

A survey of inventions aimed at preventing drowning: Study Report

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November 04, 2004

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ABSTRACT

Drowning is a major global injury problem and is the second leading cause of unintentional injury death after road traffic injuries. As a result, many inventions to prevent drowning and to rescue drowning victims have been made over the years. Because information about many of these inventions that exists in patent databases is not found in the injury literature, many academic injury researchers and practitioners may be unaware of them. Therefore, a US patent database search was conducted to identify inventions aimed at preventing drowning, for the purpose of disseminating this information among injury prevention researchers, practitioners, and policy makers. The survey identified inventions that could be broadly classified into: (1) pool fences, gates, and latches, (2) detection and signalling devices, (3) floatation devices, (4) water rescue devices, (5) devices for emergencies involving watercraft, (6) devices for preventing drowning in pools, spas, bathtubs, and toilet bowls, (7) devices for preventing scuba diving related drowning, and (8) other miscellaneous inventions. These inventions range from simple devices such as pool fences and rescue nets to complex electronic systems that monitor swimmers in a pool and automatically recognize a swimmer in distress and sound an alarm. There are many inventions that deserve systematic evaluation of their effectiveness in preventing drowning. Especially, relatively low cost devices, affordable for deployment in low- and middle-income countries, should receive particular attention, as these countries endure almost 97% of global drowning deaths.

Keywords: drowning, hypothermia, prevention, patent, inventions

INTRODUCTION

Drowning is the second leading cause of unintentional injury death globally after road traffic injuries¹. In 2000, an estimated 449,000 people drowned worldwide.² Drowning occurs in the ocean, beaches, lakes, ponds, rivers, irrigation canals, animal feeders, swimming pools, spas, and bathtubs. Young children, particularly infants may drown in buckets filled with rainwater and even in toilet bowls. People drown as a result of capsizing of watercraft, falling overboard, becoming fatigued or unconscious while swimming, getting entangled in objects underwater and many other causes. Many adult drowning deaths and injuries occur during recreational activities such as boating, swimming, and diving in open waters³. Most child drowning deaths in high income countries occur in swimming pools, particularly, domestic pools⁴⁻⁷.

Apart from actual drowning, many deaths in water occur due to hypothermia. Even if a victim can stay afloat with the help of a life vest, in cold water, hypothermia can cause death rapidly. This situation is particularly true for shipwreck victims, people who fall overboard from ships and structures such as oil rigs in cold regions and, for those who fall through a crust of ice in a frozen body of water. Rescue in cold water is especially difficult as the victims are often unable to grab a lifeline thrown to them because limbs tend to become numb very quickly in low temperature conditions.

Early detection, recovery, and prompt medical care are essential to avoid death or permanent brain injury of drowning victims. Over the years, numerous devices have been invented to prevent drowning-related deaths and injuries. These inventions

comprise devices that prevent a person's entry into water, detect unintended entry into water, keep a victim afloat in water, prevent hypothermia, and facilitate rescue. Although information on some of these inventions such as pool fences and life vests can be found in the injury literature, it represents only a small fraction of all the drowning prevention-related inventions in the patent database.

Although the patent databases are an important resource of knowledge, academic researchers very rarely use them, evidenced by the lack of citations of patents in the scientific literature. Thus, inventions that have significant potential to prevent drowning can be overlooked. Ignorance of existing devices may also lead to duplication of research effort and resources to reinvent similar devices. Therefore, the aim of this study was to identify and document the devices that have been invented to prevent drowning deaths and injuries, and to disseminate this information for the benefit of researchers and practitioners interested in the drowning problem.

METHOD

In this study we searched the United States patent database to identify inventions related to drowning prevention. A patent for an invention is a grant of property rights issued by the government of a country to an inventor to exclude others from making, using, or selling the invention within that country for a certain period of time. In the US, this period is 17 years from the patent grant date or 20 years from the earliest effective filing date, whichever is longer. The patent protection encourages inventors to disclose their inventions, and promotes technological development by allowing others to identify

the existing state-of-the-art and improve upon it. A typical patent provides the background of the invention, the prior-art, which is a description of previous inventions or knowledge in the area and their limitations, technical description of the invention including diagrams to show how it is different from the prior art. A patent document also shows information such as the name(s) of inventors, filed date, and patent grant date. The US patent database of over six and half million patents, can be searched at the US Patent and Trademark Office (USPTO) search room, at a number of patent and trademark depository libraries in the US, or through the USPTO website, www.uspto.gov.

All patents that have the term *drowning* in any search field and the term *water* anywhere in the patent abstract were searched. Additional patents were accessed by referring to the prior art inventions cited in the patents identified by the original search. Some further patents were searched by using additional search terms such as *pool*, *fence* and *gate*. These particular selection criteria may not be the optimal way to select all relevant patents, but were found to capture inventions related to a large number of drowning situations. This patent search is also limited by the fact that it did not cover other “national” patent databases such as the European Union patent database. However, as the US patent database is the largest, this search can be assumed to give a very good indication of the different types of drowning related inventions available.

RESULTS

Over 300 devices were identified in this study ranging from simple mechanical devices such as pool fences and latches to complex and sophisticated electronic systems that monitor pools, automatically recognize drowning incidents, and summon lifeguards. This article does not attempt to describe individual inventions in detail. Rather, we describe groups of similar inventions and their intended applications and characteristics. Patent numbers are cited parenthetically so that further details can be found by referring to the original patent records. Although devices such as mobile phones and global positioning system receivers, which can aid rapid emergency response, are examples of the post-injury event phase, these devices are not included in this survey as they are not specific to the drowning problem.

We classify drowning-related inventions identified in the patent search into the following categories:

1. pool fences, gates, and latches
2. detection and signalling devices
3. flotation devices
4. water rescue devices
5. devices for emergencies involving boats, kayaks, etc.
6. devices for preventing pool, spa, bathtub, and toilet bowl drowning
7. devices for preventing drowning in scuba diving
8. other miscellaneous inventions.

The above classification is by no means a definitive way to classify drowning-related inventions and some inventions may belong to multiple categories. For example a flotation vest equipped with an immersion sensor and an alarm belongs to both the second and third categories. In such cases we included the relevant invention in the category that seemed to fit the primary function of the device. Determination of compliance with national and international Standards was beyond the scope of this study.

1. Pool fences, gates, and latches

Building regulations in some countries now require domestic swimming pool fencing to prevent child drowning. Various types of pool fences (3994479, 4303226, 4143857, 5664769, 5630572, 5102103), gate latches and gate closers (5794990, 5732508, 4083591) have been patented to address this need.

2. Detection and signalling devices

A wide range of detection and signalling devices for preventing drowning were found during the patent search. These devices differ in aspects such as when and how the detection is done, types of sensors used, and in what situations the devices are applicable.

Passive interventions

Some inventions in this category intervene in the pre-drowning phase by generating an alarm before a person enters a body of water such as a swimming pool. These devices include pool door or gate alarms and pool perimeter intrusion detection systems (Table 1). Additional passive interventions sound an alarm once a person is immersed in the water (Table 2).

<TABLE 1 HERE>

<TABLE 2 HERE>

Active interventions

The aforementioned inventions are passive, where the person to be protected, usually a child, does not have to perform a specific safety action in order to receive protection. The patent search also identified a number of active interventions. Many of these devices are either worn similarly to a wristwatch or attached to an item of clothing. Some devices provide an immediate warning if the wearer submerges in water and, hence, are suitable for persons who cannot swim or fall overboard from boats. These inventions use a wide variety of approaches to generate alarms during immersion of the victim (Table 3).

<TABLE 3 HERE>

Devices that provide direction and/or range of victim

Although simply providing an alarm warning when a person is immersed in water may be sufficient for a domestic swimming pool where it is easy for a rescuer to locate the victim, it is not completely satisfactory for open waters. Therefore, some inventions also provide limited direction and/or range information (5619187, 5274359, and 6486777) about a victim immersed in water (Fig. 1). The device described in 6486777 is particularly suitable for protecting groups of children as in a summer camp because a single base unit can monitor multiple remote immersion sensor units worn by the group.

<FIGURE 1 ABOUT HERE>

Devices to detect distressed swimmers

While immersion activated sensors are useful for preventing child drowning and adults who unintentionally enter the water, they are not suitable for protecting normally competent swimmers who intentionally enter a pool for swimming but may experience difficulty on a rare occasion. A number of inventions were identified that describe different methods employed to determine whether a swimmer is distressed. Patent 3786406 describes a device with a switch, which the user needs to carry and periodically close, to keep an alarm deactivated. The alarm is activated if the time between switch closings exceeds a predetermined limit. Automatic timing devices that trigger an alarm if the wearer is submerged in water beyond a preset duration (5408222,

5091714, 5097254), detection of the sound of a swimmer's breathing and heartbeat to identify when the person is in distress (6111510), and detecting a motionless body in a pool by comparing successive images of the lower portion of the pool (5043705) are some other methods employed.

While many of the inventions that detect drowning use audible alarms in a remote receiver to warn people of a potential drowning, some devices provide visual clues to assist rescuers to locate victims. A device that detects whether a user stays immersed beyond a predetermined time and then releases a life saving apparatus and a dye to help rapid location by rescue crews (6246329) and a low-cost device that releases a dye and a nylon thread attached to a buoyant spool (4527504) are two examples.

Intelligent pool monitoring systems

One intelligent swimming pool monitoring system uses pressure sensors and artificial neural network processing to determine whether a swimmer is distressed (6154140). Some advanced systems can track individual swimmers in a pool and provide alarms when someone is drowning (5907281, 6327220, 4932009, and 6133838). The system described in patent 6133838, which is commercially available under the name Poseidon, uses video monitoring and advanced image processing technology to automatically recognize a swimmer in distress and alerts lifeguards and pinpoints the victim's location on a monitor.⁸

3. Flotation devices

Personal flotation devices (PFDs) and survival suits are interventions that assist a victim during the potential drowning event. PFDs are designed to keep a person afloat in the water. Survival-suits attempt to protect a victim from exposure to cold water and wind, and prevent hypothermia. A number of inventions were identified that combined the functions of a PFD and a survival suit. Numerous patents have been issued for inventions that improve convenience of use, visibility, hypothermia prevention, etc. of PFDs and survival suits.

Personal flotation devices

The well-known Type II PFDs recommended for recreational boating activities are comprised of foam blocks incorporated into a vest (4038713, 4380441). A wide variety of other PFDs is described in the patent database. For example, annular flotation rings that fit around the neck of a person (3750205, 3048860), a strapless life preserver (3742538), non-inflatable buoyant annular rings that fit on ankles and wrists (4936804), and a multiple component life ring buoyant collar (634445) are some examples. Another interesting invention describes a flotation fabric made of foam beads embedded in cloth, which makes the wearer float if they fall into water (660572).

In the US, eighty percent of over 700 people who drowned in boating incidents in 2000 did not wear PFDs at the time. The detrimental effects of PFDs on comfort, convenience, and appearance are some reasons why people choose not to wear them.

Therefore, some inventors have attempted to address these issues. For example, a PFD with an elastic armhole periphery that makes it easier to perform activities such as boating and kayaking while wearing the device (5823839), and a fashionable flotation device that can be used as, or with, clothing items (6231411) have been developed.

Making PFDs inflatable is one approach taken to reduce discomfort. It allows the device to be small and convenient to wear during regular boating activity but become inflated and large to provide sufficient lift in an immersion emergency. Inflatable flotation devices with many different operational characteristics have been patented (Table 4).

<TABLE 4 HERE>

Survival suits

Even if a PFD can keep a person afloat, the victim may die within minutes due to hypothermia in cold or icy water. Hypothermia is a major concern for victims who fall overboard from ships or oil rigs operating in cold regions and for people who fall through a crust of ice into a freezing body of water. Because contact with cold water can take away body heat very rapidly, it is essential to isolate the body from the water to prevent hypothermia. A number of anti-exposure survival suits (5067921, 4734072, 6551160, 4015300, 4137586, 4242769, 4394124, and 4017926), a survival suit for pilots and oil rig workers, which provides flotation, fire resistance, and heat insulation (4547904), a life preserver comprising an inflatable collar and pockets for holding arm and leg portions

that can be pulled out to form a heat trapping survival suit (4722710) have been invented. Patent 4187570 describes a personal evacuation and survival system for individual crewmen evacuating a ship in distress.

Some further inventions related to survival suits include a survival hood to be used with buoyancy garments to prevent drowning due to imbibing splashing waves and spray (4671775), survival garments that can generate heat with the help of a solar panel (6005222 and 6439942), and another equipped with compressed gas for flotation, solar panel, heating element, battery, etc. (5603648).

Inconvenience during regular activity discourages marine workers such as fishermen from wearing survival suits. Patent 4533335, a cold-proof, waterproof garment for marine workers, which is designed to be loose and comfortable during normal use, but becomes snug and insulating after inflating the air chambers to provide flotation, addresses this problem.

Increased visibility is important for rapid location and rescue of a drowning survivor. Inventions that attempt to improve survivor visibility include a life vest with a compactly attached flag, which can be retrieved and waved to get increased attention from rescue personnel (6033275), PFDs with flags to improve visibility of a downed water skier to speed-up recovery and reduce the likelihood of boats hitting and injuring the victim (4035856 and 5800227), an inflatable PFD with a long spotting streamer, which significantly increases visibility of the wearer for sea or air rescue (4725252), an

inflatable tube that forms into a highly visible polyhedron (3877096), life jackets with dye markers (2418397, 2418392), a life jacket comprising signalling devices (4551106), and a flotation device with a self-erecting antenna for emergency signalling (3095568).

A major drawback of common PFDs is that they require some effort from the user to stay in a face-up position, especially in rough water, which may be difficult for a fatigued or child victim. A flotation vest where the front left panel is larger than the front right panel to generate a rotating force to turn a victim from a face-down position to a face-up position (4131974) (Fig. 2), and an improved flotation vest that turns a child wearer into a face-up position (5030153) specifically address this drawback.

<FIGURE 2 ABOUT HERE>

Other flotation devices

Further flotation devices aim at preventing drowning in emergencies such as a boat capsize, and include inflatable life rafts (3037218, 2888690), a life raft with a roof structure that can protect occupants from exposure to cold winds (3037218), and a life raft containing a rigid main section and a number of attached inflatable stabilising arms (2888690).

Other flotation devices comprise buoyant child safety seats for use in boats that provide flotation if a boat capsizes (5514020, 4725253, 6059360, 6482060, and 6036563), a playpen for infants that can either stand on the pool bottom or float on water while

restraining an infant (4008497) (Fig. 3), a floating child restraint (5993276), and recreational buoyant devices that claim to allow infants to float safely in water (1764852, 2562080, 2946068, 3074084, 3161897).

<FIGURE 3 ABOUT HERE>

4. Water rescue devices

Self-rescue

Assisting a victim to perform a self rescue when outside help is not forthcoming has been the object of some inventions, such as a ladder that is compactly stored on the sidewall of a marina jetty, and easily deployed to enable a victim who falls into water near the jetty to climb to safety (6386318), a floating standing platform that would enable a drowning victim to climb and perform self-rescue (4019214), and a device that can be carried by people travelling over ice surfaces to enable self-rescue if they fall through ice (5310229).

Some inventions target self-rescue of victims who have fallen overboard from boats. Such patents include a boat lifeline and stirrup extending downward over the side (2651789), a boat stirrup connected by straps (2975858), chain wrapped around the boat occupant's waist to assist self-recovery (3018494), and a coiled rope with a number of loops as hand-holds to climb onto the hull of an overturned boat (3216030).

Rescue craft

Some inventions address difficulties faced by rescue craft for drowning victims in fast flowing or frozen bodies of water by providing improved stability, compact storage, and the ability to transport and deploy quickly. Such inventions include a rigid collapsible raft that can be compactly stored and easily deployed (3950804), an inflatable rescue craft with special openings and a raised fore and aft for conveniently rescuing victims in ice, mud, or water (5888111), a stable, compactly storable device comprised of a pair of elongated buoyant bodies that can be used to rescue victims who have fallen through an ice surface, or those at risk of drowning in water (5320567) (Fig. 4), and a remotely manoeuvrable rescue boat for rescuing drowning victims in fast flowing water (6604480). This latter device also provides a remotely activated life preserver to expedite the rescue.

<FIGURE 4 ABOUT HERE>

Lifelines, life rings, and the like

Throwing a lifeline to a drowning victim and pulling the victim out of the water is a common method of rescue. However, accurately throwing a lifeline to a victim at a distance is difficult. Some inventions have attempted to improve this distance and accuracy. These inventions include rescue devices enclosed in compact shells to enable easier throwing towards a drowning victim, and which inflate upon contacting water to enable the victim to stay afloat (3693202, 3812546, and 4498880), a rescue device launched using a grenade launcher that inflates upon impacting water (2496479),

and gun firing devices to launch a flotation device to a victim in icy water (3486178, 3496580, 4644930, 4799906, 5546863, 5584736, 4661077). Another device, with a safety line wound around it, splits into two floating subassemblies linked with a harness, after the line is completely unwound, so that the victim can grasp the harness (6019651). Further examples of this kind include buoyant devices that can be thrown to a victim (6475047, 6413134), rescue rings in the form of floating annular structures with grab ropes (4059859 and 3050754), flying rescue disks (5562512, 5895299, 6413134), and inflatable tubes that can be directed towards drowning victims (5813891 and 4058862).

A drowning victim may not always be able to hold on to a life ring, especially when unconscious, fatigued, numb due to cold water, or when the water is choppy. Therefore, several inventions attempt to improve life rings such that they are either easier to grab, or automatically restrain the victim (4661077, 6575799 and 4976642). One rescue device with a long line, which is fired to a victim using a spring-loaded gun, has a loop to insert the victim's hand (6398606) and the rescuer pulling on the lifeline tightens the loop.

Patent 6042440 describes a slack eliminator for the rescue tube rope that can prevent entanglement of the lifeline on nearby objects, which can injure the rescuer as well as delay rescue. A hydrodynamically shaped rescue pontoon that can be easily manoeuvred in rapidly flowing water (5687664) has been invented for situations where regular rescue tubes are difficult to use.

Rescue nets

Because of the difficulty of rescuing victims with lifelines in rapid or turbulent water, a number of inventors have developed rescue net systems. These inventions comprise rescue nets that can be held in a substantially vertical position in rapidly moving water using weights for a victim to hold or get entangled (5370565 and 5320566), a net to be deployed from a ship or a pier to wrap around and pull a victim out of the water (4652246), a buoyant net that can be thrown to a person in water (5158489), a rescue basket that can safely lift an injured drowning victim onto a ship (2557079), and a rescue net and a crane mounted on a ship (4678446). Further inventions along the same line include a flotation sling and a flotation tether to entrap a person who falls overboard a boat and haul the person out of the water and into the boat (4599073), and a crane device mounted on the mast of a sailboat to angularly extend to and lift a victim onto the boat (5435766).

Patent 4690650 describes a sea rescue kit that can be deployed by helicopter when the helicopter cannot safely attempt a direct recovery because of adverse weather conditions. This kit deploys two life rafts and a line arranged in a horseshoe shape around the drowning victims.

Safety beacon and lights

A number of patents have been issued for devices that are intended to make it easier to find and recover drowning victims in the dark. These include an underwater illumination device that floats on the surface and directs light downwards (4429350), a fluorescent light with water impervious case (4268894), and high visibility beacons for underwater searches (3016549, 4464129, 4099282, and 5109322)

Inhalation rewarming

An invention that intervenes in the post-drowning phase is an apparatus for inhalation rewarming of hypothermia victims in-situ before moving to hospital (4319566).

5. Devices for emergencies involving boats, kayaks, etc.

Many adult drowning deaths occur during water recreational activities such as boating, sailing, kayaking, and canoeing. Therefore, not surprisingly, a large number of inventions target preventing drowning associated with these activities.

Some inventions for preventing boating-related drowning include a waterproof cloth with attachment rings that can be used to cover the damaged hull of a boat to enable it to return to safety without capsizing (4026233), a facemask that would automatically start supplying air from a pressurized source to enable a trapped driver of a capsized

competitive speedboat to survive underwater until rescued (4823786), and a boat lifeline strap apparatus with loops to keep people afloat outside but attached to a capsized boat (4986785). A device with an elongated watertight tubular body to which life preservers and towlines are attached for towing life preservers in situations where all passengers on a sinking ship cannot be accommodated in available lifeboats is described in patent 1029729.

A kayak can overturn in rapid water putting the user in an inverted position with the head immersed in water. Because of the manner legs are placed inside a kayak, the kayaker may be entrapped, especially if the kayak gets stuck in a rock or other debris such as a fallen tree trunk, making it difficult to right the kayak. Inventions aimed at preventing drowning of kayakers include breathing apparatus that enables a kayaker trapped in an overturned kayak to survive underwater until freeing him/herself or being rescued (5671694, 6581591), an inflatable flotation device that can be used to right an overturned kayak (5279248), a sectional deck that comes off automatically to prevent entrapment of the user if the kayak capsizes (1792140), and a safety deck for kayaks that is normally rigid but can be released by an operator in an emergency for quick escape (4699076). An air supply life vest comprising flotation material, miniature scuba tanks, mouthpiece, and regulator to be used in emergency situations in rafting, canoeing, and kayaking is disclosed in patent 5887585.

Victims falling overboard

Someone falling overboard from a boat or ship in open waters is life threatening for the victim and can be devastating for those onboard. Factors such as rough weather and poor visibility make recovery difficult. Cold or icy water may reduce chances of survival. Many inventions aim to reduce drowning of people falling overboard. Different inventions in this class address one or more aspects such as detecting and warning that someone has fallen overboard (4714914, 5006831, 4630205, 4813025, 4305143, 4549169), locating a victim (3886612, 4305143), and retrieval of victim (4599074, 4747797, 4343056). Even if the crew becomes aware of someone falling overboard, a large boat cannot be stopped quickly and, therefore, it is easy to lose track of a victim in water. A floatable pole with satellite-based location, thrown near the victim, can keep track of the victim until the boat can turn around and return to rescue them (5408238).

6. Swimming pool, spa, bathtub, and toilet safety

Pool mats and nets

Several patents describe nets or mats that normally stay in a submerged position at the bottom of a swimming pool and are raised in the event a person is distressed in the water, bringing the victim to the surface (Fig. 5). These devices use different methods for activation and to raise the rescue structures (Table 5).

<FIGURE 5 ABOUT HERE>

<TABLE 5 HERE>

Pool covers

Domestic in-ground pools in some countries can only be used during summer months and need to be closed out of season. Covers such as plastic sheets are dangerous because they cannot support a person's weight. Inventions that attempt to overcome this problem include pool covers that can support a person falling onto them (3128478, 4109325, 4715070, 3413661, and 3600721), a rising inflatable pool cover (3889303, 3813704), an edge retainer for a floating pool cover that would prevent a child who falls or steps on the cover from falling into the water (5068929), and a pool cover made of strong lightweight panels (5740562). A more elaborate example is a pool cover platform that can be moved vertically using a pump and can also be used to vary the pool depth to suit the user's height (3760432). Another submersible pool cover claims to provide a safety floor that prevents a person diving into the pool from hitting the bottom and being injured (3000017).

Pool and spa drain safety

Pool and spa drains have been the cause of many drowning deaths and injuries. Strong suction due to water recirculation pumps can cause hair, body parts, or loose clothing to get sucked into the drain outlet. In pools or spas where the outlet drain has only a single opening, if a body part covers the outlet, it can create a vacuum in the pipeline between

the outlet and the water pump, which is sometimes strong enough to prevent the victim from freeing him or herself, causing drowning. Inventions aimed at preventing this form of drowning include hair control devices (5978981, 5799339), easily breakable fasteners to hold drain grates (6464442), apertures with multiple openings to prevent complete blockage of the drain (6453482, 6442774, 5734999, 3940807, 4658449), mechanisms to automatically break the vacuum created at the drain when suction pressure becomes excessive (6341387, 5991939), devices to automatically turn the pump off if the recirculating line is blocked (5167041), and methods to disable the pump's ability to maintain a high suction (4115878, 5347664, 5499406).

Bathtubs and showers

Interventions to reduce drowning risks for infants, young children, and invalids include an assembly that enables an invalid to use a bathtub without risk of drowning (4142259), a contoured head and neck support for comfort and preventing drowning in a bathtub (5848445), a flow-through shower bed that avoids accumulation of water for handicapped individuals (5898959), a standing bathtub for babies (6158065), and a baby bathtub with drain holes (5966752).

Infant drowning in toilet bowls

The study identified two inventions aimed at preventing the drowning of infants in toilet bowls; a spring attached to the water tank of a toilet to ensure that the cover is always in a closed position when not in use (4477933), and a wire insert placed inside the toilet

bowl to prevent an infant's head from reaching the water while still allowing the toilet to be used normally (4551871).

7. Devices for preventing drowning in scuba diving

Some inventions are specifically aimed at preventing drowning of scuba divers. Some are early warning devices such as an electronic diving system that can monitor air tank pressure, water temperature, and depth, and display them on the mask (5033818), and devices to measure the total time of the diver in water (4307449) and maximum diving depth (4336591).

Inventions that aim to assist a diver in emergency situations include an apparatus that can automatically inflate and release a tube containing audio and visual alarms (5520486), a survival suit that can turn an incapacitated diver around to a face-up floating position (6530725, 6558082), a device comprising an inflatable bladder and a hand-held trigger, which inflates the bladder and brings the diver to the surface if the trigger grip is released by an unconscious diver (5800228). Patent 3798629 describes an alarm system that automatically releases a sparkler and a dye ampule if the diver's breathing cycle is compromised.

Quick release devices for diving ballast that enable a diver to surface quickly (6530725, 6527479, 4455718, and 3670509), diving equipment that uses a surface supply of air to reduce emergency situations (3967459, 4752263 and 2120420), vest style buoyancy compensator and rescue raft to be worn by divers (5516233), air system for scuba diving (4227521), backpack with inflatable vest and compressed air (4779554), flexible

bladder (3820340), weight ballast assembly to ensure a head-up surface position (5855454), and a buoyant flagstaff to be released by an ascending diver to warn boats (3105459) are further inventions for preventing diving-related drowning.

8. Other miscellaneous inventions

Swim masks that reduce the likelihood of drowning by allowing a user to breath while keeping the head in an immersed position using an air hose attached to a floating air suction device have been developed (6435178, 5535734).

Parachutists, such as fighter pilots ejected from an aircraft, sometimes land in water, and face the danger of drowning as a result of being dragged underwater by the canopy unless the parachute harness is released quickly. Several inventions describe automatic and manual release means for quickly releasing a parachute canopy (3632066, 3774870, 4023846, 4307858). A similar quick release mechanism has been developed for aquamarine-tethering devices used in water sports such as water skiing to allow a person to release the tether quickly in an emergency (5243710).

Patent 6230838 describes a device that automatically unlocks power doors and rolls down power windows in a motor vehicle after a collision, roll over, or immersion in water to enable the occupants to escape or be rescued quickly.

An inflatable child pool with a safety seat in the middle to which the child can be strapped so that the child would be in a safe seated position is the subject of patent 6595861.

Persons wearing waders and wading in rivers and other bodies of water may drown if their waders get filled with water and they are unable to remove the waders quickly. Patent 6357050 tackles this danger by adding a low friction liner to make wearing and removing waders easy.

DISCUSSION

This paper summarises the findings of a survey of inventions aimed at preventing drowning. The aim of the study was to bring information about relevant inventions to the attention of injury researchers and practitioners. This may encourage identification and scientific evaluation of promising devices for injury prevention. Dissemination of this information would also avoid duplication of research and development efforts to *reinvent* similar devices.

The present study identified a large number of inventions in the US patent database, aimed at preventing drowning. Many of these devices are not available in the marketplace as commercial products. Many patented inventions do not become commercial successes, not for a lack of technical merit, but for other reasons such as the lack of venture capital for development, or poor marketing. This paper demonstrates the value of patent databases as a rich source of information for injury prevention

researchers, practitioners, and policy makers. Patent searches, such as this study, can uncover inventions with great potential for preventing deaths and injuries, not only due to drowning, but also other causes, although these inventions may not be commercially available.

The inventions identified in this study range from simple mechanical devices to sophisticated electronic systems. Scientific studies have assessed the effectiveness of some of these inventions, such as pool fences and some personal floatation devices. However, there are many devices that need to be similarly assessed to determine whether these are effective in preventing drowning. For example, the PFD with the asymmetric front that can turn a victim to a face-up position is a device that addresses a known problem of standard PFDs. The advanced pool monitoring system developed by Poseidon, which claims to improve pool safety is another system that deserves proper evaluation.

Simple and relatively inexpensive solutions such as rescue nets warrant, perhaps, even more attention and evaluation, as these may be useful for rescuing drowning victims in rivers and open waters in middle and low-income countries, which do not have advanced rescue services.

Some limitations of this study should be noted. This study did not produce an exhaustive list of drowning prevention-related inventions. It was limited to the US patent database. The US patent database is the largest and the most widely used patent database and

many important international inventions are also patented in the US. Therefore, the use of only the US patent data does not diminish the importance of the study findings.

The study has not attempted to evaluate the devices in terms of effectiveness or undesired effects. Furthermore, although the study describes inventions such as pool alarms, immersion alarms, and a floating playpen for infants, it is important to note that such design solutions do not replace competent adult supervision of children near water.

REFERENCES

- 1 Violence and Injury Prevention Department. *Facts about injuries: Drowning*. World Health Organization, Geneva.2003.
- 2 Peden, MM, McGee K. The epidemiology of drowning worldwide. *Injury Control and Safety Promotion* 2003;**10**(4):195-9.
- 3 Quan, L, Cummings P. Characteristics of drowning by different age groups. *Injury Prevention* 2003;**9**:163-8.
- 4 Pitt, WR, Cass DT. Preventing children drowning in Australia. We need to take a scientific approach to drowning prevention. *Medical Journal of Australia* 2001;**175**:603-4.
- 5 Lindholm, P, Steensberg J. Epidemiology of unintentional drowning and near-drowning in Denmark in 1995. *Injury Prevention* 2000;**6**:29-31.
- 6 Steensberg, J. Epidemiology of accidental drowning in Denmark 1989-1993. *Accident Analysis & Prevention* 1998;**30**(6):755-62.
- 7 Brenner, RA, Trumble AC, Smith GS, *et al*. Where children drown, United States, 1995. *Pediatrics* 2001;**108**(1):85-9.
- 8 Poseidon Technologies web site. <http://www.poseidon-tech.com/us/company.html> Retrieved on 20.08.2004

Captions for Tables and Figures

Table 1. Patents of alarm devices that detect intrusion into a protected zone such as a pool

Table 2. Patents of passive alarm devices that detect immersion of a person in the water

Table 3. Patents of active alarm devices that detect immersion of a person in the water

Table 4. Patents of inflatable floatation devices

Table 5. Patents of pool nets and mats

Figure 1. An immersion alarm that can provide direction and range information about a victim who has fallen into the water

Figure 2. Life vest with unequal left and right frontal panels to turn wearer into a face-up position

Figure 3. A floating playpen to restrain an infant in a body of water

Figure 4. A rescue craft to recover a victim who has fallen through an ice surface

Figure 5. A rescue net that can bring an unconscious victim up to the surface of a swimming pool

Table 1

Approach used for detection	Patent examples
Door or gate alarms (mainly using magnetic reed switches)	5473310, 4278968, 6014077, 5434556, 5243325
Pool perimeter intrusion detection using infrared or laser beams	3335285, 3623057, 3688298, 3711846, 3898639, 4910498, 5063288, 6259365
Detection using grids of acoustic sensor pairs	5195060
Detection using passive infrared and microwave	5631630
Intrusion detection using ultrasonic sensing	4820938

Table 2

Approach used for detection	Patent examples
Changes in water level	3953843, 3636544, 4189722
Changes in water pressure	2935582, 4121200, 4187502
Ripples in the water surface	6583724, 5910772, 4775854, 5923263, 4594582, 4510487, 4571579, 4604610, 5268673
Sound of a person falling into the water	4853691, 5041752, 3778803, 3969712
Use of radiation emitters and detectors	5874898
Detect movements in a pool	4747085
Combination of infrared perimeter detection and acoustic detection in water	5023593

Table 3

Approach used for detection	Patent examples
Water-reactive chemical	4276669
Capacitance change due to immersion in the water	6157303
Closing of an electrical path due to immersion	5619187, 4714914, 4918433
Use of acoustic transmitters and hydrophones	5049859, 5144285, 5369623
Use of ultrasonic signals	6476721, 5638048, 6476721, 3810146
Buoyancy of an object in water	1935229, 4079364, 1955053
Other methods	5486814, 5138300

Table 4

Characteristics of inflatable floatation device	Patent examples
Life vest that can be inflated by plunging a needlepoint into a gas cartridge	2173567
Pulling a manual plug to release compressed gas to inflate	3070818, 3828381, 4551106, 1208232
Inflatable hollow belts	5702279, 5954556, 5180321, 5368512, 5702279, 5382184
Self-inflatable mini collar life preserver that fits around the neck	5421760
Rain pants with an inflatable ring to keep a wearer in a face-up position	5454744
Flexible lifebelt that can be inflated to different levels according to the body size and desired level of floatation	2001384
Airbag inflation using a compressed liquid	5663932, 3935608
Automatic inflation of floatation devices	923801, 1458822, 3004269
Water-activated inflation mechanisms	650976, 5035345, 4563156, 4094028, 5311394, 5030152
Water-activated generation of lightweight foam to provide lift	3059253

Table 5

Characteristics of pool mat or net	Patent examples
Manually activated pool net	1091909
Automatic activation of net using sensors	6127930, 4747168, 2812520, 3000017, 6493885
Rescue nets raised using drum and pulley, hydraulic cylinders, or collapsible arms	3668711, 3413661, 5832547
Rescue structure raised using buoyant elements, pumped air, or ballast tanks	2970320, 4129905, 3000017, 6127930, 4129905, 3423768, 3813704
Motor-operated rescue net that can be used at the seashore or a lake as well as in a swimming pool	1796762
Sunken baffles placed on the bottom of a pool to prevent head and neck injuries in diving	3956779