talks regularly and distributing information on water safety to raise swimmers' safety awareness.

5.2 Design Implication

- The device should be easy to understand and use, even for individuals with minimal technical knowledge.
- Swimmers should be able to wear safety-enhancing products comfortably for extended periods without feeling restricted.
- The device must use waterproof and corrosion resistant materials.
- The device should be highly visible in the water, making it easier for rescuers to locate swimmers.
- The device should be compatible with standard swimwear and gear. It should not hinder the use of other swimming equipment like goggles or snorkels.
- The device should be in the size to accommodate users of different ages and body types.
- Users should be able to easily maintain and clean the equipment without hassle. Consider a combination of detachable parts and easily accessible parts.
- The device should enhance visibility in low light or murky waters.
- The device should seamlessly integrate sensor technology and provide real-time data to users.
- The device should prioritise affordability and accessibility.
- The device should be easily carried and stored when not in use.

NOTICE: INITIAL CONCEPT IN APPENDIX

6.0 CONCLUSION

In conclusion, this comprehensive research project delves into key issues in drowning prevention, revealing multifaceted challenges and potential solutions. The study recognizes that wearable technology, coupled with increased awareness and education, can play a key role in reducing the risk of drowning.

This research has unearth several important findings. Firstly, it emphasizes the need for context-specific drowning detection technologies. Sensor-based systems and image processing systems offer distinct advantages and limitations, making them suitable for different water environments. The proposed AI-controlled safety buoy specifically tailored for river ecosystems addresses this crucial gap. Secondly, the study highlights a significant gap in water safety education and awareness. Many respondents, despite recognizing the importance of water safety, had not received formal training. This education deficit is a critical challenge that needs to be addressed alongside technological innovations. Individuals need to be well-informed and prepared to use advanced safety technologies effectively.

Finally, the design implications derived from this research provide valuable guidance for the development of wearable safety technology. User-friendliness, comfort, compatibility, and affordability are key factors to consider in the design process. The device must seamlessly integrate sensor technology, ensuring real-time data provision to users while enhancing visibility and usability.

7.0 REFERENCE

Australian Water Safety Council. (2023). Towards a nation free from drowning. https://www.watersafety.com.au/

Abowitz, D. A., & Toole, T. M. (2010). Mixed Method Research: Fundamental Issues of Design, Validity, and Reliability in Construction Research. Journal of Construction Engineering and Management, 136(1), 108–116. https://doi.org/10.1061/(asce)co.1943-7862.0000026

Badmasi, Y. A. (2014). The working principle of an Arduino. In 11th International Conference on Electronics, Computer and Computation (ICECCO). https://doi.org/10.1109/ICECCO.2014.6997578

Chaudhari, T., Kava, Y., Pandit, G., & Gupta, P. (2018). Anti-drowning system using remote alert. IOSR Journal of Engineering, 8(4), 38–42.

Collins, A. (2023). U-SAFE: This Remote Controlled Life Buoy is super fast in saving lives. http://factschronicle.com/u-safe-this -remote-controlled-life-buoy-is-super-fast-in-saving-lives-4619.html

Creswell, J. W. (1999). Mixed-Method Research. Handbook of Educational Policy, 455–472. https://doi.org/10.1016/b978-012174698-8/50045-x

Peden, A. E., Franklin, R. C., Leggat, P. A. (2007). Fatal river drowning: the identification of research gaps through a systematic literature review. Injury Prevention, 13(6), 438-442.

Rafeie, M., Welleweerd, M., Hassanzadeh-Barforoushi, A., Asadnia, M., Olthuis, W., & Ebrahimi Warkiani, M. (2017). An easily fabricated three-dimensional threaded lemniscate-shaped micromixer for a wide range of flow rates. Biomicrofluidics, 11(1), 1–15.

Ramani, J. G., Gayathri, J., Aswanth, R., & Gunasekaran, M. (2019). Automatic prevention of drowning by inflatable wristband system. In 2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS) (pp. 346–349). http://dx.doi.org/10.1109/ICACCS.2019.8728368

Ramdhan, M., Ali, M., Ali, S., & Kamaludin, M. Y. (2018). An early drowning detection system for Internet of Things (IoT) applications. TELKOMNIKA (Telecommunication Computing Electronics and Control), 16(4), 1870–1876.

Royal Life Saving. (2016). Young Men & Drowning. Australia: Royal Life Saving Society. https://www.royallifesaving.com.au/__data/assets/pdf_file/0008/32687/RLS_NDR2016_ReportLR.pdf

Royal Life Saving. (2022). National Drowning Report 2022. https://rlssq.com.au/aquatic-industry/national-drowning-reports/

Shehata, A. M., Mohamed, E. M., Salem, K. L., Mohamed, A. M., Salam, M. A., & Gamil, M. M. (2021). A Survey of Drowning Detection Techniques. In 2021 International Mobile, Intelligent, and Ubiquitous Computing Conference (MIUCC). Egypt. http://doi.org/10.1109/MIUCC52538.2021.9447677

Terada, T., Shinoda, H. & Yamamoto, K. (2014). Wireless power transmission system, transmitter, and receiver, Hitachi Ltd Patent: US8892033B2. https://patents.google.com/patent/US8892033B2/en

Thanakodi, S., Talib, M. L., Syed Ali, S. A., Wahab, N. A., Ahmad, A. F., Noor, N. M., ... & Ahmad, M. A. (2021). A study into the development of a lightweight smart life buoy prototype (LWSLB). Transactions on Maritime Science, 10(2), 383–389.

WatElectronics. (2021). Arduino Technology Architecture and Its Advantages. https://www.watelectronics.com/arduino-technology-architecture-and-applications/

8.0 APPENDIX

8.1 Survey Question and Answer

Table 1: Do you engage in water related activities such as swimming, boating, or water sports?

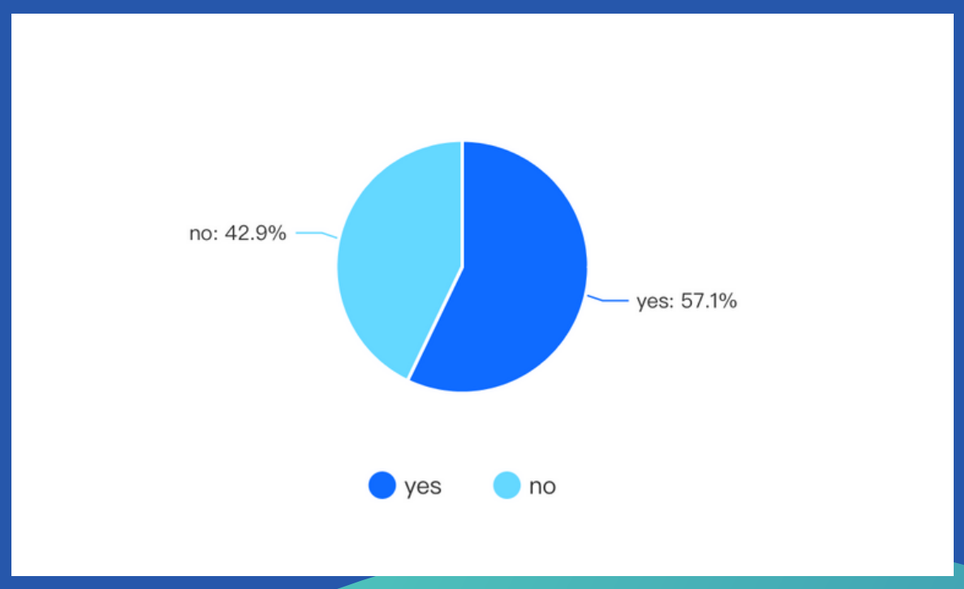


Table 2: How often do you participated in water activities?

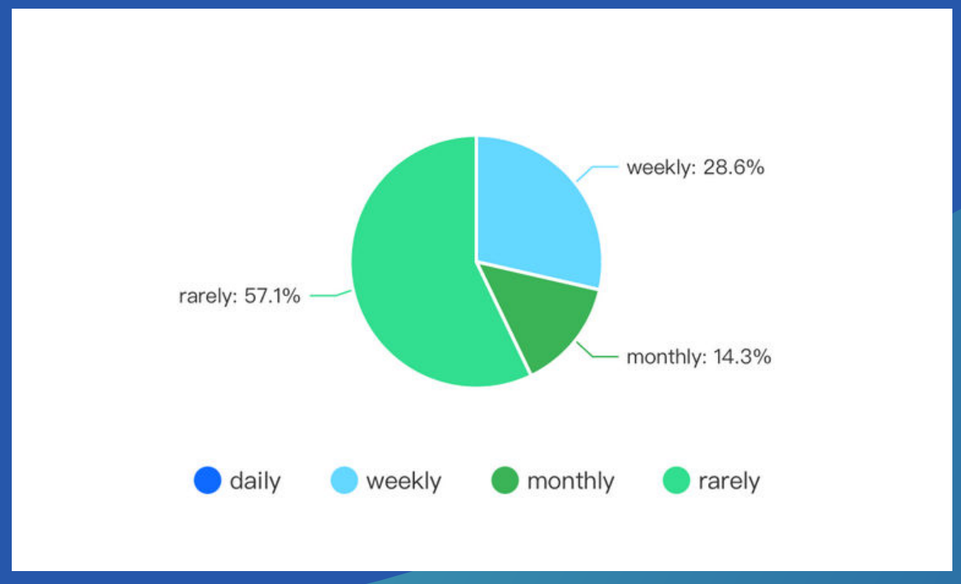
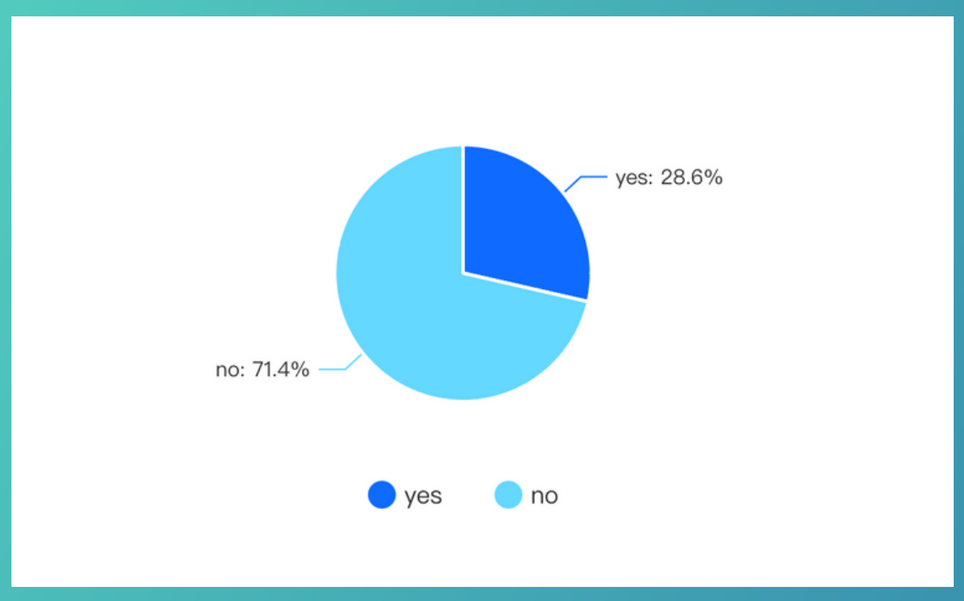


Table 3: Do you wear life jacket or other floating gear when participating in water activities?



Question: Under what circumstances do you think drowning accidents are most likely to occur?(common answer)

- Lack of supervision
- Inexperienced Swimmers
- Rough Waters and strong currents
- Engaging in non-swimming activities
- Medical conditions
- Lack of safety equipment
- Overconfidence
- Unfamiliar environment
- Unattended children

8.2 Interview people who had experienced drowning questions

1, Circumstances of drowning:

- Please share the circumstances and details of a drowning incident you have experienced.
- Where did this incident take place?
- What was your age, time, weather conditions and water conditions?

2, Safety measures and preparations:

- Did you take any special safety measures or precautions before the incident?
- Did any safety equipment or rescue tools play a role in the incident?

3, During drowning:

- How did you feel when the incident happened?
- What actions have you taken in response to the drowning?
- How has the drowning affected your physical and mental health?

4, Education and action after drowning:

- Have you received any water safety education or training before or after incident?
- Are there any lessons or educational activities that have had an impact on your awareness of water safety?

5, Future design:

- Do you think future technology could enhance the safety of swimmers and reduce the risk of drowning?
- What technology are you expecting?

8.3 Interview lifeguard, questions and answer

Q1, Work experience and training:

- How long have you been an experienced lifeguard? what lifeguard training have you received?
- How important do you think lifeguard training is in responding to drowning incidents and protecting swimmers?

A1: I have been working as a lifeguard for over 10 years and have received a variety of training including basic lifeguard training and advanced water lifesaving training. Lifeguard training is vital to our work as we need to respond quickly and effectively to emergencies.

Q2, Drowning frequency and causes:

- In your work, do you often encounter drowning incidents? what are the main causes of drowning?
- How do you think different types of water (e.g. pools, beaches, lakes) differ in terms of drowning incidents?

A2: I come across dozens of drownings every year, some of them very serious. The main reasons include swimmers not being familiar with the waters, not paying attention to safety signs and being overconfident

Q3, Monitoring and preventive measures:

- Lifeguards play an important role in maintaining the safety of swimming places. How do you ensure the supervision and safety of swimming areas?
- What preventive measures do you think are most effective in reducing drowning incidents?

A3: We ensure the safety of swimming areas by patrolling, putting up safety signs and providing swimmer education. Regular inspections of equipment and life-saving equipment are also part of our job. In terms of preventative measures, educating swimmers is key. We provide information on water safety, including emphasizing not swimming fatigue, avoiding alcohol and being aware of weather changes.

Q4, Drowning management:

- What is your job in the event of a drowning? Can you share some of your experiences dealing with drowning?
- How important is collaboration between lifeguards and other rescue workers to successfully save lives?

A4: When there is a drowning, we take immediate action. Usually, I would immediately go into the water and use life-saving equipment to pick up the swimmer and perform basic first aid. Then we call in ambulances or other emergency resources. Collaboration is very important. We will work closely with other rescue workers to ensure that rescue operations are organized in case of emergency.

Q5, Public education and awareness:

- Is it part of a lifeguard's job to educate the public about the importance of water safety? How do you educate in this area?
- Do you think that increasing public awareness and knowledge of water safety can reduce the incidence of drowning incidents?

A5: It is one of our responsibilities to educate the public. We often hold water safety talks to inform swimmers about the risks of drowning and how to stay safe. I believe that raising public awareness of water safety can reduce the incidence of drownings. People need to understand that the potential dangers in the water cannot be ignored and everyone should know how to deal with them.

Q6, Future technology and innovation:

- What role do you think technology and innovation can play in water safety in the future?
- Is there any specific technology or equipment that you think will improve the job of a lifeguard?

A6: In the future, technology will give us more tools to improve water safety. I think underwater surveillance systems and intelligent life-saving equipment will play a key role in reducing drowning. Water drones are also a big trend of the future, they can respond more quickly to emergencies, provide rescue and monitoring. This will improve our work efficiency.

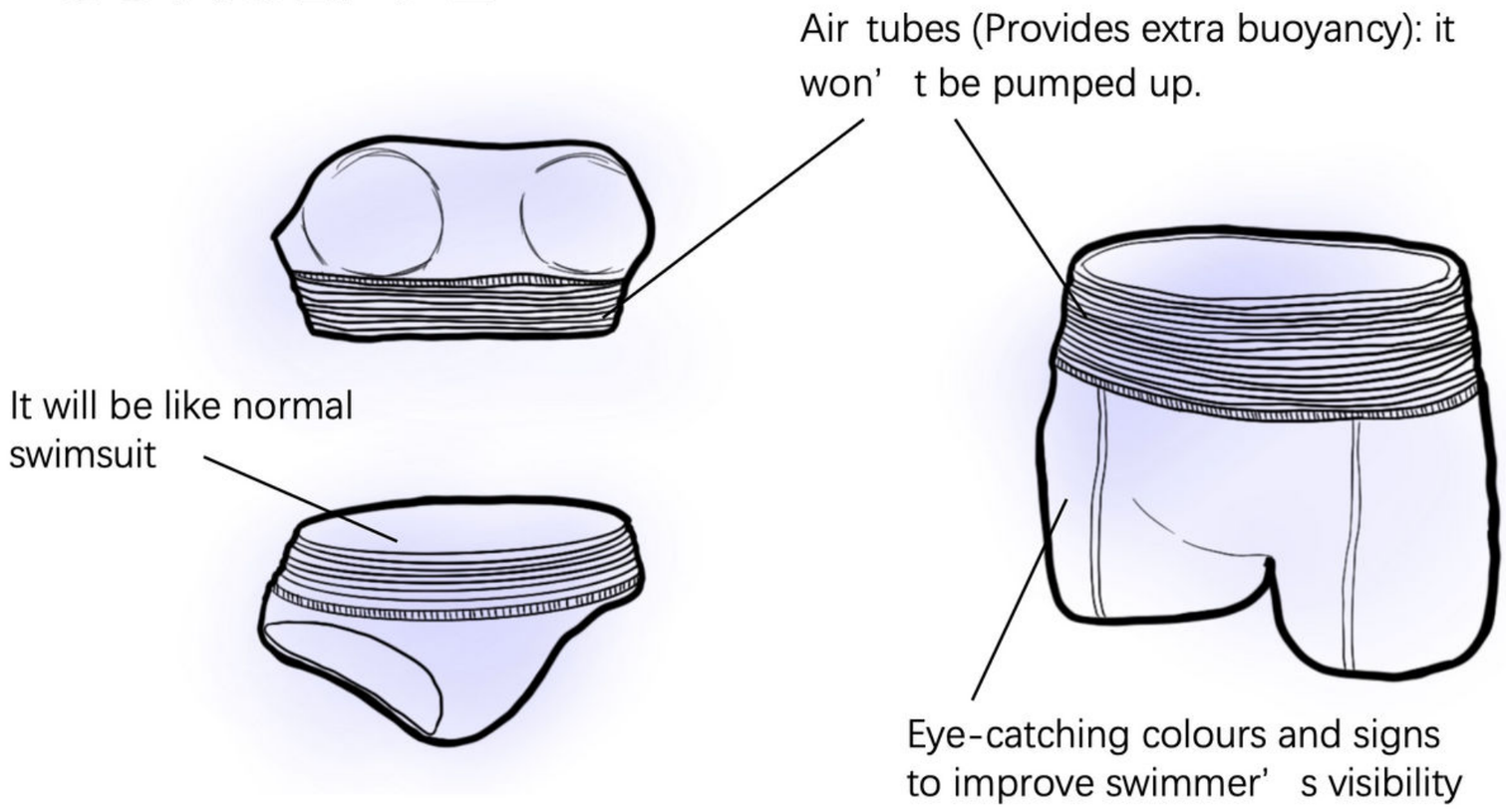
Q7, Comments and Suggestions:

- Based on your experience, what tips do you have that can help reduce drowning incidents and improve water safety?
- If you could convey one important message about water safety to the public, what would it be?

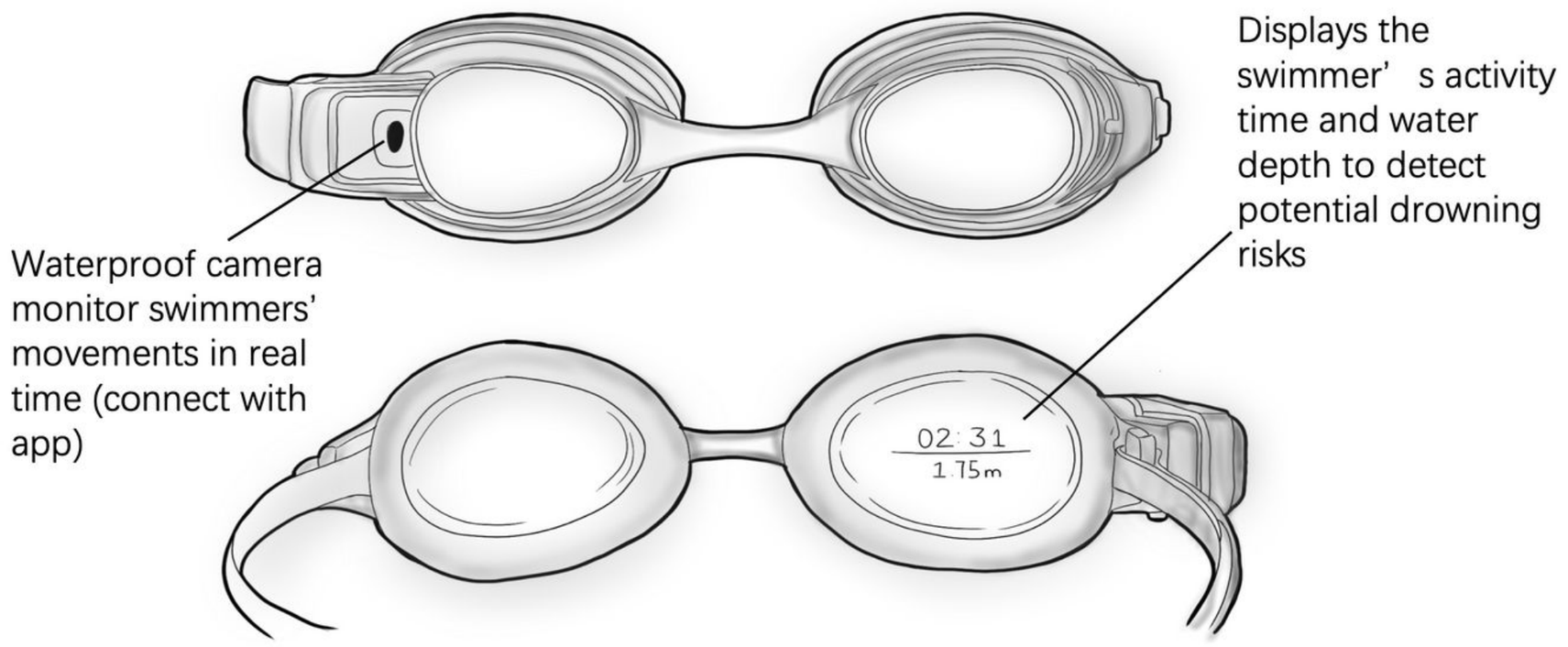
A7: I recommend that everyone receive basic water safety training, whether they are swimmers or escorts. This can help them better understand potential risks and know how to deal with them. Information about water safety should be widely disseminated, including in schools, communities and the media. We can reduce the risk of drowning by working together.

8.4 Design Implication and Initial concept

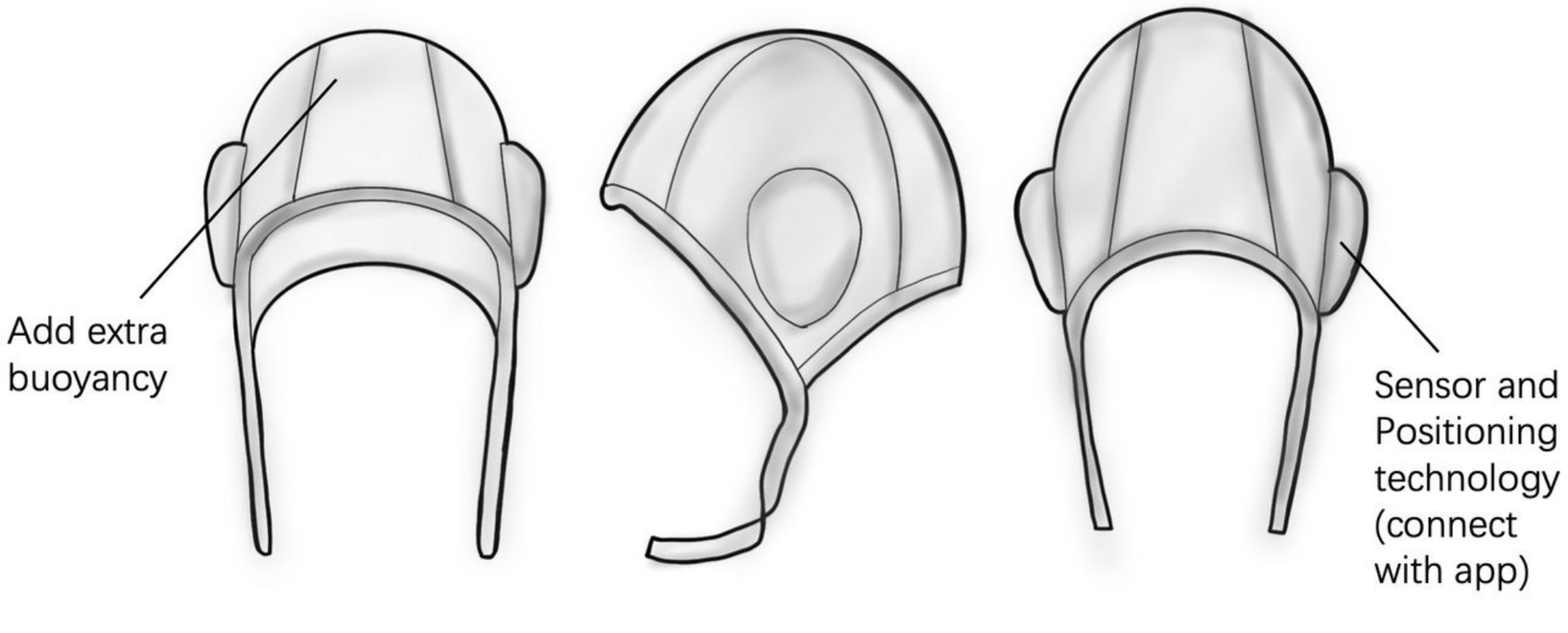
CONCEPT 1



CONCEPT 2

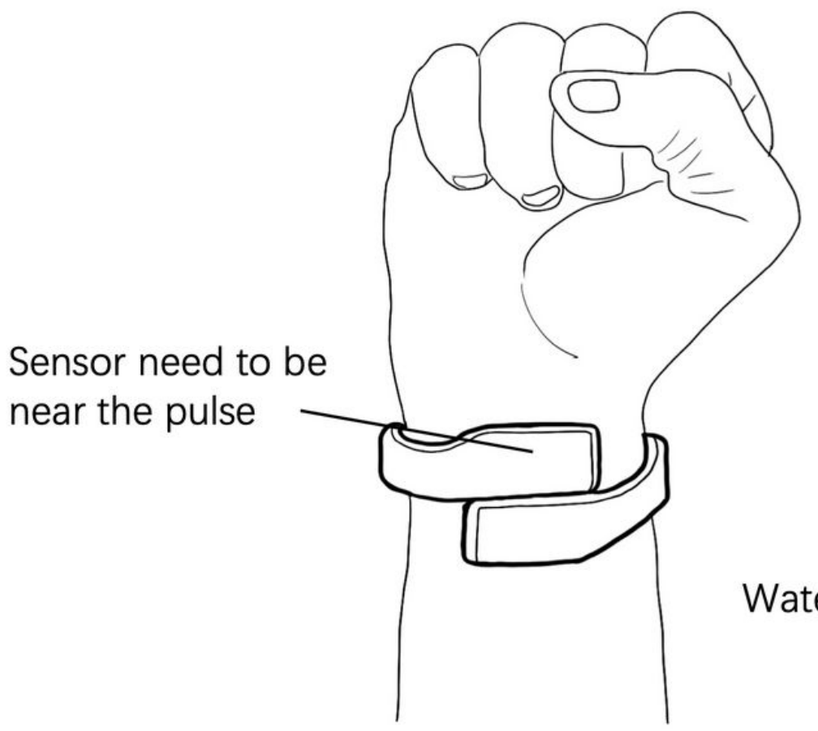


CONCEPT 3

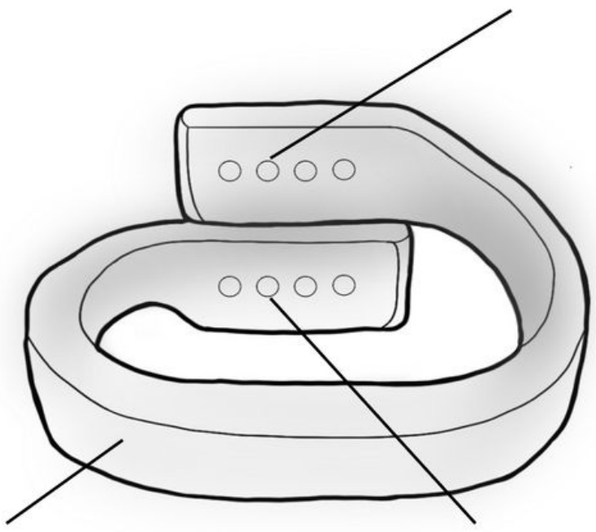


CONCEPT 4

Intelligent detection sensor: irregular swimming patterns, sudden stops, or long period underwater



Sensor need to be near the pulse

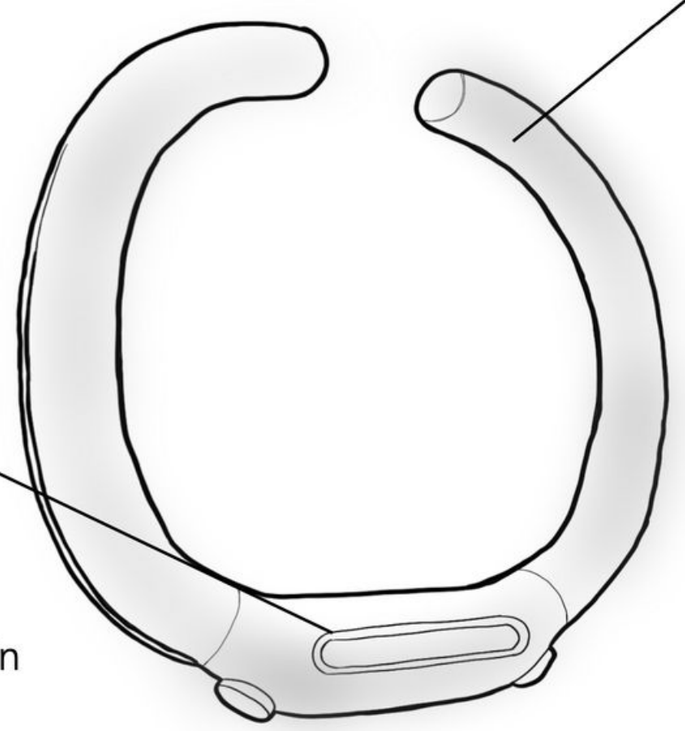


Waterproof material

Vibration feedback when a swimmer doesn’ t know they too far offshore (connect with app)

CONCEPT 5

Around the neck



Detect user’ s movement.

- If stay under water 10m
- If didn’ t move in 3 min

Automatically expands to provide buoyancy

If automatic doesn’ t work, user can do it manually

8.5 Final Design