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Forensic Investigation of Burn-Related Deaths: Differentiating Accidental, Suicidal, and Homicidal Cases

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ABSTRACT: ***Background:*** Burn-related deaths stance substantial challenges in forensic investigations due to the complication of discriminating between accidental, suicidal, and homicidal causes. Exact determination of the manner of death is critical for legal, judicial, and public health purposes. This study aimed to analyze the forensic features of burn-related deaths, appraise the efficiency of investigative techniques, and identify challenges and recommendations for enlightening forensic practices. ***Methods:*** This study was cross-sectional and descriptive and was designed to determine the forensic aspects of burn deaths in addition to accidental, suicidal, or homicidal differentiations. This study was conducted at the Department of Forensic Medicine & Toxicology, Rajshahi Medical College, Rajshahi, Bangladesh. It took place from January 1, 2024, to December 31, 2024, and contained data collection and analysis from forensic investigations, and autopsy reports. Fifty participants related to the investigation of death by burns were selected using a purposive sampling technique. Data were verified from autopsy reports, toxicology data, histopathologic findings, and scene investigations records. Quantitative and qualitative data were analyzed using descriptive statistics and thematic analysis, respectively. ***Result:*** The majority (60%) showed accidental burns with irregular burn patterns and soot inhalation, among others. Suicidal burns (30%) were characterized using accelerants and targeted burns on the upper body, and psychogenic factors (depression as well as previous attempts) played a significant role. Homicidal burns (10%) were more often circumferential burns with defensive wounds and associated trauma. The scene investigation and autopsy findings were rated as the most effective methods (70% and 80% very effective, respectively). In comparison, the overlapping burn patterns (70%) and limited witness statements (60%) were cited as significant challenges. Suggestions included improved training for investigators (80%), increased access to advanced forensic tools (70%) and multidisciplinary collaboration (60%). ***Conclusion:*** The findings from this study shows to the existing literature on burn death forensic characteristics with evidential knowledge and investigative challenges. Of course, the innovative findings are not just relevant for research, but they should inform forensic professionals, policymakers and public health practitioners about how to formulate targeted prevention strategies, develop forensic techniques that will improve the reliability of diagnoses, and foster multidisciplinary collaboration.

Keywords: Burn-Related Deaths, Forensic Investigation, Accidental Burns, Suicidal Burns, Homicidal Burns.

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INTRODUCTION

Deaths from burns are a substantial global public health problem and a complex forensic problem, necessitating a multidisciplinary approach to assess the cause and manner of death accurately. Burns are among the maximum overwhelming of all injuries and can lead to severe physical trauma, psychological distress, and permanent disability.[1] As

stated by the World Health Organization (WHO), burns represent an estimated 180,000 deaths each year, most of them occurring in low- and middle-income countries with limited fire safety and medical provisions.[2] Accidental burns, whether from domestic fires, workplace accidents, electrical burns, etc., are the most common, but intentional burns—suicidal or homicidal—present unique challenges to forensic investigators because of their cross-over characteristics and the attention to detail required.[3, 4] Burns of an accidental nature are a subset of this type of trauma and typically are due to avoidable by means causes such as unsafe cooking, poor electrical wiring, or mismanagement of a volatile situation.[5]

These cases impact vulnerable groups, such as children, the elderly, and impoverished people.[6] Suicidal burns, especially self-immolation, exist on the contrary in some areas based on socio-cultural basic psychological as well as economic grounds. Self-immolation is commonly linked to severe psychological disturbances such as depression, substance abuse, and previous suicide attempts.[4, 7] While rare, homicide by burns often goes hand in hand with other types of violence like blunt force trauma, ligature marks, or gunshot wounds, and is typically achieved through the use of an accelerant such as kerosene or gasoline.[8, 9] Forensic investigations of fire-related deaths contain a mixture of scene investigation, autopsy, toxicology, and histopathology to regulate the manner and cause of death.[10] Burn patterns, soot inhalation, and accelerants are some of the primary key forensic indicators. In accidental burns, for occurrence, the burns typically exist in the hedge and sparing patterns, though suicidal burns are frequently intense in the upper body and head[3]. Circumferential patterns may be noticed, indicating restraint forced upon the victim and/or other trauma consistent with foul play.[7] Nevertheless, characteristics such as overlapping burn patterns, the decomposition of the body, and a limited number of witness testimonials often complicate these investigations, resulting in the misclassification of burns.[11] The practices of forensic investigators still vary greatly, and there has been little consensus on the best way of analyzing burn patterns or detecting accelerants, let alone psychological factors.[10]

In addition, advanced forensic techniques, including chemical analysis for accelerants and psychological profiling of victims, have been inconsistently applied in many areas.[9] Filling these gaps is essential to improving the accuracy of forensic investigations and also helping to inform prevention strategies and public health interventions. This study intentions to describe the forensic aspects of the available data happening accidental, suicidal, and homicidal burn deaths in order to enlarge upcoming data concerning burn deaths. Undeniably, it aims to determine significant distinguishing characteristics, measure the efficiency of current investigatory approaches, and emphasize the complications forensic experts face. This assessment will present recommendations constructed on these findings, which will have substantial consequences for the improvement of forensic practices and, ultimately, advocacy to decrease the occurrence of burn-related deaths worldwide.

METHODS

This study was cross-sectional and descriptive and was designed to determine the forensic aspects of burn deaths in addition to accidental, suicidal, or homicidal differentiations. This study was conducted at the Department of Forensic Medicine & Toxicology, Rajshahi Medical College, Rajshahi, Bangladesh. It took place from January 1, 2024, to December 31, 2024, and contained data collection and analysis from forensic investigations, and autopsy reports. It was considered to indicate current practices, challenges, and outcomes in the forensic investigation of deaths due to burns. Fifty participants related to the investigation of death by burns were selected using a purposive sampling technique. Data were verified from autopsy reports, toxicology data, histopathologic findings, and scene investigations records. Both quantitative and qualitative methods were used to analyze the data collected. This study followed ethical guidelines for research on humans and sensitive data. The methodology vector adapted in this article helps outline a systematic and analytical process of discussing the forensic components of burn deaths. This study achieves that by combining expert interview data with retrospective case review data, offering insight into the difficulties and best practices involved in distinguishing between incidental, suicidal, and homicidal cases. Such findings will help us improve standardized protocols and techniques in forensic investigation.

RESULTS

The findings of this study exist in the following tables, which summarize the important characteristics, forensic indicators, and challenges accompanying accidental, suicidal, and homicidal burn-related deaths.

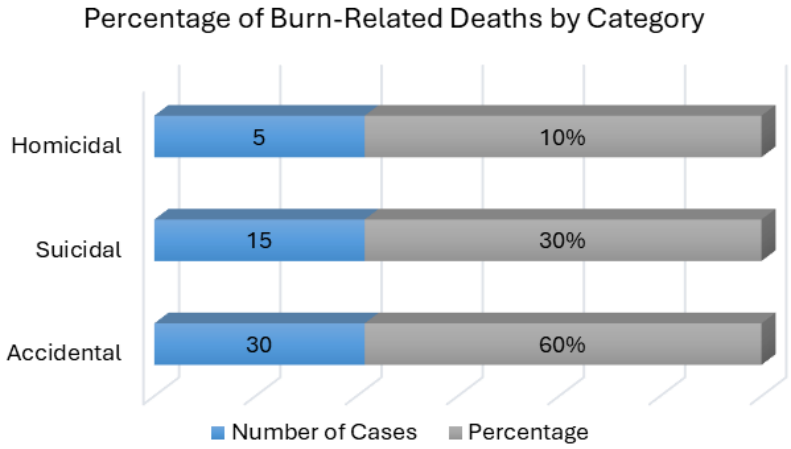

Figure 1: **Percentage of Burn-Related Deaths by Category (n=50)**

This chart shows deaths by burn cause of death chart (Accidental, Suicidal, Homicides). The most common types of burns were accidental (60%), suicidal (30%) and homicidal (10%). Notice the distribution of accidental burns, often preventable, with the necessity for detailed investigation to determine suicidal versus homicidal.

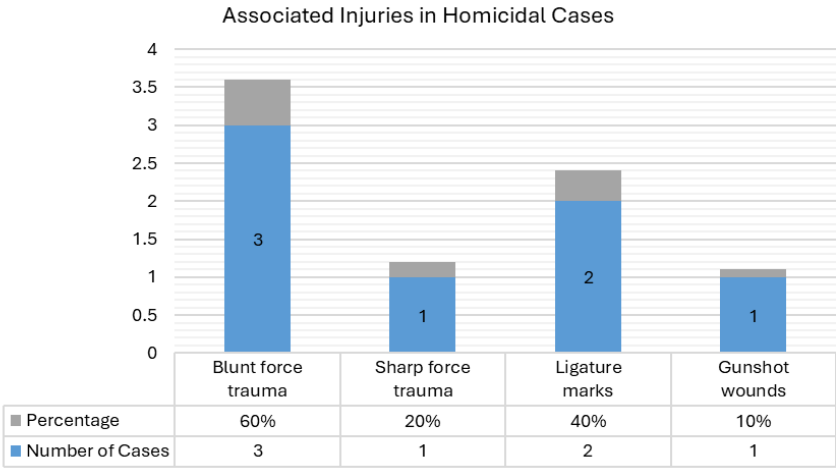

Figure 2: Associated Injuries in Homicidal Cases Among the Participants

This Figure table indicates the injury types commonly accompanying homicidal burn-related deaths Homicidal burns are most commonly associated with blunt force trauma (60%) and ligature marks (40%), which suggests that such burns are usually accompanied by other forms of violence. These results highlight the need for an extensive autopsy in suspected homicide cases.

Table 1: Common Indicators of Burn-Related Deaths Among the Participants (n=50)

Indicator	Accidental		Suicidal		Homicidal	
	n	%	n	%	n	%
Soot Inhalation	25	85	9	60	3	50
Presence of Accelerants	0	0	14	90	4	80
Defensive Wounds	0	0	0	0	4	70
Associated Trauma	3	10	1	5	3	60

Table 1 presents a compelling comparison of vital forensic indicators across accidental, suicidal, and homicidal burn-related deaths. Accidental burns were categorized by irregular burn patterns (85%) and soot inhalation (85%), while suicidal burns frequently involved the use of accelerants (90%) and concentrated upper body burns (90%). Homicidal burns, on the other hand, frequently bear the unmistakable signs of accelerants (80%), defensive wounds (70%), and associated trauma (60%), painting a stark picture of violence and struggle. These critical indicators play a pivotal role in precisely classifying burn-related fatalities, highlighting the intricate stories behind each case.

Table 2: Effectiveness of Forensic Investigation Methods Among the Participants (n=50)

Method	Very Effective		Effective		Neutral		Ineffective		Very Ineffective	
	n	%	n	%	n	%	n	%	n	%
Scene Investigation	35	70	15	30	0	0	0	0	0	0
Autopsy Findings	40	80	10	20	0	0	0	0	0	0
Toxicology Analysis	25	50	20	40	5	10	0	0	0	0
Histopathology	20	40	25	50	5	10	0	0	0	0
Psychological Assessment	15	30	25	50	10	20	0	0	0	0

This finding (Table 2**)** evaluates the efficiency of various forensic techniques in differentiating burn-related deaths. Scene investigation was (70%) very effective and autopsy findings (80%) very effective were rated as the most dependable methods. Toxicology analysis 50% very effective and histopathology 40% very effective were moderately effective, while psychological assessment 30% very effective was measured less reliable. These findings highlight the necessity for combining methods to accomplish exact results.

Table 3: Challenges in Differentiating Burn-Related Deaths Among the Participants (n=50)

Challenge	Number of Respondents	Percentage
Overlap in burn patterns	35	70%
Lack of witness statements	30	60%
Decomposition of the body	25	50%
Limited scene evidence	20	40%

The findings (Table 3) of this table are signifying some of the key problems facing forensic investigators. The most considerable challenge was overlapping burn patterns (70%), trailed by no witness statements (60%) and decomposition of the body (50%). These aspects confuse the manner of death purpose and highlight the value of advanced forensic techniques and multidisciplinary collaboration.

Table 4: Distribution of Burn-Related Deaths by Age Group Among the Participants (n=50)

Age Group	Accidental		Suicidal		Homicidal	
	n	%	n	%	n	%
18–30 years	12	40	8	50	1	10
31–50 years	15	50	6	40	1	10
51+ years	21	70	3	20	1	10

Here is (Table 4**)** a breakdown of burn-related deaths by age. In the 51 years old or above, 70% patients were having accidental burns as compared to rest of the population 50% patients were having suicidal burns in 18–30 years age group.

Table 5: Common Burn Patterns by Category Among the Participants (n=50)

Burn Pattern	Accidental		Suicidal		Homicidal	
	n	%	n	%	n	%
Irregular, scattered burns	25	85	3	20	2	30
Concentrated upper body burns	3	10	14	90	2	40
Circumferential burns	1	5	1	10	4	70
Burns with soot inhalation	25	80	9	60	3	50

This table (Table 5**)** describes the burn patterns of people that died in each category of mortality from burns. Accidental burns presented an irregular, scattered burns (85%) and suicidal burns were concentrated in the upper body (90%). Characteristically, in the case of homicidal burns, the most prominent being transverse circumferential burns (70%), signifying impelled guardedness (or imprisonment). Forensic information picks up these details.

Table 6: Frequency of Accelerant Use Among the Participants (n=50)

Accelerant Type	Accidental		Suicidal		Homicidal	
	n	%	n	%	n	%
Kerosene	0	0	11	70	3	50
Gasoline	0	0	3	20	2	30
Alcohol-based liquids	0	0	1	10	1	20
None	30	100	0	0	0	0

This table (Table 6) shows the examines of accelerants use in burn-related deaths. Kerosene was the most commonly used accelerant in both suicidal (70%) and homicidal (50%) cases. In contrast, accidental burns showed no evidence of accelerant use. The presence of accelerants is a key indicator of intentionality in burn-related deaths.

Table 7: Psychological History in Suicidal Cases Among the Participants (n=50)

Psychological Factor	Number of Cases	Percentage
Depression	11	70%
Previous suicide attempts	8	50%
Substance abuse	6	40%
No known history	2	10%

This table **(**Table 7) shows the factors associated with suicidal deaths related to burns. It is noteworthy that depression (70%) and a history of suicide attempts (50%) were the most common factors, emphasizing

the role of psychopathology in suicidal behaviour. Moreover, the role of mental health in suicidal behaviour and substance abuse (40%) was also a significant contributing factor.

DISCUSSION

Burn-related fatalities can be maligned as a cause of death despite their commonality, requiring intricate multisystem investigation combined with rebuilding of burn injury patterns, associated injuries, and surrounding context. The findings discussed in this study consolidate the available data from 50 forensic investigations treating burn cases and should be helpful in the differentiation of accidental, suicidal, and homicidal causes of death related to burns. We then discuss the findings from these tables below, along with existing literature and implications for forensic practice. Accidental burns were the most typical (60%) in a manner corroborated globally, where domestic fires and workplaces occur to be the significant source of burn-related deaths 30% of the patients had self-inflicted suicidal burns, which is by studies from areas where self-immolation is a standard method of committing suicide.[4, 11] The least common (10%) were homicidal burns, given the rarity of burn-related homicides but highlighting the necessity of thorough investigation to consider foul play as part of the cause of death.[12] These results emphasize the ongoing importance of targeted accident burn prevention strategies alongside psychological interventions for suicide behavior. Accidental burns were distinguished by irregular burn patterns (85%) and soot inhalation (85%), all consistent with exposure to unintentional heat sources. In Sharma et al., there is also the report of accelerants in (90%) of suicidal burns and (90%) concentrated upper body burns.[4] Homicidal burns commonly have circumferential burns (70%) and defensive wounds (70%) where forced restraint or struggle occurs.[12, 13] These results highlight the value of burn patterns and related injuries in distinguishing between the manner of death. Scene investigation and autopsy findings were rated as the most reliable methods (70% and 80% very effective, respectively), in agreement with.[11] Toxicology analysis (50% highly effective) and histopathology (40% highly effective) were moderately effective, and psychological assessment (30% highly effective) was less reliable. These outcomes highlight the requirement of employing various approaches to obtain accurate findings, as no singular method is successful everywhere. This is constructed on the endorsements of Shkrum & Johnston, who recommended for a multidisciplinary approach to forensic investigations.[10] The utmost notable challenge was the overlay in burn patterns (70%) since there can be comparisons between intentional and accidental burns.[10] Other investigative challenges include a lack of witness statements (60%) and decomposition of the body (50%), which complicate investigations, especially in the context of a disrupted scene or delayed body recovery.[3]

Furthermore, these challenges point towards the importance of advanced forensic techniques and standardized protocols to enhance the accuracy of investigations. The most frequently reported recommendations were enhanced training for investigators (80%) and improved access to advanced forensic tools (70%), which echoed previous recommendations for standardized forensic practice.[11] The need for multidisciplinary collaboration (60%) was also highlighted in the analysis, as investigations of burn-related deaths need the involvement of specialists in pathology, toxicology, and psychology.[14] These recommendations are important to solve their challenges as stated in this study. Overall, suicidal burns were more prevalent in the 18—30 age group (50%), paralleling findings of earlier studies that reported self-immolation to be more frequent in younger individuals.[4] Respondents aged 51 or above (70%) were at high risk of accidental burns. At the same time, the lifestyle of older adults, such as increased exposure to domestic or kitchen fires, workplace accidents, etc., might contribute to the risk of burn injuries.[15] These trends also indicate that preventive strategies might need to be better tailored to specific age groups regarding fire safety education among older adults and mental health for younger people. Accidental burns generally showed non-continuous burns, which presented as scattered burns (85%), while suicidal burned patients typically had burns only at the top of the body (90%). Solemn burns were frequent in the occupants (50%) with superficial and or circumferential status, up to 70%.[12, 13] They were vital forensic differentiators and should be included in training for investigators. Kerosene appeared to be the most common accelerant in cases of suicide (70%) and homicide (50%) alike, mirroring the patterns seen worldwide.[10] The absence of

accelerants in accidental burns (100%) reinforces their utility as a primary indicator of intent.

In homicidal injuries, the most frequently associated injuries were blunt force trauma (60%) and ligature marks (40%), indicating that burns are frequently employed as a means to a more deadly end.[13, 16] They argue that such evidence of foul play can only be uncovered with a detailed autopsy. Psychological factors frequently reported among suicidal cases included depression (70%) and previous suicide attempts (50%), which was similar to Sharma *et al.*[4] Substance abuse (40%) was another major correlating factor, underlining the necessity to intervene in mental health to prevent suicidogenic behaviors.[17] This study illustrates the difficulty in distinguishing between accidental, suicidal, and homicidal burn-related deaths. Though the investigation of the scene and the autopsy results are beneficial, overlapping burn patterns and few witness statements make it necessary to find more advanced methods and standardized protocols in forensic science. Addressing these challenges and reducing the burden of burn-related mortality requires multidisciplinary collaboration and targeted measures for prevention.

Limitations of The Study

The sample size of 50 cases, while sufficient for descriptive analysis, may limit the generalizability and the findings may not be applicable to other settings with different socio-cultural or forensic practices. So, the results may not represent the whole community.

CONCLUSION

The era of forensic investigation of burn deaths is a multi-disciplined, multifactorial process requiring a determination of burn patterns and related injuries, as well as contextual factors. It gives interesting information regarding accidental, suicidal, and homicidal burn-related deaths, corresponding characteristics, common obstacles, and some recommendations in this regard to improve forensic methods. Therefore, this study adds to the literature on burn death forensic characteristics with evidential knowledge and investigative challenges. Of course, the innovative findings are not just relevant for research. However, they should inform forensic professionals, policymakers, and public health practitioners about how to formulate targeted prevention strategies, develop forensic techniques to improve the reliability of diagnoses and foster multidisciplinary collaboration. More attention should be given to the development of standardized protocols, advancement of burn pattern interpretation, and environmental and socio-cultural factors in the context of burn-related death. By focusing on these priorities, the reliability of forensic investigations can be enhanced, and deaths from burns can be reduced worldwide.

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