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AN AUTOPSY-BASED STUDY OF EPIDEMIOLOGICAL FACTORS AFFECTING CASES OF ANTEMORTEM DROWNING

Forensic Medicine

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ABSTRACT

The World Health Organization (WHO) labels drowning as one of the world's leading causes of accidental death. Drowning is one of the most common causes of accidental death in India. About 83 people died every day in India, on average, because of drowning, according to Accidental Deaths & Suicides in India (ADSI) for 2018. Thus, drowning may be considered as an unseen public health hazard2,. Unfortunately, it is one of the neglected health problems3. In this study, an effort has been made to analyse the epidemiological profile of victims of fatal drowning which can be wielded as a helpful tool to better formulate strategies and programs to better mitigate the problem on a local level, with the scope of scaling and adapting the same to a wider population.

KEYWORDS

Drowning, Epidemiological Factors, Autopsy.

INTRODUCTION:

Drowning is defined as death due to submersion in a liquid medium[1]. It is a form of death where atmospheric air is prevented from entering the lungs due to submersion of the body in water, or any other fluid medium. It is not necessary that there should be complete submersion.

Asphyxia is a condition caused by interference with respiration at a systemic or cellular level, i.e. deprivation of oxygen and failure to eliminate carbon dioxide from organs or tissues leading to unconsciousness or death. Asphyxia represents a mode of dying, rather than a cause of death. Drowning is one of the leading causes of accidental deaths worldwide based on WHO data [2,3].

9.3% of the total number of accidental deaths in 2021[4], with almost 100 people dying every day in India. Assam is a land blessed by nature with hills, mountains, rivers, lakes and waterfalls dotting the landscape.

This blessing, however, can turn into a curse during the monsoons, when heavy rains cause floods and widespread devastation.

Drowning as the cause of death is determined on the basis of external signs, internal signs, biochemical tests for drowning and analysis of diatomaceous material (Diatom test) by the autopsy surgeon. External signs of drowning can vary depending on several factors, and it is important to remember that none of them are considered pathognomonic for drowning.

Internal signs of drowning include lung changes such as Paltauf's Haemorrhages, bulky and voluminous lungs often filled with copious amount of characteristic froth, increased lung weight[5,6] and haemorrhages in temporal bone or mastoid air cells and presence of fluid medium and water-dwelling flora or small fauna in the alimentary tract.

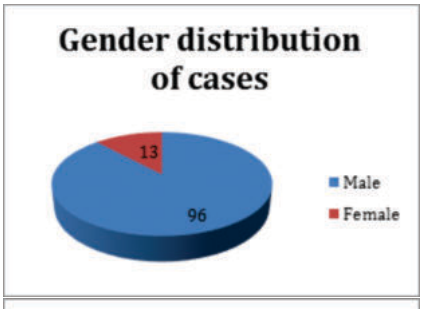
Biochemical tests include analysis of various electrolytes, esp. Chloride[7], Potassium[8] and Strontium[9,10], and Diatom[11,12,13] isolation and analysis. Changes in lung histology include acute dilatation of the alveoli, extension, elongation and thinning of septa and alveolar capillary compression.

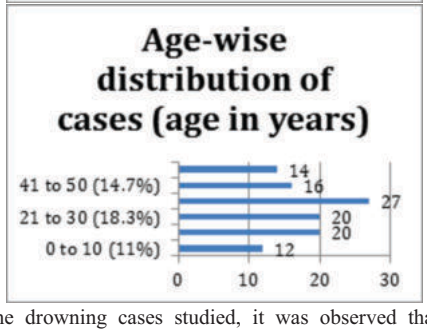
MATERIALS AND METHODS:

The present study of 109 cases of death caused by drowning, brought for post mortem examination by Police of Kamrup (M) and neighbouring districts has been carried out in the Department of Forensic Medicine, GMCH, Guwahati, Assam. During the period of July 1st, 2021 to June 30th, 2022, the data was collected from police, relatives and autopsy findings. All the data was analysed and findings were recorded. The post mortem examinations were done as per the standard procedure.

RESULTS AND OBSERVATIONS:

During the study period (1st of July, 2021 to 30th of June, 2022), a total of 3,373 medico-legal autopsies were performed at the Mortuary of the Department of Forensic Medicine, Gauhati Medical College & Hospital, Guwahati. Of these, 154 were deaths caused by drowning. However, owing to delay in locating and retrieving the bodies, 42 bodies were in decomposed state, as a result of which, they had to be excluded from the study. In addition, 3 guardians of the deceased refused participation in the study, and their wishes were respected. Of the 109 cases that were eligible for inclusion in the study, consent was taken from the accompanying guardian or next-of-kin and the observations have been recorded.





Among the drowning cases studied, it was observed that males constituted the majority of cases with 96 individuals (88.07%) and females represented only 13 (11.93%) of the total cases. The male to female ratio was 7.4:1.

It is observed that the age group of 31 to 40 is the most affected, having 27 cases each, which is 24.8% of the total number of cases. Following this are the age groups of 11 to 20 and 21 to 30, each having 20 cases, which is 18.3% of the total. 41 to 50 year-old population is fourth largest contributor with 16 cases making for 14.7% of the total and those over 50 years had 14 cases for 12.9% of the total. Children under 10 accounted for 12 cases at 11% of total.

We have found that Hinduism was the largest religion of 65.1% among the victims followed by Islam (25.7%). Christianity was the next largest religion with 7.3% adherents while other groups represented under 2% of cases, combined.

During the study, it was found that about two-thirds (66.05%; or 71 cases) of the incidents involved bodies of flowing water, which included rivers, streams, tributaries and man-made irrigation canals. Bodies of stagnant water like ponds and lakes, but which also included temporary, non-moving pools of water created by floods and pisciculture tanks and pools accounted for half the number as that of running water at 36 cases (33.03%). Man-made pools and tanks, including only those which were not used for rearing fish and an orphan category of "Others", which specifically involved a rural dug-well latrine each contributed one case (0.92%).

It was found that practitioners of agriculture/pisciculture including seasonal farm labourers and fishermen had highest incidence of drowning, with 44 cases (40.36%). Second largest group was of students with 33 cases (30.27%) followed by unemployed individuals (17 cases, 15.60% of total). Those employed in business/self-employed had second-lowest incidence rate of 9.17% with 10 such cases and those employed in service were least affected with only 5 cases (4.59%).

Very few cases occurred in people with education beyond 12 years of education, with graduates constituting 7 cases (6.42%) and those with a post-graduate degree or diploma, 4 cases (3.67%). While 27 (24.77%) victims were illiterate, including victims too young to begin schooling, majority of cases had less than years of education (55 cases or 50.45%). 16 of the victims (14.68%) possessed or were in the process of attaining an intermediate or Higher Secondary level of education.

We found that most cases of drowning (58 cases or 53.21% of total) occurred at home or in its near vicinity (1km in urban areas, 5km in semi-urban areas and 10km in rural areas), while 39.45% of cases (43 victims) died either at their workplace or while travelling to or from it. In 8 cases (7.34%), no clear significance of the relation between victim and aforementioned contexts was present. This included recreational activities like picnics, etc. It was found that urban areas accounted for only 11.92% of victims (13 cases) while semi-urban areas had 22 victims (20.18%). The vast majority of cases occurred in rural areas, with 74 such cases reported (67.89%).

During the study, we encountered 83 cases of drowning where the event was deemed to have been accidental (76.14%). Suicides accounted for 15.60% of cases (17 cases) while in 9 cases (8.26%), there was inadequate evidence to support ruling them as either suicides or accidents. No cases of homicide were reported during the study period.

24 of the cases (22.01%) were found to have external injuries on the bodies of the victims.

In the course of the study, it was discovered that 12.84% of the victims (14 cases) had a history of mental health problems. For this study, only cases with documented history of visit to a mental health professional/institution and receiving treatment for the same were accepted as being such a case. 4 victims (3.67%) were reported to suffer seizure disorder and were receiving or had received in the past, treatment for the same. Hypertension and diabetes mellitus affected 10 individuals each (9.17%) and were also noted to simultaneously exist in several victims.

The months of May and June, 2022 showed highest incidence of cases, contributing 23.85% (26 cases) and 25.69% (28 cases), respectively. In addition, January and September contributed the joint third highest number of cases, 10 each (9.17%). At the other extreme, November had only 2 cases of drowning (1.83%).

Upon investigating the time of occurrence of each incident, it was noted that most cases occurred during daylight hours, with 40 (36.70%) cases occurring between noon and dusk (6 PM), 36 cases (33.02%) occurring between dawn (6 AM) and noon, 15.60% cases (17 victims) drowned between dusk (6 PM) and midnight and 16 cases (14.68%) occurred between midnight and dawn (6 AM).

93 of the cases (85.32%) were reported to have occurred in freshwater, with only 14 cases (12.84%) occurring in shallow bodies of water. 2 of the cases (1.83%) involved secondary drowning, where the victim was rescued prior to succumbing to death and survived for a period of 24 hours or more, beyond initial drowning event.

Based on the Modified Kuppuswamy scale (2019 revision), 89.91% of the victims were determined to belong to lower class, with 6.42% being from upper lower class and 2.75% from upper middle class. Only 0.91% of the victims were from middle class while there were none from the upper class.

DISCUSSION:

Drowning is one of the leading causes of accidental death worldwide, and disproportionately affects middle- and low-income countries. The present study is a retrospective cross-sectional study carried out under the aegis of the Department of Forensic Medicine, Gauhati Medical College & Hospital, Guwahati, during the period of 1st of July, 2021 to 30th of June, 2022. During this period, 3373 medicolegal autopsies were conducted at the mortuary, out of which 154 cases were determined to have been caused by drowning. However, owing to advancing decomposition in 42 cases as a result of delay in location and retrieval of these bodies and with 3 guardians refusing consent to participate in the study, 109 cases were included in the study proper. This constituted 3.23% of all autopsies during the period of the study.

Out of a total of 3373 autopsies, 109 cases of antemortem drowning fulfilled all inclusion criteria and avoided the exclusion criteria to merit representation in the study. Together, they constituted 3.23% of autopsies. The findings of this study are similar to the study performed by Chaurasia N., Pandey S.K. and Mishra A. (2012)[14], where drowning accounted for 3.13% of medicolegal autopsies.

These findings are also in line with those of Teron, A. (2019)[15] who encountered drowning to be the cause of death in 3.77% of 3367 autopsies conducted at the same institution. However, Rao, G.S.R.K.G., R. Surendar, J. and Prasad, G.K.V.[16] recorded drowning as the cause of death in 7.05% of autopsies.

The variance may be explained by the difference in geography, topography demographics and socioeconomic background of the average member of the population being considered in each study. Males accounted for 96 cases out of the 109 studied, while females only constituted 13 cases.

These findings were similar to those of Wintemute, G.J. et al (1988)[17], Majumdar, B.C. (2002)[18], Tan, R.M. (2004)[19], Gorea, R. et al (2005)[20], Seleye-Fubara, D., Nicholas, E.E., Esse, I. (2012)[21], Donson, H. et al (2013)[22] and Teron, A. (2019).

All the studies mentioned found males to be more common than females among drowning victims. Conversely, Singh, B. (1982)[23] and Auer, A. (1990)[24] reported a near-equality of gender distribution.

Apparent overarching male susceptibility can be explained by the sex ratio in the state, compounded with the fact that males are more likely to be employed in agriculture or fishing, which contributed highest number of cases based on occupation of the victims.

14 cases were encountered belonging to the age group of less than 10 years. 14 victims were aged over 50, while 16 were between 41 and 50. The single largest grouping was in the 31 to 40 group with 27 cases while 11 to 20 and 21 to 30 each had 20 cases.

Wintemute, G.J. et al (1988), Tan, R.M. (2004) found the age group of 20 to 29 to be the most affected. 15 to 20 year-olds were most common victims in study done by Majumdar, B.C. (2002).

Singh A. et al (2003), Chakrabarty, P., Singh, P.K., Chatterjee, A. and Das, S. (2015)[25] and Teron, A. (2019) found most cases in the age groups of 11 to 20 and 31 to 40. Davoudi-Kiakalayeh, A. et al (2008)[26] found preponderance in population younger than 20.

Turgut, A., Turgut, T. (2014)[27] found 10 to 19 to be the most vulnerable group while Raez, E. et al (2015)[28] noted the age group of 50 to 70 as having the highest risk of drowning.

The involvement of those aged 11 to 40 in being responsible for about 60% of total cases is unsurprising considering that this is the

population group most likely to have repeated and frequent encounters with bodies of water in the form of swimming, farming and fishing. Children below the age of 10 and more so the youngest ones are especially vulnerable and most of the reported cases were found to occur during periods of lack of adult supervision and oversight or during playtime. This population is also unlikely to be able to swim in water in most cases.

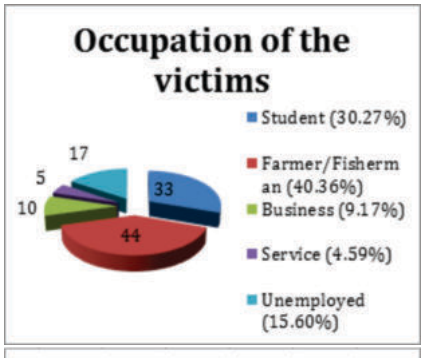
Most victims were of the Hindu faith, while Islam contributed the next largest group. 8 Christians were all found to belong to various tea tribe communities while 1 Buddhist and 1 Sikh case were also encountered. These findings are similar to those of Chaurasia, N., Pandey, S.K. and Mishra, A. (2012) and Teron, A. (2019), which is understandable given the demographic make-up of the region.

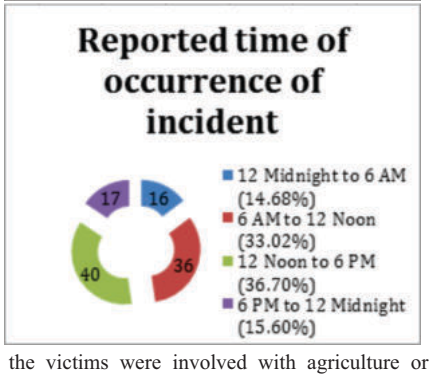
72 cases encountered during the study suffered a lethal encounter with bodies of running water (rivers, streams, tributaries and man-made canals), while stagnant sources of natural water; which included fishery ponds and irrigation tanks; contributed 36 cases. Only 1 case involved a man-made pool created for recreation and swimming, while 1 case involved the victim falling into a dug-well latrine in a rural area at night time.

These findings are in line with those of Davis, S. et al (1985) and Teron, A. (2019) who reported majority of cases to involve running water.

Chakrabarty, P., Singh, P.K., Chatterjee, A., Bhattacharya, P. and Das, S. (2015) found stagnant water bodies like ponds and lakes to have the highest representation.

The distribution of cases in this context can be seen to follow the lay of the land and can be explained by the respective frequency of each type of water body. Moreover, severe flooding across the region during the study period resulted in the impact of the rivers of the region gaining an impetus.





40.4% of the victims were involved with agriculture or fishery, including daily wage labourers at farms/fisheries and sharecroppers. 30.3% of the victims were students and only 4.6% were involved in service, which was taken as employment in the public sector.

These findings are in line with those of Teron, A. (2019), since the area covered in both studies has a large rural, agrarian population and public sector employees mostly dwell in cities or towns, where the most major associated risk of drowning appeared to be flash floods and waterlogging obscuring uncovered drains, due to poor urban development and maintenance.

Most victims encountered had less than 10 years of formal education. Second largest group was made up of the illiterate and those with an education beyond the Intermediate or Higher Secondary level had the fewest numbers of victims. This is explained by the lack of education limiting the opportunities for jobs without physical labour or exposure to the risk of drowning. It also impacts economic prospects and that in turn dictates the location and type of residence they can afford. The Illiterate group also had many suicides, which must be considered with the backdrop of the Coronavirus pandemic and the associated restrictions having adversely affected the scope for employment of this group.

Teron, A. (2019) reported similar findings.

Most of the victims (58) drowned at or near their place of residence (taken as a 1km vicinity in urban areas, 5km in semi-urban areas and 10km in rural areas). Workplace or the transit to and from it accounted for almost 40% of victims while in 8 cases, neither was true, and most of such cases were seen to occur after the victim had gone there for recreational purposes like picnicking or swimming, travelling, etc.

Gorea, R. et al (2005) reported 60% studied cases to occur in and around the house with Joanknecht, L. et al (2015)[28] and Rácz, E. et al (2015)[29] and Teron, A. (2019) reported similar findings.

74 out of 109 cases studied here occurred in a rural area, with urban areas only contributing 13 cases. The remainder were from a semi-urban setting. Considering the area covered by the study and the respective population distribution of each, this is along expected lines. In addition, the devastating state-wide that occurred in Assam during the period of the study also disproportionately affected the impoverished rural population, because that group did often not possess the liberty to await government assistance rather than continuing their agricultural practices. Where urban areas saw a robust National Disaster Relief Force (N.D.R.F.) and State Disaster Relief Force (S.D.R.F.) deployment for their safety, it was seen that awaiting rescue and independently heading to established relief camps were both fraught with peril respectively, to the detriment of many in rural regions.

Patel, A., Rathod, H. and Shah, C. (2012)[30], Fralick, M., Gallinger, Z. R. and Hwang, S.W. (2013)[31], Hossain, M. et al (2015)[32] and Teron, A. (2019) all reported similar findings. However, Auer, A. (1990) reported urban-dwellers to comprise almost 60% of total cases.

This parameter is entirely dependent on the area the study is conducted in; and the impact of the risk of drowning on the respective populations residing therein.

76.14% of the cases were reported to have been accidental. 15.6% were deemed suicidal, with the remainder being unable to be irrefutably classed as either. No homicides with drowning as the method of committing such an act were reported.

Many of the suicide cases were noted to be female and several were also seen to have been unemployed at the time of the incident.

Chaudhary, B. L., Singh, D. et al (2005)[33], Palimar, V. and Manjunath, S. (2010)[34], Seleye-Fubara, D., Nicholas, E.E. and Esse, I. (2012), Mukherjee, A.A., Dhawan, S. G. and Dhoble, S.V. (2016)[35] and Teron, A. (2019) all reported findings similar to those seen here.

Ranga Rao, G. S. R. K. G. et al (2014)[36] reported almost similar incidences of accidents and suicides. Patel, A., Rathod, H. and Shah, C. (2012) and Kumar, A. G. V., Shivramu, M. G. and Kumar, L. (2015) reported suicides to be more common.

Accidental occurrences in this context can be easily understood, given the various factors involved; and suicides were rarely seen to be committed by this method. No homicides were reported during the study period.

Only 22% of the cases studied were noted to have antemortem injuries on the bodies. Post-mortem damage due to aquatic scavengers and post-mortem artefacts caused during retrieval of the body were not considered for inclusion. Most injuries seen were located on the head and face or the extremities on the finger- and toe-tips. Teron, A. reported 26.77% cases to bear injuries.

The study found that Diabetes Mellitus and hypertension each were

reported in 10 victims, while only 4 were reported from seizure disorder. 14 cases were reported to be having mental health problems, but only victims who were reported to have attended the care of either a mental health professional or a similar institution and were provided medication for it, were considered. Mere reports of "eccentric" behaviour were not accepted as proof without further corroboration.

Wintermore, G.J. et al (1988) has mentioned a history of seizure disorder as a contributing factor in cases.

Diabetes and hypertension were also encountered in multiple victims, but given the normal course of each disease, except in the case of uncontrolled or poorly-managed long-standing disease, each is unlikely to have played any major role in the incidents.

During the course of the study, it was noted that the summer/monsoon months of May and June accounted for almost 50% of total cases. November had the least number of cases, with only 2 such deaths in that month.

Hss, A.S., Tan, P.S. and Hashim, L. (2014) have reported a similar spike in case numbers during the monsoons. Hedberg, K. et al (1990), Ranasen, P., Hakim, H., Jokelainen, J. and Tiihonen, J. (2002) and Pal, S. K., Sharma, A., Sehgal, A. and Rana, A. (2017) and Teron, A. (2019) all report a similar increase in the number of drowning cases during the summer months.

However, Teron, A. (2019) also noted a cluster of cases in November and December.

The period of this study coincided with the global Coronavirus pandemic. As such, local administration placed restrictions on the movements and congregation of the general populace and issued an advisory against popular, but risky recreational activities like picnics during the final months of 2021. These measures were suspended after January, 2022, where we see a spike in the number of cases in February before subsiding. In addition, Assam was in the grip of devastating floods during the months of April, May and June, 2022 which caused great loss of life and damage to property. While not able to be represented here, April 2022 also accounted for over 15 cases of drowning, where the bodies were too decomposed by the time of autopsy to merit inclusion in the study itself. In addition, this was also the time of closure of schools and colleges for the summer, and became a time where unsupervised children had the opportunity to interact with floodwaters, often unsupervised. Winter months contributed sparsely to the total number of cases, which, given this context can be easily understood.

During the study, it was noted that almost 70% of the cases occurred during the daylight hours or the time period of 6 AM to 6 PM. The 6 hours following midnight and before the dawn had the lowest incidence of cases, and all but one of those were reported to be associated with impaired consciousness in the form of intoxication, injury from accidents and the like.

This is similar to the findings of Donson, H. et al (2013), Hossain, M. J. and Teron, A. (2019); who all reported maximum cases occurring during the same daylight hours. This pattern is explained by the likelihood of people venturing towards water bodies mostly during the daytime and not at night.

Majority of the victims fell prey to freshwater sources, while only 2 cases of reported secondary drowning were encountered, where the victim survived the initial drowning event, received hospital care and then succumbed beyond 24 hours from the time of the original incident. Both these cases were noted to have minimal obstructions of the respiratory tree by debris or froth as a result of the medical care received, but pulmonary and cerebral oedema was encountered in both cases. Remaining 14 cases were reported to have drowned in shallow water and of these, several included cases where the victim(s) had suffered impairment by means of intoxication or injury prior to the event which typically occurred during absence of daylight.

The findings match those of Teron, A. (2019), whose study covered the same region and population group.

However, Patetta, M.J. and Biddinger, P.W. (1988)[37] and Palimar, V. and Manjunath, S. (2010) reported fresh water to contribute to less than 40% of cases.

Given the geographical location of the study and the pattern of water bodies in the area, the findings of the study can be explained based on access to water sources.

Based on the 2019 Modification of the Kuppuswamy Classification for the determination of the socio-economic bracket each victim fell into, it was seen that 98 cases belonged to the lower class, with none from the upper class.

One possible source of inadvertent inaccuracy in the method used here can be attributed to the fact that in case of minors and young adults, the educational qualification and employment of the head of the family alone is taken into consideration, rather than the respective parameters of the victims themselves. As a result, a young adult in the process of their education with an illiterate, unskilled worker as their head of the family would be placed in a class incongruous with their actual situation.

With this in mind, the study found only one victim to be from the middle class while 3 were from the upper middle class and 7 from the upper lower class. This distribution pattern of cases is understandable given the area covered, the demographic and socio-economic profile of the population residing therein and an unfortunate reticence among the population to honestly discuss finances with a complete stranger conducting a survey during a time where their family member or acquaintance has expired in a drowning incident.

The poorer sections of the society are more vulnerable due to not being likely to possess the ability to simply avoid coming in contact with a water body even under dangerous conditions. This pattern of cases is in line with the WHO Global Report on Drowning (2014)[3] which labels drowning as being a bigger problem in middle- and low-income countries than in high-income ones.

As stated by Piette, M. and De Letter, E. A. (2004)[38] "to demonstrate drowning unambiguously as the cause of death remains a difficult issue in current forensic practice.", and have stated their opinion that "the diagnosis of true drowning is not exclusively the duty of the forensic pathologist. In fact, the law enforcement authorities, have to be involved in final statement of the cause of death by drowning."

CONCLUSION:

Drowning disproportionately affects the economically vulnerable groups, with a greater preponderance in rural areas and the male gender. In this regard, the size of our population is our greatest liability, which would need concerted, sustained effort to turn into an asset.

Greater emphasis on the training of the general populace in measures to be taken in such a situation is required as lifesaving measures like Cardio-Pulmonary Resuscitation can determine whether the victim survives to reach medical treatment or succumbs prior to it. Operation of boats, ferries and other smaller craft needs to be regulated more thoroughly as improper adherence to safety measures already in place has been seen to cause catastrophic results in the recent past.

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