



Original Article

Autopsy-Based Evaluation of Sudden Natural Death at a Tertiary Care Centre in Central India

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ABSTRACT

Introduction: The World Health Organization recognizes sudden death as a major public health problem and recommends standardized definitions and accurate mortality reporting for better understanding of its epidemiology. In clinical and forensic practice, sudden death is generally considered to occur within one hour of symptom onset in witnessed cases or within 24 hours after the individual was last seen alive and symptom-free in unwitnessed cases. [2]

Materials And Methods: This prospective observational cross-sectional study was conducted in the Department of Forensic Medicine and Toxicology, Gandhi Medical College, Bhopal, Madhya Pradesh, India, over a period of 18 months (2024–2025) after obtaining approval from the Institutional Ethics Committee. Gandhi Medical College is a tertiary care referral centre catering to Bhopal and surrounding districts, receiving a large number of medico-legal autopsy cases referred by police and judicial authorities.

Results: A total of 385 sudden death cases subjected to medico-legal autopsy at Gandhi Medical College, Bhopal, were included in the study. The majority of the deceased were males (80.0%), with a male-to-female ratio of 4.9:1. The mean age was 48.5 years, and the largest proportion of cases was in the 50–59-year age group. Most cases were brought dead to the hospital (75.3%).

Conclusion: Cardiovascular disease was the leading cause of sudden natural death, predominantly affecting middle-aged and elderly males. Smoking and lower socioeconomic status were significantly associated with the underlying cause of death. The findings highlight the importance of meticulous medicolegal autopsy in accurately determining the cause of death and emphasize the need for effective cardiovascular risk reduction and tobacco-control measures to reduce preventable sudden natural death

Keywords: Sudden Death, Cardiovascular Disease, Medico-legal Autopsy, Risk Factors, Tobacco Smoking.

INTRODUCTION

Sudden natural death (SND) is one of the most challenging entities encountered in forensic medicine. It is defined as an unexpected death resulting from natural causes that occurs within a short period after the onset of symptoms in an individual who was apparently healthy or whose underlying illness was not considered immediately life-threatening. Such deaths often raise medicolegal concerns because of their abrupt and unexplained nature, making a comprehensive postmortem examination essential to establish the precise cause of death, exclude foul play, and ensure accurate death certification. Autopsy remains the gold standard for determining the pathological basis of sudden death and contributes significantly to epidemiological surveillance, medicolegal investigation, and public health planning. [1]

The World Health Organization recognizes sudden death as a major public health problem and recommends standardized definitions and accurate mortality reporting for better understanding of its epidemiology. In clinical and forensic practice,

sudden death is generally considered to occur within one hour of symptom onset in witnessed cases or within 24 hours after the individual was last seen alive and symptom-free in unwitnessed cases. [2]

Cardiovascular diseases are responsible for the majority of sudden natural deaths worldwide. Coronary artery disease, acute myocardial infarction, cardiomyopathies, myocarditis, and fatal cardiac arrhythmias constitute the principal pathological substrates identified during autopsy. However, several non-cardiac disorders, including cerebrovascular accidents, pulmonary embolism, respiratory diseases, gastrointestinal catastrophes, and endocrine emergencies, may also result in sudden unexpected death, highlighting the importance of meticulous clinicopathological evaluation. [3]

The pathophysiological mechanism of sudden cardiac death usually involves fatal ventricular arrhythmias developing in the presence of structural or functional myocardial abnormalities. Coronary atherosclerosis, plaque rupture, myocardial fibrosis, ventricular remodeling, and myocardial ischemia create an arrhythmogenic substrate that predisposes affected individuals to ventricular tachycardia or ventricular fibrillation. Recognition of these pathological alterations during autopsy has substantially improved the understanding of sudden cardiac death and remains fundamental to forensic diagnosis. [4]

Although sudden natural death predominantly affects middle-aged and elderly individuals, increasing numbers of deaths are being recognized among younger adults. Careful autopsy and histopathological examination have demonstrated that inherited cardiomyopathies, myocarditis, congenital coronary artery anomalies, and abnormalities of the cardiac conduction system may be responsible for sudden death even in individuals with an apparently normal heart on gross examination. [5]

Despite significant advances in cardiovascular medicine, sudden cardiac death continues to be a major cause of premature mortality worldwide. Identification of individuals at high risk remains challenging because many victims have no previous diagnosis of significant cardiovascular disease. Consequently, medicolegal autopsy continues to play a pivotal role in identifying pathological substrates, improving disease surveillance, and guiding preventive strategies. [6,7]

Autopsy-based studies from India have consistently demonstrated a marked male predominance and cardiovascular pathology as the leading cause of sudden natural death. Most cases occur during the fifth and sixth decades of life; however, recent evidence indicates an increasing burden of sudden death among younger individuals due to inherited cardiac disorders and other non-atherosclerotic cardiovascular diseases. These observations emphasize the need for comprehensive regional data to better understand demographic and pathological variations. [8–10]

Recent advances in molecular pathology have introduced molecular autopsy as an important adjunct to conventional postmortem examination. Postmortem genetic analysis can identify inherited channelopathies and cardiomyopathies in cases with structurally normal hearts, thereby facilitating screening of surviving family members and enabling preventive interventions. Integration of conventional autopsy with molecular techniques has therefore enhanced the diagnostic accuracy of sudden unexplained deaths and expanded the role of forensic pathology in preventive medicine. [11–14]

Despite the increasing burden of sudden natural death in India, comprehensive autopsy-based data from Central India remain limited. Regional differences in demographic characteristics, socioeconomic status, occupational exposure, lifestyle factors, and healthcare accessibility may influence the epidemiological profile and pathological spectrum of sudden natural death. Therefore, the present study was undertaken to evaluate the clinicopathological profile and causes of sudden natural death among medicolegal autopsy cases at a tertiary care centre in Central India, with the aim of generating region-specific evidence to strengthen forensic practice and contribute to preventive public health strategies.

MATERIALS AND METHODS

This prospective observational cross-sectional study was conducted in the Department of Forensic Medicine and Toxicology, Gandhi Medical College, Bhopal, Madhya Pradesh, India, over a period of 18 months (2024–2025) after obtaining approval from the Institutional Ethics Committee. Gandhi Medical College is a tertiary care referral centre catering to Bhopal and surrounding districts, receiving a large number of medico-legal autopsy cases referred by police and judicial authorities.

The study included all consecutive cases of sudden natural death brought for medico-legal autopsy during the study period. Sudden natural death was defined as an unexpected death due to natural causes occurring within 24 hours of the onset of terminal symptoms. Individuals of all age groups and both sexes fulfilling the operational definition of sudden natural death were included. Cases of traumatic death, poisoning, suicide, accidental deaths, deaths due to external causes, and cases in which adequate postmortem examination could not establish the cause of death were excluded from the study.

A consecutive sampling technique was employed, and all eligible cases were enrolled without any predetermined sample size limit. During the study period, a total of 385 autopsy-confirmed cases of sudden natural death fulfilled the eligibility criteria and constituted the final study population.

Data were collected using a structured, predesigned proforma. Demographic variables including age, sex, occupation, and socioeconomic status were recorded. Clinical information, past medical history, lifestyle factors such as smoking and tobacco use, circumstances surrounding death, and available hospital records were reviewed whenever available. Socioeconomic status was assessed using the Modified Kuppuswamy Scale.

A complete medico-legal autopsy was performed in each case in accordance with standard forensic autopsy protocols. Detailed external and internal examinations were undertaken, and gross pathological findings of all major organ systems were documented. Representative tissue samples from organs demonstrating gross pathological changes were preserved for histopathological examination whenever indicated. Ancillary investigations, including toxicological analysis, were performed whenever necessary to exclude non-natural causes before assigning the final cause of death. The final diagnosis was established after correlation of clinical history, police inquest findings, gross autopsy findings, histopathological examination, and other relevant laboratory investigations, where available.

The primary outcome measure was the determination of the cause of sudden natural death based on autopsy findings. Secondary outcome measures included the demographic profile, clinicopathological characteristics, occupational status, socioeconomic status, smoking history, and seasonal distribution of sudden natural death cases.

The collected data were entered into Microsoft Excel and analysed using Jamovi software (Version 2.6). Continuous variables were expressed as mean $\pm$ standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. Associations between categorical variables were analysed using the Chi-square test or Fisher's exact test, wherever appropriate. A two-tailed p-value <0.05 was considered statistically significant.

RESULTS

A total of 385 sudden death cases subjected to medico-legal autopsy at Gandhi Medical College, Bhopal, were included in the study. The majority of the deceased were males (80.0%), with a male-to-female ratio of 4.9:1. The mean age was 48.5 years, and the largest proportion of cases was in the 50–59-year age group. Most cases were brought dead to the hospital (75.3%).

Table 1. Baseline characteristics of the study population (N = 385)

Variable	n (%)
Male	308 (80.0)
Female	77 (20.0)
Mean age (years)	48.5
Peak age group (50–59 years)	85 (22.1)
History of smoking/tobacco use	134 (34.8)
Brought dead	290 (75.3)

Heart failure was the predominant cause of sudden death, accounting for 81.0% of all cases. Aspiration was the second most common cause (13.2%), whereas cerebral damage, cardiac tamponade, pulmonary thromboembolism, postpartum haemorrhage, and laryngeal oedema were infrequent. In 3.6% of cases, the cause of death could not be established.

Table 2. Distribution of causes of sudden death

Cause of death	n (%)
Heart failure	312 (81.0)
Aspiration	51 (13.2)
Cerebral damage	3 (0.8)
Cardiac tamponade	2 (0.5)
Pulmonary thromboembolism	1 (0.3)
Postpartum haemorrhage	1 (0.3)
Laryngeal oedema	1 (0.3)
Undetermined	14 (3.6)

A clear seasonal variation was observed. The highest number of sudden deaths occurred during the monsoon season (35.8%), with September recording the maximum number of cases (14.3%). Cardiovascular deaths showed a similar monsoon predominance. Statistical analysis demonstrated a significant association between smoking history and cause of death ($p = 0.001$) as well as between socioeconomic status and cause of death ($p < 0.001$). However, the monthly variation in cause-specific mortality was not statistically significant ($p = 0.53$).

Table 3. Important epidemiological and statistical findings

Variable	Finding
Peak month	September (14.3%)

Peak season	Monsoon (35.8%)
Smoking vs cause of death	Significant (p = 0.001)
Socioeconomic status vs cause of death	Significant (p < 0.001)
Monthly variation in causes of death	Not significant (p = 0.53)

DISCUSSION

The present autopsy-based study provides a comprehensive overview of the epidemiological and pathological profile of sudden natural deaths in Central India. A clear male predominance, peak incidence in the fifth and sixth decades of life, overwhelming cardiovascular involvement, and significant associations of smoking and socioeconomic status with the cause of death were observed. These findings highlight the importance of medicolegal autopsy not only in determining the exact cause of death but also in identifying regional epidemiological patterns that may contribute to preventive public health strategies.

The present study demonstrated a marked male predominance, with males accounting for 80% of all sudden natural deaths. This observation is consistent with previous autopsy-based studies, suggesting that men are disproportionately affected by sudden natural death because of a higher prevalence of smoking, hypertension, occupational stress, and other cardiovascular risk factors. Bhagora et al. reported a similar male predominance in medico-legal autopsy cases, emphasizing that behavioural and lifestyle-related risk factors contribute substantially to this difference. Belay et al. also observed that males constituted the majority of sudden natural deaths in their series, while Rathva and Bhoot reported comparable findings in a tertiary care hospital in western India. These observations indicate that male predominance is a consistent epidemiological characteristic across different regions of India and neighbouring countries. [15–17]

Age distribution in the present study showed that the highest number of deaths occurred between 50 and 59 years, followed by the 60–69-year age group. This pattern reflects the cumulative effect of long-standing cardiovascular risk factors, including hypertension, diabetes mellitus, tobacco use, and atherosclerosis. Rao et al. similarly reported that the majority of sudden cardiac deaths occurred during the fifth and sixth decades of life, whereas Mehdi et al. also identified middle-aged adults as the most vulnerable population. In contrast, Jain et al. observed a relatively greater proportion of sudden deaths among younger adults, suggesting an increasing burden of premature cardiovascular mortality in India. The difference may be explained by variation in study population, referral patterns, and the increasing prevalence of metabolic disorders among younger individuals. [18–20]

Cardiovascular disease was the predominant cause of sudden death in the present study, accounting for more than four-fifths of all cases. This finding is in agreement with several national and international autopsy studies, confirming that coronary artery disease and its complications remain the principal pathological substrates of sudden natural death. Daş and Buğra demonstrated that nearly 88% of sudden deaths among young adults were cardiac in origin, with atherosclerotic coronary artery disease being the leading pathology. Similarly, Bhagora et al. and Belay et al. reported cardiovascular disease as the commonest cause of sudden natural death in their respective studies. The predominance of cardiovascular pathology observed in the present study further emphasizes the importance of meticulous examination of the coronary arteries and myocardium during medico-legal autopsy. [21–23]

Although cardiovascular causes predominated, aspiration represented the second most frequent cause of sudden death, while pulmonary thromboembolism, cerebral pathology, cardiac tamponade, and postpartum haemorrhage accounted for only a small proportion of cases. Similar observations have been reported by Rathva and Bhoot, who highlighted the contribution of respiratory, gastrointestinal, and neurological disorders to sudden natural death. Jain et al. also reported that non-cardiac causes constituted an important minority of sudden deaths, supporting the need for systematic examination of all organ systems during autopsy rather than restricting the investigation to the cardiovascular system alone. [17,20]

An interesting finding of the present study was the distinct seasonal variation, with the highest number of deaths occurring during the monsoon season and a peak in September. This differs from observations reported from Europe and other temperate countries, where cardiovascular deaths commonly peak during winter. Zheng et al. demonstrated a winter predominance of cardiovascular mortality in China, whereas the monsoon peak observed in the present study may reflect the combined influence of high humidity, increased physical exertion during agricultural activities, dehydration, and environmental stress. These findings indicate that climatic and occupational factors unique to Central India may influence the temporal pattern of sudden natural death. [24]

Smoking showed a statistically significant association with the cause of death in the present study, with cardiovascular deaths occurring more frequently among smokers. Tobacco is a well-established contributor to endothelial dysfunction, accelerated atherosclerosis, thrombosis, and fatal ventricular arrhythmias. Similarly, Marijon et al. highlighted tobacco use as one of the most important modifiable risk factors for sudden cardiac death and emphasized the importance of population-based preventive strategies aimed at reducing cardiovascular mortality. [25]

Socioeconomic status was also significantly associated with the cause of death. Individuals belonging to lower socioeconomic groups demonstrated a greater burden of aspiration-related deaths and cardiovascular mortality. This may be explained by reduced healthcare access, delayed diagnosis of chronic diseases, poor nutritional status, and increased occupational exposure. Similar observations have been reported in recent Indian studies evaluating sudden natural deaths in tertiary care settings. [26]

The major strength of the present study lies in its prospective design, relatively large sample size, and comprehensive autopsy-based evaluation performed at a major referral centre in Central India. The inclusion of demographic, occupational, lifestyle, seasonal, and pathological variables provides a broader understanding of sudden natural death than studies limited solely to pathological findings. However, the study was conducted at a single centre, and molecular autopsy was unavailable for unexplained cases, which may have limited the identification of inherited arrhythmogenic disorders. Future multicentric studies incorporating postmortem genetic analysis may further improve the understanding of sudden unexplained deaths. [27–30]

Overall, the findings of the present study reaffirm that cardiovascular disease remains the leading cause of sudden natural death in Central India while highlighting the significant influence of smoking, socioeconomic factors, and seasonal variation. These observations support the need for early cardiovascular risk assessment, tobacco-control measures, improved emergency healthcare services, and continued strengthening of medicolegal autopsy services to reduce preventable premature mortality.

CONCLUSION

Cardiovascular disease was the leading cause of sudden natural death, predominantly affecting middle-aged and elderly males. Smoking and lower socioeconomic status were significantly associated with the underlying cause of death. The findings highlight the importance of meticulous medicolegal autopsy in accurately determining the cause of death and emphasize the need for effective cardiovascular risk reduction and tobacco-control measures to reduce preventable sudden natural death

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