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AN AUTOPSY STUDY OF EPIDEMIOLOGY OF DROWNING AT MEDICO-LEGAL CENTRE OF A TERTIARY HEALTHCARE CENTRE IN SOUTH-WESTERN MAHARASHTRA: NINE YEARS RETROSPECTIVE STUDY

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ABSTRACT

Introduction: Hundreds of thousands of people die from drowning every year globally making it the world's third leading cause of unintentional deaths. Moreover drowning is one of the ten leading causes of death amongst children and young people globally. In India there exists proximity of people with the water bodies like rivers, canals, wells or ponds. All these water bodies are easily accessible and there are hardly any preventive or safety measures around these places consequently there is always a risk of drowning if proper care is not taken.

Aims And Objectives: 1. To provide epidemiological data of deaths due to drowning in an urban medico legal centre of a tertiary healthcare Centre in South-western Maharashtra and to quantify and analyze them so that preventive measures can be undertaken to prevent deaths due to drowning.

2. To study epidemiologic profiles of populations at risk and the contributing factors and recommending public safety measures.

Materials and Methods: cross-sectional retrospective study of medico legal autopsies in which cause of death was asphyxia as a result of ante mortem drowning at a Medico legal Centre of a tertiary healthcare centre in Pune, a metropolitan city in South-western India from January 2009 to November 2017.

Results: Amongst 2251 autopsies drowning was the cause of death in 118 (5.24%) patients. There was a male preponderance with a M: F ratio of 3.62:1. Deaths due to drowning were seen most commonly in the age group of 21-30 (25.42 %) years and around unprotected canals (67.69 %). In majority of the cases drowning was found to be accidental (77.96 %). March, April, May and June were the most common months in which deaths due to drowning occurred. During autopsies aqua-bites were found in 39 (33 %) patients and identity of victims couldn't be established in 16 (14%) cases.

Conclusion: Morbidity and mortality due to drowning is common in India due to proximity of people with water bodies. Since the most common manner of death due to drowning is accidental the deaths due to drowning can be prevented by understanding its epidemiology and taking preventive measures and educating people about safety rules.

KEYWORDS : Asphyxial Deaths, Drowning, Epidemiology, Preventive strategy, safety measures.

Introduction:

In many countries, a major contributor to premature mortality and an important cause of deaths due to unintentional injury is drowning[1-3]. It is an important public health issue globally but it is often not getting as much attention as it deserves even though it is a highly preventable public health challenge. It is more commonly seen in low and middle income countries where data collection is limited hampering the planning, implementation and monitoring of prevention measures[4]. Since at the hindsight it is always felt that many of these deaths can be prevented there needs to be much more national and international attention focused on drowning and strategies to prevent it.

Drowning is amongst the leading cause of death which has been attributed to unintentional injury and accounts for almost 9% of all injury-related fatalities globally. According to the current estimates of World Health Organization (WHO) every year almost 0.37 million people die due to drowning out of which more than 90% of the victims are from low- and middle-income nations[4]. As per NCRBI data in the year 2013, drowning was the third major contributor which accounted for 7.5% of all un-natural causes of accidental deaths to be superseded only by 'Road accidents (34.3%) and Sudden deaths (7.8%).[5](Fig-1)

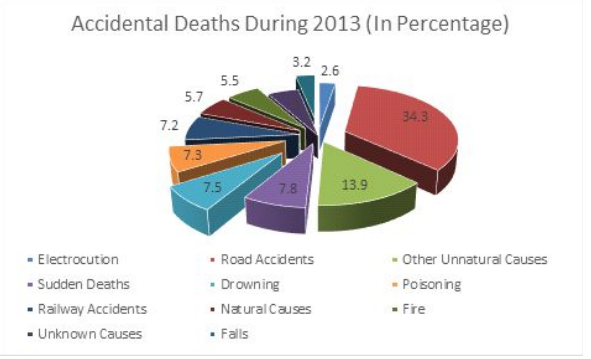


Fig 1: Accidental causes of deaths according to NCRBI.

The definition of the terms "Drowning" and "Near drowning" has undergone a drastic change since they were first defined by Model in 1981[6]. **Model** defined "drowning" as "suffocation by submersion, especially in water," and "near-drowning" as "survival, at least temporarily, after suffocation by submersion in water[7]."In the year 2002, the first World Congress on Drowning (WCOD) which was held in Amsterdam gave new definition of drowning as "the process of experiencing respiratory impairment from submersion or immersion in a liquid." and advocated abandoning the word near

drowning[8,9]. It was also decided that the terms wet, dry, active, passive, silent, and secondary drowning should no longer be used. It was a landmark event because for many decades, lack of a uniform and internationally acceptable definition of drowning has hampered the collection of data for drowning[10].An internationally accepted definition of drowning which is simple yet comprehensive would enable forensic experts in getting better epidemiological and surveillance data worldwide and thus helping in research that refines what is seen as best practice and that identifies new preventive measures and strategies, improved community infrastructure, increased public awareness and helps formulating appropriate policies and legislations.The Global report on drowning which is the first World Health Organization report dedicated exclusively to drowning has also included the new definition given by World Congress on Drowning[11,12].

In a country like India the major sources of water supply are river, canals, dams and wells. Due to easy access and lack of safety measures drowning is a common cause of unnatural deaths in any medico legal centre. Fatal drowning is an unnatural death that requires a medico-legal autopsy. At autopsy, findings are often non-specific and the diagnosis rests on a combination of circumstances and clinicopathological correlation[13, 14]. In Indian setup inquest is conducted by police which many a times take a lot of time consequently delaying the medicolegal autopsy and causing loss of critical pathological findings. Also due to easy and unsecured access to water bodies in India it becomes an easy way for disposing off bodies after homicide.

While drowning is a leading cause of death worldwide, particularly in low- and middle-income countries, prevention is possible. Evidence shows that a range of interventions are effective at preventing drowning. The aim of this study was to provide epidemiological data of deaths due to drowning in an urban medico legal centre of a tertiary healthcare Centre in South-western Maharashtra and to quantify and analyze them so that preventive measures can be undertaken to prevent deaths due to drowning. Also in the present study Epidemiologic profiles of population at risk and the contributing factors are highlighted and public safety measures are recommended.

Material and Methods

The present study was a cross-sectional retrospective study of medico legal autopsies in which cause of death was asphyxia as a result of ante mortem drowning at a Medico legal Centre of a tertiary healthcare centre of a metropolitan city in South-western India from January 2009 to November 2017. All deaths caused due to drowning were identified by a review of death certificates and autopsy reports that listed drowning as a possible primary cause of death in accordance with the International Classification of Disease-10 (ICD-10).Necessary permission was taken from the Institutional ethical committee. Data was collected using a pre-designed format from Post mortem registers/records, Inquest papers and Post mortem reports maintaining confidentiality. Demographic data gathered included age, sex, date and place of death, place of residence, site of the drowning, correctness of International Classification of Disease-10 classification, autopsy results, and a description of the circumstances surrounding death and manner of death. Police Inquest was carefully studied to know the manner of death. Various sites of drowning such as well/pond, canal, river, lake, swimming pool, tank, and drain were also recorded. Data analysis was performed by using SPSS 10 software. Associations between categorical variables within the sample were tested for statistical significance using Pearson X^2 test. A Fisher exact test was used when the expected number of the subjects was less than 5. The results were studied using appropriate statistical methods. $P < 0.05$ was taken as statistically significant. Data analysis was carried out using SPSS16.0 version software. Microsoft word and excel were used for generating charts and graphs

Inclusion criteria: Cases reported to have suffered fatal drowning and deaths suggestive of drowning by detailed postmortem examination.

Exclusion Criteria:

(1) Cases with doubtful History.
(2) Cases presented as fatal drowning but actual cause of death was found to be different.

Results

This was a cross-sectional retrospective study of medico legal autopsies in which deaths caused by asphyxia as a result of ante mortem drowning at a Medico legal Centre of a tertiary healthcare centre in a metropolitan city were included from January 2009 to November 2017.The study included, total of 118 cases in which drowning Asphyxia as a result of ante mortem drowning was the primary cause of death in accordance with the International Classification of Disease-10 (ICD-10).The analysis of causes of deaths during the study period revealed that the drowning was cause of death in 118 cases out of 2251 medicolegal autopsies making drowning as the cause of death in 5.24 % cases.

Table 1: Year-wise incidence of drowning as a cause of death amongst all the medicolegal autopsies.

Year	Total No. of Deaths	Drowning Deaths	% of Drowning Death
2009	250	19	7.60
2010	276	15	5.43
2011	272	22	8.08
2012	222	8	3.60
2013	222	10	4.50
2014	178	8	4.49
2015	148	5	3.37
2016	481	23	4.78
2017	202	8	3.96

Of all drowned victims 86 (72.88 %) were males and 32 (27.11 %) were females with a M: F ratio of 3.62:1.

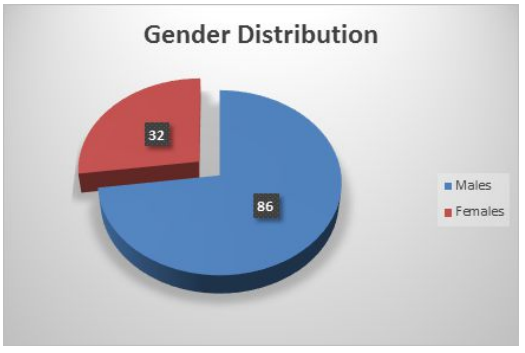


Fig 2. Distribution of Deaths due to drowning according to gender.

The analysis of M: F ratio from year 2009 to year 2017 revealed that in all the years the deaths due to drowning were more common in males than in females with the highest M: F ratio seen in 2017 which was 7:1. Mean M: F ratio in the study period between 2009 and 2017 was found to be 3.62:1

Table 2: Year wise distribution of Male to Female ratio in the victims of drowning.

Year	Male (M)	Female(F)	M:F
2009	14	5	2.8:1
2010	12	3	4:1
2011	17	5	3.4:1
2012	7	1	7:1
2013	8	2	4:1
2014	5	3	1.6:1
2015	3	2	1.5:1
2016	13	10	1.3:1
2017	7	1	7:1
Total	86	32	2.6:1

The analysis of the victims of drowning on the basis of gender as well as the age revealed that the most common age group in which death by drowning was seen was 21-30 (25.42 %) years followed by 11-20 (22.80 %) years and 31-40 (16.94 %) years. There were very few victims (3.34 %) who died due to drowning after the age of 60 years.

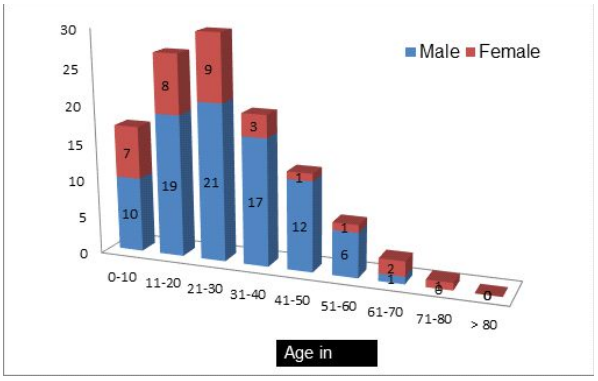


Fig 3. Graph showing the age groups of drowned victims 2009-2017.

The trends in the death rates due to drowning during the study period. (2009 to 2017) showed that a total of 118 persons suffered fatal drowning with a mean of 13 drowned victims per year, with highest of the total number of deaths in the year of 2016 (19.49 %) and lowest number in the year of 2015 (4.23 %).

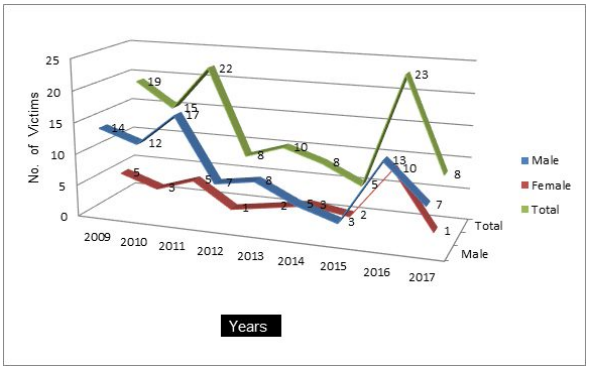


Fig 4: Year wise distribution of the deaths due to drowning.

The analysis of victims of drowning on the basis of place where they found to have drowned showed that the majority of the drowning cases 80 (67.79%) occurred in unprotected canals, followed by lakes 15 (12.71%) and wells10 (8.4%). Least cases were found in water tanks (4.23 %) and open drains (0.84 %)

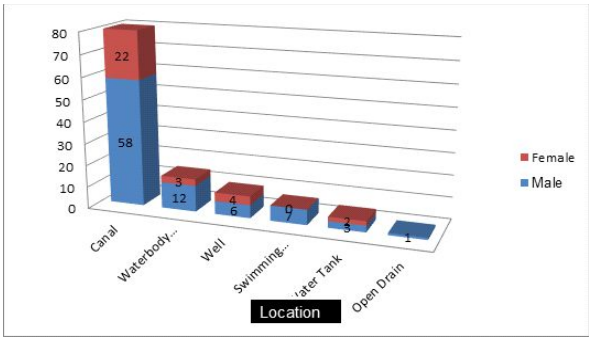


Fig 5: Distribution of the cases of drowning on the basis of the place where they died.

Figure 6 (A to E) depict the canal site where majority of the cases were reported. It has an open access and no fencing or sign boards for caution are present Image **'A'** and **'B'** indicates water flowing up to brim making easy accessibility to passerby and kids, the images also shows the absence barricades which will make easy approach to the water making drowning incidents more commoner. Image **'C'** depicts kids playing (jumping and venturing) into water without any knowledge on depth which will lead to drowning by fear in case any hurt during the play. Image **'D'** depicts the persons taking bath in a sloppy area without holding any support, slippage of any foot by small movement in case of non-swimmers will lead to drowning. Image **'E'** depicts most common activity by a women carried out along any water body, standing on a uneven edge and washing the cloths will be threat for a women fall into water by slip.



Figure 6: Typical site where majority of the cases were reported. Free and Open access, No safety measures and careless attitude of the victims contributed to incidents of fatal drowning.

Distribution of deaths according to manner of drowning during the study period showed that the accidental drowning (77.96%) was the most common manner of death, followed by suicidal drowning (5.9%) and homicidal drowning (2.5%). The caused remained undetermined in 16 cases (13.55%).

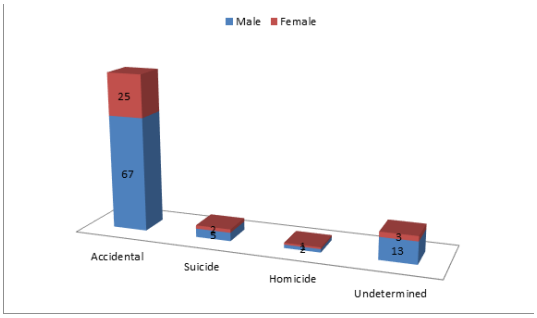


Fig 7: Manner of death in the victims of drowning.

The analysis of deaths due to drowning according to monthly distribution during the study period 2009 to 2017. Showed that March, April, May, and June were the most common months in which deaths due to drowning were happened. A total number of 56.79% of all deaths were occurred during these months.

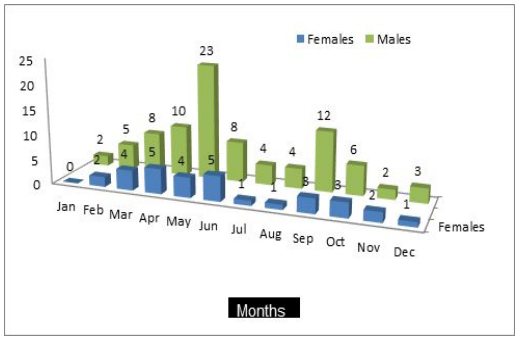


Figure 8: Monthly distribution of the cases of drowning.

During the study period the incidence of drowning according to season showed that the Maximum number of cases (46.61%) were noted between April to June and minimum number of cases were seen between October to December 17 (14.40).

Table 3: The incidence of drowning according to season.

Months (Season)	Male	Female	Percentage
Jan – Mar	15	6	17.79 %
Apr – Jun	40	15	46.61 %
Jul – Aug	20	5	21.18 %
Oct – Dec	11	6	14.40 %
Total	86	32	100%

During post-mortem aquatic bite marks were present in 39 (33%) cases and were absent in 79 (67%) cases.

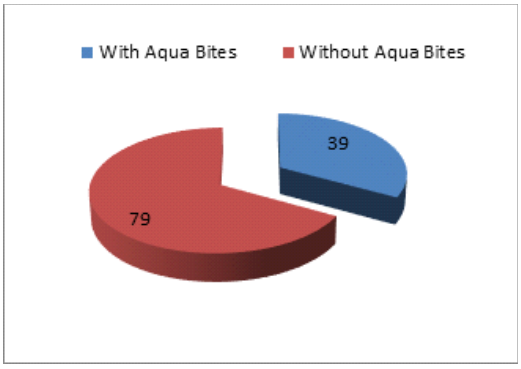


Fig 9: Presence of aqua bites during medicolegal autopsy.

Finally distribution of the victims of drowning on the basis of whether they were identified or remained unidentified showed that positive identification could be done in 102 cases (86%) and it could not be done in16 (14%) cases.

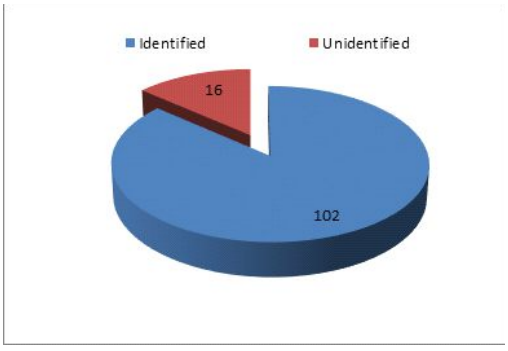


Fig 10: Distribution of cases on the basis of whether the identity was established or not.

Discussion:

The data collected in the present study clearly shows that drowning is one of the commonest modes of death. In 5.24% of medico legal autopsies conducted in the given period asphyxia due to ante mortem drowning was the primary cause of death. In deaths due to mechanical asphyxia drowning occupies the second place next only to hanging. This correlates with the findings of Ranga Rao et al[17] .The data collected in the present study revealed that in 9 years under consideration, the male drowning mortality rate was much higher than the female drowning mortality rate This may be due to increased exposure of men to water and adventurous behavior, such as swimming/fishing in water. Similar findings were noted in other studies[15-20].

The average male to female ratio ranged from as low as 1.3:1 in the year 2016 to as high as 7:1 in the year 2012. This correlates with the finding of Shetty et al[15] in which they reported a ratio of 2.3 - 8.7, similar findings were also reported by Tan[16]et al (2.7–11.3). The average of male to female ratio was 3.62:1 which is in line with similar studies done in other countries. During the period from 1974–1985 a proportion of 4.16 males for every female was reported by Wintemute et al[17]in USA. In other studies, the following results were observed: 2.31 males for every female in Denmark for the period 1987–1989 and 5.3 males for every female in Minnesota for the period 1980–1985 [17,18,19].

In this 9-year study, the age group of 21 to 30 had the largest number of drowned victims which correlates with findings of Shetty et al[15]. The next vulnerable age group was 31-40 years. This age group was reported with highest incidence of drowning in a study by Shetty Mahabaleshwhich may be due to a different population settings[20,21].

In our study, drowning of children below the age of 10 years was much lower unlike the western countries where it is generally higher, a possible explanation is that the parents in India usually do not leave their children unattended due to better family support and joint family system[22,23,24].

The drowning rates of present study were comparable to those of low and middle income countries worldwide. The males are far more at risk of death by drowning than the females. It is also seen that that the age group of 21– 30 years is at more risk of death by drowning, followed by 11-20 years and 31-40 years and the most likely locations for drowning incidents were canals followed by lake, well and swimming pools respectively. In our study, there was an interesting case of death caused due to drowning in open drain. No case of death caused due to drowning in bathtubs was seen in our study and death due to drowning in swimming pools accounted for 7 (5.9%) cases. This is in contrast to developed countries where death caused due to drowning in swimming pools and bathtubs constituted 22–44.5% and 7% of all drowning deaths respectively[25,26].Similar to findings were seen in study conducted by Shetty et al.[15]In the present study, it was seen that most of the drowning cases have been reported from canal which passes through the middle of the city and have free access to nearby population especially slum dwellers, construction workers, and children's. There is free access to these canal sites without any restriction resulting in its use for washing of clothes, utensils, bathing and swimming by the local population. It is observed that there is a gradual rise in the number of drowning victims from February to May and than a gradual decline from May to August. This can be explained as the temperature rises gradually from February to summer season for getting respite from heat many people use these canals for swimming and other recreational activities and accidently getting drowned in it since there is no provision of lifeguards in these areas. With the onset of Monsoon season the decrease in drowning rates is evident with gradual fall in the number of drowning victims from May to August. It is suggested that the open access to these canal sites should be restricted by way of fencing and supervision by local authorities should be done so that these canal sites are not utilized for bathing/swimming purpose and community bathrooms should be constructed which the local population near these canal sites can use. The increase or decrease in the incidence of drowning deaths in a year is closely related to seasons and climatic factors[27,28]. The present study confirms that the majority of deaths took place during the summer season (between March – June) these findings are in sync with findings of the west where the majority of deaths took place during the warmer months of the year[29,30].

With regard to the medico legal etiology accidental drowning cases were the most common cause of deaths 92 (77.96%) followed by suicide and homicide (5.9% and 2.5% respectively).

Accidental submersion was found to be the most common cause of deaths caused due to drowning. The present study confirms the fact that 77.96%, (92) of all submersions were accidental with the male to female proportion key being 2.68:1. Figures that ranged between 80% and 90% of the total number of deaths caused due to submersion have been reported by Wintemute et al[17], Giersten[30],

Copeland[31] and Derobert[32]. The findings of the present study defers from those specified by Shepherd[14],Hedberg et al[19], O'Carroll et al[26], and Bierens et al[33]in their studies. These variations may be due to differences in the geographic zones where the study was conducted. In the present study it was noted that 5.9% cases were of suicidal submersion, i.e. 07 cases out of total of 118 cases with 2.5:1 male female ratio. This is lower than what has been reported by Avis, i.e. 8.9%, Auer, 18.6% and Shetty et al[33,34,35]

In the present study as per the sex of the victim, following observations were present. In the case of females drowning of this nature, a proportion of 28.57 % of all suicidal submersions was present. These percentages are very similar to the obtained by Rodes et al[36]in the districts of Elda and Villena (Spain) and are significantly lower than the 41.41% and 36.36% obtained by Copeland[31]in Florida and by Avis[34] in Newfoundland, respectively. With regard to males, suicidal submersion reached a proportion of 71.42% of all submersions of this etiology. Similar observations of 80% were obtained in the districts of Elda and Villena[36],while 58.6% and 63.63% were obtained in Miami[33]and Newfoundland[34] respectively.

In this present study it is observed that homicidal submersion is not very common. Only 03 cases of homicide were found i.e. two male and one female victim. These cases represented 2.54% of all deaths caused due to submersion, which is in line with studies by Wintemute et al[17]and Copeland[31]in the countries of Sacramento and Florida reporting 1% and 2.3% respectively.

The bodies whose identity and manner of death could not be established are considered as unknown (undetermined) bodies, which constituted mere 13.55%, i.e. 16 cases of total deaths caused due to drowning in our studies in which males were 13 (81.25%) and females were 3 (18.75%), with male to female ratio being 4.33:1. However, only the location and sex was considered for statistical purpose.

Finally the measures which may reduce the incidences of fatal drowning may include strategic use of barriers to control access to water, provision of safe places such as day care centers for pre-school children, and teaching school-age children basic swimming skills and development of national water safety policies. Advances in many of these areas are feasible for low- and middle-income countries, although political will and technical support is crucial to achieve them. The multispectral nature of drowning prevention demands improved coordination across various agendas and sectors. There is an urgent need for targeting vulnerable populations in exposed communities with strategies most likely to save lives. Drowning poses a daunting challenge that can only be tackled by governments, nongovernmental organizations and international bodies. Also it is recommended that for better understanding of the epidemiology of drowning better data collection and more scientific research with specific risk factors is done

The limitations of this study include non-availability of past medical records, demographic data and profession of the victim for analysis (due to the fact that it was a retrospective study). Moreover whether victim had any history of substance abuse was also not available. Lastly identity and manner of death of some of the victims remained unconfirmed.

Conclusion:

Drowning is one of the common causes of accidental Asphyxial deaths in developing countries including India. Moreover given the fact that majority of the Indian rural population lives in proximity with unguarded and easily accessible water sources making them vulnerable for accidental drowning. The incidents of drowning can be prevented by understanding its epidemiology and taking preventive measures and educating people about safety rules.

Conflict Of Interest: None.

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