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Statistical Analysis of Accidental Deaths in India

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ABSTRACT

Accidental deaths represent a significant public health and socio-economic concern in India. This study presents a comprehensive statistical analysis of accidental deaths categorized into **natural causes and unnatural causes** over a period of seven years (2019–2025). The data used in this study is secondary in nature and collected from official records including police reports, hospital data, and government publications.

The study applies **descriptive statistics, ABC analysis, t-test, ANOVA, and Tukey's post hoc test** to identify patterns, variations, and significant differences among accident categories. The results indicate that certain causes such as **lightning, exposure to cold, and other causes** contribute significantly to total accidental deaths.Further, ANOVA results confirm the presence of statistically significant differences among accident categories across years, and Tukey's test identifies specific group differences. The findings provide insights for policymakers to implement targeted safety measures and reduce accidental deaths.

Keywords: Accidental Deaths, ABC Analysis, ANOVA, Tukey Test, Statistical Analysis, India

INTRODUCTION

An accident is an unplanned event that results in injury, death, or damage. Accidental deaths are broadly classified into:

- Natural causes (environmental factors like lightning, floods, cyclones)
- Unnatural causes (human-related factors like road accidents, drowning, poisoning)

These deaths have been increasing due to population growth, urbanization, and environmental changes

Accidental deaths not only result in loss of life but also create serious economic and social impacts on society

Theoretical Background

Accidental deaths arise from both environmental and human-related factors. Natural causes include climatic and environmental events such as lightning, floods, landslides, and cyclones. Unnatural causes include human-induced incidents such as road accidents, drowning, poisoning, and electrocution.

Previous studies have shown that accidental deaths are influenced by multiple factors including environmental conditions, lack of safety awareness, and inadequate preventive measures.

Statistical techniques such as descriptive statistics, ANOVA, and classification methods are widely used to analyze accident data and identify significant patterns. These methods help in understanding variations across categories and time periods.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue IV, April 2026

Need of the Study

Accidental deaths have become a serious social and public health issue in recent years. The increasing number of incidents highlights the need for systematic analysis.

Most available data provide only descriptive information without detailed statistical interpretation. Therefore, there is a need to apply statistical techniques to:

- Identify major causes of accidental deaths
- Analyze variations across years
- Provide data-driven insights for policy decisions

This study aims to bridge this gap by applying statistical tools to accident data.

Research Design and Source

The present study is analytical and descriptive in nature. It focuses on examining accidental deaths in India by classifying them into natural and unnatural causes over a period of seven years (2019–2025). The study aims to identify patterns, variations, and significant differences among accident categories using statistical techniques.

The study is based entirely on secondary data collected from reliable sources such as police records, hospital records, and government reports

Outlier Treatment

To ensure the reliability and accuracy of the analysis, the dataset was examined for the presence of extreme values (outliers). Outliers may arise due to data recording errors or unusual events such as natural disasters or sudden spikes in accident cases.

The identification of outliers is important because extreme values can distort statistical results such as mean and variance. In this study, the data was carefully reviewed, and no abnormal or inconsistent values affecting the analysis were considered. Since the dataset is based on officially recorded reports, it is assumed to be reliable and consistent for statistical analysis.

Thus, all observations were retained for further analysis.

Mathematical and Statistical Model

The study employs statistical techniques to analyze variations in accidental deaths across different causes and years.

Let:

Xij

The two-way classification model is given by:

$X_{ij}=\mu+\alpha_i+\beta_j+\epsilon_{ij}$

Where:

- μ = overall mean number of deaths
- α_i = effect of the i^{th} accident cause

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue IV, April 2026

- β_j = effect of the j^{th} year
- ϵ_{ij} = random error term

This model helps in analyzing variation due to both **causes (rows)** and **years (columns)**.

In addition, descriptive statistics, ABC analysis, t-test, ANOVA, and Tukey test are used to support the analysis

Assumptions of the Model

The validity of the statistical analysis is based on the following assumptions:

1. **Independence:** The observations of accidental deaths are independent across causes and years.
2. **Normality:** The data is assumed to be approximately normally distributed for applying statistical tests such as t-test and ANOVA.
3. **Homogeneityof Variance:** The variance among different groups (causes or years) is assumed to be equal.
4. **Additivity of Effects:** The effects of causes and years are additive in nature.

These assumptions ensure that the results obtained from statistical methods are valid and reliable.

Hypothesis Formulation

To examine whether there are significant differences among accident causes and years, the following hypotheses are formulated:

For Causes (Rows):

- **H_{01}:** There is no significant difference among the mean number of deaths due to different accident causes.
- **H_{11}:** There is a significant difference among the mean number of deaths due to different accident causes.

For Years (Columns):

- **H_{02}:** There is no significant difference among the mean number of accidental deaths across years.
- **H_{12}:** There is a significant difference among the mean number of accidental deaths across years.

Decision Rule:

- If Fcal>Ftab$Fcal > Ftab$ → Reject H_0
- If Fcal<Ftab$Fcal < Ftab$ → Accept H_0]

Statistical Analysis – Natural Causes

Descriptive Statistics Analysis

Descriptive statistics is used to summarize and present the data related to natural causes of accidental deaths in a meaningful way. It helps in understanding the overall pattern, central tendency, and variability of the data. Measures such as mean and standard deviation are used to identify the average number of deaths and the extent of variation among different causes over the study period.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue IV, April 2026

S.No	CAUSES	2019	2020	2021	2022	2023	2024	2025	MEAN	S.D
1	Avalanch	35	13	8	29	24	20	19	21	9.18
2	Exposure to cold	796	776	618	720	733	674	656	710	64.65
3	Cyclone	33	37	118	9	2	13	4	31	40.83
4	Tornado	15	16	1	0	1	0	0	5	7.39
5	Flood	948	959	656	547	266	142	89	515	362.36
6	Heat/Sun Stroke	1274	530	374	730	804	520	446	668	307.12
7	Landslide	264	295	380	269	239	267	259	282	46.33
8	Lightning	2876	2862	2880	2887	2560	2631	2570	2752	156.35
9	Torrential Rain	69	43	63	89	61	74	77	68	14.48
10	Forest Fire	9	13	23	7	6	8	7	10	6.02
11	Other causes	1824	1861	2004	2773	1748	2270	2346	2118	366.63
	TOTAL	8143	7405	7125	8060	6444	6613	6338	7161	744.46

The above table presents the summary statistics of various natural causes of accidental deaths over the selected period.

Interpretation

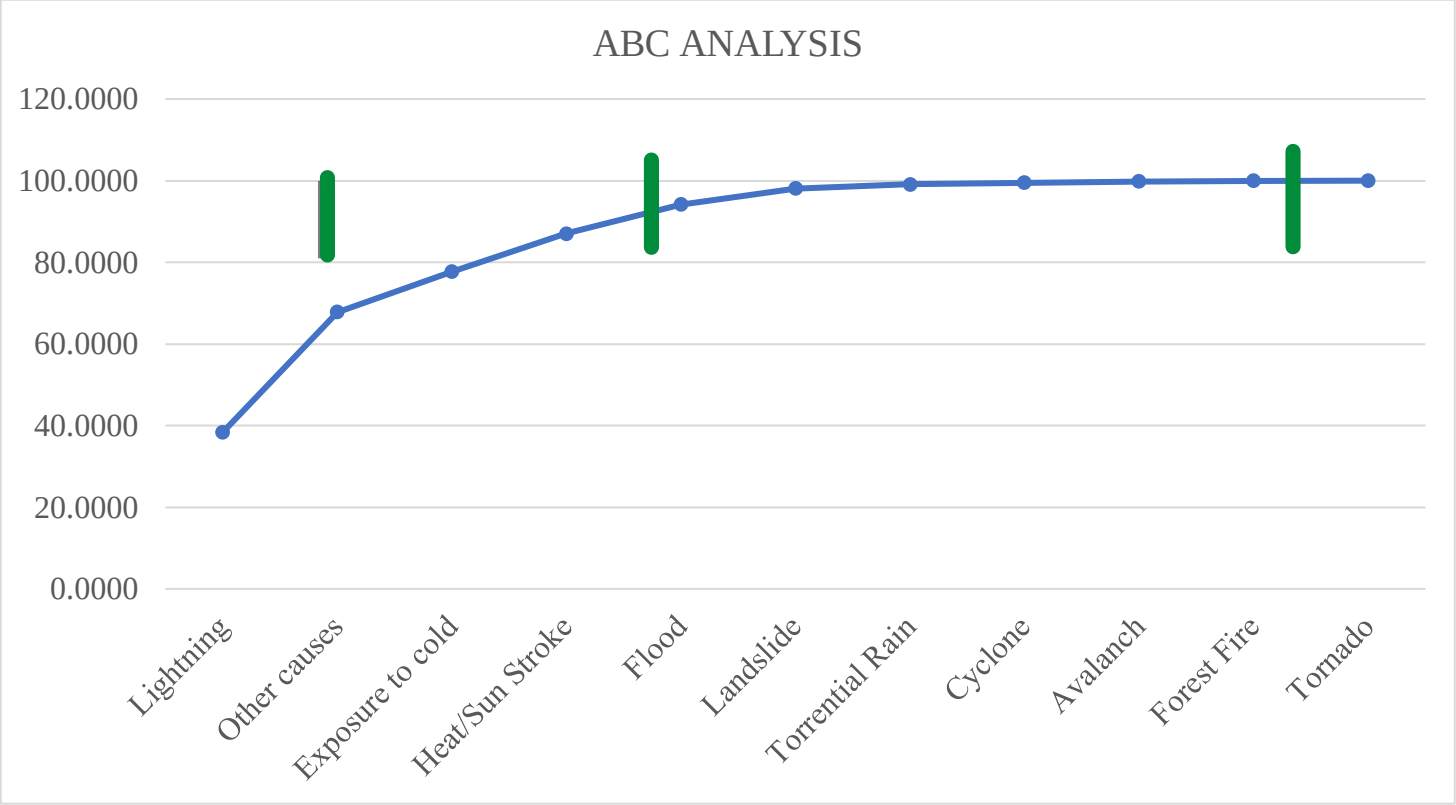
- Lightning shows the highest mean
- Flood and Heat Stroke show high variation
- Minor causes contribute less

ABC Analysis

ABC analysis is applied to classify the natural causes of accidental deaths based on their contribution to total deaths. This technique helps in identifying the most significant causes (Category A), moderately significant causes (Category B), and least significant causes (Category C), enabling better prioritization and decision-making.

S.No	CAUSES	TOTALS	% CAUSES	CUMULATIVE	CATEGORY
1	Lightning	19266	38.3256	38.3256	A
2	Other causes	14826	29.4930	67.8187	A
3	Exposure to cold	4973	9.8923	77.7109	B
4	Heat/Sun Stroke	4679	9.3074	87.0184	B
5	Flood	3607	7.1761	94.1945	B
6	Landslide	1973	3.9240	98.1185	C
7	Torrential Rain	476	0.9469	99.0654	C
8	Cyclone	216	0.4289	99.4943	C
9	Avalanch	148	0.2952	99.7895	C
10	Forest Fire	73	0.1448	99.9344	C
11	Tornado	33	0.0656	100	C
	TOTAL	50270			

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue IV, April 2026



The classification of causes into A, B, and C categories based on cumulative percentage is shown in the above table.

Interpretation

- Category A contributes highest
- Category C contributes least

T-Test Analysis

The t-test is used to compare the mean number of deaths between two major causes, namely Lightning and Other Causes. This test helps in determining whether the difference in their mean values is statistically significant.

t-Test (Assuming Equal Variances)		
Mean	2752.285714	2118
S.D.	156.3721142	366.6274221
t	4.210327378	
P-Value (two-sided)	0.00121	

The results of the t-test comparing the two major causes are presented in the above table.

Interpretation

- p-value < 0.05
- Significant difference exists
- Lightning contributes more

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue IV, April 2026

ANOVA Analysis

B-Category Causes

Analysis of Variance (ANOVA) is applied to examine whether there are significant differences among the B-category causes across different years. This helps in understanding whether variations are due to causes or time.

ANOVA Table							
Factor	SS	DF	Ms	F		P-Value	F(0.05)
A (Columns)	794775	2	264925	5.465755144	** (P<=0.01)	0.007535	3.1599076
B (Rows)	602512.2143	6	100418.7024	2.071771404	Not Significant (P>0.05)	0.108	2.6613045
Error	872459.5	12	48469.97222				
Total	2269746.714	20					

The ANOVA results for B-category causes are presented in the above table.

Interpretation

- Causes are significant
- Years are not significant

C-Category Causes

ANOVA is also applied to C-category causes to analyze whether there is any significant variation among the minor causes across years.

ANOVA Table							
Factor	SS	DF	Ms	F		P-Value	F(0.05)
A (Columns)	396312.7857	5	79262.55714	131.0554714	*** (P<=0.001)	1.92E-19	2.5335545
B (Rows)	7019.666667	6	1169.944444	1.934426875	Not Significant (P>0.05)	0.1075	2.4205232
Error	18144.04762	30	604.8015873				
Total	421476.5	41					

The ANOVA results for C-category causes are shown in the above table.

Interpretation

- Highly significant difference among causes
- Years not significant

Tukey Test

Tukey's Honestly Significant Difference (HSD) test is applied after ANOVA to identify which specific pairs of causes differ significantly from each other. It helps in detailed pairwise comparison.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue IV, April 2026

B-Category

ANOVA					
CASES					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	147554.815	2	73777.408	4.314	.000
Within Groups	1378861.657	18	76603.425		
Total	1526416.472	20			

C-Category

ANOVA					
CASES					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	396158.823	5	79231.765	113.217	.000
Within Groups	25193.509	36	699.820		
Total	421352.331	41			

The multiple comparison results obtained using Tukey test are presented in the above table.

Interpretation

- No significant pair differences
- Causes behave similarl

Statistical Analysis – Unnatural Causes

Descriptive Statistics

Descriptive statistics is used to summarize the data related to unnatural causes of accidental deaths. It provides an overview of the distribution, average, and variability of deaths across different causes.

S.No	CAUSES	2019	2020	2021	2022	2023	2024	2025	MEAN	S.D
1	Collapse of Structure	1929	1536	1630	1644	1644	1538	1492	1630	145.02
2	Drowning	32671	37238	36362	38503	37738	39922	41062	37642	2712.88
3	Electrocution	13432	13446	12529	12918	13835	13315	13343	13260	419.55
4	Accidental Explosion	655	494	454	436	498	396	359	470	95.67
5	Falls	20901	20579	21609	23786	25150	25917	27087	23576	2592.73
6	Factory/Machine Accidents	1001	705	774	684	670	562	494	699	162.74
7	Accidental Fire	10915	9110	8348	7435	6891	5623	4651	7567	2119.72
8	Firearm	320	318	278	262	240	219	197	262	47.09
9	Mines Or Quarry Disastar	82	77	78	83	57	62	58	71	11.53
10	Stampede	12	14	25	22	32	35	40	26	10.67
11	Sudden Deaths	47295	49925	50773	56653	63609	65458	69393	57587	8655.82
12	Deaths Of Women During Pregnancy	1160	1121	975	1072	1134	1062	1052	1082	62.12

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue IV, April 2026

13	Deaths Due to consumption of poisonous liquor	1296	947	782	617	522	269	82	645	409.92
14	killed by animals	1425	1305	1264	1510	1742	1701	1785	1533	212.84
15	poisoning	21196	22221	23472	21606	21785	22225	22281	22112	719.36
16	suffocation	1598	2096	1235	1631	1485	1402	1333	1540	282.54
17	Drug Over Dose	704	514	737	681	654	678	685	665	71.23
18	Other causes	16666	15097	40450	41382	16085	33473	35985	28448	11995.16

The summary statistics for unnatural causes are shown in the table.

Interpretation

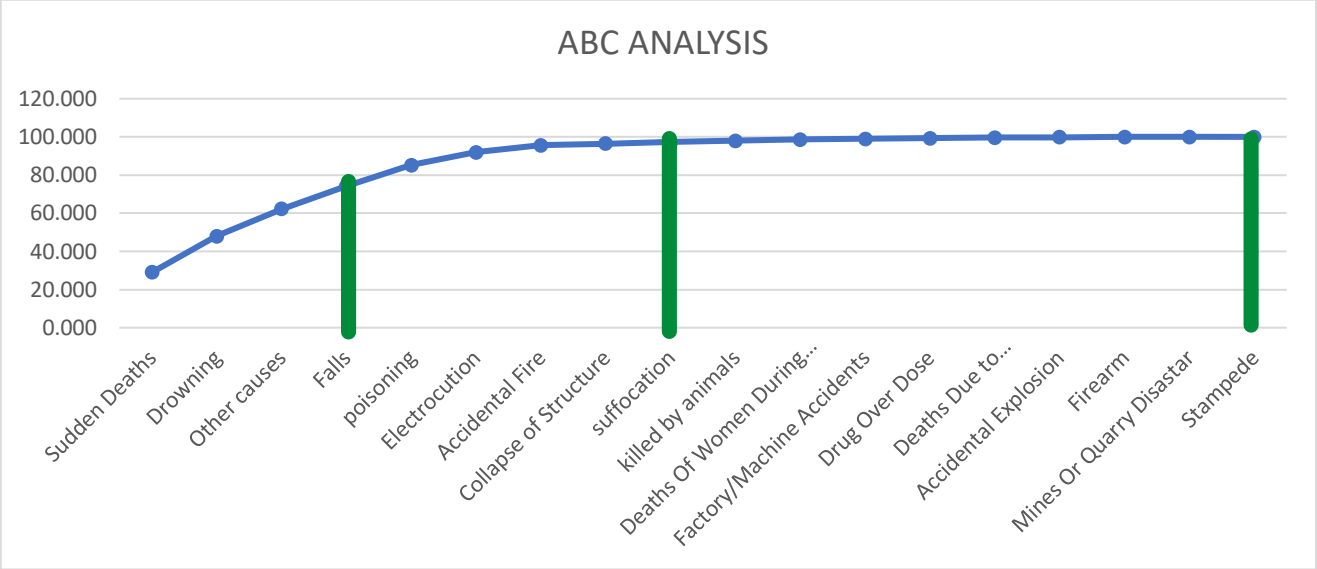
- Major causes dominate
- Some causes show high variation

ABC Analysis

ABC analysis is used to classify unnatural causes based on their contribution to total deaths, helping to identify high-priority accident types.

S.No	CAUSES	TOTAL	PERCENATGE	% CUMMULATIVE	CATEGORIES
1	Sudden Deaths	403106	28.9649	28.965	A
2	Drowning	263496	18.9333	47.898	A
3	Other causes	199138	14.3089	62.207	A
4	Falls	165029	11.8580	74.065	A
5	poisoning	154786	11.1220	85.187	B
6	Electrocution	92819	6.6694	91.857	B
7	Accidental Fire	52972	3.8063	95.663	B
8	Collapse of Structure	11413	0.8201	96.483	B
9	suffocation	10779	0.7745	97.257	B
10	killed by animals	10732	0.7711	98.029	C
11	Deaths Of Women During Pregnancy	7576	0.5444	98.573	C
12	Factory/Machine Accidents	4890	0.3513	98.924	C
13	Drug Over Dose	4653	0.3343	99.259	C
14	Deaths Due to consumption of poisonous liquor	4515	0.3244	99.583	C
15	Accidental Explosion	3291	0.2365	99.820	C
16	Firearm	1834	0.1318	99.951	C
17	Mines Or Quarry Disastar	497	0.0357	99.987	C
18	Stampede	181	0.0130	100	C
	TOTAL	1391706			

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue IV, April 2026



The classification of unnatural causes into different categories is presented in the table.

Interpretation

- Category A contributes most
- Useful for prioritization

ANOVA Analysis

ANOVA is applied to test whether there are significant differences among various unnatural causes across years.

A-Category

ANOVA Table							
Factor	SS	DF	Ms	F		P-Value	F(0.05)
A (Columns)	4741988614	3	1580662871	39.02352957	*** (P<=0.001)	4.38E-08	3.1599076
B (Rows)	668231730.9	6	111371955.1	2.749559608	* (P<=0.05)	0.04471	2.6613045
Error	729096829.4	18	40505379.41				
Total	6139317174	27					

B-Category

ANOVA Table							
Factor	SS	DF	Ms	F		P-Value	F(0.05)
A (Columns)	2112913720	4	528228429.9	490.3529569	*** (P<=0.001)	1.25E-22	2.7762893
B (Rows)	5868448.4	6	978074.7333	0.907944008	Not Significant (P>0.05)	0.5058	2.5081888
Error	25853789.89	24	1077241.245				
Total	2144635958	34					

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue IV, April 2026

C-Category

ANOVA Table							
Factor	SS	DF	Ms	F		P-Value	F(0.05)
A (Columns)	13017833.43	8	1627229.179	59.19677925	*** (P<=0.001)	3.02E-22	2.1382288
B (Rows)	242437.4921	6	40406.24868	1.469934177	Not Significant (P>0.05)	0.2086	2.2946013
Error	1319446.794	48	27488.47487				
Total	14579717.71	62					

The ANOVA results for unnatural causes are presented in the table.

Interpretation

- For **A, B, and C categories**, causes show **highly significant differences ($p \leq 0.001$)**
- Years are mostly **not significant**

This means variation is mainly due to **type of cause, not year**

Tukey Test

Tukey test is used to identify the specific pairs of unnatural causes that differ significantly after ANOVA.

A-Category

ANOVA					
CASES					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4742008653.672	3	1580669551.224	27.149	.000
Within Groups	1397334981.580	24	58222290.899		
Total	6139343635.252	27			

B-Category

ANOVA					
CASES					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2112936589.036	4	528234147.259	499.506	.000
Within Groups	31725387.260	30	1057512.909		
Total	2144661976.296	34			

C-Category

ANOVA					
CASES					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13016734.516	8	1627091.814	56.243	.000
Within Groups	1562206.720	54	28929.754		
Total	14578941.236	62			

The pairwise comparison results are shown in the table.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue IV, April 2026

Interpretation

- For **A category**, most pairs show **significant differences** (e.g., Sudden Deaths vs others)
- For **B category**, all causes show **significant differences**
- For **C category**, many pairs are also significant This indicates strong variation between causes

CONCLUSION

The present study analyzes accidental deaths in India by classifying them into natural and unnatural causes over the period 2019–2025. The analysis using descriptive statistics shows that a few causes contribute more significantly to the total number of deaths.

The ABC analysis indicates that category A causes such as lightning and other causes dominate the total deaths, while category C causes contribute very less. The t-test results reveal that there is a significant difference between selected groups of natural causes.

Further, ANOVA results show that there is a significant difference among accident causes and across years. The Tukey test confirms that specific causes differ significantly from others.

Thus, it is concluded that accidental deaths are not uniformly distributed and are influenced by both environmental and human-related factors.

Suggestions

- Proper awareness programs should be conducted to reduce accidental deaths.
- Effective disaster management systems should be implemented for natural causes.
- Safety measures should be improved in workplaces and public areas.
- Government should take necessary steps to control major causes of accidents.
- Regular monitoring and statistical analysis should be carried out for better planning.

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