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LEADING ARTICLE

PERSONAL VIEW: MILITARY FORENSIC MEDICINE – FORENSIC MEDICINE IN A MILITARY SETTING

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ABSTRACT

This paper advocates for the establishment of a dedicated scientific forum for Military Forensic Medicine (MFM). Within Europe, the number of forensic medicine professionals possessing direct experience in military contexts remains limited. These (frequently hostile) environments often involve operational, legal, and logistical complexities that differ significantly from those encountered in civilian forensic practice. As a specialised and emerging field, MFM would benefit from a supranational platform aimed at advancing scientific discourse, fostering collaboration, and disseminating expertise across national boundaries. The proposed forum could facilitate structured networking between military and civilian forensic specialists, thereby enhancing preparedness and interoperability. Such an initiative could be supported under the auspices of established international bodies, such as the International Committee of Military Medicine (ICMM) or the North Atlantic Treaty Organisation (NATO) Committee of the Chiefs of Military Medical Services (COMEDS).

Keywords: ***Cause of death; forensic ballistics; forensic medicine; forensic pathology; military medicine***

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THE CONCEPT OF MILITARY FORENSIC MEDICINE

The conceptualisation of Military Forensic Medicine (MFM) has emerged through ongoing discussions among the authors, who recognised the need for a specialised scientific forum dedicated to this field. We define MFM as "*the application of forensic medicine expertise (both clinical and pathological) within the military context*"[1]. A potential question that arises is whether there is a need to establish yet another medical/forensic speciality given the already extensive range of existing specialities. The answer is no, MFM does not necessitate the creation of a new medical/forensic speciality per se. However, numerous reports from colleagues across various countries highlight that individuals lacking specific knowledge or training in military forensic medicine often face significant challenges when applying forensic principles to casework in military settings.

The integration of forensic medicine within an environment that inherently involves the application of bodily harm or even lethal force may initially seem incongruous. Yet, the fundamental tenet of MFM is to derive valuable insights from the bodily injuries, whether physical or psychological, inflicted upon or sustained by

adversaries in the context of military operations. This knowledge serves a dual purpose: first, to better prepare and equip military personnel to operate effectively in hostile environments, and second, to advance the understanding of the evolving pathology of warfare and its profound impact on both survivors and their families.

In this paper, we will explore several key aspects of MFM, highlighting both the solutions and challenges faced by various countries, predominantly North Atlantic Treaty Organisation (NATO) members. One significant benefit of MFM is the establishment of standardised methodologies for documenting and describing injuries across different nations, thereby enabling uniform evaluation of findings related to both deceased soldiers and survivors. Furthermore, the expertise of military medical examiners plays a crucial role in determining the causes of death in military personnel, thus contributing to valuable lessons learnt that can inform improvements in equipment design and recommendations for safeguarding the health and well-being of soldiers.

SCOPE OF MFM

Most, if not all, of the domains encompassed by MFM are already established subdisciplines within the broader field of forensic medicine or forensic sciences. These include forensic pathology, radiology, odontology, toxicology, genetics, and anthropology. While there is considerable overlap between military and civilian forensic cases, military contexts often present unique challenges that civilian forensic practitioners may not be equipped to address.

For instance, although parachuting incidents also occur in civilian settings—possibly even more frequently in terms of volume—the nature of military parachuting introduces distinct complexities. Special equipment, mission context, and operational secrecy can significantly affect the forensic investigation. One illustrative case involved the death of a Special Forces operator during a parachute jump as part of a covert operation. In such cases, civilian forensic pathologists may lack the necessary familiarity with military procedures, equipment, and operational parameters, particularly when access to classified information is restricted. In this instance, resolution was achieved through interdisciplinary collaboration among a military pathologist, a flight surgeon, and a military parachuting expert.

Another important dimension is clinical forensic medicine, particularly in cases involving allegations of sexual assault or physical violence. These cases frequently fall under the purview of military physicians and nurses who mostly lack specialised forensic training. The military environment—often characterised by geographic and social isolation in remote camps—can exacerbate this gap. Personnel primarily trained in life-saving interventions may not be adequately prepared to collect and document forensic evidence to the standards required by judicial processes[2]. Consequently, there is a clear need for targeted forensic training for military healthcare providers operating in such contexts.
Finally, we contend that experts in military forensic medicine can serve a critical function in truth-seeking efforts during and in the aftermath of armed conflicts[3-5]. Their expertise is particularly valuable in the forensic investigation of alleged violations involving the use or misuse of weapons and weapon systems, especially in cases where such actions may contravene the Geneva Conventions or established Rules of Engagement concerning both military personnel and civilian populations. The ongoing conflict in Ukraine has underscored the relevance of such investigations[6].

Table 1 outlines several domains in which the involvement of professionals possessing both civilian forensic training and operational military experience would be advantageous. In the following sections, we will examine a selection of these areas in greater detail.

Table 1: Domains in which the involvement of professionals possessing both civilian forensic training and operational military experience would be advantageous

- Anthropology – fragmented body parts
- Clinical forensic medicine
- Chemical, Biological, Radiological, and Nuclear (CBRN)
- Crime scene investigation in the military setting
- Disaster Victim Identification (DVI)—particularly aviation pathology
- Ethics
- Forensic odontology—particularly DVI
- Handling of deaths in the military setting
- Hypothermia, hyperthermia
- International humanitarian law – weapons effects
- Investigation of alleged war atrocities - Katyn massacre
- Military medical handling in role1/role2 setting and (air)medevac (relevant for pathology and clinical forensic medicine)
- Military pathology for training military physicians
- North Atlantic Treaty Organization (NATO) medical standards and their medicolegal consequences
- Parachute accidents
- Toxicology – particularly abuse of illicit drugs
- Underwater medicine – drowning, diving and hyperbaric treatment
- Use and interpretation of military reports regarding trauma by the pathologist: Tactical Combat Casualty Care (TCCC) card, 9-liner
- Weapons screening
- Wound ballistics
- Wound ballistics, including lesions due to explosions, behind armour trauma, and blast trauma

CARE OF THE DEAD

It is an unfortunate but well-recognised reality that military personnel may die in combat or in circumstances resembling warfare. Accordingly, it is generally assumed that all nations maintain formal procedures for managing such fatalities. In most cases, the logical approach would be to adapt established civilian protocols to the military context wherever feasible. Responsibility for formulating and implementing these procedures falls not only to medical professionals but also to relevant administrative authorities.

Comprehensive training is essential for all personnel involved in the post-mortem care process, including physicians, nurses, chaplains, and enlisted service members, who are tasked with preparing the deceased for repatriation and completing the necessary documentation. Clear assignment of responsibilities is critical; under no circumstances should bereaved families be confronted with military representatives who appear unprepared or uncertain in their duties, as this can exacerbate their distress.

Each nation may determine who is best suited to develop and oversee these procedures. However, in most NATO member states, the only military-affiliated professionals regularly involved in the care of the deceased are civilians, such as reserve pathologists[7]. These individuals, through their civilian roles, are routinely engaged in communicating with bereaved families and are thus well-versed in the sensitivities involved. Their existing protocols may serve as a valuable foundation for adaptation to military contexts.

WOUND BALLISTICS

Wound ballistics is a foundational speciality within military medicine, involving contributions from a diverse range of medical disciplines. In some countries, leading experts in wound ballistics have traditionally been surgeons, such as T. Kocher and M. Fackler, while in others, forensic pathologists or collaborating scientists have been at the forefront, including figures such as K. Sellier and B. Kneubuehl[8]. It is, however, imperative that military forensic pathologists possess more than just a rudimentary understanding of wound ballistics[9-14]. A key aspect of their role involves ensuring that military operations adhere to the Laws of War, notably the Geneva Conventions and similar international agreements[15,16].

More than a century ago, The Hague Declaration of 1899 introduced restrictions on weapon usage, and since then, it has been the responsibility of legal experts, surgeons, and forensic pathologists to assess the impact of new weaponry.

According to Article 46 of the Geneva Convention, all new weapons must undergo a "legality" investigation before being deployed in combat. This legal and medical scrutiny ensures compliance with international humanitarian standards. One of the authors has been directly involved in "weapon screening" processes, particularly when new types of small arms ammunition are proposed, to verify that such innovations do not contravene the principles set forth in The Hague Declaration or the Geneva Conventions. While technicians may possess in-depth knowledge of the weapons themselves, it is the forensic expert who focuses on understanding the resulting lesions and injuries caused by these weapons.

DVI – DENTAL AND ANTHROPOLOGY

Disaster Victim Identification (DVI) is not typically associated with MFM, yet certain aspects of DVI work share a close relationship with military forensic practices[17]. A primary example is the identification of aircrew members in the aftermath of aircraft accidents. The United Kingdom's Royal Air Force has long operated the Institute of Aviation Pathology and Tropical Medicine at RAF Halton, which specialised in such efforts[18]. Additionally, several years ago, NATO introduced Standardisation Agreement (STANAG 2464) and Allied Medical Publication (AMedP-3.1), which provide guidelines on forensic odontology, thereby significantly stimulating the involvement of military dentists in victim identification processes.

In the context of aircraft accidents, anthropological expertise is also frequently required, a speciality that is actively applied within the US Armed Forces Medical Examiner system. Military forensic pathologists have also contributed to civilian disaster response, as demonstrated in the aftermath of the Thai Tsunami, where experts from the French Gendarmerie Nationale and the Italian Carabinieri were deployed. Furthermore, the Dutch Rijksidentificatieteam is a military-led unit, and the Belgian DVI team traces its origins to the Belgian Gendarmerie/Rijkswacht.

The ongoing crisis in Ukraine has highlighted the potential for violations of international humanitarian law, and in the early stages of the conflict, national DVI teams were called upon by Interpol and the Prosecutor of the International Criminal Court (ICC) to assist in identifying buried victims, underscoring the critical role of forensic experts in the identification process during conflict situations.

HYPERBARIC AND AVIATION PATHOLOGY

The human body can be exposed to both hypo- and hyperbaric environments, which can result in specific pathologies that are encountered in both civilian and military settings. Diving accidents, which can occur due to human or non-human errors in hyperbaric conditions, may lead to various injuries, including drowning and decompression sickness (commonly referred to as caisson's disease). Diving has long been a popular recreational activity for civilians, and professional divers have always been integral to civilian maritime operations, particularly within shipping and port authorities. However, it is within the naval forces of many nations that much of the scientific research on diving physiology and safety has been conducted. While respiratory physicians and anaesthesiologists have typically been the primary experts in this area, forensic pathologists also play a crucial role in multidisciplinary teams when accidents occur, particularly in investigating the causes of mishaps and preventing further incidents[19].

Similarly, military flights involve aircraft that subject the human body to unique accelerations and pressures, distinct from those encountered in civilian aviation. These physiological phenomena must be thoroughly understood and integrated into forensic analysis[20] to accurately assess the factors that may have contributed to incidents such as the loss of aircraft control. The skills required to operate military aircraft differ significantly from those needed in civilian aviation, and thus, the forensic evaluation of fatal or material accidents in this context necessitates specialised knowledge. Furthermore, pathology related to peculiarities of military aviation (e.g., ejection seat injuries) may be encountered[21,22]. In cases where criminal justice proceedings are initiated, the ability to make an informed determination regarding the cause of such accidents becomes imperative.

CLINICAL FORENSIC MEDICINE

Forensic medicine can be broadly categorised into clinical forensic medicine and forensic pathology. Forensic pathology primarily focuses on the examination of deceased individuals, while clinical forensic medicine is more encompassing, dealing with the examination of living victims and perpetrators of physical, psychological, and sexual violence. In civilian contexts, these cases are typically managed by various authorities, with forensic physicians or pathologists and forensic nurses being the primary professionals responsible, depending on the country. However, in some instances, civilian physicians such as general practitioners or gynaecologists may also conduct such examinations.

In military settings, particularly during operations in foreign countries, the responsibility for conducting these examinations typically falls to the unit's medical officer or medical authority. Unfortunately, these officers are often insufficiently trained for the specific demands of a forensic examination in cases of assault or violence. Given this, it is logical that military forensic pathologists, who possess both civilian expertise and an understanding of the unique constraints of the military environment, should assume a central role in training military medical personnel[23]. This ensures that the necessary skills and knowledge are imparted to those responsible for conducting such critical examinations in the field.

TOXICOLOGY

This speciality is already actively engaged within the military in managing Chemical, Biological, Radiological, and Nuclear (CBRN) situations[24,25]. However, when addressing cases involving the influence of alcohol or drugs (e.g., aviation mishaps), this area is most effectively managed by the forensic pathologist. Forensic pathologists, particularly those with experience in clinical forensic pathology or within the autopsy suite, possess the requisite expertise to handle such cases with precision.

It is essential that this work is carried out in close collaboration with toxicologists, whether military or civilian. The success of this interdisciplinary approach depends on the integration of forensic pathology and toxicology, ensuring comprehensive analysis and accurate conclusions in cases involving substance-related influences.

ORGANIZATION OF MFM

Only the major global powers, such as the United States and France, possess dedicated institutes or departments of forensic medicine. In contrast, countries with limited resources or those that do not consider permanent staffing of such departments to be cost-effective must seek alternative solutions. We identify two primary approaches to addressing this challenge.

The first approach is a laissez-faire model, where, in the event of a forensic issue, local forensic pathologists are contacted in the hope that they possess the necessary expertise to handle the case. Moreover, it is hoped that these pathologists can quickly acquire a sufficient understanding of the military environment to offer a statement that integrates both the professional forensic considerations and the military context. However, through discussions with colleagues from various NATO countries, we have become increasingly convinced that this reactive approach is not optimal or even acceptable.

The second approach, which has been implemented in Belgium and Denmark, involves employing forensic pathologists who work full-time in civilian forensic institutes or departments but also serve as reserve officers, having undergone comprehensive military training from the ground up. While these specialists are few, they ensure access to the requisite military expertise and context by establishing connections with colleagues who possess specialised knowledge that can be adapted for military applications. Additionally, they should focus on building an international network to facilitate the exchange of information and experiences.

To support this model, we propose the creation of an “International Society for Military Forensic Medicine”. Such a scientific organisation, ideally

supported by the Surgeons General, would serve as a resource to offer assistance across NATO, as well as provide guidance to military entities on the establishment of MFM frameworks within their respective countries. Such an initiative could be supported under the auspices of established international bodies, such as the International Committee of Military Medicine (ICMM) or NATO's Committee of the Chiefs of Military Medical Services (COMEDS).

By leveraging the experience of full-time or reserve forensic pathologists, dentists, anthropologists, and nurses, this society would provide valuable insights into what has been successful and what pitfalls should be avoided. The aim is to ensure that lessons learnt from prior efforts are applied effectively while minimising the risk of repeating past mistakes.

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CONFLICTS OF INTEREST

The author declared no conflicts of interest.

DISCLOSURE

These views reflect the personal opinions of the authors and do not represent official policy.
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AUTHOR CONTRIBUTIONS

PJTK: Design of the work; drafting the work; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **GV:** Design of the work; drafting the work; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **WJ:** Design of the work; drafting the work; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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ORIGINAL ARTICLE

ACCIDENTAL FATAL BURNS AMONG THE ELDERLY IN A METRO CITY OF INDIA - A RETROSPECTIVE SINGLE-CENTRE STUDY

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ABSTRACT

Introduction: In recent years, the increase in life expectancy and the disintegration of nuclear families have been a global phenomenon. These socio-dynamic changes and the rise in life expectancy have compelled the elderly population to live by themselves, despite their age-related decline in physical and mental abilities. This has made them vulnerable to accidents, including burns. In this background, a study to assess fatal accidental burns among the elderly in a metro city of India has been planned.

Objectives: This study aims to elucidate the circumstances surrounding the incidence, extent of burn injury, period of survival after sustaining burns, and cause of death, and to suggest preventive measures.

Methods: This descriptive, cross-sectional study was conducted at an autopsy centre in Kolkata, India, over a year. Data were obtained from reports of post-mortem examinations and police inquests, compiled in Microsoft Excel, and analysed by using frequency and percentage.

Results: In the study population, 84% were females. Incidents of burns have occurred between 8 am and 8 pm in 86% of the reported cases. Burns occurred from “Diya” (pious lamp) or candle while performing “Puja” (a ritual of worship among different religions) in 55% of the cases, and during cooking in 30% of the cases. 16% of the study population died within a day of the accident, suffering an average of 77% of total body surface area burns. 82% of the study population died due to septicaemia and multi-organ dysfunction syndrome.

Conclusions: In this study, 85% of the deceased sustained burns either while performing “Puja” or during cooking due to exposure to open flame. Containment of the flame during “Puja” and the use of a flameless heating system during cooking can substantially reduce fatal accidental burns among the elderly.

Keywords: ***Body surface area; burns; Diya; elderly population; Puja***

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INTRODUCTION

Control of fire by man is a major milestone in human civilisation. It provided ancient man with a source of warmth and light. The use of fire enabled them to protect themselves from wild animals, make more advanced tools, and cook food. Despite all its advantages, fire also causes burns, which may even lead to death. Presently, injuries and death due to burns are a major global public health problem. Worldwide, an estimated 300,000 people die every year due to burns, and the estimated annual fatal burn injuries are 140,000 in India[1]. In recent years, a significant change has taken place in demography worldwide, particularly in developing countries like India, i.e., a change in the composition of the population. In the last century, life expectancy increased steadily due to the advancement of medical sciences, particularly the control, elimination, and eradication of many infectious diseases, which were the major killers of mankind. The number and proportion of people aged 60 years and older in the population are increasing. Globally, in the first decade of the 21st century, people aged 60 years and above numbered 673 million, and by 2050, it is expected to increase to 2 billion[2]. In 1951, the life expectancy of an Indian male was 32.45 years, and that of an Indian female was 31.66 years. In the past 70 years, it has steadily increased up to 70 years[3]. This change contributed to both the increase in the proportion and the absolute number of the elderly population in this country. In 2020, people aged 60 years and above accounted for 8.1% of the population, totalling approximately 11 million[3]. At the same time, in society, more and more people are living in nuclear families instead of joint families. In a nuclear or elementary family, there is only one married couple along with their dependent children. But in a joint or extended family, there is more than one married couple of different age groups, young and old. The orthodox Hindu family in India is a joint family. It provides economic and social security to the old[3]. At the all-India level, 50% of the 318 million households were nuclear in 2022, compared to 37% of households in 2008, according to the available data[4]. Due to these changes, the elderly population, with age-related decline in physical and mental abilities, has to live by themselves, not adequately assisted or supported in their day-to-day activities. This makes them vulnerable to accidents, including burns. Studies suggest that, as elderly people, who are a medically challenging group, have to live independently for a long time, burn injuries among them will be more[5]. In this scenario, the present study has been planned.

METHODS

This was an observational, descriptive study, cross-sectional in design. The study was conducted at the Department of Forensic and State Medicine, Institute of Postgraduate Medical Education & Research (IPGME&R), Kolkata, West Bengal, for one year, from 1st January 2021 to 31st December 2021. Permission was obtained from the relevant authority before the commencement of this study. Data was then collected, maintaining anonymity. The sources of data were the postmortem reports and reports of police inquests, which include a summary of the incident, the “Injury Report”, the report of recording the medicolegal cases, and the “Medical Certification of the Cause of Death (MCCD)”. The study population consisted of individuals aged 60 years and above who died due to burns; the manner of death was accidental. The sampling technique was complete enumeration. Ethical clearance was obtained from the Institutional Ethics Committee and the Research Advisory Committee of the Institute after giving an undertaking that the identity of the deceased would not be revealed in any form. During the study period, a total of 2686 postmortem examinations were conducted in the Autopsy Centre. Among them, 638 deceased subjects were aged 60 years and above.

Death due to natural causes, i.e., disease, debility, and old age, was seen among 182 subjects. The unnatural causes of death in this age group, i.e., death due to suicide, alleged homicide, and accidents, were seen among 456 subjects. Among them, 56 individuals died due to accidental burn injuries. They constitute the population of this study (Fig. 1).

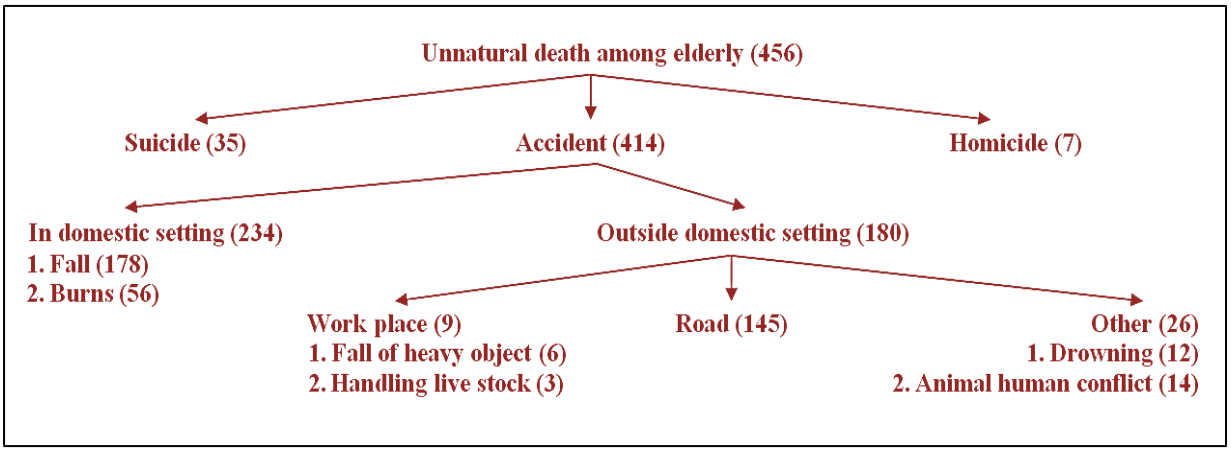

Figure 1: Cause and manner of unnatural death among the elderly.

STATISTICAL ANALYSIS

The compilation of the data was done in Microsoft Excel and then analysed by Simple Table, using frequency and percentage.

RESULTS

The total number of study subjects in this period was 56 (Table 1). It showed that 84% of the deceased are female in gender.

Table 1: Gender-wise distribution of fatal accidental burns among the elderly (n=56)

Gender	Frequency	Percentage (%)
Male	9	16
Female	47	84

It has been revealed from the police inquest that 30% of the fatal accidental burns among the elderly occurred during morning hours (0800–1159 hours) of the day, while another 30% occurred during the afternoon (1200–1559 hours). 26% of the fatal accidental burns among the elderly occurred during evening hours (1600-1959 hours) of the day (Table 2).

Table 2: Time of occurrence of fatal accidental burns among the elderly (n = 54*)

Time of occurrence	Frequency	Percentage (%)
Midnight (0000–0359 hours)	1	2
Early morning (0400-0759 hours)	2	4
Morning hours (0800 - 1159 hours)	16	30
Afternoon (1200–1559 hours)	16	30
Evening (1600-1959 hours)	14	26
Night (2000-2359 hours)	5	9

*One charred body, one readmission

From the report of the police inquest, it has been revealed that burns occurred from “diya” or candles while performing “Puja”- a worship ritual of Hindus, in 55% of the cases, and during cooking in 30% of the cases (Table 3).

Table 3: Circumstances leading to fatal accidental burns among the elderly (n=56)

Circumstances	Frequency	Percentage (%)
From Diya during “Puja”	31	55
During cooking, using an open flame	17	30
Other (electric/burning of waste/firecracker/ lighting Bidi*/fireplace)	8	15

*"Bidi" is an indigenous mini cigarette smoked in the Indian subcontinent. It is made from unprocessed tobacco wrapped in "Tendu leaf" (leaf of *Piliostigma racemosum*), and tied by a string.

The study revealed that 16% of the study population died within a day (24 hours) after sustaining a burn injury, while another 41% of the study population died within a week, and another 36% within a month. 7% of the study population survived more than 30 days (Table 4).

Table 4: Average days of survival in accidental burns among the elderly (n = 56)

Days of Survival	Frequency	Percentage (%)
0 i.e. < 24 hours	9	16
1-7	23	41
8 - 30	20	36
31 and more	4	7

In this study, it has been found that those who died within 24 hours of the accident had burn injuries affecting, on average, 77% of total body surface area (TBSA). Those who survived beyond 24 hours up to one week suffered burn injuries affecting an average of 67% of TBSA, and for those who survived beyond one week up to one month, the average TBSA affected was 45%, which further reduced to 42% of TBSA for those who survived beyond one month (Fig. 2).

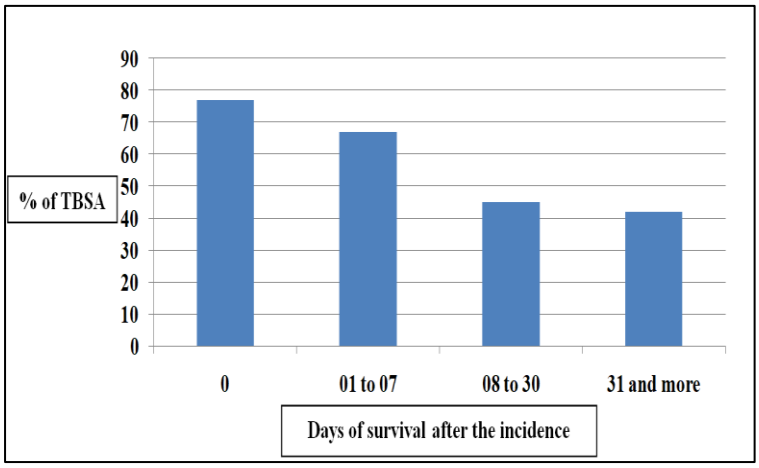

Figure 2: Distribution of study population according to average TBSA affected during fatal accidental burns among the elderly and days of survival thereafter (n=56)

In this study, 82% of the victims of fatal accidental burns among the elderly population died due to septicaemia and Multi-Organ Dysfunction Syndrome (MODS), 11% due to neurogenic shock, and 7% due to hypovolaemic shock (Table 5).

Table 5: Cause of death in accidental burns among the elderly (n = 56)

Cause of death	Frequency	Percentage (%)
Neurogenic shock	6	11
Hypovolemic shock	4	7
Septicaemia and MODS	46	82

DISCUSSION

The National Burns Programme of India, revealed that 65% of those who died due to burns were women. An audit of burn deaths among older adults in North India stated that 58.4% of victims were females[6]. In our study, 84% of the study population (victims of fatal accidental burns among the elderly) were female (n=47). This is considerably more than the results of the two former studies. In our study, it has been found that 55% of these fatal accidental burns were sustained from "Diya" while performing "Puja," and in another 30% of cases, it happened during cooking. In both situations, there is an open flame as the source of fire. During "Puja", the images and idols of gods and goddesses are placed upon a throne or pedestal, with offerings of flowers and sweets (Fig. 3).

Figure 3: The "Puja" ritual with the "Diya" (the holy lamp) placed at the centre.

"Diya" is an Indian word meaning a "lamp", which is a small, cup-shaped oil lamp made from brass or baked clay, having a cotton wick dipped in oil or "ghee" - clarified butter. The lamp is lit during worship and waved, accompanied by singing of devotional hymns to show respect to the Gods. The lighted lamp is considered pious and is an integral part of the act of worship. In every Hindu household the rituals of "Puja" is done at least once daily in which, lighting the "Diya" is mandatory (Fig. 4). In this process, there are chances that the clothes, hair of the person or any inflammable articles kept in the vicinity of the lighted "Diya" may catch fire.

Figure 4: The lighted "Diya" - the holy lamp

In another study conducted in India, "Puja" burns constituted 16% of the total burn cases[7]. In the same study, it has been observed that accidental burns while performing "Puja" happen during the morning hours of the day. In our study, 86% of fatal accidental burns among the elderly occurred between 8 am and 8 pm, evenly distributed throughout that period. Asma et al. observed in their study that 65% of victims died within a week of hospitalisation[7] while Nayak et al. in their study stated that 74.4% of the victims (n=224) died within 1 week of the incident, out of which 44.5% (n=134) of cases died within 24 hours[8]. In our study, 57% of the deceased (n=32) succumbed to death within seven days of the incident, with 16% (n=9) dying within a day.

It has been observed in our study that individuals affected with a greater percentage of TBSA burns survived for fewer days. Those who died within 24 hours of the accident had burn injuries affecting an average of 77% of TBSA. Those who survived beyond 24 hours up to one week suffered from burn injuries affecting an average of 67% of TBSA, and for those who survived beyond one week up to one month, the average TBSA affected was 45%, which further reduced to 42% of TBSA for those who survived beyond one month. This finding corroborates the findings of other similar studies. Nayak et al., in their study, observed that most fatalities occurred when greater than 40% of TBSA is involved, and with an increase in the percentage of burn surface area, the duration of survival decreases[8]. Kumar et al., in their study, observed that 82.5% of the victims had more than 50% of total body surface area (TBSA) burns, which is incompatible with life[6]. In our study, 82% of the victims of fatal accidental burns among the elderly population died due to septicaemia and MODS, 11% due to neurogenic shock, and 7% due to hypovolaemic shock. Lam et al. reported that the most common complications among elderly burn patients in the National Burn Hospital, Hanoi, Vietnam were multiple organ failure (4.1%), pneumonia (4.1%), and septic shock (2.9%)[9]. The incidence of MODS in the study of Alam et al. was 63.3%[10]. The findings of both studies are different from our study.

CONCLUSIONS

Accidents are preventable, and so are accidental burns. Fatal accidental burns are the tip of the iceberg of the problem related to accidental burns, with the huge, submerged portion representing the morbidity due to the non-fatal cases. Burns are a leading cause of loss of disability-adjusted life-years (DALYs) in low- and middle-income countries. The World Health Organization (WHO) also recommends the enclosure of fires and limiting the height of open flames in the domestic environment. They promote the use of safer cooking devices and less hazardous fuels, generate awareness, and motivate people to adopt safe practices[11].

In this study, it has been found that 85% of the fatal accidental burns among the elderly are sustained while performing "Puja" and cooking. Both of these activities cause burns from open flame (flame burns). If the use of open flame during "Puja" and cooking can be replaced by suitable alternatives, these fatal accidental burns can be prevented. The use of open flame while performing "Puja" is an age-old mandatory custom in Hindu and other religions. A device can be designed, like a miniature hurricane lantern/lamp, with an ignition facility operated with a switch. This will provide safety during ignition and during burning by providing a barrier to the flame (Fig. 5).

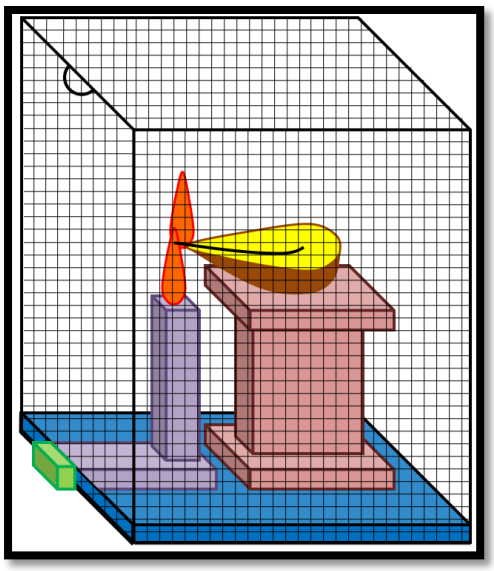

Figure 5: "Safe Diya". Switch (green) operated gas lighter (purple), lighting the cotton wick (black) of "Diya" (brown), filled with oil/ghee (yellow) and kept on a stand (pink). The whole assembly is enclosed in a wire cage, providing a barrier to the flame. Conceptualised and designed by author K. Bag.

Recently, the use of electric induction heaters as an alternative to gas burners is gaining popularity. This may be encouraged by providing subsidies or waiving taxes during the purchase of the appliances by senior citizens.

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CONFLICTS OF INTEREST

The authors declared no conflicts of interest.

ETHICAL ISSUES

Ethical clearance was obtained from the IPGME&R Research Oversight Committee (Institutional Ethics Committee), Institute of Post Graduate Medical Education and Research, Kolkata, West Bengal, India (IPGME&R/IEC/2021/531, Date: 25/09/2021).

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None

AUTHOR CONTRIBUTIONS

ID: Conception of the work; the acquisition, analysis, and interpretation of data for the work; revising the work critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **KB:** Design of the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **CKJ:** Acquisition, analysis, and interpretation of data for the work; revising the work critically for important intellectual content; final approval of the version to be published; agreement to be accountable

for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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ORIGINAL ARTICLE

MICROSCOPIC ANALYSIS OF HEARTS AND REVISIT OF MEDICO-LEGALLY SIGNIFICANT DEATHS CONCLUDED AS ISCHEMIC HEART DISEASE IN A TERTIARY CARE HOSPITAL IN SRI LANKA

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ABSTRACT

Introduction: Interestingly, the heart has the most frequent diagnostic agreement and the least refinements after histological examination. However, few studies have found a diagnostic disharmony after histological examination. In routine practice, it is usual to give the cause of death as Ischemic Heart Disease (IHD), especially with the positive clinical history and suggestive gross pathology in Sri Lanka.

Objectives: We designed this study to determine the importance of microscopic findings in concluding the cause of death as IHD.

Methods: A retrospective review of the autopsy reports of the cases concluded as IHD was conducted, and the cardiac sections obtained at autopsy were reviewed microscopically.

Results: Among the total sample of 100 autopsies, the microscopic sections had been obtained only for academic purposes in 60% of cases where the cause of death had been concluded as IHD based on gross pathology and the clinical picture. At the microscopy review, positive histopathological findings were identified in 69%, and out of them, findings confirmed the macroscopic cause of death in 57%. In contrast, 9% had revealed a different cardiac cause of death. There were 22% autopsies with negative microscopy, even though the cause of death had been concluded as IHD based on gross pathology and clinical history.

Conclusions: The study reiterates the importance of microscopy in concluding the cause of death as IHD, even though the macroscopic examination could offer crucial initial insights. The findings highlight the need for improved integration of histopathology into routine forensic practice and underscore its significance in achieving accurate cause-of-death.

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INTRODUCTION

The autopsy is important in establishing the cause of death accurately in natural deaths as well as in the event of unnatural deaths. In the process of administration of justice, courts tend to rely heavily on the postmortem report, which an expert in this field must conduct. The autopsy report is expected to reveal the truth that could not be picked up by clinicians or radiologists in

their investigations. Therefore, it is considered a gold standard in certifications of death.

The cause of death may look quite obvious, especially in mechanical injuries. However, determining the exact manner of death and the conditions contributing to death can be problematic[1]. Forensic experts are expected to reveal the natural pathologies that either caused or contributed to death after a thorough autopsy and ancillary tests, even though there is a high rate of non-natural deaths. However, it is well known that most experts rely primarily on gross or macroscopic pathology to come to conclusions. Most of the Judicial Medical Officers in Sri Lanka conclude the cause of death based on gross findings and await microscopic results to conclude the cause of death only in required cases. This is mainly due to a lack of facilities in most centres to cope with the workload. However, a significant number do obtain samples for microscopy.

Forensic histopathology is an instrumental ancillary test in the case of a sudden death, which could be a purely natural death or where trauma and poisoning need to be ruled out. Further, it plays an important role when a trivial trauma worsens or augments the progression of the disease.

A retrospective study by Nashelsky and Lawrence on natural deaths has found that most presumed and actual causes of death were cardiovascular, and the majority were due to ischemic heart disease. However, the presumed cause of death was found to be wrong in 28% of cases[2]. Ischemic heart disease (IHD), also known as coronary artery disease, represents a group of pathophysiologically related syndromes resulting from myocardial ischemia[3].

In routine practice, it is usual to give a cause of death (COD) as IHD based purely on the clinical picture and macroscopic findings. However, other cardiac pathologies such as myocarditis, deposition diseases such as amyloidosis, and inflammatory diseases such as sarcoidosis, etc. may be misinterpreted as IHD when concluding based on gross color changes of the myocardium at autopsy such as redness, paleness, the grey-white scar of fibrosis, leading to an incorrect cause of death.

The heart is the organ with the most frequent diagnostic agreement and, interestingly, with the least diagnostic refinements after histological examination. One possible explanation for this finding is that the heart is frequently affected by vascular disorders, leading to acute or chronic ischemic or hemorrhagic changes that are usually obvious macroscopically[4].

Few studies have addressed the issue of diagnostic changes after histological examination in different organs at necropsy[4]. Discordance between the macroscopic and microscopic evaluation of the heart (coronary artery atherosclerosis) by Kandy *et al*. (2014)[5] found 13.5%, Bernadi *et al*. (2005)[4] found 22.56%, Neil *et al*. (2006) found 30.43%, and Mangal *et al*. (2007) found 17.14%[4]. Myocardial infarction was among the diseases that were correctly diagnosed in more cases than not. In studies correlating clinical diagnoses with autopsy findings, many have reported similar results, except for cases in which the patient had chronic myocardial ischaemia. In the group of "false" infarctions that were clinically suspected but not revealed at autopsy, the underlying cause was frequently pulmonary embolism. Cameron and McGoogan *et al*. indicated that such conditions as acute abdominal and pulmonary embolism, which most frequently mimicked infarction in their study, produced similar clinical features, i.e., acute pain, shock, or a combination of the two[6]. Over 20% of clinically unexpected autopsy findings, including 5% of significant findings, can be correctly diagnosed only by histological examination[7].

We designed a retrospective descriptive study to determine the importance of microscopic findings in concluding the cause of death as IHD and to evaluate the microscopic findings in relation to the described gross pathology.

METHODS

We reviewed the cardiac microscopic slides of cases where the cause of death was given as “ischaemic heart disease,” “atherosclerotic heart disease,” or “occlusive coronary artery disease,” or the cause of death was contributed by any of the above IHDs (acute myocardial infarction [MI], chronic IHD with sudden arrhythmia or heart failure, or sudden cardiac death) according to the postgraduate trainees who performed autopsies

at a major teaching hospital, during a period of 1 year (from 2022 January to 2023 January). The postmortem reports of the above cases were perused to obtain the historical and gross pathological findings to fill the proforma.

All the data were recorded in the printed proforma and then transferred to a Microsoft Excel spreadsheet for data analysis.

Histology review of prepared slides

All the slides about the individual cases were examined for the specific objective by the principal investigator and the supervisor. A qualitative grading to assess the level of achievement of the specific objectives developed by Bandara *et al*. in their study "A retrospective study to evaluate the significance of routine and special histopathological investigations and their application by the experts in medico-legal autopsies conducted at Teaching Hospital Ragama"[8] was modified and used as follows in this study (Table 1).

Table 1: Qualitative grading to assess the level of achievement of the objective.

Level of achievement	Observation
A	**Positive histological findings were identified, and the cause of death could be ascertained**
A-1	Findings revealed the cause of death (COD), which was not identified macroscopically.
A-2	Findings confirmed the macroscopic COD /probable COD.
A-3	Findings can be used to exclude possibilities other than COD.
B	**Positive histological findings were identified, but the cause of death could not be ascertained.**
B-1	Findings are not compatible with macroscopic findings.
B-2	Findings are not significant/relevant to the COD.
B-3	Findings cannot be used to confirm COD or to draw any other conclusions.
C	**No histological findings were identified.**

RESULTS

Demographic Characteristics

The total sample included 100, based on the yearly postmortem statistics of the centre during the period from January 2022 to January 2023.

In terms of gender, a majority were male, amounting to 73% of the total sample, and even though the majority (53%) were above 40 years of age, there was a surprising 20% of the sample comprised of those between the ages of 30 and 39 years (Table 2).

Table 2: Age distribution of the sample

Age groups	Frequency
18 - 29 years	**4**
30 - 39 years	**20**
40 - 49 years	**25**
50 - 59 years	**28**
60 - 70 years	**23**
Total	**100**

Preceding clinical history of IHD

Interestingly, a majority of 52% had only had a short duration of illness, and 34% of the subjects did not have an adequate clinical history available at the time of death (Table 3).

Table 3: Preceding clinical history of IHD

Category of clinical history	Frequency
Long duration of ill health	4
No proper history was available	34
Short duration of ill health	52
Documented evidence of IHD is available	8
Other	2
Total	100

The conventional practice of performing histopathology in our setting

In 60%, a histopathology slide review had yet to be performed, even though the samples had been obtained for academic purposes. However, a notable 39% was performed to confirm the ascertained cause of death, 3% to define the contributory causes for the cause of death, and 1% to find the cause of death itself, where macroscopic examination alone was inconclusive.
(Note that the percentages stated above override, as multiple purposes have been quoted in certain records.)

Level of achievement of the objectives

As described above, a qualitative grading was used to assess the level of achievement of the objectives of the study. The respective grades achieved have primarily been divided under the umbrella groups 'A' (those where positive histological findings were identified and the cause of death had been ascertained), 'B' (those where positive histological findings were identified but the cause of death could not be ascertained), and 'C' (where histological findings have not been identified).Of the total, in 78% of the samples, positive histological findings were identified, of which in 88% (n=69), the cause of death could be ascertained, and in the remaining 12% (n=9), it could not be (Table 4).

Further to the data outlined above, of the 69% of the total samples where positive histological findings were identified and the cause of death ascertained, 57% confirmed the macroscopic cause of death that had been proposed. Of the remainder of this proportion, 9% revealed the cause of death in cases where it had not been identified macroscopically prior to it. In another 3%, the histological evidence was instrumental in excluding other possible causes for the death.
It was also evident that in 4% of the sample, the histological findings were incompatible with the macroscopic findings. On the other hand, in 22% of the samples, no histological findings were identified despite the cause of death being decided upon as ischaemic heart disease (and its relevant conditions stated earlier on) through macroscopic findings and historical evidence.

Table 4: The relevant proportions of the levels of achievement of the objectives

Level of achieve-ment	Observation	The proportion of the total sample that had achieved relevant grade
A	**Positive histological findings were identified, and the cause of death could be ascertained.**	**69%**
A1	Findings revealed the COD, which was not identified macroscopically	9%
A2	Findings confirmed the macroscopic COD /probable COD.	57%
A3	Findings can be used to exclude possibilities other than COD.	3%
B	**Positive histological findings were identified, but the cause of death could not be ascertained.**	**9%**
B1	Findings are not compatible with macroscopic findings	4%
B2	Findings are not significant/relevant to the COD	0%
B3	Findings cannot be used to confirm COD or to draw any other conclusions.	5%
C	**No histological findings were identified.**	**22%**

DISCUSSION

In forensic medicine, accurate diagnosis through autopsy is paramount for judicial processes, and histopathological examination can provide invaluable insights that may otherwise be missed by gross inspection alone. The Royal College of Pathologists in 2002 recommended histological sampling of all major organs as part of a complete autopsy in its guidelines on autopsy practice[9]. Lack of histology significantly detracted from the quality of the autopsy report in 28% of reports examined by the National Confidential

Enquiry into Perioperative Deaths (NCEPOD) of the United Kingdom in their 2001 report, in which only some papers specifically examined histology[10]. Those that did showed that diagnoses made on macroscopic examination were altered by histology and that macroscopically normal organs showed histological abnormalities. Microscopy gave diagnoses not made macroscopically in 5% of primary diagnoses and 23% of all unexpected diagnoses in one study[11].

The majority of this sample who had deaths due to or associated with IHD were in the age group above 40 years of age, as expected. However, interestingly, there was a significant proportion of deaths in the age group of 30 to 39 years. This may have been contributed mainly by the absence of preceding illness or diagnosis among the young, leading the inquirers to order a compulsory autopsy. At the same time, among the older age group with preceding clinical diagnoses, an inquest may not be indicated, and even after an inquest, there is a probable cause of death to satisfy the inquirer. According to a current review of literature by Abbas *et al*., sudden cardiac deaths are less common in the age group below 35 years[12]. However, a study among Italian students aged 13 to 19 detected significant ECG abnormalities among 13%[13]. A study on sudden unexpected deaths autopsied at a tertiary care hospital in Sri Lanka revealed that 50% of the deaths were due to cardiac causes[14].

The absence of a preceding history was observed among 52% of the cases, which is self-explanatory since the sample is from the group that had undergone a medico-legal autopsy. However, sudden cardiac death is a well-recognised presentation of ischaemic heart disease[15]. On the other hand, the lack of comprehensive clinical data further emphasises the critical role of autopsy in uncovering undiagnosed pathologies and ensuring that the actual cause of death is identified. The absence of a detailed clinical history reinforces the need for forensic pathologists to rely on gross and microscopic findings to reach an accurate conclusion[5]. The findings of this study revealed that histopathological examination had a significant impact on the accuracy of the cause of death determination in 59% of the cases, with the majority confirming macroscopic findings. However, importantly, in 9% of the cases, microscopy revealed a cause of death that was not identified in the gross examination. This corroborates previous studies that emphasise the importance of microscopic examination in cases of heart disease, where subtle or complex pathologies may not be readily apparent on gross inspection. For example, conditions like MI, myocarditis, and deposition diseases such as amyloidosis or inflammatory diseases such as sarcoidosis can be easily misinterpreted as IHD based solely on macroscopic features such as the colour changes of the myocardium, fibrosis, or the presence of atherosclerosis[5,16]. By offering a more detailed analysis of myocardial tissue, histopathology can help distinguish these conditions and thus refine the cause of death. Furthermore, the microscopic slides can be used as reviewable evidence, especially in controversial cases. The significant percentage (57%) of cases in which histological findings confirmed the macroscopic diagnosis aligns with findings from other studies showing a high rate of diagnostic agreement between gross and microscopic heart examination[4,17].

On the other hand, in 9% of the cases, microscopy revealed a cause of death that was not identified in the gross examination. There was another 9% where the microscopic findings were nonspecific, and the findings were either incompatible with the gross findings (4%) or could not be used to reach conclusions (5%). All these instances could be considered diagnostic errors since all these cases have already been concluded as ischaemic heart disease based on clinical history and gross pathology. These instances highlight the potential for errors in diagnostic interpretation during the macroscopic phase, underscoring histopathology's importance in verifying and ruling out other possible causes[18]. This is further highlighted by the fact that 22% of cases had no positive histological findings despite a definitive COD being reached based on macroscopic observations and historical data. The finding reiterates the importance of microscopy and suggests the possibility of misdiagnosis from gross pathology. However, in some instances, the macroscopic and clinical evidence alone may be sufficient to ascertain the cause of death, especially in well-documented cases of IHD[9].

Interestingly, only 39% of the cases underwent histopathological examination to confirm the cause of death, despite 60% having histology samples collected. This highlights an important challenge in forensic practice, particularly in settings with limited resources or high caseloads. Given that histological examination significantly contributes to the accuracy and comprehensiveness of postmortem investigations, this finding calls for a review of practices regarding the routine use of histopathology in autopsies, especially for cases involving IHD and other cardiovascular conditions[10].

The study also points to the broader implications of forensic histopathology, including its potential to detect inherited cardiac diseases that may pose a risk to surviving family members, such as cardiomyopathies. Identifying such conditions could not only aid in public health but also inform clinical management for relatives, potentially preventing further fatalities due to undiagnosed cardiac conditions. This aspect aligns with the growing recognition of forensic medicine's role in providing valuable information for medical practitioners and the public[16].

In conclusion, this study reinforces the essential role of histopathology in forensic autopsies, particularly in cases where the cause of death is initially suspected to be ischaemic heart disease. While macroscopic examination offers crucial initial insights, histopathological examination often provides definitive answers, clarifies diagnostic uncertainties, and identifies conditions that may be overlooked. Furthermore, histopathology is also a useful tool in excluding microscopic pathologies of the heart in cases of sudden cardiac death in the young, so that inherited cardiac conditions such as channelopathies can be screened for in the next of kin. The findings highlight the need for improved integration of histopathology into routine forensic practice and underscore its significance in achieving accurate cause of death determinations, ultimately enhancing the quality of autopsy reports and supporting the broader medico-legal process. Future studies could explore the impact of improving histopathological access and protocols in resource-limited settings, aiming to further optimise the diagnostic accuracy and clinical utility of forensic autopsies.

LIMITATIONS OF THE STUDY

As this was a retrospective study, carried out by examining the slides obtained by postgraduate trainees, it is impossible to corroborate the exact locations the samples were obtained from the heart. Furthermore, fixation and processing artefacts, especially concerning cross sections of coronary arteries, may have impacted the findings to a certain extent.

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None.

CONFLICTS OF INTEREST

The authors declared no conflicts of interest.

ETHICAL ISSUES

The ethical approval for this study was granted by the Ethics Review Committee, Faculty of Medicine, University of Kelaniya, Ragama, Sri Lanka (Ref. No.: P/48/05/2021).

SOURCES OF SUPPORT

None.

AUTHOR CONTRIBUTIONS

NNVDR: Conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and reviewing it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **IDGK:** Conception and design of the work; drafting the work and reviewing it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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ORIGINAL ARTICLE

ROAD TRAFFIC ACCIDENTS IN SRI LANKA: A RETROSPECTIVE ANALYSIS AND ARTIFICIAL INTELLIGENCE-BASED SOLUTIONS FOR PREVENTION

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ABSTRACT

Introduction: This study aims to conduct a retrospective, descriptive analysis to identify the factors contributing to road traffic accidents (RTAs) and propose artificial intelligence (AI)-based solutions for their prevention.

Methods: The ninety-nine postmortem reports belonging to the investigators and documents connected to death investigations due to RTA were selected from fatalities reported to the Colombo North Teaching Hospital, Ragama, Sri Lanka, from 2001 to 2021. Data was gathered based on a pre-prepared questionnaire and analysed using IBM SPSS Statistics version 26. Strict confidentiality of individual information was maintained throughout the analysis and presentation of the results.

Results: Among the selected population, 83.8% were male, and the majority belonged to the 51-60 year age group (19.2%). Pedestrians were the most vulnerable group (41.5%), followed by motorcycle riders (17.2%). Main roads (72.7%) were the most frequent place for RTA. The most common time for RTA was between 06.01 pm and 12.00 am (38.4%). The majority of the RTAs had contributory human factors (85.8%), but most of them did not have any identifiable contributory environmental, road-related, or vehicle-related factors. Breaking road regulations was the most common contributory human factor (27.3%). It was followed by poor judgment (25.3%). Blood for alcohol was sent in 60.6% of the selected population, and 18.2% were found to be positive with available reports. (> 80mg/dl). Blood alcohol reports could not be traced in 14.1% of victims. Head injuries (41.4%) and multiple trauma (37.3%) were the most common causes of death among the fatalities due to RTA.

Conclusions: By analysing the data from history, toxicology reports, and other information provided by police, it can be inferred that the majority of RTAs had contributory human factors. It is postulated that supervised AI-based solutions could reduce the number of fatalities attributable to human errors.

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INTRODUCTION

Road traffic accidents (RTAs) continue to play a pivotal role in causing numerous fatalities, injuries, and socioeconomic challenges. Every year, approximately 1.19 million people are cut short as a result of a road traffic crash[1]. In Sri Lanka, road traffic accidents reveal an upward momentum over the past decade.

According to the statistics for the year 2022 available with the Ministry of Transport, Highways, Ports, and Civil Aviation, the number of persons killed in road accidents involved 820 motorcyclists, followed by 720 pedestrians. Overall, 2515 deaths took place in the year 2022. The 908 motorcycles were involved in fatal accidents, being the largest contributor[2]. Road traffic accidents arise from a multitude of intertwined factors, including road users' behaviour, road infrastructure, vehicle conditions, and environmental elements. Understanding the factors that contribute to these road traffic accidents is crucial for developing effective preventive measures and ensuring safer road environments[3-7].

The significant advancements in the field of artificial intelligence (AI) have shown promising results in solving complex problems in several identified domains. By harnessing the power of AI, we can potentially enhance our ability to identify and mitigate the factors leading to road traffic accidents, ultimately paving the way towards a safer future. While traditional methods have provided valuable insights into accident causation, the integration of AI technologies holds immense potential for revolutionising accident prevention strategies. AI encompasses a range of techniques, including machine learning, computer vision, and natural language processing, which can be leveraged to process and analyse vast amounts of data efficiently. This enables the identification of patterns, trends, and risk factors associated with road traffic accidents that may not be readily discernible through conventional approaches[8].

Retrospective descriptive studies offer an invaluable approach to retrospectively examine past accidents, identify contributing factors, and establish correlations between variables. By leveraging data from postmortem reports, we can uncover critical information that sheds light on the dynamics of road traffic accidents. Although many studies are available to find factors that cause road traffic accidents, no comprehensive postmortem report data on identifying the factors contributing to road traffic accidents in Sri Lanka with an approach towards utilising artificial intelligence can be found. Analysing these postmortem reports and death investigations information is essential for gaining comprehensive insights into accident causation patterns, focusing on the safety measures that can be adapted in futuristic vehicles that travel on the road. This research aims to undertake a retrospective descriptive study to identify the factors contributing to road traffic accidents using postmortem report data and propose AI-based solutions for their prevention. Though the CCTV footage may provide a more detailed option to analyse traffic accidents, it may not be a practical technique in all situations.

OBJECTIVES

The main objectives of this study are to describe the demography of deaths following road traffic accidents, to gather contributory factors from death investigations, and to suggest plausible preventive measures using artificial intelligence.

METHODS

The 99 post-mortem reports belonging to the investigators and documents connected to death investigations due to RTAs were selected from fatalities reported to Colombo North Teaching Hospital (CNTH), Ragama, Sri Lanka, from 2001 to 2021. Data was gathered based on a pre-prepared questionnaire. Information regarding gender, age, place of the incident, type of collision, injuries, and environmental and road-related factors was included in the questionnaire. Police sketch data was also used to further evaluate the RTAs in selected cases, and all data were analysed using IBM SPSS Statistics version 26. Strict confidentiality of individual information was maintained throughout the analysis and presentation of the results.

RESULTS

The majority of road traffic accidents reported to CNTH and handled by the investigators involved men (83.8%), and 17.2% involved females. The majority of victims belonged to the age group of 51-60 years (19.2%), followed by 61-70 years (18.2%), 41-50 years (16.2%), and 21-30 years (16.2%).

Pedestrians were the most vulnerable group (41.5%) among the road users, and motorcycle riders (17.2%) were the second largest group facing road traffic accidents based on the available data (Table 1).

Table 1: Types of vulnerable road users

Vulnerable road user	Frequency (n)	Percentage (%)
Pedestrian	41	41.5
Motorcycle rider	17	17.2
Pillion Rider	4	4
Passenger of a vehicle	12	12.1
Three-wheel driver	3	3
Any other	22	22.2
Total	99	100

Major roads with heavy traffic (72.7%) were the most frequent places for RTAs, followed by junctions (16.2%), by-roads (6.1%), and bends (1%). Side impacts were the most common collision pattern (41.4%), followed by head-on collisions (28.3%) and rear-end collisions (18.2%). In the remaining 12.1% of the cases, details regarding the type of collision were not recorded.

The majority of accidents occurred between 6.01 pm and 12 am (38.4%) (Table 2). The accident rate was lowest between 12.01 am and 6 am (9.1%).

Table 2: Analysis of RTA based on collision time

Time of collision	Frequency (n)	Percentage (%)
6.01 am - 12 pm	26	26.3
12.01 pm – 6 pm	24	24.2
6.01 pm – 12 am	38	38.4
12.01 am- 6 am	9	9.1
Details not available	2	2.0
Total	99	100

The majority of the RTAs (85.8%) had contributory human factors, based on the inference from available history and other investigative documents submitted by the police. It was difficult to infer positively about any documented contributory environmental, road-related, or vehicle-related factors with the available data. Following careful analysis of the available data by the investigators, 27.4 %, 23.6%, and 7.5% of the cases were identified as due to breaking road regulations, poor judgement, and overspeeding, respectively (Table 3) Poor lighting (5.1%) and road bumps (1%) are some road and environmental factors that may have contributed to RTAs in selected situations.

Table 3: Analysis of RTA based on human factors contributing to RTA

Contributory human factors	Frequency (n)	Perecentage (%)
Intoxication	12	12.1
Overspeeding	7	7.1
Breaking road regulations	27	27.3
Poor Judgement	25	25.2
Vision/Hearing impairment	2	2
Any other disabilities	4	4
Any other	8	8.1
Details not available	8	8.1
None	6	6.1
Total	99	100

Head injuries (41.4%) and multiple trauma (37.4%) were the most common causes of death, followed by chest injuries (8.1%) and neck injuries (1%) from the available data. Other causes contributed to death in 12.1% of the cases. Blood for alcohol was sent in 60.6% of the selected population, and 18.2 % were found to be positive with available reports (>80 mg/dl). Blood alcohol reports could not be traced in 14.1% of victims.

DISCUSSION

This study found that middle-aged (51 to 60 years) male adults were the most frequent victims of RTAs. According to similar research done in teaching hospitals in Kandy and Kurunegala, it has been revealed that the most common age group involved in RTAs was 26-35 years, and 97% of victims were males[9]. A study

done by Wazeema in 2018 also found that the majority of the victims of RTAs that occurred in Sri Lanka were male[10]. This is presumably due to the fact of shouldering family responsibilities and thus frequenting motorways as pedestrians, motorcycle riders, or occupants of other passenger vehicles. The slight shift in the age group is based on the data available to the investigators, and it may not necessarily reflect the trends at a national level. In addition, it must also be noticed that although young adults are more prone to non-fatal crashes, the aged may have a higher death rate[11].

According to the global road safety data from the World Health Organisation in 2018, more than half of the worldwide road fatalities involve pedestrians, cyclists, and motorcyclists[12]. A previous descriptive study done at NCTH also found that the high fatality rate among pedestrians (37.2%) was followed by bicycle or motorcycle riders or pillion riders (44%), [13]. A case study done in Kandy also revealed that pedestrians involved in road traffic accidents are at a very high percentage[14]. During the past decade, a significant elevation in the number of accidents involving motorcycles has been identified in Sri Lanka. According to the statistics for the year 2022 available with the Ministry of Transport, Highways, Ports and Civil Aviation, the number of persons killed in road accidents mostly involved motorcyclists and pedestrians[2]. The young age, desire to ride motorcycles, and the easy availability of motorcycles at an affordable rate may have contributed to the increasing numbers. A study conducted by Pathak *et al.* also concluded that motorcycles were the most common vehicle type involved in vehicular accidents in India during the 2009-2011 period[15].

Furthermore, this study observed that unfavourable behaviour, mostly breaking road regulations by pedestrians and drivers (27.3%), may be the primary contributory human factor. Driving at excessive speed had been a contributory cause in 7.5% of accidents, according to this study. A study conducted by Pathak *et al.* proved that vehicles that had a speed range of 40-60 km/h (37.9%) were responsible for higher percentages of accidents[15]. Further, 27.3 % of incidents were reported in this study due to violations of road rules and regulations while walking and driving on the roads. This is supported by research done in Nigeria. The Federal Road Safety Commission (FRSC) of Nigeria identified that human factors contributed to more than 80% of road traffic accidents[16].

Driving under the influence of alcohol is another risk factor that promotes road crashes.

Alcohol intoxication was identified in 18.2% of accidents in this study, where the alcohol level was >80 mg/dl, based on the toxicology reports. Another Sri Lankan study had observed that the consumption of alcohol is an important human factor contributing to RTA[6]. Poor judgement of road users (23.6%) could be another main reason behind RTAs in this study. The authors, by inferring the available data recorded during the death investigation process, opined that poor judgement may have had a role in the causation of the accident when opportunities were there to avoid a collision. The investigators were limited by a lack of visuals from CCTV footage, which may increase the accuracy of interpretation; however, careful analysis of data often identified poor judgement as a contributory human factor supported with sketch analysis.

In addition to that, the majority of road traffic accidents occurred on roads with heavy traffic during the evening hours due to the large number of vehicles and pedestrians occupying the main roads compared to junctions and by-roads during this period, as well as lower visibility of the surroundings. A descriptive cross-sectional study was conducted at teaching hospitals in Kandy and Kurunegala also found that the majority of RTAs had occurred after 6 pm and 76.9% of RTAs had occurred on carpeted main roads rather than on any other types of roads[9]. Side impacts were the main method for collision identified in this study, amounting to 41.4%, followed by head-on at 28.3% and rear-end at 18.2%. Faults in the braking system, defects in the engine, and a lack of modern safety features are the vital factors affecting road accidents. Also, environmental factors and road conditions are considered major contributory factors for RTAs[17]. Weather

conditions, including temperature, wind speed, and humidity, represent the principal external factors that have an impact on road traffic crashes. In this study, only a few incidents were identified due to environmental and road factors. This may be partly due to the lack of complete data available at the time of the death investigation.

Recognising the factors that contribute to road traffic accidents and taking preventive actions is essential to save the valuable lives of people in the world. The persisting problem of road crashes will not be solved merely by the strict implementation of road rules and severe punishments. Therefore, this study proposes potential remedies for reducing road traffic accidents using applications of artificial intelligence. With the introduction of artificial intelligence, it is rapidly transforming the vehicle industry and revolutionising road safety. Based on this study's data, as well as the most common vehicle used on Sri Lankan roads, this study proposes a motorbike that is developed using applications of artificial intelligence.

Driver Assistance Systems (DAS) have become a sought-after technology with the advances in artificial intelligence[18]. Autonomous driving systems are one of the major applications in DAS (Fig. 1). The incorporation of AI algorithms makes a vehicle more autonomous, resulting in self-navigation and perceiving and adapting to dynamic environments, resulting in a safer journey. In order to work without manpower, an autonomous system has been included with cameras to monitor the vehicle's position within the lane and detect the rider's mental condition while driving. It may be presumed that an emotionally unstable person, showing signs suggestive of fatigue, may be more prone to collisions, and thus, the driving can be switched to a DAS. Researchers found that a person's emotions and feelings can be interpreted with more than 60% accuracy by analysing their eye expressions[19]. Based on that information, it is proposed that the autonomous motorbike system include an eye-expression-sensitive camera on its helmet. Also, this system can be included with various sensors to automatically measure the speed of the vehicle and light intensity of the surroundings and provide real-time feedback to assist riders in making safe decisions while driving. The sensors above a certain speed limit or very poor road surface may activate an alarm system to alert the driver, and similarly, when the environmental lighting is not sufficient, the intensity of the headlight and other supportive lighting systems can be activated. Research done in the recent past reiterates that the sweat alcohol levels correlate with blood alcohol level[20]. Biosensors can be attached to detect the alcohol level, blood pressure, and heart rate of the motorcyclist. Based on biosensor data, an autonomous system can recognise the physiological condition of the rider and alert the driver regarding their fitness to drive and may suggest automated driving to minimise collisions, basically, to follow road regulations more precisely and to minimise errors in judgement.

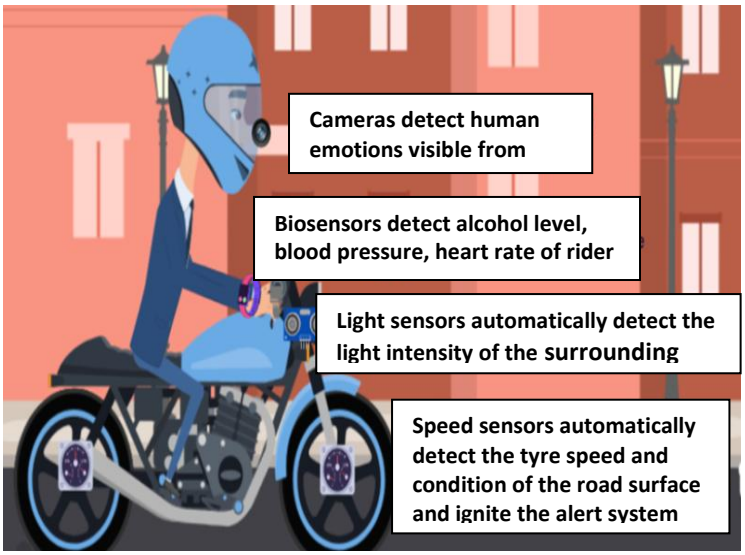

Figure 1: Proposed Autonomous Driving System

One of the most significant advances in road safety has been collision detection and prevention technology (Fig. 2). Vehicles now use AI to detect potential collisions and implement preventive steps to avoid them. The motorbikes of the future can be facilitated with AI-powered collision avoidance systems with radar sensors to avoid objects in the path, including humans, by using an 80 GHz wideband Frequency

Modulated Continuous Wave (FMCW) radar sensor on a maximum measurement range of 5.69 yds with a movable radar target[21]. These systems can intervene autonomously by adjusting the motorcycle's speed, steering, or braking to avoid or mitigate crashes.

Figure 2: Proposed collision detection system

The increasing urban population has become a major challenge in managing traffic flow, resulting in road traffic accidents worldwide. To address these problems, cities are looking for smart traffic management systems that use AI algorithms to analyse real-time data from several sources, such as GPS devices on vehicles (Fig. 3). Royo *et al.* (2019) stated that GPS uses the signal from a network of satellites[22].

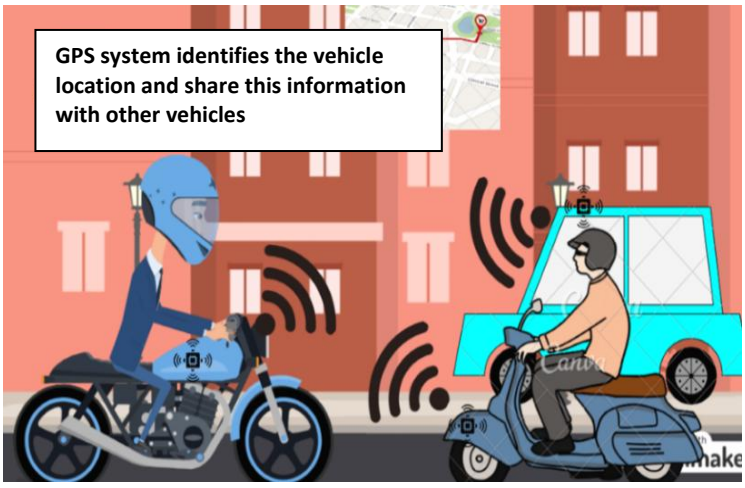

Figure 3: Proposed Traffic management system

AI algorithms can identify traffic patterns, predict changes in conditions, and provide recommendations for optimal traffic settings. This helps reduce traffic congestion and improves the smooth movement of vehicles. It detects locations in real-time, designed to detect accidents rapidly, which can reduce emergency response times, remove reporting errors, and save more lives.

CONCLUSIONS

Road traffic accidents have become a major barrier in the development process of Sri Lanka, which highly impacts all spheres of life. The road traffic accidents and deaths were a result of multiple factors, including human factors, poor environmental conditions, mechanical defects in vehicles, and demographic characteristics of the accidents. However, results of this study based on available data show that the majority of the contributory factors were human-related, and by that we can suggest supervised AI-based technologies that could detect human factors that may contribute to breaking road regulations and poor judgement in advance, and convert the riding experience under the guidance of AI. Further, poor environmental and road conditions can be addressed with additional mechanisms to be operated within the bike by the AI. This will prevent most fatalities and provide the complementary support needed to enhance road safety for a better future.

RECOMMENDATIONS

Existing studies on AI technologies and their potential applications in advancing traffic accident prevention in Sri Lanka are inadequate. Therefore, comprehensive case studies or pilot projects in specific regions or cities in Sri Lanka are needed to demonstrate the effectiveness of AI in reducing road traffic accidents.

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CONFLICTS OF INTEREST
The authors declared no conflicts of interest.

ETHICAL ISSUES
None. The authors have retrospectively used the postmortem data from their records, institutional guidelines and without divulging the identity of the subjects.

SOURCES OF SUPPORT
None

AUTHOR CONTRIBUTIONS
WGSRT: The acquisition and analysis of data for work, interpretation of data for the work; drafting the work or revising it critically for important intellectual content; final approval of the version to be published; agreeing to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **MTKLT:** The acquisition and analysis of data for work, interpretation of data for the work; drafting the work or revising it critically for important intellectual content; final approval of the version to be published; agreeing to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **WACJH:** The acquisition and analysis of data for work, interpretation of data for the work; drafting the work or revising it critically for important intellectual content; final approval of the version to be published; agreeing to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **WNSP:** Conception or designing of the work, the acquisition of data for work, interpretation of data for the work; drafting the work or revising it critically for important intellectual content; final approval of the version to be published; agreeing to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **PP:** Conception or designing of the work, the acquisition of data for work, interpretation of data for the work; drafting the work or revising it critically for important intellectual content; final approval of the version to be published; agreeing to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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ORIGINAL ARTICLE

UTILITY OF FORENSIC TOXICOLOGY AND HISTOPATHOLOGICAL EXAMINATION IN COMMUNITY-RELATED DEATHS AT A TEACHING HOSPITAL IN INDIA - A RETROSPECTIVE STUDY

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ABSTRACT

Objectives: This retrospective study was undertaken to assess the utility of forensic toxicology and histopathological examination to determine the cause of death in community-related deaths that were brought dead to a teaching hospital in India.

Methods: All community deaths in 2020 were studied based on the inquest report, medico-legal autopsy report, histopathological examination report, and forensic toxicology report at RVRS Medical College, Rajasthan, India. The probable cause of death after the medicolegal autopsy and the final cause of death after receiving reports of forensic toxicology and histopathological examination were compared to assess the utility of chemical analysis and histopathological examination.

Results: Viscera were preserved for forensic toxicology in 171 cases. Out of these, 53 were cases of mechanical injuries, and in 4 cases, probable cause after a medico-legal autopsy was undetermined. Out of a total of 171 cases, viscera were preserved for histopathological examination in 54 cases. Out of these, 12 were cases of other natural causes, 2 were cases of snake bite, and 2 were cases of hanging as a probable cause after medico-legal autopsy. Histopathological examination was useful in 3 cases of other natural causes, 3 cases of undetermined causes, and 1 case of snake bite. Overall, forensic toxicology caused an impact on the cause of death in only 16 cases out of 171 cases, and histopathological examination caused an impact on the cause of death in only 7 cases out of a total of 54 cases.

Conclusion: The current retrospective study suggests that microscopic examination and forensic toxicology investigations should be used, as and when needed, in specific circumstances, but are not necessary as a routine investigation in each and every case.

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INTRODUCTION

Medico-legal autopsy is essential in all types of unnatural deaths, as well as natural deaths when the cause of death cannot be ascertained by the treating physician[1]. During autopsy, meticulous examination of all organs and preservation of necessary samples for forensic toxicology and histopathological examination are vital to determine the cause of death. Community-related deaths mean cases that were brought dead to the hospital without any positive history, and in such cases, preservation of viscera for forensic toxicology and histopathological examination is very crucial. To practice humanitarian forensics, judicious use of histopathological examination and forensic toxicology should be there[2]. This study aims to find out the utility of forensic toxicology and histopathological examinations in community-related deaths during medico-legal autopsy by analysing retrospective data. The study performs a **functional audit** of how histopathology and toxicology can **confirm, refine, or change** the initial medico-legal opinion.

METHODS

This study was conducted retrospectively using stored data at RVRS Medical College, Rajasthan, India. The aim was to study the utility of forensic toxicology and histopathological examinations in community-related deaths where individuals were brought to the hospital deceased in the year 2020. RVRS Medical College is affiliated with the Rajasthan University of Health Sciences, Rajasthan, India, and is approved by the Medical Council of India (the National Medical Commission). All the community-related deaths where individuals were brought to the hospital deceased in the year 2020 were studied using the inquest report, medico-legal autopsy findings, histopathological examination report, and forensic toxicology report.

During the COVID-19 pandemic, all medico-legal autopsies were conducted with high precautions, strictly following guidelines, and using complete PPE kits. Decisions on conducting a thorough, meticulous autopsy or a minimally invasive autopsy, as well as the preservation of viscera, were made on a case-by-case basis. Major organs, including the brain, heart, lungs, liver, spleen, and kidneys, were routinely preserved in 10% formalin during autopsy for histopathological examination, which was conducted by the Pathology Department. For forensic toxicology, three bottles were routinely used: the first contained the stomach and a loop of small intestine (first 30 cm) with its contents; the second contained sections from the liver (about 500 g with the gall bladder) and both kidneys (half of each); the third contained a sample of blood. The most common preservative used for forensic toxicology was a saturated solution of common salt. Though it is not an ideal preservative, it is routinely used in the Indian setup. The bottles were sealed, labelled, and handed over to the investigating officer (police personnel) for submission to the Forensic Science Laboratory for forensic toxicology analysis.

Forensic toxicology analysis was conducted following the standard protocols and procedures established by the Directorate of Forensic Science Services, Ministry of Home Affairs, Government of India, through the designated forensic science laboratory[3]. The probable cause of death after medico-legal autopsy and the final cause of death after receiving reports of forensic toxicology and histopathological examinations were compared in each case to assess the utility of forensic toxicology and histopathological examination.

RESULTS

A total of 171 cases of community deaths were brought dead for medico-legal autopsy in the year 2020, in which viscera were preserved for forensic toxicology or histopathological examination. A total of 30.99% of the cases were from the 21-30 years age group, 24.56% of cases were in the 31-40 years age group, whereas only 2.34% were under ten years of age (Table 1).

Table 1: Age distribution of the study sample

Age group (years)	No. of cases (%)
≤10 years	4 (2.34)
11-20	21 (12.28)
21-30	53 (30.99)
31-40	42 (24.56)
41-50	23 (13.45)
51-60	17 (9.94)
>60	11 (6.44)
Total	171 (100)

Out of 171 cases, 61.99% were male, 38.01% were female, and no transgender cases were noted (Table 2). The male-to-female ratio was 1.6:1.

Table 2: Gender distribution of the study sample

Sex	No. of cases (%)
Male	106 (61.99)
Female	65 (38.01)
Total	171 (100)

Viscera were preserved for forensic toxicology in a total of 171 cases. This cohort consisted of 53 cases of mechanical injuries, 29 cases of hanging, 18 cases of drowning, 16 cases of snake bites, 14 cases of electrocution, 12 cases of other natural causes, 11 cases of burns, 8 cases of cardiac causes, 6 cases of poisoning, and 4 undetermined cases.

Out of the total of 171 cases, viscera were preserved for histopathological examination in 54 cases that, based on the probable cause of death, included 12 cases of other natural causes, 9 cases of electrocution, 8 cases of cardiac causes, 5 cases of burns, 4 undetermined cases, 3 cases of drowning, 2 cases of poisoning, 2 cases of snake bites, and 2 cases of hanging.

After a full medico-legal autopsy, including forensic toxicology and histopathological examinations, the preliminary cause of death has remained unchanged in 18 cases of drowning, 11 cases of burns, 14 cases of electrocution, and 6 cases of poisoning. This suggests that there is not much of an impact of chemical analysis and histopathological examination on the cause of death. In poisoning cases, chemical analysis was useful to detect the type of poison by qualitative analysis, but quantitative analysis was not done.

Forensic toxicology was useful in 1 case of hanging, 2 cases of mechanical injuries, 2 cases of cardiac causes, 5 cases of other natural causes, 5 cases of snake bites, and 1 undetermined case. In these cases, forensic toxicology played a crucial role in determining the cause of death, which was not ascertained after medico-legal autopsy. Poisoning was detected in all the above cases after chemical analysis, which changed the probable cause of death as per the inquest, and poisoning was given as the new cause of death in the final report.

Histopathological examination was useful in 3 cases of other natural causes, 3 undetermined cases, and 1 case of snake bites. In these cases, histopathological examination played a crucial role in determining the cause of death, which was not ascertained during medico-legal autopsy. Cardiac pathology was detected in 6 cases, and lung pathology was detected in one case, which changed the probable cause of death; thus, histopathological examination helped to assign the new cause of death in the final report.

During the inquest, police wrongly identified fang marks over the body and gave probable cause of death as snake bite in 16 cases, but following a meticulous autopsy, only 10 cases were true snake bites, with features of envenomation. Forensic toxicology helped to identify poisoning as the cause of death in 5 cases, and histopathological examination helped to identify cardiac pathology as the cause of death in one case, which was wrongly considered a snake bite by the police.

Overall, forensic toxicology was useful for the cause of death in only 16 cases out of 171 cases, and histopathological examination for only 7 cases out of 54 cases (Table 3). The p-value (0.618) is greater than the conventional significance level (0.05), indicating that there is no statistically significant difference between the cause of death as determined at different forensic stages. This suggests that autopsy findings largely confirm the initial inquest conclusions**,** with only a few cases showing discrepancies between forensic and histopathological examinations.

Table 3: Impact of forensic toxicology and histopathological examinations on the cause of death.

Cause of death	Probable cause of death as per inquest	Cause of death immediate after autopsy	The cause of death changed after receiving forensic toxicology report (New Cause of Death)	The cause of death changed after receiving histopathological examination report (New Cause of Death)
Hanging	29	28	1 (Poisoning)	0
Drowning	18	18	0	0
Burns	11	11	0	0
Electrocution	14	14	0	0
Mechanical injuries	53	51	2 (Poisoning)	0
Cardiac cause	8	6	2 (Poisoning)	0
Other natural causes	12	4	5 (Poisoning)	3 (2 Cardiac pathologies + 1 lung pathology)
Poisoning	6	6	0	0
Snake bite	16	10	5 (Poisoning)	1 (Cardiac pathology)
Undetermined	4	0	1 (Poisoning)	3 (Cardiac pathology)
Total	171	148	16	7

(Chi-Square Statistic (χ^2): 8.11, Degrees of Freedom (df): 10, p-value: 0.618)

DISCUSSION

From our study population, a majority of 30.99% of the cases were in the 21-30 years age group. It differs from a study by Yadiyapur U *et al*., in which the majority of cases (25.86%) were in the age group of 51-60 years.[4] N. L. Disania *et al*. reported that the maximum number of deaths (27.27%) belonged to the 3rd decade of life,[5] whereas, Gupta *et al*. reported that the 31-50 years age group topped with 48.89% of cases from the total.[6] The wide range of age groups in different studies indicates that community-related deaths, where the deceased were brought dead to the hospital, can occur in any age group.

In this study, the male-to-female ratio was 1.6:1, which differs from various studies like Yadiyapur U, *et al*., N. L. Disania, *et al.,* Gupta, *et al*., and Apurba Biswas, *et al.,* who reported male-to-female sex ratios of 4.88:1, 1:0.18, 5.92:1, and 4.40:1, respectively.[4,5,6,7]

In our study, forensic toxicology was useful in 1 case of hanging, 2 cases of mechanical injuries, 2 cases of cardiac causes, 5 cases of other natural causes, 5 cases of snake bites, and 1 undetermined case.

Our study showed that histopathological examination was useful in 3 cases of other natural causes, 3 undetermined cases, and 1 case of snake bite. According to Langlois, histological analysis determined the cause of death in 49 out of 203 cases (24%), where macroscopic examination alone did not provide a definitive cause. The probable cause of death, which was decided after complete gross examination, was changed in 4.8% of the cases. However, the histological findings did not alter the determined manner of death.[8] Another study by Molina *et al*. found that among 189 cases, microscopic examination influenced the cause of death in only one case and had no impact on the manner of death in any case. Therefore, we believe that routine microscopic examination, where histologic analysis is performed in all cases regardless of the cause and manner of death, is not essential in forensic autopsies. Microscopic examination of organs should be used, as and when needed, in certain circumstances on a case-by-case basis, and it is not mandatory to follow as a standard procedure in every case[9].

Despite the statistical analysis not showing a significant association between ancillary tests and change in cause of death (p=0.618), it is crucial to interpret these findings with caution. In forensic medicine, even a small number of cases

where the cause or manner of death changes due to ancillary tests like toxicology or histopathology can have profound legal and ethical implications. For instance, in the present study, two cases initially recorded as mechanical injuries were later revised to poisoning based on forensic toxicology results. Similarly, two cases thought to be due to cardiac causes were ultimately attributed to poisoning. These findings underscore the indispensable role of ancillary investigations in refining or correcting initial assessments made at autopsy. This highlights the importance of a thorough and case-by-case evaluation before deciding to omit such tests, especially in equivocal or complex cases. While the routine use of these methods may not be resource-feasible, selective application guided by preliminary findings can substantially impact justice delivery and accuracy in cause of death determination.

Postmortem examinations are very much needed for several reasons for investigating authorities. Medical or pathological autopsies are conducted with the consent of the deceased's next of kin to assess the extent of a disease process or evaluate the effectiveness of treatment. In contrast, medico-legal autopsies are performed by a forensic pathologist or medical officers in India to determine the cause and manner of death, interpret injuries, diagnose infectious or natural diseases that lead to death, report to appropriate agencies, provide information to family members and investigating agencies, and give evidence in the courts. Medico-legal autopsies may include histological analysis, but unlike medical autopsies, it is not always performed.

In India, most of the autopsy work is done by medical officers, who are government employees at primary care centres or community health centres. In many places, there are no facilities for histopathological examination or nearby laboratories for forensic toxicology. Often, the medical officer has to make a prudent decision depending upon his autopsy skills, whether preservation of viscera is required or not, on a case-by-case basis. No rule of thumb can be applied to preserve viscera in all cases, given the constraints of resources and facilities in a developing country like India.

It is better to follow good medical practice by taking necessary tissue samples in most cases for future examination if ordered by a competent authority. In cases of sudden death or when the forensic diagnosis remains uncertain, histological examination should be conducted to accurately determine the cause of death. This approach would greatly minimise the risk of forensic medical malpractice[10]. There is a need to generate more evidence for the utility of forensic toxicology and histopathological examination on a case-by-case basis to practice evidence-based forensic medicine.

One study noticed that diagnostic discrepancies or refinements impacted the cause of death after microscopic examination of lung tissue[11]. The quality of histological sampling is also a very important factor in getting a positive result. Whether necropsy can be completed without systematic histological sampling in every case is debatable. Reasons for limited sampling or lack of sampling are cost limitations, lack of time, high caseload, lack of interest in dealing with postmortem histology, increased turnaround times, and even as a reaction to the media or sentiments of the general public[12].

Determining the cause of death in cases of suspected poisoning becomes challenging when the toxicology report yields negative results, creating confusion for the doctor who conducted the autopsy, legal authorities, and the public. The inability to detect poison in preserved viscera in poisoning-related deaths is a common issue in India. Several factors contribute to this challenge, including delays in sample testing, improper preservation, use of incorrect analytical techniques, rapid decomposition of poisons, complete metabolism of toxins in the body, minimal quantities of poison present in the viscera, and the absence of appropriate chemical reagents for certain poisons.

The inability to detect poison in preserved viscera in poisoning-related deaths is a common issue in India. Although not mandatory in all cases, the Forensic Science Laboratory (FSL) report is crucial in cases where there are allegations of death due to poisoning. The absence of an FSL report or a negative FSL finding significantly weakens the prosecution's case, as not all cases have sufficient

circumstantial evidence to establish that the accused administered poison to the deceased[13].

According to one study, 81.6% of the population is concerned about the removal of organs or body parts during an autopsy[14]. Considering the economic burden for the country and ethical principles[15], the autopsy surgeons must decide on the need for chemical analysis and histopathological examination to help the judicial system. Extensive research via funding agencies[16] and various educational programs via recent educational technologies like e-learning[17,18,19], case-based discussion[20], Google sites[21], etc., may help to create awareness among autopsy surgeons. Analytical methods for poison detection and the protocol for viscera preservation should be aligned with international standards.

This kind of comparison is underexplored in forensic studies, particularly in the Indian context. It has implications for medical education, legal standards of death certification, accuracy of public health statistics, etc. The use of saturated salt solution (though suboptimal) reveals systemic issues in forensic preparedness. By stating this openly, the study invites discourse around the need for better preservatives (e.g., sodium fluoride for blood) and capacity-building in medico-legal infrastructure and practice.

CONCLUSION

Histopathology is used to aid in the diagnosis by confirming the macroscopic findings, while forensic toxicology is very useful in death due to poisoning. Routine microscopic examination and forensic toxicology in all cases, regardless of the cause and manner of death, are generally unnecessary in a highly populous country like India. Microscopic examination and forensic toxicology should be conducted when necessary in specific cases, but are not required as routine procedures in a developing country like India.

SUGGESTIONS

A facility for forensic toxicology and histopathological examinations must be developed within the Forensic Medicine Department, which is conducting medico-legal autopsies in tertiary care hospitals, that can offer services to the peripheral centres of the concerned districts. In current practice, forensic toxicology samples are handed over to investigating police officers, who deliver them to a central forensic science laboratory, which is causing significant delays in analysis and in getting the final report. Forensic toxicology sample collection, preservation, and analysis must be done as per the standard international protocol and procedures of developed countries. In the same way, histopathological examination must be carried out in the Forensic Medicine Department instead of sending samples to the Pathology Department. An autopsy surgeon must be well-trained to decide when to preserve viscera to avoid unnecessary exercise of histopathological examination and forensic toxicology in every case.

LIMITATIONS

This study was conducted by retrospectively analysing data from one year from a single tertiary care forensic centre only.

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None.

CONFLICTS OF INTEREST

The authors declared no conflicts of interest.

ETHICAL ISSUES

None.

SOURCES OF SUPPORT

None.

AUTHOR CONTRIBUTIONS

PB: Conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and reviewing it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **AKB:** Conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and reviewing it critically for important intellectual content; final approval of the version to be published; and

agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **PP:** Conception and design of the work; reviewing the work critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **GR:** Acquisition, analysis, and interpretation of data for the work; reviewing the work critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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CASE REPORT

CRAVE ENDS IN GRAVE – GEOPHAGIA: A CASE REPORT

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ABSTRACT

This is a case of acute toxic dilation of the bowel loops resulting in a toxic megacolon with a rapidly fatal outcome in a 12-year-old girl with habitual intake of chalk pieces. The child presented with acute abdominal pain, abdominal distension, and intense thirst before death. On examination, dilated bowel loops were seen pushing the diaphragm into the thoracic cavity. Histopathology showed extensive erosions and focal atrophy of mucosal glands. Geophagia is likely to result in various abdominal complications, and one such resulting complication seen here in this report is toxic megacolon, further complicated by electrolyte disturbances and decreased cardiac output, causing death. This case report highlights the importance of recognising geophagia as a potential health risk and the need for comprehensive management strategies. Through this case, we aim to promote better understanding and research into the complex aetiology and consequences of geophagia.

Keywords: ***Constipation; geophagia; pica; soil; toxic megacolon***

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INTRODUCTION

Geophagy is the intentional practice of consuming earth or soil-like substances such as chalk, clay, or termite mounds. It is a behavioural adaptation that occurs in many nonhuman animals and is more common in primates. Eating behaviour in a child is a complex process associated with sociodemographic characteristics. Good parenting leads to improved eating behaviour in children. The prevalence of unusual eating behaviour in adolescent children in our nation ranges from 10% to 18.5%[1]. This is a case of aberrant eating behaviour of a child due to supervisory neglect, deprivation of care, and lack of parental capacity to seek early medical attention, resulting in grave complications for the child.

CASE REPORT

A 12-year-old girl was brought dead to the casualty at the Government Coimbatore Medical College & Hospital for autopsy with an alleged history of giddiness and unresponsiveness at her residence. On eliciting the history, following an intake of a heavy meal the previous day, she had the complaints of acute abdominal pain with distension, intense thirst with multiple episodes of vomiting in the last 24 hours before death. On probing further into her parents, we found that she had a habitual intake of chalk pieces frequently since childhood, associated with constipation on and off, which was relieved by native treatment. No appropriate medical measures were taken.

Autopsy Findings

The girl was moderately built and nourished. Rigor mortis was present all over the body. Fingernails and toenails were pale. The abdomen was found uniformly distended with a girth of 90 cm. No ante-mortem injuries were noted anywhere on the body.

On dissection of the chest and abdomen, extensively dilated loops of the large intestine were seen, compressing the small intestine and other abdominal organs, and it was also pushing both hemidiaphragms into the thoracic cavity (Fig. 1). The colon weighed 3.2 kg, and on dissection after fixation, a huge amount of sand and gravel admixed with faecal material was observed (Fig. 2). Bowel impressions were seen over the undersurface of the liver (Fig. 3). The stomach contained a few grams of undigested food particles with 20 ml of yellow-coloured mucoid fluid with no specific smell; its mucosa showed erosions with haemorrhagic patchy areas. The small intestine was dilated and contained sand particles with chyme; its mucosa showed erosions with patchy haemorrhagic areas. Other internal organs were normal. The scalp, skull, dura, and base of skull were intact. The brain was pale and oedematous. Neck structures were intact.

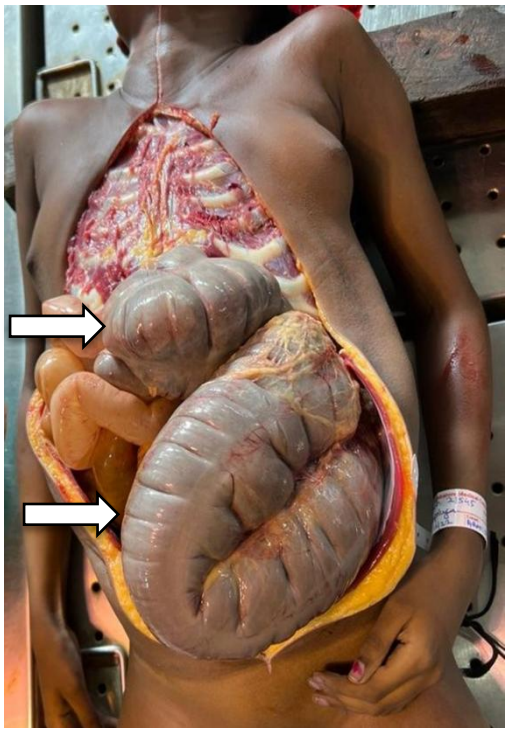

Figure 1: Extensively dilated loops of the large intestine (arrows).

Figure 2: Colon showed a huge amount of sand admixed with faecal material (arrow).

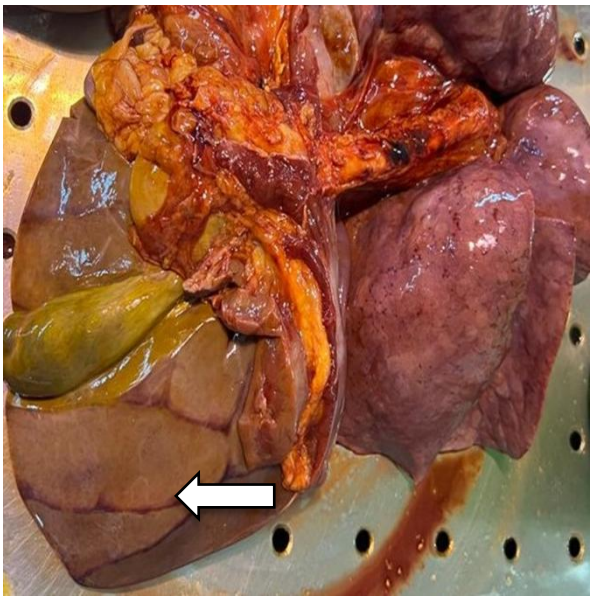

Figure 3: Bowel impression noted over liver (arrow)

Histopathological Examination Findings

Multiple sections of the large intestine showed extensive erosions and focal atrophy of the mucosal glands (Fig. 4). A dense chronic inflammatory cell infiltrate, composed of lymphocytes and histiocytes, was noted in the lamina propria and submucosa, suggestive of a chronic inflammatory pathology (Fig. 5).

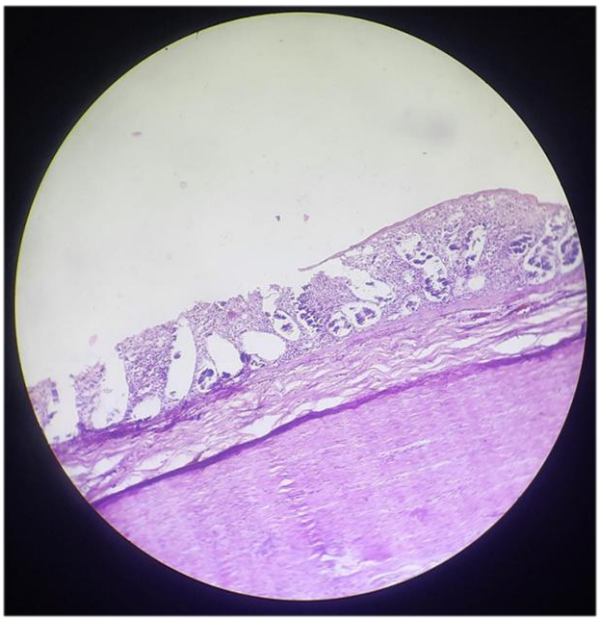

Figure 4: Extensive erosions and focal atrophy of mucosal glands (H&E x10)

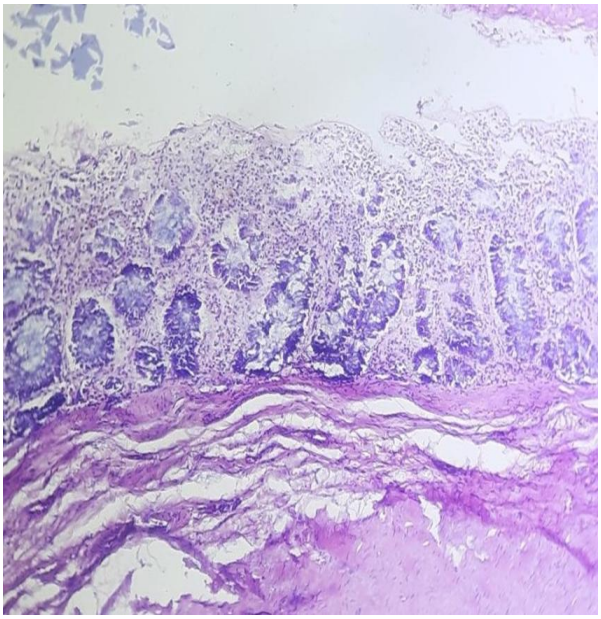

Figure 5: Dense inflammatory cells in lamina propria and submucosa (H&E x10 magnification)

DISCUSSION

Geophagia, a form of pica, is the persistent craving and compulsive eating of chalk, soil, and clay deposits with irresistible desire[1]. Under Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5 TR), the criteria for Pica are as follows: Persistent eating of non-nutritive, non-food substances over at least one month. The eating of such substances is inappropriate to the developmental level of the individual. The eating behaviour is not a part of a culturally supported or socially normative practice[2]. It is commonly reported among school children, pregnant women, and people with psychological disorders[3,4]. Predisposing factors are nutritional deficiency, cultural factors, and psychological reasons. Although pica is seen in children, it is also a common eating disorder in intellectually impaired patients. In women, it is most often seen during pregnancy. In some parts of the world, the consumption of non-nutritive substances is culturally accepted. Pica usually occurs as an isolated disorder, but there are instances when it may co-exist with schizophrenia, obsessive-compulsive disorder (OCD), and trichotillomania. Adolescents without developmental delay raised the possibility that some form of it fits under the umbrella of obsessive–compulsive (OC) spectrum disorder[5]. Geophagia often goes unrecognised, with patients presenting only when complications occur[6]. This disorder may be associated with mental retardation, which was reported in many studies. Clinically, abdominal pain and vomiting were the most frequently encountered signs. The abdominal plain x-ray may show a significant individualisation of a granite-like content throughout the digestive tract, which reflects the massive amount ingested by the patient. Radiological signs can easily be missed if they are not specifically sought. The chances of detecting soil in the stomach are higher if early pictures are taken. In the small intestine, the sand is much less visible because of its dilution by the large volume of intestinal fluid. Optimal opacification occurs in the colon because of the high absorption of water at this level[7]. Complications are closely linked to the type and amount of ingested material, which includes constipation, intestinal obstruction, perforation, peritonitis, electrolyte disturbances, parasitic infestations, and heavy metal toxicity. They are rare, but the associated mortality is very high[8]. Cases of bowel obstruction (up to 20%) secondary to geophagia in children were commonly reported in the age limits of 5 to 14 years in the literature[6,8]. When the quantities of non-nutritive substances ingested exceed the capacity of hydration of the digestive tract, they may go to severe bowel obstructive pathophysiological changes leading to

death as reported in this case[9] (Fig. 6). Dilated bowel loops secondary to toxic megacolon cause inhibition of intestinal secretion, which results in electrolyte disturbances, and the compressive effect of the dilated bowel loops on the diaphragm and the IVC results in a reduction in cardiac output, finally causing death. Although many factors contribute to geophagy, child neglect plays a crucial role. Child neglect related to geophagy can have serious consequences: neglect may be indicated if a child's geophagy is causing harm and not being adequately addressed by caregivers, also linked to inadequate supervision, nutrition, or health care. The potential consequences include nutritional deficiency, toxicity from contaminants, gastrointestinal problems, and developmental delays.

If there is any suspected child neglect case, reporting to the concerned local child protection services or authorities is crucial. The following preventive strategies may be helpful to reduce the incidence of geophagy: raising awareness about the risk associated with geophagy through school programs or workshops, training teachers and health care providers to recognise signs of geophagia, providing balanced meals and snacks to address potential nutritional deficiencies, teaching alternative coping mechanisms and stress management techniques to the affected children, engaging parents in monitoring and supporting the children's health, and environmental modifications like removing access to harmful substances or soil[9-11].

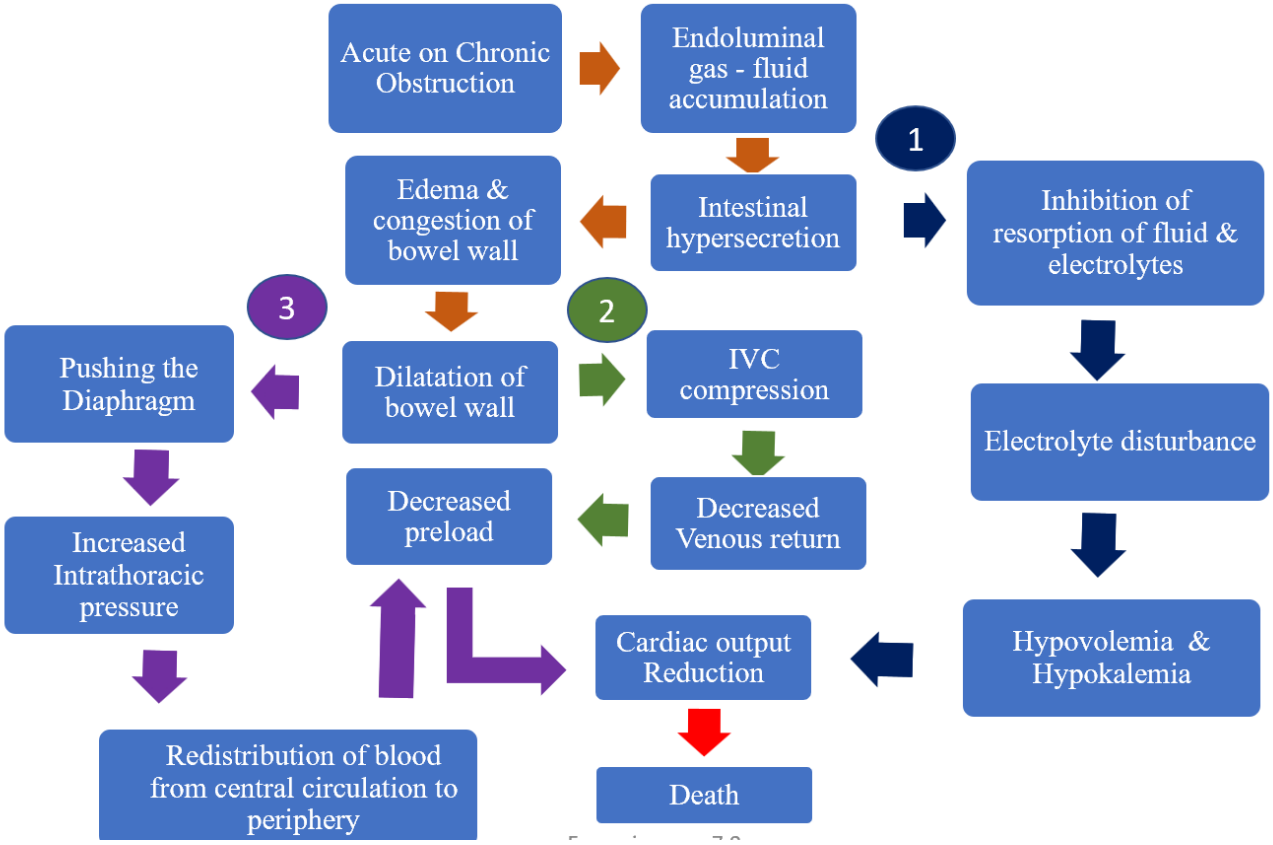

Figure 6: Mechanism of factors contributing to death.

CONCLUSION

Geophagia and its complications are easily preventable but missed because of various factors. So, the approach should not only be limited to early diagnosis and treatment; it needs psychological assessment, nutritional education, and behaviour therapy for the affected children. Parents need to be educated about the risks and health hazards of pica and how to prevent the exposure of their children. Forensic experts and medical professionals might investigate such cases to determine the extent of neglect and potential harm to the children. There should be an inter-disciplinary collaboration between health care professionals, social services, and law enforcement. Hence, geophagia warrants a multi-disciplinary medical and psychological approach for prevention and cure.

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CONFLICTS OF INTEREST

The authors declared no conflicts of interest.

ETHICAL ISSUES

The ethical approval for this case presentation was granted by the Institutional Ethics Committee of the Coimbatore Medical College, Coimbatore, India (Ref. No. 192/2024).

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AUTHOR CONTRIBUTIONS

RB: Conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **RU:** Conception and design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **LP:** Design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **RPR:** Design of the work; the acquisition, analysis, and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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CASE REPORT

DEATHS DUE TO WILD ELEPHANT ATTACK - A CASE SERIES

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ABSTRACT

Human fatalities caused by wild elephant attacks in India are increasing and are more common in areas close to elephant habitats. Victims are villagers who reside in settlements close to forest reserves. Although they are aware of the presence of elephants in their neighbourhood, they often enter forests to feed cattle or collect firewood. Here, we report three cases of adult males from villages near forests who were attacked by wild elephants. These cases are rather uncommon when compared to other types of cases autopsied at our centre, as during the attack, all three were alone and in remote places where timely help was not feasible. All succumbed to polytrauma, mainly crush injuries involving large areas of the body, and their bodies were found later by forest guards. Though there were no eyewitnesses to these incidents, autopsy findings and circumstantial evidence ruled out other causes for these types of crush injuries, and the cause of death was attributed to an elephant attack.

Keywords: ***Asiatic elephant; autopsy; death; forensic medicine; wild animal***

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INTRODUCTION

Karnataka is one of the southern states of India, which has a significant population of Asian elephants. Cauvery Wildlife Sanctuary is a protected area located in Southern Karnataka, which is home to many wild animals, including Indian elephants[1]. According to a survey done in 2012, the population of elephants in the Mysore Elephant Range in South Karnataka was 6072, and there were about 169 elephants in Ramanagara District[2]. There are eight villages enclosed and thirty within a radius of 5 km from the sanctuary, which has a total population of approximately 39,000, whose main occupation is farming and cattle rearing[1]. Humans and elephants co-exist in these settlements and can sometimes cause conflicts. When threatened, surprised, or while protecting their young ones, elephants attack humans and cause severe, life-threatening injuries.

The immense force of an elephant's weight and strength can cause fatal external and internal injuries. These types of cases are limited to some parts of the world with elephant habitat, and this case series aims to contribute to the existing literature by presenting a collection of cases highlighting the pattern of injuries and deaths caused by elephant attacks.

All three cases were found dead by the forest rangers in the vicinity of forests in Ramanagara, District of Karnataka and were subjected to postmortem examination at the Department of Forensic Medicine, Dr. Chandramma Dayananda

Sagar Institute of Medical Education and Research, Ramanagara District, Southern Karnataka, India.

CASE HISTORY

Case No. 1:

A 61-year-old male from "Gullatti Kavalu" village had gone to Bannerghatta Forest Reserve, which is nearby, in search of his cow on 27th February 2023. He was reported missing and was found dead by forest guards on 1st March 2023 near the forest area at about 1030 hrs. An elephant attack was suspected.

An autopsy was conducted on 2nd March 2023. The body was in a decomposed state. External injuries ranged from abrasions to fractures. Multiple abraded contusions were seen over the face, scalp, the back of the right elbow, wrist, right ankle, and both upper and lower limbs. Only one lacerated wound was seen over the inner aspect of the lower lip, with fracture dislocation of the angle of the mandible. Ribs were fractured on both sides: 2nd to 7th on the right side and 3rd to 5th on the left side. Multiple lacerations were seen over both lungs. The cause of death was multiple injuries sustained by blunt trauma. Considering the police investigation findings and autopsy findings, blunt injuries were attributed to an elephant attack.

Case No. 2:

A 55-year-old male from "Kodihalli" village had gone to graze his sheep on 25th December 2023 in the morning. He did not return home till evening. His body was found by forest guards, with suspicion of being trampled by an elephant in the fields on 27th December 2023. Elephant dung was also present near the body (Fig. 1). Coils of intestines and fractured bones of the left leg were also visible (Fig. 2).

A postmortem examination was conducted on 28th December 2023. The body was discoloured, and the skin was peeling off. Maggots were seen over the body, each measuring 0.5 to 1 cm in length, showing signs of decomposition. Multiple crush injuries were seen over the abdomen and lower limbs, exposing the underlying fractured bones, lacerated muscles, vessels, nerves, coils of intestine, and lacerated lungs, liver, and kidneys (Fig. 3). A ruptured heart and urinary bladder were also seen. All ribs were fractured at the outer angle; the sternum, scapula, and clavicle were fractured and dislocated. Cervical vertebrae 3 and 4 (C_3 and C_4), thoracic vertebrae 2 and 4 (T_2 and T_4), and pelvic bones were fractured. The cause of death was multiple injuries sustained by blunt trauma. Considering the facts provided by the police and autopsy findings, blunt injuries were attributed to an elephant attack.

Figure 1: Elephant dung (circled) present at the place where the body was found.

Figure 2: Fracture of bones of left leg (circled) with visible coils of intestines (arrow).

Figure 3: Thoracic cavity showing crushed and displaced organs.

Case No. 3:

A 38-year-old male had gone to his agricultural fields to water mulberry plants at around 0300 hours on 6th July 2024. He was suspected of having been attacked by a wild elephant (Fig. 4).

Figure 4: Body when found showing torn shirt, deformed right upper limb (circled), and contusions over chest and abdomen (arrow).

An autopsy was performed on 6th July 2024. The deceased was moderately built and nourished. Externally, injuries ranged from multiple abraded contusions to lacerations and were present over the head, trunk, as well as both upper and lower limbs (Fig. 5).

Figure 5: Multiple contusions present over the head and trunk (arrows)

Underlying bones of the cranium, ribs, and limb bones were fractured. Internal structures in the neck, thorax, and abdomen were crushed and displaced (Fig. 6).

Figure 6: Crushed neck structures

The scrotum was swollen, and the testes were contused. Cervical vertebrae 5 to 7 (C_5 to C_7), lumbar vertebrae 4 and 5 (L_4 and L_5), and pelvic bones were fractured into multiple pieces.

The brain was covered with subdural and subarachnoid haemorrhages. Both lungs were lacerated into multiple pieces. The heart showed a laceration over the left ventricle. Mesenteric contusion was seen. The liver and spleen showed multiple lacerations. Both kidneys were contused. The cause of death was multiple injuries sustained by blunt trauma. It was concluded to be because of an elephant attack based on circumstantial evidence, autopsy findings, and ruling out other causes for these types of crush injuries in this circumstance.

DISCUSSION

Agriculture is the prime occupation in rural India, and there are many human settlements and agricultural lands in the close vicinity of forest reserves. Villagers venture into the forest for the collection of firewood, minor forest produce, and the grazing of cattle. In Karnataka, these activities contribute to the livelihoods of many tribal and indigenous communities. Ramanagara district in Southern India, where our institution is located, has a significant number of wild elephants. The perimeter of elephant reserves has been fortified with solar-powered wire fences, rubble walls, and elephant-proof ditches. However, these are inefficient[2]. More frequently, elephants are seen near the villages crossing roads, and there is sometimes unauthorised entry of villagers into the forest areas. This has resulted in an increase in human-elephant conflicts in places where there are forest reserves.

Human-elephant conflicts resulted in 2,853 human deaths during the past five years, with the number of fatalities reaching a five-year high of 628 in 2023, according to government data. The data revealed that Odisha recorded 624 such deaths during this period, followed by Jharkhand with 474, West Bengal with 436, Assam with 383, Chhattisgarh with 303, Tamil Nadu with 256, Karnataka with 160, and Kerala with 124[3]. In Myanmar, between 2001 and 2020, 143 cases of elephant-caused human mortality were recorded[4].

Attacks by elephants occur most commonly in farmlands, near homes, or in forests when people intrude on their habitat[5]. Higher human density and dependency on forest resources are causative factors. In addition, people who live near elephant migration routes are more vulnerable to elephant attacks[4]. Most victims are marginalised people who live along the forest fringes. Resource competition is, therefore, likely the main reason for human mortality[6]. Elephants use their trunk, feet, or tusks to inflict injury on humans. Among Indian elephants, only male elephants have tusks, whereas in African elephants, both males and females have tusks.

In a tertiary rural hospital like ours, we rarely come across cases suspected to have succumbed to an elephant attack. Only three cases were reported and brought to our centre in the last five years. In all three cases examined at our centre, victims were adult males, and they were in places near known elephant habitat for their livelihood. They were from rural India, where cattle rearing and agriculture are the main sources of income. In a study done in West Bengal, another Indian state with a high elephant population, all 14 victims were from the rural areas and belonged to the low socioeconomic group. The ages of the deceased were between 30 and 65 years, with 11 of them being above 40 years. Males comprised 78.5% (11) of the victims[6].

Most of the injuries seen were crush injuries to the chest, abdomen, and pelvic region, sparing the head. Among fractures, rib fractures were common in all cases, followed by fractures of the extremities. Last were vertebral fractures. Soft tissue injuries like multiple lacerations were seen in all the cases, exposing the underlying injured structures and organs. Internal injuries in the form of contusions and lacerations were observed in all the thoracic and abdominal organs, commonly affecting the lungs, liver, and heart. The spleen, kidneys, and testes were also injured in at least one case. In all cases, blunt force injuries affected large surface areas of the body, and external injuries were conspicuously crush injuries. There were no patterned contusions to suggest a different type of trauma, such as a run-over road traffic accident, and there were no defence injuries present. The death scene investigation did not reveal any other footprints or tread marks of any vehicular movements. These findings, along with police investigation reports, ruled out road traffic accidents and gang assaults.

Elephants primarily target the chest and head regions. However, they lack specificity due to their massive size, hence causing injuries over a large surface area[7]. In our cases, there were no crush injuries to the head, but there were contusions, lacerations, and fractures. Complete transection of the pancreas was observed in a case who survived[8]. Singh *et al.,* in their study on victims of elephant attacks, have observed that blunt injuries to the chest and abdomen predominated along with extremity injuries[9]. Injuries were mild to moderate in severity and involved the chest in common in three survivors of elephant attacks in Odisha, India[10].

The large size and body weight of elephants and the severity of impact during attacks make the injuries caused by them different from those due to other animal attacks. Immense force and momentum are generated by the weight and speed of the elephant during the attack (on average 6 tonnes and 15 miles per hour, respectively). This leads to lethal crush injuries and fractures in humans. Severe blunt injuries to the trunk or head are caused by trampling, stomping, squeezing, tossing, or crushing[7]. The tusker, or male Indian elephant, can cause impaling injuries like stab injuries and penetrative injuries to the abdomen and thorax. When the elephant's foot comes in contact with the victim, the mere weight of the elephant produces severe compressive forces on the body, causing direct trauma and crush injuries. As the elephant's foot moves over the victim, friction and shear forces cause other blunt force injuries to soft tissues. The type of injuries varies from severe maxillofacial trauma and perforating lacerated tusk injury of the chest with multiple rib fractures to blunt intra-abdominal trauma, including bowel transection, liver and abdominal aorta lacerations, and pelvic fractures[11]. Injuries by elephants differ from those by other animals due to the severity of the impact. Gross facial and bodily deformity and the involvement of a larger area of the body are characteristics that often result in fatality[12].

Various factors influence the severity of injuries, viz., proximity of the victim to the elephant's path, victim's position (standing, sitting, or lying down), duration and repetition of trampling, speed of rolling, and weight of the elephant. The majority of the injuries, especially crush injuries, are caused by trampling, and others, like abrasions, contusions, lacerations, and fractures, are caused by trunk impact and trunk compression. Lack of eyewitnesses and the inability of forensic pathologists to visit the scene of death are the limitations related to these cases.

CONCLUSION

This case series analyses three cases of death due to elephant attack, revealing the following key findings. All three victims were young male villagers residing in the vicinity of the forest and were farmers. Assault by blunt force weapon and run-over road traffic injuries were excluded during autopsy and death scene investigation by the police. All victims had blunt polytrauma, specifically, crush injuries involving large areas of the body, with fractures of underlying bones. This pattern of injuries in these cases, considering the circumstances, is specific to injuries caused by elephant attacks. However, other causative factors for blunt polytrauma need to be ruled out before considering elephant attack. Villagers need to be warned to restrict their movements, and they should be extra careful and vigilant. Further long-term study is recommended to come up with preventive measures. Since most of the cases are always fatal, preventive measures are more vital in minimising casualties.

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CONFLICTS OF INTEREST

The authors declared no conflicts of interest.

ETHICAL ISSUES

The presented cases were conducted for medico-legal purposes, and the findings were used for academic purposes, with the informed written consent of the next of kin, without divulging the identity of the individuals.

SOURCES OF SUPPORT

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AUTHOR CONTRIBUTIONS

KBG: Conception of the work; acquisition, analysis, and interpretation of data for the work; reviewing the work critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **SHJ:** Conception of the work; acquisition, analysis, and interpretation of data for the work; drafting the work and reviewing it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **MP:** Conception of the work; acquisition, analysis, and interpretation of data for the work; drafting the work and reviewing it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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INNOVATION ARTICLE

ARTIFICIAL INTELLIGENCE-DRIVEN DIGITISATION OF LEGAL SYSTEM IN SRI LANKA - A CHALLENGING APPROACH

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ABSTRACT

The judiciary in Sri Lanka faces serious problems of case backlogs, resulting in inevitable delays in the delivery of justice. This paper considers the possibility of utilising computer technology and artificial intelligence (AI) as a method of overcoming this urgent problem. The introduction of AI-powered tools to study the digitised legal records helps to automate the administrative workload, manage the case flow through predictive analytics, and identify inefficiencies in the system. It aims to streamline the judicial process by ultimately improving the efficiency of Sri Lanka's legal system. Evidence for this proposal is derived from publicly available data, including Ministry of Justice reports and global best practices in digital legal systems. The paper highlights the feasibility of digitalising certain areas of the legal system and implementing AI-based solutions based on successful examples from countries like Australia, China, India, and Singapore. The expected outcomes include faster resolving of cases, reduced administrative burdens, and improved public trust in the legal system, ensuring all citizens have timely access to a more transparent criminal and civil justice system.

Keywords: ***Artificial intelligence; case backlog; digitisation; legal system; Sri Lanka***

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INTRODUCTION

The contribution of the judiciary to the advancement of the economy, socio-cultural development, and maintaining the peace, justice, and harmony of the country is enormous. Remedial measures to mitigate delays in resolving legal cases are a need of the day across the globe. Managing the judicial process efficiently with the limited resources of the existing system while incorporating digital assistance will be a proactive but challenging measure. Case statistics, according to the Ministry of Justice, show a rising number of pending cases from 1,096,118 in 2021 to 1,127,265 in 2022. In 2023, the number of pending cases was as high as 1,122,113, with an average number of 4,432 cases per judge in the district and magistrate courts[1].

Currently, almost all court cases are heavily paper-based, resulting in significant delays in resolving cases[2]. Digitising case records presents an opportunity to improve case management and reduce delays. This paper explores how digitalisation could positively transform the way legal cases are managed by the judiciary and other relevant authorities involved in the criminal

and civil justice system in the country. It also discusses the possible barriers to the wide-scale implementation of this concept at present.

Around the world, it has already been evident that digitisation and incorporation of artificial intelligence (AI) could certainly help in better case management, minimising human errors, and expediting the legal processes. The Victorian Law Reform Commission, as indicated in its consultation paper in October 2024 titled 'Artificial Intelligence in Victoria's Courts and Tribunals,' identifies six principles for the responsible and fair use of AI in courts and tribunals. These include fairness and equity, accountability, human oversight, transparency, contestability, privacy, and data security[3]. In Sri Lanka, applying AI could modernise the traditional methods, making the legal system more responsive, effective, and efficient[4].

Delay in resolving cases, both criminal and civil, leads to considerable social, emotional, and financial strain on the aggrieved parties and their associates. This also leads to reduced public trust and heightened frustration towards the entire legal system of the country. The dictum "justice delayed is justice denied" (*lex dilationes abhorret*) highlights the need for expedited legal procedures warranting urgent change[5]. Digitising records and automating processes such as submissions and authorisation during the legal process will, among many other advantages, make case management faster, reduce communication delays, and improve how resources are allocated.

Sri Lanka's judicial system already faces a significant backlog of cases. The COVID-19 pandemic made this problem worse, as the present court system heavily relies upon a process mandating the physical presence of parties (prosecution, defense, counsel, and witnesses) and paper documents. While new projects like the Ministry of Justice's digitisation plan have been introduced and are moving forward, there is still a need for specific reforms aimed at expediting the process of resolving cases[6,7]. The number of judges for hearing a disproportionately heavy number of cases is 15 per 1 million of the population in Sri Lanka. In addition to the number of judges, there is also a severe shortage in the rest of the manpower in courthouses, the physical (infrastructural) facilities in the courts, as well as the number of courts (especially magistrates and district courts) throughout the country[1].

Compared with the international standards, the above situation in Sri Lanka could be considered quite unsatisfactory and may even contribute to lowering the international rankings of Sri Lanka, as the proper and timely execution of justice is one parameter/determinant of measuring how civilised a society is. Prompt and proper execution of justice without undue delay is invariably one aspect considered by foreign investors before launching large-scale investment projects in Sri Lanka. Therefore, while using the existing facilities, digitalisation of legal records and court proceedings using AI will contribute immensely to the clearance of backlog cases and expedite existing cases, improving the legal system and its outcomes[6,7].

This paper proposes the digitisation of legal records and procedures and the use of AI as a method of expediting the legal processes and improving the quality of the existing system. It also discusses the possible challenges and solutions to overcome them.

DISCUSSION

The delay in the legal procedure of the execution of justice frequently stems from the use of manual methods for handling data and personnel. Bureaucratic barriers, too, will greatly add to this. The outcome is a negative impact on the effectiveness of the court system. Nonetheless, several countries in Asia, including China, India, Singapore, Malaysia, and Japan, have implemented sophisticated digital technologies to speed up the process of investigation, demonstrating the potential of digital transformation in the justice system[6,7]. Research indicates that artificial intelligence can greatly boost the legal sector by reducing mistakes, speeding up the resolution of cases, and enhancing overall productivity[7,8,9]. Therefore, the adaptation of digitisation at an institutional level, implementing centralised systems to improve efficiency, is necessary to prevent the delays that we experience today.

An electronic case management system can be initiated, allowing electronic recording of statements in police reports with e-signatures to ensure authenticity[8]. The capacity to send electronic files to the Attorney General's Department, other legal authorities, and courts, with scanned documents attached, would further accelerate the legal process[10]. To enhance the accessibility of justice, recording verbal proceedings in all courthouses and transcribing them electronically becomes essential. Additionally, video conferencing for evidence presentation and submitting expert written evidence through online portals can address the logistical challenges faced by expert witnesses, including the judicial medical officer (JMO), officials from the Government Analyst's department, and so on[7].

The digitisation of legal records and processes is becoming increasingly essential to modern judicial systems. Several innovative practices are already in use globally. They could significantly benefit Sri Lanka's legal system too. For instance, many countries have introduced electronic summons (e-summons) systems, which also include a confirmation of receipts generating system-created digital delivery receipt. This ensures transparency in legal notifications and accelerates communication, minimising the delay in tendering the summons, which is a significant contributory factor to the undue delay in the initiation of legal action in present-day Sri Lanka[10]. Centralised registers of expert witnesses, complete with present working place, reliable contact number, and other contact information such as official and personal e-mails, can further enhance operational efficiency[11]. It is common knowledge how much the police struggle to find out the current whereabouts of a JMO when he is either transferred to another station, is temporarily on foreign soil for further studies, has left the country for good, has retired, or is even not alive anymore. Centralised e-registers will automatically provide such information and the details of the officer currently covering the duty of the officer concerned. At present, there is no streamlined system to trace medical expert witnesses, and registrars of courts generally tend to quote the next higher official (the director of the hospital or even the director general of health services) as a rather ineffective means of summoning a particular doctor whose whereabouts are not clear. As such, e-portals and e-registers will streamline the summons process[8]. Furthermore, tracking information of the suspects across pending cases in different courts provides a more unified judicial approach, minimising unwanted delays[11]. The digitisation of hearings and their transcription improves accessibility and allows for better record-keeping, curtailing challenges from the defense due to discrepancies in records. This will drastically reduce the space used as a 'record room' in present-day courts, where heaps of paper documents are kept for many decades even after the case is long over. Electronic case records, especially of cases heard in superior courts, will enable easy reference by lawyers seeking precedents and by law students. This will revive the presently almost dormant NLR (New Law Reports) and SLR (Sri Lanka Law Reports).

Furthermore, videoconferencing/ teleconferencing facilities for presenting evidence alleviate logistical challenges for witnesses (including expert witnesses, vulnerable witnesses such as the mentally ill and minors, and high-risk witnesses such as political prisoners), provide a protective environment for the parties as well as those in the courtroom, reduce valuable time and resources required to travel long distances, enhance the ability to obtain second opinions from those across the globe in highly contested cases, and allow permanent recording in a retrievable form, all of which will contribute to a more efficient, accurate, and 'client-friendly' legal procedure[7].

Further, digital assistance will speed up the process of concluding the case. In China, AI tools examine extensive collections of data from previous cases, propose appropriate punishments, and recognise discrepancies in statements, resulting in quicker and more precise judgments[10]. This will assist in minimising human error in interpretation and corroboration of facts and evidence in lengthy case records, assisting the honourable judges in arriving at more accurate decisions. Furthermore, AI technologies have played a key role in refining criminal investigations and the delivery of legal outcomes by managing cases and administrative duties more efficiently[11,12].

Proposed AI-based System for Sri Lanka

Considering the situation in the country, this paper proposes an AI-driven system for digitising legal records in Sri Lanka as a pilot project with the possibility of expanding it in several directions. The system automates the conversion of handwritten notes, voice recordings of hearings, and images into digital formats, which are then stored in a centralised database/server with restricted access. This facilitates easy case referrals and progress tracking, leading to resolving the cases in an expedited manner. By digitising police records at an institutional level and expanding them into a central system, the legal process can be significantly streamlined, reducing delays and prioritising urgent cases[13]. Initiation of improvements in infrastructure facilities has already commenced since 2021, and this bold venture needs to be expedited[1]. The pilot project can select one high court from each province and several police stations in the jurisdiction of the relevant high court. Progress can be compared with other stations where the digitisation has not yet been introduced.

The first step involves digitising existing police records into a centralised database. These records will include crime details, accompanying legal proceedings, and their durations. Optical character recognition (OCR) tools will be employed to convert paper-based documents into searchable digital formats, allowing for efficient organisation and analysis of records[4,9]. This will be more efficient than using human data entry operators to convert paper documents into digital form and will minimise the possibility of human error.

Once digitised, the data will be classified into key variables such as crime type, historical data, evidence, charges, legal procedures, investigation duration, tentative resolving time, etc. These structured data are used in predictive analytics and process optimisation. Effective data preprocessing is crucial for predictive accuracy, as demonstrated by Gutierrez-Osorio and Pedraza[9]. The steps involved will include:

1. **Digitising Police Records**: Converting handwritten documents, voice recordings, and images related to legal cases into digital files using tools such as optical character recognition (OCR), a technology that can read and convert text into a digital format.

2. **Centralising Data**: This step involves the creation of a single and easy-to-use database for all related data, including incident details, evidence, and current case status, just to mention a few. This data could be stored on a large server (with backup facilities) with restricted access.

3. **Automating Processes**: This includes utilising AI to carry out tasks that are repetitive in nature, such as case referral for different departments, report generation, case prioritisation based on the level of urgency, and the communication of such developments to the relevant authorities.

4. **Forecasting the Time Needed for Resolving the Case:** An AI machine is used for examining the previous cases, and thus, it can postulate how long similar ones would take, and the tool can assist the authorities in getting the right time frame and setting the deadline accordingly.

The proposed AI system is made up of the following four essential components:

1. **Data Collection and Integration**: The entire set of crime records in the Police Department will be incorporated into a single system accessible to relevant individuals and organisations with restricted access for updating and modifying the information.

2. **AI Engine**: AI will carry out data analysis to estimate the duration for resolving cases and perform tasks like case prioritisation and automated report generation.

3. **Automated Module**: The part of the system that performs the automation of routine tasks, such as case status updates and report generation, is aimed at alleviating the burden upon administrative and clerical staff.

4. **User Interface (UI)**: A user-friendly dashboard will allow law enforcement and

legal professionals to track the progress of cases and communicate effectively.

Algorithmic Fairness

AI can sometimes, though unintentionally, be biased. As such, we need to make sure that the system treats all cases equally. Regular oversight by a professional will ensure fairness and transparency.

This proposed AI-based system can be implemented in selected police divisions to begin with, and the gathered experience will help in further refining a centralised program across the country.

Addressing Legal Bottlenecks

Following necessary legal reforms, digitising police records, and integrating AI, the system addresses many manual bottlenecks currently delaying the legal process. Predictive analytics will enable better resource allocation, while automation will alleviate most of the administrative burdens. Similar AI-driven systems across the globe have shown promising results in their own legal environments, enabling the rapid resolution of cases[6,10,11].

Societal Benefits

The proposed AI-based digitisation system offers a wide array of societal benefits[14,15]. Reducing delays in legal proceedings helps restore public trust in the judiciary. Additionally, the system ensures timely justice for the aggrieved parties, increases transparency and accountability within law enforcement, and helps Sri Lanka align its legal processes with global standards[2].

Ethical and Legal Aspects and Future Challenges

It is extremely important to consider the confidentiality of information and ethical and legal issues related to transitioning to digital records, despite the many advantages. Implementing rigorous data security measures is essential to safeguard police records and judicial data from unauthorised access.[6]. AI systems must be implemented with a clear framework for accountability, preventing AI hallucinations, and ensuring that AI decisions adhere to legal standards and human oversight[16]. In addition, AI algorithms raise ethical concerns about bias, as mishandling of data could impact the fairness and integrity of judicial proceedings[11]. The transition from paper-based systems to AI-driven digital processes will require significant development and infrastructure training[8]. It is essential to digitise manual reports, witness statements, and court documents in a structured manner. In addition, it is essential to provide training for police officers, administrative and clerical staff, and legal professionals (including judges, state counsellors, and lawyers of the private bar) to guarantee the smooth integration of AI technology into the current judicial system. Extensive changes (reforms and repeals as well as the introduction of new laws) to existing statutes such as the Civil and Criminal Procedure Codes, Admission of Electronic Evidence, etc., have to be introduced and implemented[17]. These legal reforms take time, and they should be implemented under the guidance of a multidisciplinary advisory panel including legal, scientific, and computer-related experts. The new laws should be wide enough to cover foreseeable future challenges in the AI field as well as flexible enough to acknowledge and adapt to unforeseeable challenges[18,19]. This step-by-step method not only makes the transition easier but also fosters confidence in the use of artificial intelligence in the legal system[9]. Already recognised courtrooms and police stations, as suggested before for the pilot project of digitalisation, will make the implementation easier. Finally, even the conventional teaching of law in the state sector (the Law College under the Incorporated Council of Legal Education and the faculties of law under the University Grants Commission) as well as the training of judges by the Judges Training Institute, etc., too have to be adequately modified to address these new changes and future challenges, which are already being addressed in many developed countries in the world[20].

Cost and Feasibility

While setting up this system will require an initial investment, the long-term benefits, such as faster resolving of cases, reduced administrative burdens, and improved public trust, etc., will

justify the initial cost and, in the long run, will far outweigh the initial expenditure[7,8]. The system will be implemented in phases, starting with already recognized courtrooms and gradually expanding, which will help spread out the costs and ensure smooth integration while allowing a chance for revisiting the entire process and rectifying certain areas accordingly[6,10].

CONCLUSION AND THE FUTURE

Considering the delay in concluding the legal cases as shown in the statistics, the AI-driven digitisation system proposed in this document provides a scalable solution to reduce delays in legal proceedings. By automating data entry, case tracking, and document processing, the system significantly improves efficiency[4], reduces administrative bottlenecks[6], and accelerates case completion[7]. The reduction of the number of backlog cases per year will indicate the rate of efficiency of the system. Although the initial cost of digitising case records is considerable, the long-term benefits, such as decreased administrative workload and improved legal productivity, make the investment meaningful.

This system can be started in phases, starting with high-priority case records, which will be digitised and integrated into the central database. Subsequent phases will involve deploying AI engines, automating tasks, and integrating user interfaces. Proper training of staff to operate and maintain the system in a foolproof manner, addressing the inevitable legal and technical challenges, will be crucial for successful implementation [21,22].

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CONFLICTS OF INTEREST

The authors declared no conflicts of interest.

ETHICAL ISSUES

None.

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AUTHOR CONTRIBUTIONS

WNSP: Conception and designing of the work, the acquisition of work, interpretation of concepts for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; agreeing to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **AMP:** Conception and designing of the work, the acquisition of work, interpretation of concepts for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; agreeing to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **SH:** Conception and designing of the work, interpretation of concepts for the work; revising the work critically for important intellectual content; final approval of the version to be published; agreeing to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **PP:** Conception and designing of the work, the acquisition of work, interpretation of concepts for the work; drafting the work and revising it critically for important intellectual content; final approval of the version to be published; agreeing to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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POINT OF VIEW

LEGAL AND STATUTORY GUIDELINES FOR MEDICAL DEATH CERTIFICATION IN HOME DEATHS: INSIGHTS FROM SRI LANKA

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ABSTRACT

Introduction: A significant proportion of deaths occur outside healthcare facilities in Sri Lanka, where the general practitioner plays a substantial role in issuing the medical certificate of cause of death. The primary statutory document governing the medical death certificate is the Births and Deaths Registration Act. The Sri Lanka Medical Council released a guideline for medical practitioners on issuing the medical certificate of cause of death. Though general practitioners are legally obliged to provide the medical certificate of cause of death for home deaths, there are instances where they are reluctant to do so. This has led to family members of the deceased resorting to the alternative pathways in obtaining the medical certificate of cause of death in which the cause of death is decided by *grama niladhari* (a public administrative officer at village level) or an inquirer (a government appointee who plays a similar role as the coroner) both of whom are not medically trained. As a result, the quality and the accuracy of the cause of death given in these medical certificates of cause of death are poor. This affects families, mortality statistics, and public health research. It appears that the general practitioners tend to underreport deaths to the inquirer.

Objectives: The article aims to provide a concise and updated guide on the legal and ethical aspects of medical death certificates, particularly concerning home deaths, addressing many of the concerns and misconceptions.

Methods: We independently searched statutory legislations, acts, amendments, and ethical guidelines published up to September 2024 that contained legal and/or ethical provisions related to medical certification of death in Sri Lanka.

Conclusions: We suggest capacity building for general practitioners in medical death certification and providing them with access to resource materials to encourage them to complete the medical certificate of death, particularly in home deaths. This will minimise the public resorting to other non-medical government administrative officials for issuing the medical certificate of death. We also suggest reforms to the Birth and Death Registration Act of Sri Lanka and the Code of Criminal Procedure on the death investigation process, and update the Sri Lanka Medical Council guidelines on death certification.

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INTRODUCTION

The Annual Health Bulletin of the Ministry of Health, Sri Lanka, reported 52000 deaths in all health care facilities in 2017[1]. In addition, the Department of Census and Statistics recorded 140000 total deaths during the same period[2]. Accordingly, about 70% of deaths occurred outside healthcare facilities. This percentage includes deaths that occur at home.

In home deaths, through the Births and Deaths Registration (BDR) Act of 1951 of Sri Lanka, several officials, namely, the medical practitioner who treated the deceased last, the grama *niladhari* (a public administrative official at the village level), the inquirer into sudden death (a government appointee who plays a similar role as the coroner), police officer, or estate superintendent (if the deceased is an employee of a plantation estate) are empowered to issue the medical certificate of the cause of death (MCCD)[3]. It is worth noting that out of the above officials, only the medical practitioner has medical training. The MCCD is a statutory document that is needed to obtain the Death Certificate (DC) from the Registrar of Births and Deaths. DC is a vital document mandatory for various procedures, including the disposal of the body, financial and legal transactions involving the deceased, and family members. In a significant proportion of natural deaths occurring at home, the next of kin of the deceased contact their general practitioner (GP) for the MCCD. However, there are instances where the GPs are reluctant to provide the MCCD, leaving the family members with no choice but to take an alternate pathway to obtain the MCCD from 'non-medical' officials who are empowered to issue the MCCD. Studies identified significant errors in the cause of death in the DC issued by such officials, which can affect families, mortality statistics, and public health research[4,5].

The inquest is important in providing valuable mortality statistics, public safety, and justice. However, GPs tend to 'under-report' deaths to the inquirer[6]. Furthermore, studies have found that the GPs correctly identified only 3% of all deaths that should have been reported to the inquirer[7]. Several factors can contribute to this, including a lack of knowledge about reportable deaths and family pressure to avoid an inquest procedure, which can delay the funeral arrangements. Similarly, under-reporting can lead to serious consequences such as distorting the mortality statistics and unmasking potential public health issues such as outbreaks of disease and patterns of violence. The under-reporting to the inquirer and the legal safety mechanism of the inquest were further highlighted in the "Luce inquiry" on the Harold Shipman controversy [8].

These deficits highlight the necessity for continuous education of GPs as a professional development strategy implemented by many countries to ensure a high-quality death registration system. This paper is written with GPs in mind, and some of the information applies only to Sri Lanka. It aims to fill that lacuna by providing a concise and updated guide on the legal and ethical aspects of medical certification of cause of death, particularly concerning home deaths, addressing many of the concerns and misconceptions.

METHODS

We independently searched statutory legislations, acts, amendments, and ethical guidelines published up to September 2024, which contained legal and/or ethical provisions related to certification, reporting, investigation, and registration of death in Sri Lanka. Table 1 shows the documents and relevant sections that were identified. We did not include circulars or regulations that were introduced in special circumstances, such as the Prevention of Terrorism Act, death disposal during the COVID-19 pandemic, or emergency regulations.

Table 1: Statutory documents and published guidelines related to the medical certification of the cause of death reviewed for this article.

	Document	Year of last update/ amendment	Relevant areas
1	Criminal Procedure Code of Sri Lanka	1979	Sections 369-373
2	Births, Deaths Registration Act No. 17 of 1951	2008	Sections 29 - 39
3	Sri Lanka Medical Council Guidelines for Medical Practitioners and Dentists Medical Certification of Death	2016	Guidelines regarding certificates of cause of death (Pages 3-5)
4	Sri Lanka Medical Ordinance	2018	Sections 29,33
5	Ministry of Justice circular (13/2018) on mandatory post-mortem on maternal deaths	07.09.2018	Whole circular
6	Ministry of Justice circular (3/2008) on indications for mandatory post-mortems	02.10.2008	Whole circular

DISCUSSION

1. Professional guidelines and laws on medical certification of the cause of death in Sri Lanka

The statutory procedure related to the issuing of an MCCD is detailed in the Births and Deaths Registration Act[3]. "In the event of the death of any person who has been attended during his last illness by a medical practitioner, a certificate in duplicate, substantially in the form J set out in the schedule, stating to the best of his knowledge and belief the cause of the death, shall be forthwith issued without fee or reward by such practitioner to the person required under this act to give information."

The Sri Lanka Medical Council (SLMC) released a guideline in 2004 related to issuing medical certificates[9]. This guideline incorporates the above legal provisions and criteria that need to be fulfilled to issue an MCCD. In 2021, the Ministry of Health, Sri Lanka, issued a "Handbook for Sri Lankan Doctors on Cause of Death Certification", [10] which includes procedural details as well as theoretical aspects of writing the cause of death based on the World Health Organisation's guidelines. Accordingly, to issue an MCCD, the medical practitioner should ensure that,

- The cause of death is known.
- The cause of death is natural.
- The doctor is the attending physician of the last illness that has led to the death of the deceased.
- The doctor has treated the deceased recently.
- The doctor has viewed the body.
- Based on these guidelines, several thematic elements are discussed that are relevant to GPs (Fig. 1).

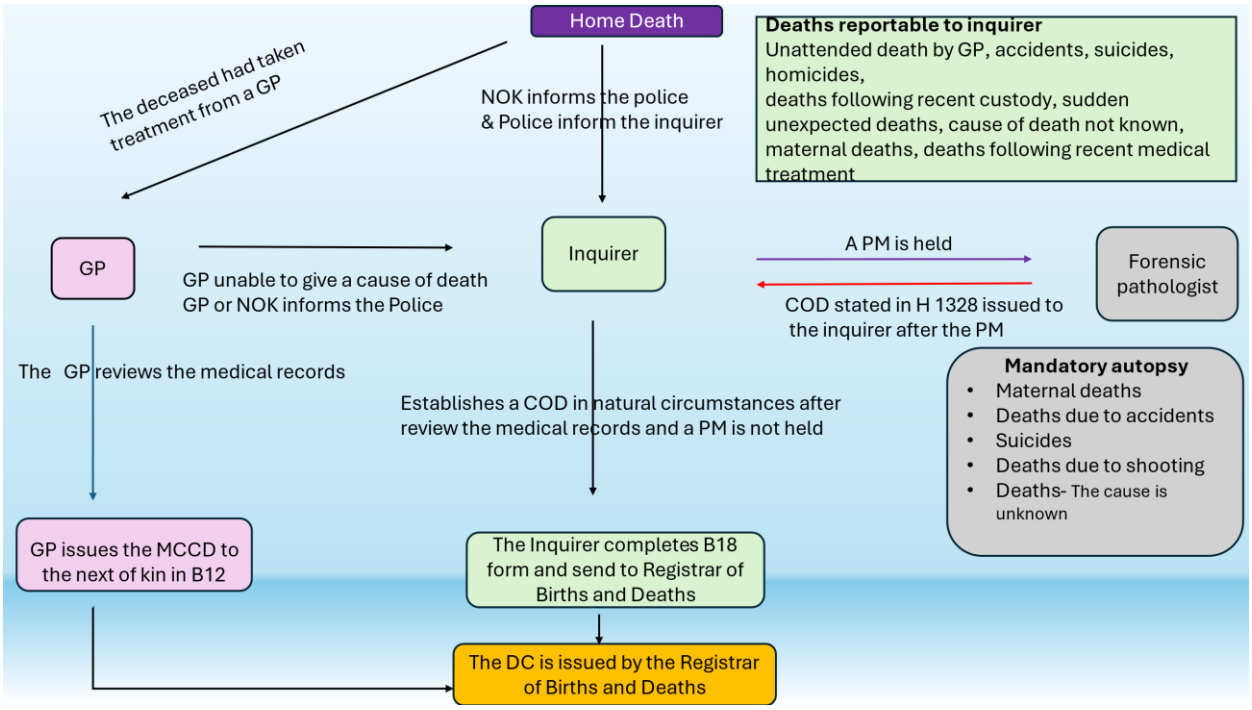

Figure 1: Navigating home death certification: a stakeholder flowchart. COD – cause of death, DC - death certificate, GP – general practitioner, MCCD – medical certification of cause of death, NOK – next of kin, PM – post-mortem.

1.1. The medical certificate of the cause of death should be issued by a medical practitioner

Here, the term "medical practitioner" refers to a doctor who treats the deceased individual, working in public or private hospitals, including GPs practicing within the community. Sri Lanka has a health care system that is a combination of allopathic and indigenous medical practices, and there is often a cross-utilisation of both types for the same illness[11]. In terms of the Births and Deaths Registration Act, however, only allopathic doctors or apothecaries who are registered in the SLMC are legally allowed to provide MCCDs[3]. This has been further ratified in the section 37 of the Medical Ordinance[12]. For more than a century, GPs have played a predominant role in the primary healthcare sector of Sri Lanka[13], and a large proportion of these GPs cater to a specific community throughout their career. Recent attempts to improve the primary health care system have also introduced specialist family physicians affiliated with state hospitals[14]. Therefore, especially in home deaths, GPs have the primary legal responsibility to issue an MCCD.

A GP who refuses to issue an MCCD without a valid reason could be penalised through Section 65 of the Births and Deaths Registration Act, which states that "Every medical practitioner who neglects or refuses to issue a certificate as required by section 31 shall be guilty of an offence and shall be liable to a fine[3]. However, as discussed in the subsequent sections, this would apply only to deaths that occur due to natural illnesses for which the GP had treated the deceased.

1.2. The doctor should be the attending physician of the last illness of the deceased and have treated the deceased recently

In well-established GP health systems in developed countries, the patient is registered in the health institution, and the GP is a registered practitioner of the institution. The patient nominates the GP as his regular GP. Thus, with a clear therapeutic relationship, the GP is bound to issue the MCCD to patients registered under the GP.

Although the term 'attended' can present a degree of confusion, particularly as it is not clearly defined in the guideline, it means a doctor who had cared for the patient during the illness that led to the death[15]. Moreover, the death declaration form (form B33 of the Government Press of Sri Lanka) has highlighted that "the medical practitioner who treated the deceased must complete this form." However, in today's context of complex and multidisciplinary health care, most illnesses are treated by a combination of doctors, in which the GP may have played a minor part in the treatment or only been a referral point. When the GP has access to the relevant medical records and is familiar with the deceased's medical history, investigations, and treatment, the GP can issue an MCCD if the GP is certain of the progression of the illness. However, there should be a recent encounter of the patient with the relevant GP before the demise. The GP responsible for the deceased person's medical care during their last illness should be adequately convinced as to the cause of the death, and no other circumstances are present that require the death to be reported to the coroner/inquirer[16]. Even when a deceased's GP is absent or unavailable, another GP in the practice can complete the death certificate provided they have sufficient information to do so, and the death is not required to be reported to the coroner/inquiry[16].

On the other hand, if the GP only attended to the deceased during their final moments or was called after death and just certified the death, they cannot give an MCCD due to insufficient knowledge, as the GP should have treated the last illness that had led to the death. Therefore, the GP should not issue the MCCD in an "unattended death" where the GP has not been involved in the patient's care.

Similarly, there are no clear guidelines regarding the duration acceptable for 'treated the deceased recently' in Sri Lanka, which creates a degree of confusion, particularly as the term 'recently' is not clearly defined. However, many guidelines from developed countries have defined this duration[15,17].

This can be as long as 6 months, indicating even with a regular patient, if the patient was not treated at the specified time, an MCCD cannot be issued[18]. The concept here is that the doctor who treated the patient should know the extent of the disease, its complications, the patient's response to treatment, etc.

1.3 The doctor is the attending physician of the last illness that has led to the death of the deceased

It is also necessary to ensure that the death is due to the most recent illness for which the deceased was treated by the GP. These apply even to patients with chronic illnesses, as the cause of death may still be different. Understandably, to issue an MCCD in an illness, a competent GP should be able to consider if death is a likely outcome of that illness or its treatment. If a patient dies who is on treatment for a non-fatal condition like a simple upper respiratory tract infection or osteoarthritis of the knee, the GP would not be able to determine the cause of death, as the death is unexpected. Thus, GP needs to refer this to the inquirer for an inquest.

1.4 The medical certificate of cause of death should be issued in a specific format

The statutory form to be used by GPs when issuing an MCCD is given in the Births and Deaths Registration Act as form J. The same form is commonly known as form B12, as per its reference number given by the Government Press. The local guideline highlighted the importance of issuing the MCCD on the B12 form rather than on their personal letterheads or blank sheets[9]. Furthermore, as per the Births and Deaths Registration Act, the B12 form must be provided to the next of kin in duplicate. Printed B12 forms can be obtained at the Registrar's Office of the Divisional Secretariat.

1.5 The medical certificate of cause of death should be issued without a fee or reward

The Births and Deaths Registration Act clearly states that the MCCD should be issued as an honourable service, and the MCCD cannot charge a professional fee nor receive any form of reward or benefit. This law should also apply to private hospitals where they charge for issuing the MCCD

and include that in the hospital bill, disregarding the Births and Deaths Registration Act.

1.6 The issue of the medical certificate of cause of death to a relative

In many countries, the GP is unable to issue an MCCD if the deceased is a close relative of the GP. This is to prevent issues related to conflict of interest and ensure objectivity of the process. [19]. However, no statutory provision in Sri Lanka bars a doctor from issuing an MCCD to a relative, friend, or neighbour if the GP has been directly involved in that person's care during the last illness. However, this may pose specific ethical and legal challenges. It may raise conflict of interest issues and even allegations of improper conduct, as well as medical negligence, if suspicions are raised regarding the death.

1.7 The cause of death given in the medical certificate of cause of death should be valid and defendable

It is understood that a general practitioner is not expected to determine the cause of death with complete certainty[3]. However, the GP needs to be able to determine the cause of death based on the understanding of the illness and the patient's medical history, recent investigation findings, and the circumstances surrounding the death. When the cause of death is uncertain, reasonable steps should be taken to obtain sufficient information to determine the cause of death, which includes reviewing the medical records and contacting other health professionals involved in the recent care of the deceased. If the GP is still unable to ascertain the cause of death after all such steps have been taken, then the death must be reported to the inquirer. If any legal issue arises regarding the death in the future, the MCCD can be subjected to legal scrutiny. If the opinion of the GP does not hold up under the adversarial cross-examination in court, this could raise doubts about the GP's competence. The penalty for providing false information in the MCCD is substantial. As per the section 68 of the Births and Deaths Registration Act, any individual who issues a false certificate will be liable to a fine and rigorous imprisonment for a maximum of 7 years[3]. Similarly, as per the section 33 of the Medical Ordinance, if a medical practitioner is found guilty of making a false statement to register a birth, death, or stillbirth or obtain a certificate, their name may be removed from the register [12]. Therefore, the GP is expected to provide a rational, evidence-based opinion on the cause of death, which should be justified based on the medical records and clinical features.

1.8 The cause of death should be known, and the circumstances of death should be natural

The GP responsible for the patient's care should thoroughly review medical records and relevant facts before issuing an MCCD. The GP must have convincing evidence to support the opinion that the death is due to natural circumstances. A natural death is defined as a death related to an internal bodily event not influenced by external occurrences[16]. Thus, a death caused by pneumonia, infections, cancer, stroke, or heart disease is classified as a natural death from a medical point of view. Unnatural deaths are homicides, accidents, suicides, poisoning, medical errors, and drug overdose[20]. Sometimes it can be difficult to determine whether an individual's death is simply 'natural' or 'unnatural' due to the multifactorial nature of deaths in people who are undergoing treatment for diseases. Wherever death has an association with an external factor, either due to the fault of the patient or a third party, it should be considered unnatural. It is important to remember that sometimes deaths that are clinically perceived to be natural may legally be considered unnatural[20]. Examples include a patient bedridden following a motor vehicle accident, dying from pneumonia several months after the event, or a patient dying of renal failure from a chronic exposure to a toxic substance.

1.9 The body should be viewed before issuing a medical certificate of cause of death

The final criterion in the SLMC guidelines is that the GP must conduct an external examination of the body. Although a medical diagnosis of the cause of death cannot be established with the external examination, it provides additional information to serve the judicial process and public interest[21]. The external examination is an important screening process to prevent the

concealment of deaths due to violence or negligence[21]. Reviews have shown several instances where homicides have been missed or overlooked during medical death certification[21]. Ideally, the external examination must be carried out with the body of the deceased completely undressed and all regions of the body, including all body orifices, the back, and especially the head and neck, visible. However, this can be a difficult task for obvious reasons. However, a GP is expected to view the body with this level of scrutiny[21]. Therefore, the GP must use his or her good sense and judgement and take adequate precautions to satisfy himself or herself that the circumstances are natural and clear. Furthermore, if the history or medical records do not indicate a likely natural cause of death, the GP may be unable to establish the likely cause of death. Thus, as per the Criminal Procedure Code (CPC) Act and the guidelines, when the COD is unknown or if a person dies suddenly when in apparent good health, an inquest must be held[22].

2. The legal and ethical obligations of the general practitioner in Inquests

2.1 Obligations to refer deaths for Inquests

The GP can refuse to grant an MCCD if the death was not due to the illness that he had treated. In situations where such death is unexpected and the GP is unable to determine a cause of death or if the GP believes that the death may have been due to unnatural causes, the legal obligations of the GP would then fall under that of any ordinary citizen to notify sudden or unnatural deaths, death by violence, or deaths under suspicious circumstances as stipulated in section 21(b) of the CPC[23]. "Every person aware of such death shall, in the absence of reasonable excuse, carry the burden of proof, which shall lie upon the person so aware, and forthwith shall give information to the nearest Magistrate's Court or the Officer in charge of the nearest police station or to a peace officer or the *grama niladhari* of the nearest village, of such commission or intention or of such sudden, unnatural, or violent death or death under suspicious circumstance or of the finding of such dead body"[23]. Therefore, the GP has a legal obligation to notify the police or the *grama niladhari* of such deaths. Such information would then normally lead to an inquest as per the CPC (Table 2). As deaths that are to be reported to the nearest police or *grama niladhari* are grouped very broadly in the CPC, we would like to expand Section 21(b) of the CPC and suggest deaths indicated in Table 2 to be considered as 'reportable deaths.' We present this as an easy reference for GPs, and it is still in accordance with the CPC. Many developed countries have laws on reportable causes of death to the coroner/inquirer[24].

Table 2: Suggested 'reportable deaths' to the Police in Sri Lanka (as per section 21(b) of the Criminal Procedure Code)

i.	Death due to poisoning, exposure to a toxic substance, death due to use of a medicinal product, controlled drug, or psychoactive substance.
ii.	Death due to violence, trauma, or injury.
iii.	Death was due to self-harm.
iv.	Death was due to neglect, including self-neglect.
v.	Death was due to a person undergoing a medical treatment or surgical procedure of a similar nature.
vi.	Death was due to an injury or disease attributable to any employment held by the person during the person's lifetime.
vii.	Death was unnatural, but does not fall within any of the circumstances above.
viii.	The cause of death is unknown, or sudden and unexpected deaths not caused by a readily recognized disease.
ix.	The person died while in custody of the police or in a mental or leprosy hospital or prison.
x.	There is no attending medical practitioner to sign the death certificate.
xi.	The identity of the deceased person is unknown.
xii.	Deaths that occurred while the woman concerned was giving birth or that appear to have been a result of that woman being pregnant or giving birth.
xiii.	Died under suspicious circumstances, or any person is found dead without being shown that such a person came by his death.
xiv.	Died due to rash or negligent act of another person.
xv.	Been killed by another person.

2.2 Inquest law in Sri Lanka

The law on inquests in Sri Lanka is specified in the sections 369 to 373 of the CPC Act No. 15 of 1979[22]. "Every inquirer on receiving information that a person has committed suicide or has been killed by an animal or by machinery or by an accident or has died suddenly or from a cause that is not known shall immediately proceed to the place where the body of such deceased person is and there shall make an inquiry and draw up a report of the apparent cause of death. The report shall be signed by such inquirer and shall be forthwith forwarded to the nearest magistrate. If the report or other material before him discloses a reasonable suspicion that a crime has been committed, the magistrate shall take over the proceedings. When any person dies while in the custody of the police or in a mental or leprosy hospital or prison, the officer who had the custody of such person or was in charge of such hospital or prison, as the case may be, shall forthwith give information of such death to a magistrate of the magistrate's court within the local limits of whose jurisdiction the body is found, and such magistrate shall view the body and hold an inquiry into the cause of death."

In Sri Lanka, inquests are conducted by the magistrate or the inquirer, with the overarching authority being placed on the magistrate. The inquirer stipulated in the above sections of the CPC is commonly known as the inquirer into sudden death (ISD). They are appointed by the Ministry of Justice according to the provisions given by the CPC and have been granted certain legal powers by the CPC, such as the power to summon any individual or obtain any documents that may be considered important for the inquest. In situations where the GP can provide information regarding the deceased person's previous health status, such information could greatly facilitate the inquest process and ease the burden on the family. In the authors' experience, GPs rarely contribute to the inquest procedure, often due to an exaggerated 'fear' of the legal process. This reluctance may also be due to the inadequate health record-keeping among GPs, which has been identified as a deficiency in primary health care service in Sri Lanka[25].

2.3 The GPs' role in home deaths where medical certification of death is not possible

Even if the GP cannot provide an MCCD, there are several ways in which the GP can still contribute and assist the family and next of kin in sudden and unnatural home deaths.

i. Verification of death and the identity of the deceased person

As a medically trained doctor, the GP is in the best position to confirm that the patient is dead. Where the patient has been seen by the GP previously, the GP can verify the identity of the deceased person. It is recommended to attach name bands with the deceased person's information, such as name, date of birth, and address, to their wrist or ankle when verifying their death[26]. The GP may also be able to provide important medical information, such as evidence of previous surgeries, therapeutic interventions, and even radiological images, which may be useful identification markers to confirm the identity of the deceased. This is especially important when the body is in a visually unrecognisable state due to decomposition or mutilating trauma.

ii. Ascertaining the time of death

When a death occurs under medical supervision, the time of cardiac arrest or confirmation of fixed dilated pupils can be taken as the time of death. However, in the home death situation, often where the dead body was found without being attended to by any paramedics, this would not be possible. Nevertheless, the GP, a medically trained person present at the scene of the death, could at least establish the upper and lower limits of the possible time since death.

iii. Facilitating the inquest process

GPs need to have a good understanding of the legal policies and procedures related to inquests in home deaths so that they can educate the family members on the importance of the inquest procedure, including the necessity of submitting previous medical records, proper identification documents, and ensuring the presence of a legally valid next of kin. In the authors' experience, many families are unaware of these procedures and face several hardships during the inquest. In this respect, the GP can be

a vital referral point as well as a facilitator to further enhance the family's cooperation and smooth completion of the inquest.

RECOMMENDATIONS

Improve capacity building for GPs on medical death certification in the form of regular multidisciplinary workshops involving GPs, legal experts, and public health officials to cover legal, ethical, and procedural aspects, and develop online courses to streamline the process.

To provide GPs with access to resource material such as a handbook, clear user-friendly guidelines, and manuals that outline the process of death certification, including examples of common scenarios.

Conducts regular audits on death certification and provides constructive feedback to the GP to enhance skills.

Suggest amendments to the sections 369 to 373 of the CPC to introduce the mandatory reporting of certain types of death by medical practitioners to the inquirer when they become aware of the deaths during their professional duties, clearly outlining the specific circumstances under which such notification to the police is required and the circumstances in which a mandatory autopsy is required.

The existing guidelines on death certification issued by the SLMC require revision to ensure greater clarity and consistency in medical death certification with unambiguous definitions and to eliminate potential areas of confusion, such as the appropriateness of issuing a medical certificate of cause of death to relatives of the certifying medical practitioner. Furthermore, a precise definition of what constitutes "a doctor has treated the deceased recently" should be clearly outlined.

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CONFLICTS OF INTEREST

The authors declared no conflicts of interest.

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None.

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AUTHOR CONTRIBUTIONS

PA: Conception and design of the work; the acquisition, analysis, or interpretation of data for the work; drafting the work and reviewing it critically for important intellectual content; final approval of the version to be published; and Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **RS:** Drafting the work and reviewing it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. **SAG:** Drafting the work and reviewing it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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CONTENTIOUS ISSUES

EMERGING MEDICAL CONCEPT OF 'FETAL PAIN' AND RELATED CONTROVERSIES IN LAW

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ABSTRACT

The research explores an emerging field of law that deals with medical jurisprudence, but takes a multidisciplinary approach, as it does not purely demarcate an intersection between law and medicine. The instant research intends to analyse the foetal pain perception while referring to the developments in law. Not only the law but also the ethical conduct of the professionals dealing with the foetus is challenged by the developed neuro-scientific evidence supporting the potential human being's sensory perceptions. The researcher has adopted a qualitative approach to unfold the identified controversies in law. One of the significant aspects of the methodology is the comparative method, utilising the main jurisdictions (the United Kingdom and the United States) in the world. The United Kingdom has been discussed to highlight the British Medical Association's stance on foetal pain, whereas the United States provides a solid foundation for the research with case law. The concluding perspective of the paper presents that the legal recognition of foetal pain has changed the doctor-patient relationship that exists between the pregnant woman and the medical professional who deals with her condition.

Keywords: ***Autonomy; foetal pain; law; rights***

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INTRODUCTION

The research is interwoven around a rare field of discussion in the legal fraternity. The prominent concern of the research is on the foetus (unborn human) and its pain perception. 'Pain' is a term that can be defined in different ways. However, in the scope of medicine, it has been given a technical definition, namely an 'unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage'[1]. In the general sense, 'pain' is a common sensory perception to all human beings who are already born. However, there is a controversy in the field of medicine about the fact of whether a 'potential' human being, such as a fetus, can feel pain. The specific controversy relating to foetal pain has arisen with the debate relating to the termination of pregnancy and the subsequent developments of foetal medicine/in utero treatment of the foetus. In addition to this, the expert medical professionals who are involved in the process of treating the foetus *in utero* face ethical problems (the breach of beneficence and nonmaleficence) when they disregard the pain of the foetus. Even though the recognition of foetal pain is considered an advancement in the field of clinical medicine, opponents come up with the argument in favour of the autonomy of the pregnant

woman. This creates a collision between the rights of the pregnant woman and the foetus. The paper studies the emerging medical concept of foetal pain and the maternal-foetal conflict that originates from it. It further analyses the stance of comparative jurisdictions in dealing with the legal implications of the same. The methodology that will be adopted in the research is purely qualitative. The researcher prominently focuses on primary and secondary sources of law. Primary sources of law include international/ national legislation, and the secondary sources of law that will be used by the researcher are the medical law textbooks, scientific articles on foetal pain, and guidelines of professional organisations such as the British Medical Association (BMA). In addition to the literature survey, the researcher conducts a comparative study with two developed jurisdictions in the world, namely the United Kingdom (UK) and the United States of America (USA).

DISCUSSION

The discussion that focuses on foetal personhood is interlinked with the concept of 'foetus as a patient.' Not only the matter of patienthood of the foetus, but the research is inclined to consider the rights of the pregnant woman. The exposition on foetal and maternal rights leads to a clear idea of the maternal-fetal conflict. The conflict between the rights of the pregnant woman and the foetus has another facet. The constant collision between the interests of the mother and the unborn inflicts a substantial influence on the 'duty of care' and ethical obligations of medical professionals. This matter has frequently arisen in instances where procedures are performed for the benefit of the foetus.

The evolutionary aspects of personhood and ethics relating to the pregnant woman and the foetus

The recognition of foetal rights is creating controversies. As per the view of Isaacs (2003), the grant of full moral rights to the foetus leads to identifying it as a separate entity from the existence of the pregnant woman[2]. This leads to a conflict of interest between the pregnant woman and the foetus. Under 'No Foetal Rights,' Isaacs (2003) quoted the view of Mary Warren, who has asserted that the foetus has no moral status independent of the pregnant woman[2].

'Personhood' has sparked an ongoing controversy, and it has become an argumentative factor among philosophers[3]. The beginning of personhood has been interpreted in diversified ways, among which is the view that the personhood of the human starts at the point of fertilisation, whereas the contrary view supports the argument that personhood starts at an arbitrary point after fertilisation[4]. The status of being a patient is worthwhile to discuss. A human becomes a patient based on the ethical principle of beneficence, and it is based on the fulfilment of two components. The first component is a patient presenting to a physician, whereas the second component is the existence of clinical interventions that benefit the patient[5].

The significant aspect of being a patient is the autonomy he/she has to make decisions about diagnosis, prognosis, and relevant medical treatments. However, the grant of the status of a patient to a foetus has caused controversies relating to the autonomy it exercises. This issue arises mainly in the domain where the foetus is detected with abnormalities, and the professionals insist on the treatment of the foetus in utero. 'Foetus' as a patient is not autonomous due to its inability to possess its values and perspectives[6]. However, the treatments to the foetus in utero are administered through the body of the pregnant woman by making her a patient in the same procedure. In such an instance, the autonomy of the pregnant woman is significant. Pregnant women have the right to make autonomous decisions in the purview of medical care[7]. The scope of her autonomy includes the ability to decline medical advice while exercising the right of informed refusal[8]. Thus, the autonomy of a pregnant woman in deciding whether or not to undergo a foetal intervention is significant. This creates a doubt on the stage at which the foetus becomes a patient. Thus, at what instance does the foetus become a patient? The foetus becomes a patient when the pregnant woman is presented for obstetric care[5]. It is evident that the decisional supremacy of the pregnant woman decides the status of the foetus, and the well-

being of the latter should be facilitated through the protection offered to the former.

The emerging concept of fetal pain in the contexts of the termination of pregnancy and the treatment of the foetus

It is evident that the medical concept of 'foetal pain' did not emerge overnight. That was a result of a considerable effort in research and experiments. However, the existence of neuroscientific evidence has given rise to foetal pain perception. It has emerged as a main topic in the purview of performing termination of pregnancy and the treatment of the foetus. The application of the concept of 'foetal pain' in termination of pregnancy has been censured as a burden exposing pregnant women to inappropriate interventions, risks, and distress[9]. When treating a foetus as a patient, the discussion of the concept of foetal pain is emerging. The subjective experience of pain in the early stages of human development is unknown. This contention is further inclined towards the objective evidence of foetal pain, namely the physiologic, hormonal, and behavioural responses[10]. However, the rejection of foetal pain is considered impossible. The denial of foetal pain is grounded on the notion that it restricts the termination of pregnancy and women's autonomy, but the recognition of foetal pain is still compelling[11]. BMA in 2020 has cited the findings of the foetal awareness evidence review, a report of the Royal College of Obstetricians and Gynaecologists (RCOG -2022)[12]. It has been noted in the report that there is an unlikelihood of pain perception in foetuses less than 28 weeks of gestation. However, BMA has recommended that doctors be attentive in taking due measures to minimise the pain of foetuses. Such recommendations of the professional bodies imply that doctors owe a duty of care to protect the interests of the unborn. The utilisation of analgesia and anaesthesia in the performance of surgical procedures for the benefit of the foetus started in the early 1980s, which encompasses the administration of foetal anaesthesia during all invasive foetal procedures[13].

Developments in law- foetal pain legislations

The early judicial pronouncements of the courts in the USA provide a clear idea about the reluctance to accept foetal pain as a ground to curtail the autonomy of pregnant women. In *Charles V Carey,* the enforcement of Illinois statutes governing abortion was disputed. One of the disputed provisions required the physicians to inform the patients about the reasonable certainty of organic pain to the foetus from the methods of abortion that would be employed by the physician. Not only the 'reasonable certainty of pain,' but it was also required for the physicians to inform about the methods that can be employed to control the pain. The statutes imposed criminal liability on physicians who do not comply with this requirement of informing the patient (pregnant woman). The court viewed that these statutes are unconstitutionally intruding on the physician-patient relationship[14]. In addition, the court asserted that requiring such an informed process is medically meaningless and medically unjustified, which results in creating cruel and harmful stress to the patients[14]. However, the later developments in law in the USA have shown that there is a state interest in preserving the foetus. In *Planned Parenthood of Southeastern Pennsylvania V. Casey*, the court expressed its views on the maternal-foetal conflict and the state's compelling interest in the viable foetus[15]. The power of the pregnant woman in autonomous decision-making and the interest of the viable foetus should be balanced[15]. This contention was further supported by *Women's Medical Professional Corp. V. Voinovich,* which reviewed a statute restricting partial birth abortion. The view expressed by the court on this statute was positive, where it was identified as a way of accommodating the interest of the state in preventing cruelty to foetus[16]. If further elaborated, the statute was recognised as avoiding unnecessary cruelty to the foetus.

In the USA, different states have enacted foetal pain legislation to restrict the decision-making of pregnant women on termination of pregnancy. The state of Nebraska in the USA was the first to pass a law on foetal pain[17]. Subsequent to the above developments, one of the milestones in the legal framework in the USA is the "Pain-Capable Unborn Child Protection Act"

(PCUCPA)[18]. The objective of enacting the Act was to protect the unborn children from pain in the course of abortions. In a general sense, the substantial medical evidence has shown that the foetus feels pain by 22 weeks of gestation[18].

The current positivity in the USA has been adopted by the UK. As discussed above, the BMA has emphasised the necessity of medical scrutiny to prevent foetal pain[12]. The legislative process of the UK relating to foetal pain prominently dealt with the concept of foetal sentience. The Foetal Sentience Committee Bill, as introduced by the UK, is more inclined to the scientific and medical evidence and stresses the importance of such evidence for the formulation of policies and law making process[19]. The bill further accepted that there is a debate existing in the community about foetal sentience and foetal pain[19].

CONCLUSION

The emerging medical concept of foetal pain is applicable in two main instances, namely the termination of pregnancy and the treatment of the foetus in utero. This reflects the consideration of pain that the foetus feels when undergoing surgical procedures. The paper identifies the foetus as a dependent potential living being lacking autonomy. The pregnant woman is considered autonomous in every aspect. The recognition of foetal pain in the scope of abortions has been viewed as a restriction on the exercise of autonomy by the pregnant woman. Even though the proof of foetal pain is purely based on a higher extent of scientific and medical evidence, the professional bodies in foreign jurisdictions have insisted that doctors should focus on the minimisation of pain to the foetus. The comparative jurisdictions: The USA has enacted foetal pain legislation, whereas in the UK, a bill is in existence to address the matter. In the USA, PCUCPA recognises the application of foetal pain perception to unborn children who have passed 22 weeks of gestation. This is the same in the UK, where the Foetal Sentience Committee Bill has accepted the capability of an unborn child to feel pain after 28 weeks of gestation.

It is evident that foetal pain perception has currently developed into a legal yardstick in the world to control the actions of physicians and the wishes of pregnant women. The development of medical technologies to view the foetus in utero has turned into a conduit for providing the necessary scientific basis to form relevant policies and legislation. The emerging trends of legal recognition of foetal pain have been creating a specific 'duty of care' on the part of the physician. This has substantially altered the traditional doctor-patient relationship that existed between the pregnant woman and the medical professional who is involved in the termination of pregnancy or the treatment of her foetus in utero. The legal recognition of foetal pain can be interpreted in two ways. The first is the medical duty of care of the professionals to the foetus (this is mainly applicable to the professionals who conduct procedures for the treatment of the foetus, they have a duty not to cause pain to the foetus). The second is the restrictions on termination of pregnancy on the grounds of foetal pain, which depict the curtailment of reproductive freedom, bodily integrity, and the autonomy of the pregnant woman.

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The author declared no conflicts of interest.

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AUTHOR CONTRIBUTIONS

APR: Design of the work; analysis, and interpretation of data for the work; drafting the work; final approval of the version to be published; and agreement to be accountable for

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