



Medicolegal Investigation of Burn Injury Patterns in Bintan, Indonesia: Implications for Scene Reconstruction and Criminal Prosecution

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A B S T R A C T

Introduction: Burn injuries pose a significant public health challenge in Indonesia, with Bintan being no exception. Medicolegal investigations of burn injuries are critical in determining the cause and manner of death, aiding scene reconstruction, and supporting criminal prosecution when necessary. **Methods:** This retrospective study analyzed 150 medicolegal autopsy reports of burn injury cases from Bintan between 2018 and 2023. Data collected included demographics, burn injury characteristics, cause of death, and circumstances surrounding the incident. Statistical analysis was performed to identify patterns and associations. **Results:** The majority of victims were male (65%), with a mean age of 38 years. Scalds were the most common type of burn (45%), followed by flame burns (35%). Most deaths resulted from complications of burn injuries, such as sepsis and respiratory failure. Scene investigation and witness testimonies were crucial in differentiating between accidental, suicidal, and homicidal burn injuries. **Conclusion:** Medicolegal investigations of burn injuries in Bintan play a vital role in scene reconstruction and criminal prosecution. Understanding the patterns and circumstances surrounding burn injuries can aid in developing preventive strategies and improving the justice system's response to such cases.

1. Introduction

Burn injuries constitute a formidable global health concern, inflicting substantial morbidity and mortality rates across diverse populations. The World Health Organization (WHO) estimates that approximately 180,000 deaths annually are attributable to burn injuries, with the majority of these occurring in low- and middle-income countries (WHO, 2018). The burden of burn injuries extends beyond mortality, encompassing long-term physical and psychological sequelae, economic hardships, and social stigmatization for survivors.^{1,2}

Indonesia, a sprawling archipelago nation with a population exceeding 270 million, grapples with a

significant burden of burn injuries. Epidemiological studies reveal that burn injuries are a leading cause of accidental death and disability in the country, particularly affecting vulnerable groups such as women, children, and the elderly (Anwar et al., 2018). The multifaceted nature of burn injuries necessitates a comprehensive approach to prevention, treatment, and rehabilitation, underpinned by robust medicolegal investigations. Bintan, an island nestled within the Riau Islands province, is not immune to the scourge of burn injuries. Although specific epidemiological data for Bintan remains limited, anecdotal evidence and clinical observations suggest that burn injuries pose a considerable public health challenge in the region. The

geographical isolation of Bintan, coupled with sociocultural factors and potential delays in accessing medical care, can exacerbate the severity and consequences of burn injuries. Medicolegal investigations of burn injuries assume paramount importance in Bintan, as in other parts of Indonesia. These investigations serve to elucidate the cause and manner of death, reconstruct the circumstances surrounding the incident, and provide crucial evidence for potential criminal prosecution. The medicolegal autopsy, a cornerstone of these investigations, entails a meticulous examination of the deceased's remains to ascertain the nature, extent, and severity of burn injuries, along with any associated trauma or underlying medical conditions.³⁻⁵

The interpretation of burn injury patterns holds pivotal significance in medicolegal investigations. Burn patterns can offer valuable clues regarding the type of burn (e.g., scald, flame, contact), the source of heat, the duration of exposure, and the victim's position or movements during the incident. These insights can be instrumental in differentiating between accidental, suicidal, and homicidal burn injuries, thereby aiding in scene reconstruction and the pursuit of justice. Scene reconstruction, a collaborative endeavor involving forensic experts, law enforcement personnel, and medical professionals, strives to recreate the sequence of events leading to the burn injury. This process entails a meticulous examination of the physical scene, collection and analysis of trace evidence, and integration of witness testimonies and other pertinent information. Scene reconstruction can unveil critical details regarding the ignition source, the presence of accelerants, the victim's actions or inactions, and any potential struggle or foul play. In cases where burn injuries are suspected to be the result of criminal activity, medicolegal investigations play a pivotal role in supporting criminal prosecution. The forensic evidence gathered from the autopsy, scene reconstruction, and other ancillary investigations can be presented in court to establish the elements of the crime, identify the perpetrator, and secure a conviction. The pursuit of justice in burn injury cases is essential not only for the victims and their families

but also for deterring future acts of violence and ensuring public safety.⁶⁻⁸

The challenges inherent to medicolegal investigations of burn injuries in Bintan are multifaceted. Limited resources, including inadequate forensic facilities and manpower shortages, can impede the thoroughness and timeliness of investigations. Sociocultural factors, such as stigma associated with burn injuries and reluctance to report cases of domestic violence, can further complicate the investigative process. Additionally, delays in seeking medical care, often due to geographical barriers or financial constraints, can compromise the preservation of evidence and hinder the accurate determination of the cause and manner of death.^{9,10} This study aims to address these challenges by conducting a comprehensive analysis of medicolegal autopsy reports of burn injury cases in Bintan between 2018 and 2023.

2. Methods

This retrospective study meticulously analyzed medicolegal autopsy reports of burn injury cases in Bintan, Indonesia, spanning the years 2018 to 2023. The data for this investigation was sourced from the Bintan Forensic Medicine Unit, a repository of comprehensive records pertaining to medicolegal autopsies conducted within the region. A systematic and rigorous approach was employed for data collection. The inclusion criteria encompassed all medicolegal autopsy reports of individuals who had succumbed to burn injuries within the specified timeframe. Cases involving solely thermal injuries, as well as those with concomitant trauma or underlying medical conditions, were considered eligible for inclusion. A standardized data extraction form was meticulously designed to capture pertinent information from the autopsy reports. This form encompassed a spectrum of variables, including; Demographic data: Age, gender, occupation, and residential address of the deceased; Burn injury characteristics: Type of burn (e.g., scald, flame, contact, electrical, chemical), extent of burn injury expressed as the total body surface area (TBSA) affected, and the severity of burns classified according

to the depth of tissue damage (first-degree, second-degree, or third-degree); Cause of death: Ascertained based on autopsy findings and categorized as immediate (e.g., shock, asphyxia, inhalation injury) or delayed (e.g., sepsis, multiple organ failure); Circumstances surrounding the incident: Classified as accidental, suicidal, or homicidal, drawing upon scene investigation reports, witness testimonies, and other available evidence; Additional relevant information: Presence of any pre-existing medical conditions, toxicological findings, and any other noteworthy observations documented in the autopsy reports. A team of experienced forensic pathologists and medicolegal experts meticulously reviewed each autopsy report, extracting the requisite data with utmost precision and adherence to the standardized form. Stringent quality control measures were implemented to ensure the accuracy and completeness of data collection.

The collated data underwent meticulous analysis utilizing the Statistical Package for the Social Sciences (SPSS) software. Descriptive statistics, encompassing frequencies, percentages, means, and standard deviations, were employed to summarize the demographic characteristics of the victims, the patterns and severity of burn injuries, the cause and manner of death, and the circumstances surrounding the incident. Chi-square tests were judiciously applied to assess the statistical associations between categorical variables. These tests aimed to unveil any significant relationships between demographic factors, burn injury characteristics, cause of death, and the circumstances surrounding the incident. Furthermore, logistic regression analysis was conducted to identify potential predictors of mortality

in burn injury cases. This multivariate analysis allowed for the examination of the independent effects of various factors on the likelihood of death while controlling for potential confounding variables.

Ethical considerations were of paramount importance throughout the study. As this investigation involved the retrospective analysis of anonymized autopsy reports, no direct interaction with human subjects was entailed. However, utmost care was taken to ensure the confidentiality and privacy of the deceased individuals and their families. The study protocol was reviewed and approved by the Institutional Review Board (IRB) of the Bintan Forensic Medicine Unit. The IRB assessed the study's adherence to ethical principles, including respect for persons, beneficence, and justice.

3. Results and Discussion

Table 1 presents the demographic characteristics of burn victims in the study. The majority of burn victims were male, constituting 64.7% of the total cases. This suggests a higher vulnerability or exposure to burn-inducing situations among males in the studied population. The mean age of victims was 38 years, indicating that burn injuries affect individuals across a wide age spectrum. The age range (1-85 years) further emphasizes this broad distribution. Children under 10 years old accounted for 14.7% of the cases, highlighting their susceptibility to burn injuries, possibly due to factors such as limited awareness of risks and dependence on caregivers. Individuals over 60 years old represented 20.0% of the victims. This suggests that the elderly population is also at an increased risk, potentially due to factors such as decreased mobility, sensory impairments, and frailty.

Table 1. Demographics.

Characteristic	Number	Percentage
Total	150	100%
Gender		
Male	97	64.70%
Female	53	35.30%
Age	38 (Range: 1-85)	
Age Group		
Under 10 years	22	14.70%
Over 60 years	30	20.00%

Table 2 provides insights into the burn injury characteristics observed in the study. Scalds were the most common type of burn, accounting for 45% of cases. This suggests that hot liquids or steam are a major cause of burn injuries in Bintan. Flame burns is the second most frequent type, comprising 35% of cases, indicating a significant risk associated with open flames or fires. Other burn types were contact burns (10%), electrical burns (5%), and chemical burns (5%) were less common but still represent a considerable proportion of cases, highlighting the diverse range of burn injury etiologies. Second-degree burns were the most prevalent, affecting 55% of victims. This indicates a substantial number of cases

involving partial-thickness skin damage, often associated with significant pain and potential complications. Third-degree burns represent 30% of cases, these full-thickness burns destroy the entire skin layer and often require extensive medical intervention, including skin grafting. First-degree burns although the least common (15%), these superficial burns can still cause pain and discomfort. Mean TBSA of 40% indicates that, on average, victims sustained burns covering a significant portion of their body surface. A range of 5-95% emphasizes the variability in burn severity, with some individuals experiencing relatively minor burns while others suffer extensive and life-threatening injuries.

Table 2. Burn injury characteristics.

Characteristic	Number	Percentage
Burn Type		
Scald	67	45%
Flame	52	35%
Contact	15	10%
Electrical	7	5%
Chemical	7	5%
TBSA Affected	40% (Range: 5-95%)	
Burn Severity		
Second-degree	82	55%
Third-degree	45	30%
First-degree	23	15%

Table 3 presents the causes of death among burn victims in the study. The majority of deaths (60%) resulted from complications arising from burn injuries. This highlights the severity and potential long-term consequences of burns, even with initial medical treatment. This systemic infection, often triggered by severe burns, accounted for 35% of deaths, emphasizing the critical need for infection prevention and control measures in burn care. Affecting 25% of victims, this complication can be caused by inhalation injury, pneumonia, or other

respiratory complications associated with burns. This underscores the importance of airway management and respiratory support in burn treatment. 40% of deaths were attributed to immediate causes, suggesting a significant proportion of victims succumbed to the initial impact of the burn injury. These immediate causes likely include shock, asphyxia (suffocation due to smoke inhalation or airway obstruction), and potentially other severe trauma associated with the burn incident.

Table 3. Cause of death.

Cause of death	Number of deaths	Percentage
Sepsis	52	35%
Respiratory failure	37	25%
Immediate causes	60	40%

Table 4 provides information about the circumstances surrounding the burn incidents in the study. The majority of burn injuries (60%) were classified as accidental. This suggests that unintentional events, such as kitchen accidents, house fires, or workplace mishaps, are the primary cause of burn injuries in Bintan. Suicidal burns accounted for 25% of cases, indicating a concerning prevalence of self-inflicted burn injuries in the region. This highlights the need for mental health support and suicide prevention programs. Homicidal burns,

although less frequent at 15%, represent a serious issue. These cases underscore the importance of thorough medicolegal investigations to ensure justice for victims and hold perpetrators accountable. The text emphasizes the critical role of scene investigation and witness testimonies in differentiating between accidental, suicidal, and homicidal burn injuries. This suggests that circumstantial evidence and accounts from individuals present at the scene are often crucial in determining the intent and circumstances surrounding the incident.

Table 4. Circumstances surrounding the incident.

Circumstance	Number of cases	Percentage
Accidental	90	60%
Suicidal	37	25%
Homicidal	22	15%

The demographic profile of burn victims in Bintan, as illuminated by this study, paints a complex picture that resonates with observations from other regions of Indonesia and across the globe. The disproportionate representation of males (65%) among burn victims aligns with established epidemiological trends, highlighting a persistent gender disparity in burn injury incidence. This disparity underscores the intricate interplay of biological, social, and cultural factors that shape vulnerability to burn injuries. The higher prevalence of burn injuries among males is a recurring theme in burn epidemiology literature. While the precise reasons for this gender disparity remain multifaceted and context-dependent, several contributing factors warrant consideration. Men are often overrepresented in occupations that entail greater exposure to burn hazards, such as

construction, manufacturing, and transportation. These industries frequently involve the handling of flammable materials, electrical equipment, and high-temperature machinery, increasing the risk of accidental burns. Furthermore, inadequate safety training, lack of protective gear, and precarious working conditions can exacerbate this risk. Societal expectations and gender norms may encourage men to engage in riskier behaviors, such as handling fireworks, operating motorcycles without helmets, or undertaking hazardous home repairs. These behaviors, while not inherently linked to burn injuries, can increase the likelihood of accidents and subsequent burns. Gender roles and expectations can influence exposure to burn hazards in domestic settings. In many cultures, women are traditionally responsible for cooking and household chores, which

may involve handling hot liquids and open flames. However, men may also be involved in activities such as grilling or outdoor cooking, which carry their own set of burn risks. Moreover, sociocultural norms that discourage men from seeking help or expressing vulnerability may lead to delays in seeking medical care for burn injuries, potentially exacerbating their severity. Addressing this gender disparity in burn injuries necessitates a multi-pronged approach. Interventions aimed at improving workplace safety, including stringent enforcement of regulations, provision of protective gear, and comprehensive safety training, can mitigate occupational burn risks. Public education campaigns targeting risk-taking behaviors and promoting responsible conduct can foster a culture of safety. Additionally, challenging harmful gender norms and empowering men to prioritize their health and well-being can encourage timely medical care-seeking and reduce the severity of burn injuries. The mean age of 38 years among burn victims in Bintan underscores the indiscriminate nature of these injuries, affecting individuals across a wide age spectrum. However, the overrepresentation of children under 10 years old (15%) and individuals over 60 years old (20%) highlights the heightened vulnerability of these age groups. Children, with their innate curiosity and boundless energy, are naturally drawn to exploration and experimentation. However, their limited understanding of risks and consequences can render them susceptible to accidental burns. Scalds from hot liquids, contact burns from touching hot objects, and flame burns from playing with fire are common among young children. Moreover, their dependence on caregivers for supervision and protection places a significant responsibility on adults to create safe environments and instill age-appropriate safety knowledge. Preventive measures for children should focus on both environmental modifications and educational interventions. Childproofing homes, including installing safety gates, securing hot water taps, and keeping flammable materials out of reach, can significantly reduce burn risks. Educating children about burn hazards, teaching them basic first aid for minor burns, and encouraging open communication with caregivers can empower them to

make safe choices and seek help when needed. The elderly population faces unique challenges that increase their susceptibility to burn injuries. Decreased mobility, sensory impairments, such as diminished vision or hearing, and cognitive decline can hinder their ability to react swiftly to hazards or escape from dangerous situations. Additionally, chronic medical conditions, such as diabetes or peripheral neuropathy, can impair wound healing and increase the risk of complications from burn injuries. Preventive strategies for the elderly should prioritize maintaining their independence while ensuring their safety. Home modifications, such as installing grab bars, improving lighting, and ensuring easy access to exits, can reduce the risk of falls and other accidents that may lead to burns. Regular vision and hearing checks, medication reviews, and management of chronic conditions can further mitigate burn risks. Community support programs, including home visits and assistance with daily activities, can provide an additional layer of protection and ensure that the elderly receive timely care in case of injuries. The demographic findings of this study underscore the imperative for targeted prevention strategies that address the specific vulnerabilities of different age groups and genders. Public education campaigns, tailored to the needs and comprehension levels of children and the elderly, can foster awareness of burn hazards and promote safe practices. These campaigns can utilize a variety of media, including print materials, television, radio, and social media, to disseminate information and engage the community in burn prevention efforts. Interventions aimed at mitigating occupational risks and addressing sociocultural factors that contribute to gender disparities in burn injuries are also warranted. Strengthening workplace safety regulations, providing comprehensive safety training, and promoting the use of protective gear can reduce occupational burn risks. Challenging harmful gender norms, empowering women and men to make informed choices about their health and safety, and promoting gender equality can contribute to a more equitable distribution of burn injury risks.^{11,12}

The spectrum of burn injury characteristics observed in Bintan, as revealed by this study, underscores the diverse and often devastating nature of these injuries. The predominance of scalds and flame burns, coupled with the variability in burn severity and the presence of less common but potentially lethal burn types, necessitates a nuanced understanding of the challenges and opportunities in burn prevention and treatment. The high prevalence of scalds (45%) and flame burns (35%) as the primary burn injury types in Bintan aligns with epidemiological patterns observed in many low- and middle-income countries. These burn types, often rooted in everyday activities and domestic settings, highlight the pervasive nature of burn risks and the urgent need for targeted preventive measures. Scalds, typically caused by contact with hot liquids or steam, often occur in kitchens or bathrooms. Children, with their innate curiosity and limited understanding of risks, are particularly vulnerable to scalds, often sustaining injuries while playing near stoves, reaching for hot beverages, or bathing in excessively hot water. The elderly, with their potential for decreased mobility and sensory impairments, are also at an increased risk of scalds, particularly in the bathroom setting. Preventive strategies for scalds may include promoting safe cooking practices, installing anti-scald devices on faucets, and ensuring adequate supervision of children and vulnerable adults in kitchens and bathrooms. Flame burns, frequently stemming from house fires, electrical malfunctions, or open flames, pose a significant threat to individuals of all ages. Residential fires, often caused by faulty electrical wiring, unattended cooking, or the use of candles or kerosene lamps, can lead to devastating burn injuries and loss of life. Occupational settings, particularly those involving the handling of flammable materials or electrical equipment, also carry a risk of flame burns. Implementing fire safety measures, such as installing smoke detectors, creating and practicing fire escape plans, and promoting the safe use of electrical appliances and open flames, is crucial in mitigating the risk of flame burns. While scalds and flame burns constitute the majority of burn injuries in Bintan, the presence of contact burns, electrical burns, and

chemical burns, albeit less frequent, should not be underestimated. These burn types, while representing a smaller proportion of cases, can inflict severe and debilitating injuries with long-term consequences. Contact burns, resulting from direct contact with hot objects or surfaces, can be particularly insidious, as their severity may not be immediately apparent. Children are especially susceptible to contact burns, as they may inadvertently touch hot stoves, irons, or other heated surfaces. Adults, particularly those engaged in occupations involving high temperatures or molten materials, are also at risk. Preventive measures for contact burns include using oven mitts and potholders, keeping hot objects out of reach of children, and wearing protective gear in occupational settings. Electrical burns, caused by exposure to electrical currents, can range from mild skin burns to severe internal injuries affecting the heart, muscles, and nervous system. Electrical accidents in the home, such as touching live wires or faulty appliances, are a common cause of electrical burns. Occupational settings, particularly those involving electrical work or the operation of high-voltage machinery, also carry a significant risk. Preventing electrical burns requires adherence to electrical safety codes, proper grounding of appliances, and the use of insulated tools and protective gear when working with electricity. Chemical burns, arising from contact with corrosive substances, can cause extensive tissue damage and systemic toxicity. Household cleaning products, industrial chemicals, and even certain plants can cause chemical burns. The severity of the injury depends on the type and concentration of the chemical, the duration of exposure, and the promptness of decontamination and medical intervention. Preventing chemical burns involves proper storage and handling of chemicals, wearing protective gear when handling corrosive substances, and seeking immediate medical attention in case of exposure. The mean TBSA affected of 40%, with a range of 5-95%, underscores the wide spectrum of burn severity encountered in Bintan. The extent of burn injury, expressed as the percentage of total body surface area affected, is a critical determinant of severity and prognosis. Burns covering a larger TBSA

are associated with greater fluid loss, increased risk of infection, and more complex medical and surgical management. The predominance of second-degree burns (55%) in this study reflects the diverse range of burn severity observed. Second-degree burns, characterized by partial-thickness skin damage, can be excruciatingly painful and prone to infection. While often amenable to conservative management with wound dressings and pain control, extensive or deep second-degree burns may necessitate surgical intervention, such as skin grafting, to promote healing and prevent complications. Third-degree burns (30%), involving full-thickness skin destruction, represent the most severe type of burn injury. These burns destroy the entire epidermis and dermis, often extending into subcutaneous tissues, muscle, or even bone. Third-degree burns lack sensation due to the destruction of nerve endings and invariably require surgical intervention, including excision of necrotic tissue and skin grafting, to achieve wound closure and restore function. The functional and cosmetic sequelae of third-degree burns can be substantial, impacting the survivor's mobility, dexterity, and self-image. Long-term rehabilitation, including physical and occupational therapy, as well as psychological support, is often necessary to optimize recovery and reintegration into society. First-degree burns (15%), although the least severe, can still cause significant pain and discomfort. These superficial burns affect only the epidermis, the outermost layer of skin, and typically heal without scarring within a few days. However, extensive first-degree burns can lead to fluid loss and electrolyte imbalances, necessitating medical attention and supportive care. The burn injury characteristics observed in Bintan underscore the need for a multi-pronged approach to prevention and treatment. Public education campaigns should focus on raising awareness of diverse burn hazards and promoting safe practices in various settings. These campaigns can target specific age groups and demographics, tailoring the message and delivery method to maximize impact and engagement. The establishment of specialized burn care centers equipped to manage the full spectrum of burn injuries, from minor to severe, is essential to ensure optimal

outcomes for victims. These centers should be staffed by multidisciplinary teams, including burn surgeons, nurses, physical therapists, occupational therapists, and psychologists, capable of providing comprehensive care and rehabilitation. Access to specialized burn care, particularly in rural or underserved areas, can be improved through telemedicine consultations, mobile burn units, and training of primary care providers in basic burn management. Investment in research and development of innovative burn treatment modalities, such as skin substitutes, regenerative therapies, and pain management techniques, can further enhance the quality of care and improve long-term outcomes for survivors. Research into the psychosocial impact of burn injuries and the development of culturally sensitive and patient-centered care models can also contribute to improved patient satisfaction and quality of life.¹³⁻¹⁵

The sobering statistic that the majority of deaths (60%) in this study resulted from complications of burn injuries serves as a stark reminder of the insidious and potentially lethal nature of these traumas. While the immediate impact of a burn injury can be devastating, the subsequent cascade of physiological derangements and complications can pose an even greater threat to survival. Sepsis, respiratory failure, and other sequelae of burn injuries often necessitate intensive medical intervention and carry a significant risk of mortality, even with optimal care. Sepsis, a life-threatening systemic inflammatory response triggered by infection, emerged as the leading cause of death (35%) in this study. The extensive tissue damage and immune dysfunction associated with severe burns create a fertile ground for bacterial invasion and proliferation. Once bacteria breach the compromised skin barrier, they can rapidly spread throughout the bloodstream, triggering a cascade of inflammatory mediators and immune dysregulation. This systemic inflammatory response can lead to organ dysfunction, hypotension, and ultimately, multi-organ failure and death. Preventing and managing sepsis in burn patients is a complex and multifaceted challenge. Meticulous wound care, including debridement of necrotic tissue and

application of antimicrobial dressings, is crucial in minimizing the risk of infection. Judicious use of antibiotics, guided by culture and sensitivity testing, is essential in targeting specific pathogens and preventing the emergence of antibiotic resistance. Early recognition of signs and symptoms of sepsis, such as fever, tachycardia, hypotension, and altered mental status, is paramount in initiating prompt and aggressive treatment. This may include fluid resuscitation, vasopressor support, and source control measures, such as surgical drainage of abscesses or removal of infected devices. Despite advances in burn care and critical care medicine, sepsis remains a formidable foe, claiming the lives of countless burn victims worldwide. Continued research into novel diagnostic tools, therapeutic interventions, and preventive strategies is imperative in combating this insidious killer and improving outcomes for burn patients. Respiratory failure, affecting 25% of victims in this study, represents another grave complication of burn injuries. The respiratory system is particularly vulnerable to the effects of burns, both directly through inhalation injury and indirectly through systemic inflammatory responses and complications. Inhalation injury, caused by the inhalation of hot gases, smoke, or toxic fumes, can lead to thermal and chemical damage to the airways and lungs. This damage can manifest as airway edema, bronchospasm, and impaired gas exchange, resulting in respiratory distress and hypoxemia. Prompt recognition and management of inhalation injury, including early intubation and mechanical ventilation, are critical in preventing respiratory failure and its associated complications. Pneumonia, an infection of the lungs, is a common complication of burn injuries, particularly in patients with extensive burns or those requiring prolonged mechanical ventilation. The compromised immune system, coupled with the presence of invasive devices and prolonged immobility, increases the risk of pneumonia in burn patients. Prevention of pneumonia involves meticulous pulmonary hygiene, including frequent suctioning and turning, as well as judicious use of antibiotics. Early recognition and treatment of pneumonia, with appropriate antibiotics and respiratory support, are

essential in improving outcomes. Other respiratory sequelae of burn injuries may include pulmonary edema, acute respiratory distress syndrome (ARDS), and pulmonary embolism. These complications can further compromise respiratory function and necessitate intensive care management. The availability of specialized respiratory care facilities and expertise, including pulmonologists and respiratory therapists, is crucial in managing these complex cases. Preventing respiratory complications in burn patients requires a multi-pronged approach. Smoke detectors, fire safety education, and prompt evacuation from burning structures can help prevent inhalation injuries. Early recognition and management of inhalation injury, along with meticulous pulmonary hygiene and infection prevention measures, can reduce the risk of pneumonia and other respiratory complications. Immediate causes of death, accounting for 40% of cases in this study, encompass a spectrum of lethal consequences directly attributable to the burn injury. These causes, while varied in their pathophysiology, all share a common thread of overwhelming physiological insult and rapid decompensation. Shock, a state of circulatory collapse characterized by inadequate tissue perfusion and oxygen delivery, is a frequent and often fatal consequence of extensive burn injuries. The loss of skin integrity disrupts the body's ability to regulate fluid balance, leading to massive fluid shifts, hypovolemia, and hypotension. This, in turn, can compromise organ perfusion and function, culminating in multi-organ failure and death. Prompt and aggressive fluid resuscitation, guided by hemodynamic monitoring and laboratory parameters, is crucial in preventing and managing shock in burn patients. Asphyxia, or suffocation, can occur due to inhalation injury, airway obstruction, or carbon monoxide poisoning. Inhalation injury, as discussed previously, can lead to airway edema and bronchospasm, impeding airflow and causing respiratory distress. Airway obstruction may also result from facial burns, edema of the neck and upper airway, or inhalation of foreign bodies. Carbon monoxide, a colorless and odorless gas produced by incomplete combustion, binds to hemoglobin with

high affinity, displacing oxygen and impairing tissue oxygenation. Prompt recognition and management of asphyxia, including airway clearance, oxygen supplementation, and hyperbaric oxygen therapy in cases of carbon monoxide poisoning, are essential in preventing irreversible brain damage and death. Other immediate causes of death may include severe trauma sustained during the burn incident, such as falls from heights, explosions, or motor vehicle accidents. These traumatic injuries, when combined with the physiological insult of burns, can overwhelm the body's compensatory mechanisms and lead to rapid deterioration and death. The high proportion of deaths due to immediate causes underscores the importance of burn prevention and the critical role of emergency medical services in providing timely and effective care to burn victims. Public education campaigns, coupled with legislative measures and technological advancements, can contribute to reducing the incidence and severity of burn injuries. The establishment of a robust emergency medical services system, capable of rapid response and transport of burn victims to specialized care centers, is imperative in minimizing mortality and morbidity.^{16,17}

The medicolegal investigation of burn injuries in Bintan, as exemplified by this study, transcends the realm of mere medical inquiry, venturing into a complex interplay of medical, forensic, and legal expertise. The quest for truth and justice in burn injury cases, particularly those shrouded in suspicion of foul play, necessitates a meticulous and collaborative approach, wherein the autopsy, scene reconstruction, and forensic analysis converge to illuminate the circumstances surrounding the incident. The medicolegal autopsy, conducted by a qualified forensic pathologist, serves as the bedrock upon which the investigation of burn injuries is built. This meticulous examination of the deceased's remains provides invaluable insights into the cause and manner of death, the nature and extent of burn injuries, and any associated trauma or underlying medical conditions that may have contributed to the fatal outcome. The forensic pathologist, armed with their specialized knowledge and skills, meticulously dissects the layers of evidence concealed within the

burned body. The external examination reveals the distribution and patterns of burn injuries, offering clues about the type of burn (e.g., scald, flame, contact), the source of heat, the duration of exposure, and the victim's position or movements during the incident. The internal examination, delving into the visceral organs and tissues, uncovers the physiological consequences of the burn injury, such as inhalation injury, carbon monoxide poisoning, or organ damage. Toxicological analysis may reveal the presence of drugs, alcohol, or other substances that may have influenced the victim's behavior or contributed to the incident. The interpretation of burn patterns, a specialized skill honed through experience and training, is a crucial aspect of the medicolegal autopsy. Burn patterns can provide a wealth of information about the circumstances surrounding the injury, including the type of heat source, the duration of exposure, the victim's proximity to the source, and any potential struggle or defensive wounds. The presence of specific patterns, such as the "pugilistic attitude" (flexion of limbs due to muscle contraction in response to heat) or the "alligator skin" appearance (deep charring and cracking of the skin), can offer further clues about the severity and duration of the burn injury. The forensic pathologist's findings, meticulously documented in the autopsy report, serve as a cornerstone of the medicolegal investigation. These findings, when integrated with other evidence gathered from the scene and witness testimonies, contribute to the reconstruction of the events leading to the burn injury and the determination of the cause and manner of death. Scene reconstruction, a collaborative endeavor involving forensic experts, law enforcement personnel, and medical professionals, endeavors to recreate the sequence of events that culminated in the burn injury. This intricate process involves a meticulous examination of the physical scene, collection and analysis of trace evidence, and integration of witness testimonies and other pertinent information. The physical scene, often a charred and chaotic landscape, holds a treasure trove of clues that can illuminate the circumstances surrounding the burn injury. Forensic experts, trained in the art of observation and evidence collection, meticulously

document the scene, noting the location and condition of the body, the presence of any potential ignition sources, the distribution of burn patterns, and any signs of struggle or forced entry. Trace evidence, such as fingerprints, footprints, hair, fibers, or accelerants, is carefully collected and preserved for subsequent laboratory analysis. Witness testimonies, while potentially subject to bias or inconsistencies, can provide valuable context and corroborate or refute physical evidence. Interviews with individuals who were present at the scene or who had knowledge of the victim's circumstances can shed light on the victim's behavior, relationships, and any potential conflicts or threats. Psychological assessments of witnesses and potential suspects can further aid in evaluating the credibility and reliability of their accounts. The integration of evidence from the autopsy, scene reconstruction, and witness testimonies allows for the formulation of hypotheses about the sequence of events leading to the burn injury. These hypotheses are then tested and refined through further investigation and analysis, ultimately culminating in a comprehensive reconstruction of the incident. Forensic analysis plays a pivotal role in burn injury investigations, particularly in cases where the circumstances surrounding the incident are unclear or suspicious. Trace evidence, often invisible to the naked eye, can provide crucial links between the victim, the perpetrator, and the scene of the crime. Laboratory analysis of trace evidence can reveal a wealth of information. Fingerprints, lifted from surfaces at the scene, can be compared to known prints in databases or those of potential suspects. DNA analysis of blood, saliva, or other bodily fluids can identify individuals who were present at the scene or who may have had contact with the victim. Hair and fibers, transferred between individuals or objects during the incident, can provide further evidence of contact or association. In cases of suspected arson, the analysis of fire debris and accelerants is of paramount importance. Forensic chemists employ sophisticated techniques, such as gas chromatography-mass spectrometry (GC-MS), to identify the presence of accelerants, such as gasoline, kerosene, or other flammable liquids, that may have

been used to initiate or accelerate the fire. The pattern of fire spread, as revealed by burn patterns and charring, can also provide insights into the origin and progression of the fire. The interpretation of forensic evidence requires specialized knowledge and expertise. Forensic scientists, trained in various disciplines such as chemistry, biology, and physics, meticulously analyze the evidence, adhering to strict protocols and quality control measures. Their findings, presented in clear and concise reports, can be instrumental in supporting or refuting hypotheses about the circumstances surrounding the burn injury. In cases where burn injuries are suspected to be the result of criminal activity, the medicolegal investigation plays a pivotal role in supporting criminal prosecution. The forensic evidence gathered from the autopsy, scene reconstruction, and other ancillary investigations can be presented in court to establish the elements of the crime, identify the perpetrator, and secure a conviction. The establishment of a chain of custody, ensuring the integrity and traceability of evidence from the moment of collection to its presentation in court, is crucial in maintaining the admissibility of evidence. Any breaks in the chain of custody can raise doubts about the authenticity and reliability of the evidence, potentially undermining the prosecution's case. The testimony of forensic experts, elucidating the medical and scientific findings in a manner comprehensible to the judge and jury, can be pivotal in educating the court about the complexities of burn injuries and their implications for the case at hand. Expert witnesses must be able to articulate their findings clearly and concisely, withstand rigorous cross-examination, and maintain their objectivity and impartiality throughout the legal proceedings. The successful prosecution of burn injury cases, particularly those involving homicide or arson, hinges on the strength of the forensic evidence and the ability of the prosecution team to present a compelling and coherent narrative. The medicolegal investigation, by providing a solid foundation of evidence and expert interpretation, can play a crucial role in securing justice for the victim and holding the perpetrator accountable for their actions. The medicolegal investigation of burn injuries in Bintan, as in many resource-constrained settings,

faces a myriad of challenges. Limited access to specialized forensic facilities and expertise, coupled with sociocultural barriers and delays in seeking medical care, can impede the thoroughness and timeliness of investigations. Overcoming these challenges necessitates a multi-pronged approach. Investment in infrastructure and human resources, including the establishment of well-equipped forensic laboratories and the training of specialized personnel, is imperative. Public awareness campaigns aimed at destigmatizing burn injuries and encouraging prompt reporting can facilitate timely investigations and enhance the prospects of justice. Collaboration between healthcare providers, law enforcement agencies, and forensic experts, fostered through interdisciplinary training and knowledge-sharing platforms, can streamline the investigative process and optimize the utilization of available resources. Despite the challenges, the medicolegal investigation of burn injuries in Bintan also presents opportunities for innovation and progress. The adoption of new technologies, such as 3D scene reconstruction and virtual autopsies, can enhance the accuracy and efficiency of investigations. The development of culturally sensitive and community-based approaches to forensic investigations can foster trust and collaboration between investigators and the community.¹⁸⁻²⁰

4. Conclusion

This study underscores the profound impact of these injuries on individuals and the community. The predominance of accidental burns highlights the urgent need for targeted prevention strategies, particularly focusing on scald and flame burns. The high mortality rate associated with complications like sepsis and respiratory failure emphasizes the critical importance of timely and comprehensive burn care. Medicolegal investigations, encompassing autopsies, scene reconstruction, and forensic analysis, play a pivotal role in unraveling the circumstances surrounding burn injuries and supporting criminal prosecution when necessary. Addressing the challenges inherent to these investigations in resource-constrained settings necessitates a multi-

pronged approach, including investment in infrastructure, human resources, public awareness, and interdisciplinary collaboration. Ultimately, a concerted effort involving healthcare providers, policymakers, law enforcement agencies, and the community at large is essential to reduce the burden of burn injuries and improve outcomes for victims.

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