

Comprehensive Analysis of Drowning Fatalities: A Prospective Autopsy Study at GMC Purnea Bihar

Pankaj Kumar¹, Abdul Wahab²

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Abstract

Background: Drowning is a significant cause of mortality worldwide, necessitating comprehensive investigations. This prospective autopsy study aimed to analyze drowning fatalities comprehensively, focusing on demographic, circumstantial, and forensic aspects.

Methods: Conducted at GMC Purnea Bihar from Jan to Dec 2023, the study included 100 drowning cases. Approval was obtained from the Institutional Ethics Committee. Data were systematically collected and analyzed using descriptive statistics.

Results: Among 100 cases, males predominated (88%), with individuals aged 11-20 years most affected (46%). Accidental drownings were common (43%), followed by suicidal cases (19%) and undetermined incidents (37%). Postmortem findings included froth from the mouth, washer woman's hands and feet, and internal petechial hemorrhages. Most incidents occurred in lakes and rivers (92%), with heightened risk during the rainy season. Ethanol positivity was noted in 43% of cases, and males exhibited higher lung weights than females.

Conclusion: The study provides insights into drowning incidents, highlighting demographic disparities and seasonal variations. Enhanced preventive measures and awareness campaigns are crucial to mitigate drowning-related fatalities. Addressing identified risk factors is essential for community safety.

Keywords: Drowning; Autopsy; Epidemiology; Cyanosis; Pulmonary edema.

INTRODUCTION

India, endowed with a plethora of water bodies such as rivers, ponds, wells, and an extensive coastline, experiences a high frequency of drowning incidents. In such an environment conducive to aquatic activities, medico-legal expertise is frequently required for investigations into these fatalities. Recent epidemiological studies, such as the Global Burden of Disease (GBD) report, highlight the substantial global impact of drowning, attributing 7% of all injury-related deaths to drowning (WHO,

Author's Credentials: ¹Assistant Professor, ²Tutor, Department of Forensic Medicine, Government Medical College and Hospital, Purnea 854301, Bihar, India.

Corresponding Author: Pankaj Kumar, Assistant Professor, Department of Forensic Medicine, Government Medical College and Hospital, Purnea 854301, Bihar, India.

Email: pankajkumarfmt1978@gmail.com

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2010).¹ The latest data reveals that approximately 236,000 individuals die annually due to drowning. This tragic phenomenon disproportionately affects young children, with those aged 1-4 years being the most vulnerable, followed by children aged 5-9 years. Notably, 90% of these drowning incidents occur in low and middle-income countries.² The World Health Organization (WHO) estimates the annual global incidence of drowning-related deaths to be approximately 400,000 (WHO, 2010).³ According to data from the GBD, approximately 449,000 individuals succumbed to drowning worldwide in the year 2000, resulting in 1.3 million years of lost life and disability (WHO, 2010).⁴

An estimated 38,000 people die from drowning in India each year, with children aged 5 to 14 being at higher risk. The lack of national coordination, legislation, and compulsory swim training in schools exacerbates the issue.⁵ The present study aims to analyze drowning incidents comprehensively, including demographic, circumstantial, and forensic aspects, to inform preventive measures effectively.

MATERIALS AND METHODS

A prospective autopsy study spanning one year was conducted to analyze fatalities resulting from drowning cases. The study was carried out at the Department of Forensic Medicine & Toxicology, GMCH Purnea Bihar, from January 2023 to December 2023. Prior approval was obtained from the Institutional Ethics Committee (IEC) before commencing the study. Data pertaining to drowning incidents were systematically collected, analyzed, and tabulated for comprehensive examination. Statistical Analysis, data from the autopsy study underwent thorough statistical analysis, summarizing demographic profiles, incident circumstances, and forensic findings using descriptive statistics.

Observation

Table 1: Sex Wise Distribution

Male	Female	Total
88	12	100

As per Table 1, the distribution of drowning cases according to sex reveals a notable gender disparity. Among the total 100 cases examined, the majority were male, accounting for 88 cases (88%), while only 12 cases (12%) were female. This indicates a significantly higher prevalence of drowning incidents among males compared to females in the studied population.

Table 2: Age Wise Distribution

Age Group In Years	Total Cases
0-10	13
11-20	46
21-30	15
31-40	06
41-50	10
51-60	03
61-70	07
71-80	00
81-90	00

As per Table no 2, the age-wise distribution of drowning cases exhibits a distinct pattern, with the majority of cases clustered within specific age groups. Among the total cases examined, the highest proportion was observed among individuals aged 11 to 20 years, accounting for 46 cases (46%). This age group represents the most vulnerable segment in terms of drowning incidents. Additionally, individuals aged 0 to 10 years and 21 to 30 years also accounted for notable proportions, with 13 cases (13%) and 15 cases (15%), respectively. In contrast, the number of cases declined significantly beyond the age of 40, with only sporadic instances reported in the age groups of 41 to 50 years, 51 to 60 years, and 61 to 70 years. Interestingly, no cases were recorded in the older age brackets of 71 to 80 years and 81 to 90 years.

Table 3: Manner Of Death

Suicidal		Accidental		Homicidal		Undetermined	
M	F	M	F	M	F	M	F
11	08	31	12	01	00	32	05
19		43		01		37	

As per Table 3, accidental drownings were the most common, comprising 43% of cases. Suicidal drownings accounted for 19%, while homicidal drownings were rare at 1%. A significant portion, 37%, were undetermined, indicating uncertainty in the manner of death.

Table 4: Postmortem Findings

Pm Findings	Total Cases (%)
Cyanosis	28
Froth from mouth and nostrils	44
Washer woman's hands and feet	36

Table Cont...

Bleaching of skin	39
Internal petechial hemorrhages	52
Presence of heavy, voluminous, edematous and congested lungs with c/s showing copious frothy fluid	64
Presence of water in stomach	69
Animal bites and decomposition	06

As per table 4, postmortem findings in drowning cases included cyanosis in 28%, froth at the mouth/nose in 44%, “washer woman’s hands/feet” in 36%, skin bleaching in 39%, and internal petechial haemorrhages in 52%. Heavy, congested lungs with frothy fluid were observed in 64%, and water in the stomach in 69%. Animal bites and decomposition were noted in 6% of cases.

Table 5: Place of Occurrence

01	Lakes/Rivers	92
02	Wells	04
03	House tanks	03
04	Swimming pools	01

As per table 5, the vast majority occurred in natural water bodies, specifically lakes and rivers, constituting 92% of the cases. A small proportion of cases occurred in other confined water sources, including wells, house tanks, and swimming pools. Wells accounted for 4% of the cases, indicating the potential hazards posed by uncovered or poorly secured wells, particularly in rural areas. House tanks and swimming pools each accounted for 3% and 1% of the cases, respectively, suggesting the importance of safety precautions and supervision in residential settings to prevent drowning incidents, especially among young children.

Table 6: Season of occurrence

	Season of occurrence			Total No of cases
	Winter	Summer	Rainy	
04		12	84	100

As per table 6, among the total 100 cases examined, the majority occurred during the rainy season, constituting 84% of the cases. This observation suggests a pronounced association between increased precipitation and heightened risk of drowning, likely due to factors such as swollen rivers, overflowing water bodies, and hazardous conditions in aquatic environments during periods of heavy rainfall. In contrast, a smaller proportion of cases occurred during the summer season, accounting for 12% of the total cases. The winter season accounted for the fewest drowning cases, comprising only 4% of the total.

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Table 7: Causes of Death

Sr. No	Causes of Death	No of Cases
01	Drowning	64
02	Near Drowning	09
03	Drowning + Drug Intoxication	21
04	Drowning + Other causes	06
Total		100

As per table 7, among the total 100 cases examined, drowning was identified as the primary cause of death in the majority of cases, accounting for 64% of the total cases. A smaller proportion of cases were classified as near-drowning, comprising 9% of the total cases. In a significant number of cases, drowning was found to co-occur with drug intoxication, accounting for 21% of the total cases. Additionally, a subset of cases involved drowning in conjunction with other causes, such as trauma or medical conditions, comprising 6% of the total cases.

Table 8: Toxicological analysis Results

Sr. No	Toxicology Result	No of Cases
01	Negative	37
02	Ethanol Positive	43
03	Positive to Other Drugs	07
04	Positive to Ethanol + Other drugs	06
05	None Consumed	07
Total		100

As per table 8, 37% of cases showed no detectable levels of alcohol or drugs, ethanol was detected in 43% of cases, 7% tested positive for non-ethanol drugs, 6% had both ethanol and other drugs, and 7% tested negative for both alcohol and drugs.

Table 9: Characteristics of Autopsy cases

Characteristic	Yes	No	Total
Pulmonary edema	67	33	100
Decomposition	16	84	100
Stomach Content	83	17	100

As per table 9, among the total 100 autopsy cases examined, pulmonary edema was identified in 67 cases (67%). Decomposition was observed in 16 cases (16%) among the examined autopsy cases. Stomach content analysis revealed the presence of material in the stomach in 83 cases (83%).

Table 10: Organ weight findings at Autopsy

Gender	Brain Weight (gm) Mean \pm SD	Right Lung Weight (gm) Mean \pm SD	Left Lung Weight (gm) Mean \pm SD	Combined Lung Weight (gm) Mean \pm SD
Male	1269.3 \pm 138.37	595.12 \pm 130.2	622.2 \pm 185.81	1217.32 \pm 227.07
Female	1178.6 \pm 131.29	487.65 \pm 218.31	592.4 \pm 180.2	1080.05 \pm 283.0

As per Table 10, males had a mean brain weight of 1269.3 grams and females 1178.6 grams. The mean right lung weight for males was 595.12 grams and for females 487.65 grams. The mean left lung weight was

622.2 grams for males and 592.4 grams for females. The mean combined lung weight was 1217.32 grams for males and 1080.05 grams for females.

Table 11: The correlation between organ weight and various attributes

Mean \pm SD		Brain weight (gm)		Left Lung (Gm)		Right Lung weight (gm)		Combined Lung Weight (g)	
		P-value	Mean \pm SD	P value	Mean \pm SD	P-value	Mean \pm SD	P-value	
Decomposition	Yes	1301.23 \pm 130.3	0.03	367.21 \pm 101.26	0.1	238.18 \pm 102.31	<0.01	724.63 \pm 184.69	<0.01
	No	1364.21 \pm 112.6		601.31 \pm 182.34		648.68 \pm 156.48		968.21 \pm 368.39	
Pulmonary edema	Yes	1286.12 \pm 126.7	<0.01	598.06 \pm 184.44	<0.02	603.32 \pm 148.27	<0.001	989.29 \pm 263.21	<0.001
	No	1123.34 \pm 103.2		468.94 \pm 198.54		498.69 \pm 152.9		994.32 \pm 383.61	

As per table 11, cases with decomposition showed a mean brain weight of 1301.23 grams, lower than non-decomposition cases (1364.21 grams). Combined lung weight was higher in decomposition cases (724.63 grams) compared to non-decomposition cases (968.21 grams). Pulmonary edema cases had higher brain weights (1286.12 grams) and combined lung weights (989.29 grams) than non-edema cases. Left and right lung weights trended higher in decomposition and edema cases. These findings indicate that decomposition and pulmonary edema significantly affect brain and lung weights.

DISCUSSION

The analysis of the data in the present study provides valuable insights into the demographic characteristics, circumstances, and postmortem findings associated with drowning cases. The findings reveal significant patterns regarding the sex distribution, age groups, manner of death, postmortem indicators, place of occurrence, seasonal variations, and causes of death, toxicological results, autopsy characteristics, and organ weight differences between genders. These insights shed light on the complex nature of drowning incidents and offer a comprehensive understanding of the factors contributing to such fatalities.

Drowning is characterized as the impairment of tissue

oxygenation following submersion in a fluid medium. Mukherjee AA⁴ Mason JK⁶ approximates that globally; around 140,000 individuals succumb to drowning annually, a figure that is on the rise due to increased water transport and adventure water sports. In India, accidental drowning claims nearly 40,000 lives each year, with a significant portion occurring among non-swimmers who exceed their depth in bodies of water. It is noted that drowning is the primary method of suicide in India, with a study by Modi⁷ revealing that out of 231 suicide cases, 90 were attributed to drowning. Particularly, Indian females tend to resort to drowning as a means of suicide even with minimal provocation, often by jumping into nearby wells or tanks. Drowning is a critical public health concern globally, with a substantial number of fatalities annually, especially in India where it is a prevalent method of suicide among females, emphasizing the need for comprehensive preventive measures and awareness campaigns.

The study findings from Table 1 and Table 2 highlight the sex and age distribution of drowning cases, aligning with existing literature. The male predominance in drowning incidents, as evidenced by 88% of cases being male, is consistent with studies by Kanchan T,⁸ Byard R W⁹, Davoudi-Kiakalayeh A,¹⁰ and Ardeshir Sheikhezadi *et al.*¹¹ which have reported similar trends with male-female ratios ranging from 6.5:1 to 90%. This underscores the heightened risk faced by males in aquatic environments. Regarding age distribution, individuals aged 11 to 20

years accounted for the highest proportion of cases at 46%, emphasizing the vulnerability of this age group to drowning incidents. Studies by Sayed ZAT,¹² Chormunge *et al.*¹³ Amandeep Singh *et al.*¹⁴ Salachin *et al.*¹⁵ Gross VA *et al.*¹⁶ Momanchand *et al.*¹⁷ and Srinivasa Reddy P¹⁸ have also highlighted the susceptibility of younger individuals to drowning accidents. The absence of drowning cases in older age brackets aligns with general trends in drowning research, emphasizing the need for targeted preventive measures focusing on vulnerable age groups.

Table 3 provides insights into the manner of death in drowning cases, revealing distinct patterns in the circumstances surrounding these incidents. Accidental drownings were the most prevalent, constituting 43% of the cases, indicating a significant proportion of unintentional drowning incidents. Suicidal drownings accounted for 19% of the cases, highlighting deliberate self-inflicted deaths by drowning. Homicidal drownings were rare at 1%, emphasizing the infrequency of intentional drowning as a method of homicide. Notably, 37% of cases were undetermined, indicating uncertainty in assigning a specific manner of death. The findings align with a study by Mukherjee AA *et al.*⁵ where accidental drownings accounted for 37.14% of cases, suicidal drownings for 27.14%, and 35.72% of cases remained undetermined.

The postmortem findings detailed in Table 4 offer crucial insights into the physiological changes and external indicators associated with drowning-related deaths. These findings provide valuable forensic evidence to ascertain the cause of death and the circumstances surrounding drowning incidents. Studies by Mukherjee AA *et al.*⁵ and similar research have likely reported comparable postmortem findings, reinforcing the reliability and significance of these indicators in determining drowning as the cause of death.

Table 5 provides valuable insights into the distribution of drowning cases based on the place of occurrence, highlighting the prevalence of drowning incidents in natural water bodies compared to other confined water sources. The majority of cases occurred in lakes and rivers, constituting 92% of the total cases, emphasizing the significant risk posed by these open water environments. In contrast, a smaller proportion of cases were reported in wells, house tanks, and swimming pools, indicating the diverse settings where drowning incidents can occur. Chidanand C *et al.*¹⁹ study reported lakes as the commonest place of submersion (37.6%), followed by wells (17.8%), aligning with our findings that highlight lakes as a predominant site for drowning incidents. Similarly, Prabir *et al.*²⁰ study revealed that maximum cases drowned in ponds (35%), followed by rivers (23%) and lakes (22%), further supporting the prevalence of drowning in natural water bodies observed

in our study.

Table 7 presents a comprehensive overview of the causes of death in drowning cases, highlighting the primary factors contributing to fatalities in the studied population. Among the total 100 cases examined, drowning emerged as the predominant cause of death, accounting for 64% of the cases. Near-drowning cases constituted 9% of the total, the association between drowning and drug intoxication, with 21% of cases involving both factors. a subset of cases (6%) involved drowning in conjunction with other causes, such as trauma or underlying medical conditions. Chidan and C *et al.*¹⁹ reported similar trends in drowning cases, highlighting drowning as a prevalent cause of death. Additionally, studies by Prabir *et al.*²⁰ and other researchers have also underscored the significance of drowning as a leading cause of mortality in aquatic incidents.

As per the Table 8 insights into the toxicological profiles of drowning victims, 37% of cases showed no detectable levels of alcohol or drugs, while ethanol was present in 43% of cases. Positive tests for drugs other than ethanol were found in 7% of cases and 7% of cases involved no substance consumption. Girela-López *et al.* (2022)²¹ reported ethanol positivity in 58% of cases and other drugs in 16.8%, aligning with our high prevalence of ethanol positivity. Kringsholm *et al.*²² found over 0.1 gm% ethanol in 53% of cases, comparable to our 43%. Lunetta *et al.*²³ noted ethanol in 51.6% of drowning deaths, supporting our significant ethanol presence.

As per Table 9 Pulmonary edema was identified in 67% of cases, consistent with other studies such as Lunetta *et al.* (2004)²⁴, who reported pulmonary edema in a majority of drowning deaths. Decomposition was observed in 16% of cases, aligning with Di Maio and Di Maio (2001)²⁵, who found similar rates in water related deaths. Stomach content analysis revealed material in 83% of cases, supporting Byard *et al.* (2013)²⁶, who noted that the presence of stomach contents is common in drowning cases. As per Table No. 10 mean brain weight was higher in males (1269.3 grams) compared to females (1178.6 grams), which aligns with studies by Ho KC *et al.* (1980)²⁷ that found similar gender differences. The right lung weight was also greater in males (595.12 grams) than females (487.65 grams), Left lung weight showed a smaller difference, with males at 622.2 grams and females at 592.4 grams, supported by findings from Thurlbeck WM *et al.*, (1975).²⁸

Table 11 shows significant differences in organ weights based on the presence of decomposition and pulmonary edema. In cases with decomposition, the mean brain weight (1301.23 grams) was lower than in non-decomposition cases (1364.21 grams). The combined lung weight was higher in decomposition cases (724.63 grams) compared to non-decomposition

cases (968.21 grams). These findings align with de la Grandmaison *et al.* (2001)²⁹, who provided normative data for organ weights, indicating variations due to pathological conditions. In cases of pulmonary edema, both brain weight (1286.12 grams) and combined lung weight (989.29 grams) were significantly higher than in non-edema cases. This correlates with findings by Mubbunu *et al.* (2018)³⁰, which showed that internal organ weights could be influenced by body weight and pathological states.

CONCLUSION

Our study sheds light on the intricate dynamics surrounding drowning incidents, revealing a pronounced gender disparity, with males being disproportionately affected, and highlighting the vulnerability of younger age groups, particularly those aged 11 to 20 years. Accidental drownings were predominant, emphasizing the need for

enhanced water safety measures and awareness campaigns. The forensic indicators detailed in our analysis provide valuable insights for accurate cause-of-death determinations and underscore the multifactorial nature of drowning incidents. Addressing these findings through targeted interventions and policies is crucial to mitigate the burden of drowning-related fatalities and ensure the safety of communities worldwide.

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Conflict of Interest: The authors declare no conflicts of interest regarding the publication of this article.

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