Sri Lanka Journal of Forensic Medicine, Science & Law — 2023; 14(2):10-17
DOI: https://doi.org/10.4038/sljfmsl.v14i2.7939

RESEARCH ARTICLE

A RETROSPECTIVE DESCRIPTIVE STUDY ON DEATHS DUE TO FIREARM INJURIES IN WESTERN PROVINCE, SRI LANKA

Alwis DN*, Govinnage DPS, Kulathunga DL, Perera WNS, Paranitharan P
Department of Forensic Medicine, Faculty of Medicine, University of Kelaniya, Sri Lanka

ABSTRACT

Introduction: The use of firearms is a well-recognized method of committing a homicide. In Sri Lanka, the use of firearms was prominent among terrorists and underworld criminals. The analysis of the injury pattern will help to find the trends related to firearm injuries. Deaths that deviate from the routine pattern of injuries will be highlighted.
Objectives: The objective of the study was to identify injury patterns in firearm-related deaths and the methods used to identify the range.
Methods: The data from 40 firearm-related autopsies conducted at Offices of the Judicial Medical Officer at Colombo North Teaching Hospital, Colombo South Teaching Hospital, and Office of the Judicial Medical Officer, Colombo from 2000 to 2019 were collected from the post-mortem reports using pre-formed questionnaires and entered into the SPSS statistical package for analysis.
Results: The majority were between 21 and 40 years of age (75%) and male (97.5%). Head alone was involved in 25% of deaths and head in combination with other regions was involved in 45% of the deaths. Cause of death (COD) in 50% of cases was head injuries alone and in 12.5% of cases, COD was from head injuries in combination with other injuries. The commonest circumstance was homicide in 72.5% of cases. Rifled firearm was the most common weapon used (90%). Range or the distance of fire was in the distant range in 65% of cases followed by close range in 17.5% of cases. Distance of fire was decided by the history, if available, the appearance of the entry wound, and other observations.
Conclusions: Scientific evaluation of deaths following firearm injuries demands proper assessment of the range or the distance of fire based on modern technology. This becomes more relevant if there is an incompatibility with the history and the appearance of the wound, especially when deciding the circumstance of death.

Keywords: *Autopsy; Cause of death; Gunshot wounds; Homicide; Suicide*

Corresponding author: Alwis DN
dulanuwanthi@gmail.com
ORCID iD: https://orcid.org/0000-0001-9332-2209

ARTICLE HISTORY
Received: 09.04.2023 Received in revised form: 12.08.2023
Accepted: 10.09.2023 Available online: 22.12.2023

INTRODUCTION

Gun violence and gun control are topics of great contention among the national and international community. Guns, to a certain demographic, signify safety against violence, whereas to another demographic, are a threat to the most basic of human rights, "the right to life"[1]. In Sri Lanka, 464 cases of homicides were recorded in the year 2020[2]. Information regarding the involvement of firearms in these deaths was not available in official sources. However, it was observed that 22 (3.72%) out of the 590 cases of suicides reported in the year 2020, had employed firearms as a method[3].

A retrospective analysis done on post-mortem reports of alleged homicidal deaths reported to

Judicial Medical offices of Colombo and Ragama, from July 2005 to June 2006 found that out of 256 alleged homicides 83 (31%) were due to gun violence[4]. A similar retrospective analysis conducted at Karapitiya Teaching Hospital from the 1st of January 2011 to the 31st of December 2011 observed that 30% of the homicidal deaths reported were due to firearm injuries[5].

The National Centre for Health Statistics, United States of America (USA) reported 19,141 homicides in the year 2019 of which 14,414 (75.30%) were classified as firearm homicides[6]. The USA being the country with the most firearms per capita in the world has a high homicide rate compared to other high-income countries[7]. In England and Wales, the homicides reported to police in 2019 and 2020 were 809[8]. Only a minority (4%) of the reported cases were due to firearm injuries, while the majority (40%) were due to sharp force injuries[8]. Out of the reported 45,878 homicides in India during the year 2014, 3,655 (7.96%) were due to firearm injuries[9].

The dead must be spoken for to protect the rights of the living. One crucial part of speaking for the dead is the post-mortem examination conducted by a qualified professional. Analysis of fatal firearm injuries regarding their type, direction, dating, range, etc., is of utmost importance to come to conclusions about the cause of death, circumstance, and details regarding the perpetrators. Determining the range or distance of a firearm injury observed at the post-mortem in the process of opinion formation is one of the areas that may have not received much attention in studies done in the region, if not worldwide.

Sri Lanka even though is one of the many lower middle-income countries in the South East Asian region, has the highest Human Development Index value[10]. Thus, Sri Lanka is in a unique position to seek innovative but cost-effective methods of analysing fatal firearm injuries. Integrating analysis of the type and range of firearm injuries with information technology will be the obvious step forward. The objectivity associated with deep learning of artificial intelligence backed by the knowledge and experience of subject experts will enhance the objective interpretation of injuries. However, relying solely on technology is not advocated in matters that deal with inherently subjective humans. The authors would like to put forth the idea of combining photogrammetry: with the use of ubiquitously present smartphones and their high-definition cameras and deep learning with modern software to analyse fatal firearm injuries.

OBJECTIVE

The objective of the study was to identify the injury patterns in firearm-related deaths and patterns in methods that were used to identify the range.

METHODS

The data from 40 firearm-related autopsy reports belonging to the investigators from the Offices of the Judicial Medical Officer at Colombo North Teaching Hospital, Colombo South Teaching Hospital, and Office of the Judicial Medical Officer, Colombo from 2000 to 2019 were collected using a pre-formed questionnaire and entered into the SPSS statistical package for analysis. Microsoft Word and Microsoft Paint software were used for the generation of pictograms that are illustrated in this article.

Sampling was done using the convenience sampling method and all the reports belonging to the investigators meeting the inclusion criteria were selected. Deaths involving multiple types of trauma such as sharp or blunt force trauma, deaths with no eyewitness statements, and deaths following complications of firearm injuries where there was a difficulty with interpreting initial injuries were excluded from the study.

The number of shots fired, the region of the body injured and the wound characteristics important for the estimation of range of fire were given prominence when gathering data from the autopsy reports.

RESULTS

Epidemiology

The study sample included 40 deaths with the majority being between 21 and 40 years of age (75%). Out of the study cohort, the majority were male (97.5%) except for one female (2.5%) who was a housewife. The majority were Sri Lankan nationals, except for one foreign national skilled worker. Available details on the occupations of the deceased are summarized in Table 1.

Table 1: Occupations of the deceased

Occupation details	Frequency	Percent (%)
Professional	13	32.5
Details not available	10	25.0
Skilled worker	7	17.5
Non-skilled	7	17.5
Unemployed	3	7.5
Total	40	100

Body Regions involved

When considering body regions involved in the path of the gunfire, the head alone was involved in 25% of the cases. Chest alone was involved in one case (2.5%). Multiple region involvement (head, chest, abdomen, etc.) was noted to be more common (65%, n=26) compared to solitary region involvement (35%, n=14) (Table 2).

Table 2: Body Regions involved in the path of the gunfire

Region	Frequency	Percentage (%)
Head	10	25.0
Head in combination with other regions (excluding chest)	5	12.5
Chest	1	2.5
Chest in combination with other regions (excluding head)	9	22.5
Head and chest	3	7.5
Head and chest in combination with other regions	8	20.0
Abdomen	1	2.5
Abdomen and upper extremities	1	2.5
Neck	1	2.5
Pelvis	1	2.5
Total	40	100.0

The total number of shots fired according to the post-mortem findings in these 40 cases amounts to 158. The head and chest have been the target of most entry wounds in the examined dead bodies. This is illustrated in Figure 1. Most victims had sustained either one (22.5%, n=9/40) or two (22.5%) entry wounds. Further details are elaborated on in Figure 2.

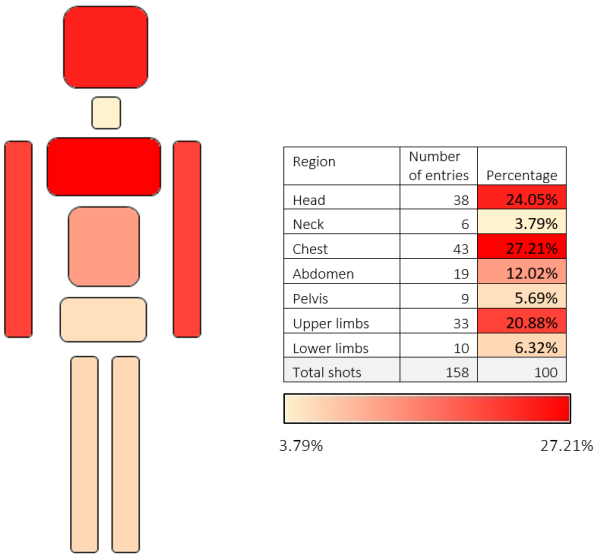

Figure 1: Distribution of entry wounds of firearm injuries.

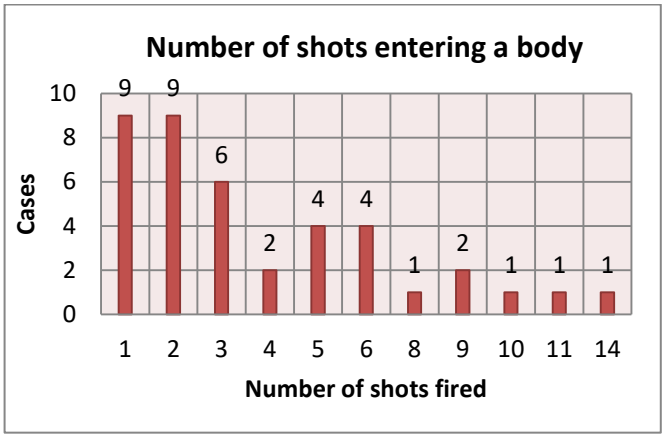

Figure 2: Frequency of number shots entering a body.

The cause of death (COD) in 50% of cases was head injuries alone and in 12.5% of cases, the COD was due to head injuries in combination with other injuries. The chest injuries, by itself, were the COD in 5% of the cases. The chest in combination with other injuries was documented as the COD in 35% of the cases. Out of those, 12.5% are a combination of head, and chest injuries or in combination with an injury to another region.

The manner of death was homicide in 35 (72.5%) cases. There were three suicides, of which two were committed using a smooth-bore weapon. These were single shots aimed at the head which resulted in their deaths. Another case of suicide was done by service personnel using an automatic assault rifle. The injuries were to the head and neck region with a single entry wound in the neck. The manner of death was not known in two cases; an expatriate

who went fishing and later found dead and a drug dealer.

Determining the range of fire

Range or the distance of fire can be divided into contact, near contact, close, intermediate, and distant ranges depending on the characteristics of the entry wound. The wound characteristics that are inferred from analysis of products of firing, i.e., soot, and powder residue, can vary depending on clothing and other intervening objects in the path of fire. This was given consideration when handling autopsies. The contact wounds and near-contact wounds are self-explanatory. Close range is defined as less than six inches, intermediate between six inches to six feet, and distant range as beyond six feet distance of fire from the victim[11].

In the 40 cases analysed, five (12.5%) cases were presumed to be contact or near-contact wounds. Two cases with contact wounds were due to smooth-bore weapons while the others were due to rifled weapons. One case with the rifled weapon injuries appeared to be of distant range as there was no burning, blackening, or tattooing. Only an abrasion collar was documented. In this particular case, two shots were fired at the head and both shots had exited. The injury pattern was incompatible with the history given by eyewitnesses. A naked eye observation of a contusion collar may have been documented as an abrasion collar.

One victim suffered both a distant range rifled firearm injury and a contact range smooth bore firearm injury. In this case, there was no burning, blackening, or tattooing found surrounding the injuries caused by both weapons. The latter was decided as contact due to the presence of a wad and cork inside the brain and other wound features supportive of the burst effect. One rifled weapon injury was concluded as a contact injury due to the presence of a contusion collar which was located in the occipital region.

There were eight (20%) close-range injuries. One of them was caused by a smooth bore weapon, which had a local large bursting effect which helped to determine the range as contact. Others were all from rifled weapons. One rifled weapon entry wound had all three features of burning, blackening, and tattooing observed. Four wounds had a combination of two of the three different features of burning, blackening, and tattooing. The most consistent feature observed was blackening, which was observed in six out of eight cases, with two cases reporting blackening alone as the reason for determining range. Only one (2.5%) intermediate-range injury was observed, which didn't have any burning or blackening, but had tattooing and an abrasion collar.

There were 27 (67%) distant range injuries. All of the 27 were from rifled weapons except one case where the weapon could not be identified. The absence of burning, blackening, and tattooing alone was used to state the range as distant in 18 cases, with two cases having eyewitness accounts in addition to the above evidence to support the range as distant. Seven cases had only an abrasion collar. In the case of one rifled injury found in a decomposed skeletonized body, the range was indeterminate. A detailed infographic analysis of reasons for determining the range is given in Figure 3.

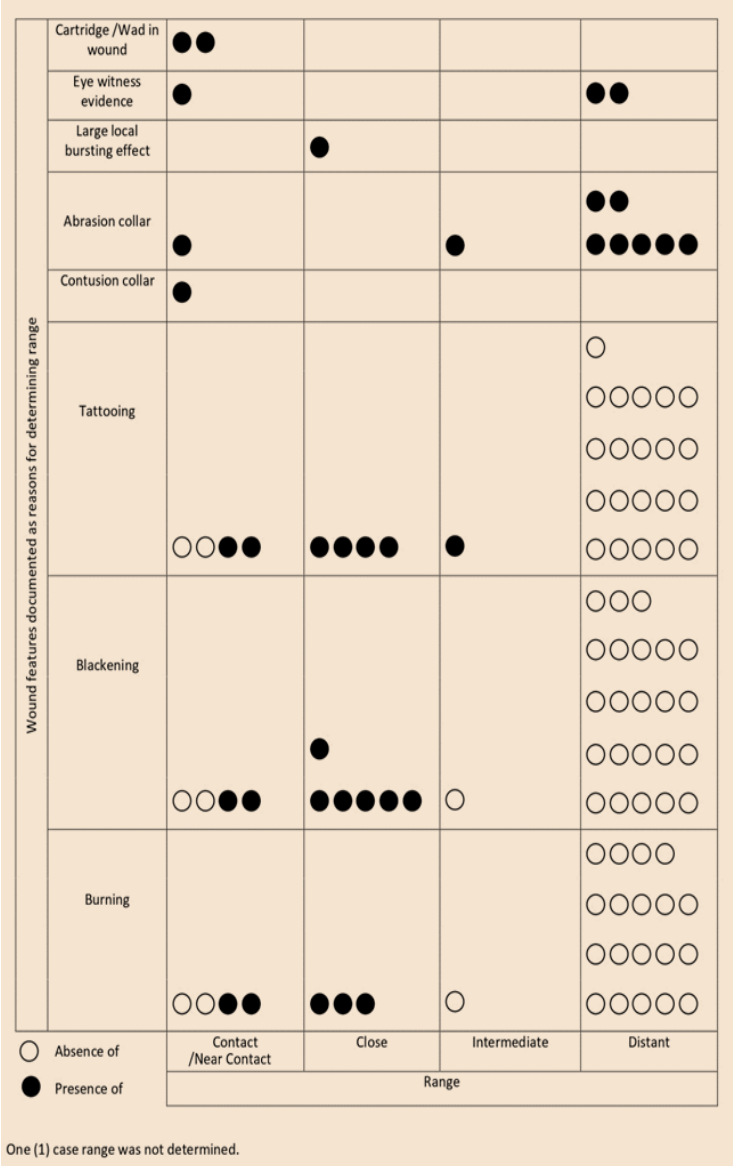

Figure 3: Range with the reason/s stated in the post-mortem report to determine the range.

Firearm and bullet trajectory

The rifled firearm was the sole weapon used in 90% of the cases (n=36/40). The smooth-bore weapon was the sole weapon used in 5% (n=2/40) cases. Both rifled and smooth-bore weapons were used in one case (2.5%). In one case, where an individual in a factory was shot multiple times, the weapon used was not identified. Among the 37 cases which involved rifled weapons, 16 were cases that involved automatic assault rifles, 8 cases involved either a handgun or a pistol, and further details were not available in another 13 of the cases. Bullet ricochet was identified in two of the cases where rifled weapons were used.

DISCUSSION

The dominance of male victims is noted in this study is compatible with another study from Sri Lanka which showed a 41:1 male: female ratio[4]. A study from India had 92.48% male victims[12] and a study from Bangkok had 91.3% male victims[13]. Both studies had a greater proportion of female victims compared to studies from Sri Lanka. This increase in female victims is also observed in European countries. Sweden had 35%[14], Denmark had 29.43%[15], and Italy had 7.6%[16] female gun violence victims. America with its controversial gun violence policies had 13.56%[17] female deaths.

Considering the total 158 shots fired at the victims of the current study, the chest (27.21%, n=47) had been the most targeted body region, with the head (24.05%, n=38) being the second. This pattern is inversed in another study conducted in Sri Lanka where the head was the most preferred target (36%, n=30) followed by the chest (30%, n=25)[4]. This is in direct contrast with one study conducted in India from 2008 to 2010 which noted the abdomen (48.49%, n=32) as the most targeted region[18]. This study considered victims who died due to complications of gunshot wounds. However, two other studies from India[19,20] showed the chest as the most targeted and the head as the second, which is consistent with the pattern observed in the current study. Studies from Thailand[21] and Denmark[15] had a similar pattern of having the head being the most targeted followed by the thorax. A Polish study has demonstrated that the head was the most common target in suicides, whereas, in homicides and accidental firearm fatalities, the chest region was the most common target[22]. The USA study noted that the head was the most common target despite the motive but, suicides had the head as the target in 89.1% of cases, whereas homicides had the head as a target in 38.3%, followed by chest (22.2%) at a close second. (The USA study only considered single gunshot wound fatalities in the study.) The head and neck region being the targets of the three cases of suicides in this study is compatible with the above findings. The head and chest being the most common target depict human understanding of the vitality of the head and chest to life. The chest is the most common or prominent target in most homicidal deaths involving firearms and in our study with only two cases of suicidal deaths by firearms, probably because the chest is the widest part of the human body.

However, case-by-case consideration of regions involved in the path of the gunfire, rather than the individual shots fired. The head alone was involved in 25% of cases (n=10) with the head region alone or in combination with other regions including the chest being involved in 65% of cases (n=26). Chest alone was involved in 2.5% of cases (n=1) with chest region alone or in combination with other regions including the head was involved in 52.5% of cases (n=21). The head is the most common region involved by itself or in combination with other regions despite the lesser number of shots fired at it signifies the fatality of a gunshot wound to the head. The chest region by itself was only involved in one case even though it was the most common region that had entry wounds. Chest in combination with other regions was less involved when considering cases individually, which probably points towards the reduced fatality of chest wounds. This is confirmed when considering the causes of death of individual cases where in 50% of cases head injuries alone and in 12.5% of the cases head injuries in combination with other injuries were responsible.

The manner was a homicide in the majority of cases, with only three cases of suicides. This is compatible with other studies from developing countries where guns are used for homicides rather than suicides[18,19,23]. The inverse is true for developed countries[14, 23,24].

There are no articles published analysing the reasons for determining range. Figure 3 is a graphical representation of the reasons that could be considered in the decision-making process when considering the range retrospectively by perusing the reports. This graph includes both shotgun and rifled weapon injuries with varied reasons useful in determining the range that are both unique and common to both types of weapons. This effort was made by the authors to look for any strong objective evidence knowing the subjective variations that may occur in determining the range and to propose better scientific analysis. A similar analysis could not be found in other articles published despite

extensive searches in 'Google Scholar' and 'PubMed' search engines.

As represented by Figure 3 interpreting distance and the type of weapon is not an exact science. It needs expert knowledge and experience to determine the above. As the world is moving forward, information technology is playing an increasingly important role in scientific investigations. Photogrammetry as defined by the American Society of Photogrammetry and Remote Sensing is the "art, science and technology of obtaining reliable information about physical objects and the environment, through the process of recording, measuring and interpreting imagery and digital representations of energy patterns derived from noncontact sensor system"[24]. The idea of using photogrammetry for assistance in forensic autopsy is not novel. In 1994, Brueschweiler et al. evaluated the photogrammetric method for the documentation of patterned wounds in forensic medicine[26]. During the past two decades, research has established that regions with body hair and reflective moist areas are poorly documented in photogrammetry despite the use of different scanning methods[27]. The authors hold hope that these barriers are not permanent in the face of constantly advancing technology. The idea of using smartphones to create an original database with the 3D reconstruction of the body and interpreted data at autopsies with regards to the type of weapon and range of fire, to be fed to deep learning software, is novel. Deep learning is a type of machine learning that simulates one of the basic human learning methods: learning by example[28]. More examples provided to the deep learning software will lead to more intelligent output of processed data. Ultimately, this deep learning software could give suggestions about the type of weapon and range. Understandably this need not be limited to injuries caused by firearms. This could be used as a recording tool and an assisting tool that adds validation to medico-legal autopsies in the future.

CONCLUSION

The chest and head were the regions involved most in fatal firearm injuries with upper limb injuries occurring in combination may suggest defence injuries. Blackening is the most observed feature used in determining close-range injury. Scientific evaluation of deaths following firearm injuries demands proper assessment of range. Analysis of wound appearance with modern technology will enhance accuracy.

The chest and head were the regions involved most in fatal firearm injuries with upper limb injuries occurring in combination may suggest defence injuries. Blackening is the most observed feature used in determining close-range injury. Scientific evaluation of deaths following firearm injuries demands proper assessment of range. Analysis of wound appearance with modern technology will enhance accuracy.

LIMITATIONS AND RECOMMENDATIONS

The study is limited by the number of autopsy reports analysed and by the convenient sampling method. When further studies are undertaken, the survey method of collecting data, even for a small duration might be more suited for the actual construction of the database suggested.

Another limitation in the analysis process is the subjective analysis used to represent range and reason for determining range. Adding an annexure containing a questionnaire with standard questions to the post-mortem reports of victims of firearm injuries might lead to standardization of reporting of firearm injuries. It will easily provide data needed for the construction of a database with sophisticated analysis. The whole endeavour can be enhanced with the widely available information communication (IT) network and IT literacy in professionals involved in the whole post-mortem process. This is a realistically far-set goal. However, the distance to the goal could be shortened by small steps taken by academics in pioneering change.

ACKNOWLEDGEMENTS

None

CONFLICTS OF INTEREST

There are no conflicts of interest.

ETHICAL ISSUES

The post-mortem reports that were selected for analysis belonged to the investigators and were kept in safe custody. The victim's identity is protected as investigators have not used any personal information that would lead to an identity and only the collective data is used for analysis Thus the study was conducted adhering to fundamental ethical principles including confidentiality.

SOURCES OF SUPPORT

None

AUTHOR CONTRIBUTIONS

DNA: Analysis of 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. **DPSG:** Analysis of 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. **DLK:** Acquisition and analysis of work; interpretation of data for the work; final approval of the version to be published. **WNSP:** Conception or designing of the work; acquisition of work; interpretation of data for the work; final approval of the version to be published. **PP:** Conception or designing of the work, acquisition of 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.

REFERENCES

1. Amnesty International. *Gun violence – key facts*. Available from: https://www.amnesty.org/en/what-we-do/arms-control/gun-violence [Accessed on 22nd February 2023].

2. Sri Lanka Police. *Grave crime abstract for the year 2020 for whole island from 01.01.2020 to 31.12.2020*. Vol 3.; 2020.

3. Sri Lanka Police. *Crime Statistics – 2020, Mode of Suicides - for year 2020*. Available from: https://www.police.lk/index.php/crimetrends [Accessed 30th September 2021].

4. Edirisinghe PAS, Kitulwatte IGD. Homicidal firearm injuries: A study from Sri Lanka. *Forensic Science, Medicine, and Pathology*. 2010;6(2):93-98. https://doi.org/10.1007/s12024-009-9139-z.

5. Rathnaweera RHAI. Trends of homicides in Galle-Sri Lanka. *Medico-Legal Journal of Sri Lanka*. 2016;3(1):16. https://doi.org/10.4038/mljsl.v3i1.7318.

6. Centers for Disease Control and Prevention: National Center for Health Statistics. *FastStats – Homicide, 2019*. Available from: https://www.cdc.gov/nchs/fastats/homicide.htm [Accessed 29th September 2021].

7. Grinshteyn E, Hemenway D. Violent Death Rates: The US Compared with Other High-income OECD Countries, 2010. *American Journal of Medicine*. 2016;129(3):266-273. https://doi.org/10.1016/j.amjmed.2015.10.025.

8. Statista. *Homicide-Method of killing in England and Wales 2020*. Available from: https://www.statista.com/statistics/1214211/homicides-in-england-and-wales-by-ethnicity [Accessed 22th September 2021].

9. International firearm injury prevention and policy. *India- Gun fact, figures and law*. Available from: https://www.gunpolicy.org/firearms/region/india [Accessed 22nd September 2022].

10. United Nations Development Programme. *Human Development Report 2020 The Next Frontier: Human Development and the Anthropocene*. 2021;21.

11. Gunshot and Explosion Deaths. Saukko, P. and Knight, B. *Knight's Forensic Pathology*. 4th ed. Boca Raton: CRC Press; 2015. P. 249-250.

12. Kumar A, Sachan R, Verma A. General Medico-Legal Evaluation of Firearm Injuries — An Original Study from India with Review of Literature. 2015;60(January):83-87. https://doi.org/10.1111/1556-4029.12593.

13. Myint S, Rerkamnuaychoke B, Peonim V, Riengrojpitak S. Fatal firearm injuries in autopsy cases at central Bangkok, Thailand: A 10-year retrospective study. *Journal of Forensic and Legal Medicine*. 2014;28:5-10. https://doi.org/10.1016/j.jflm.2014.09.002.

14. Junuzovic M, Rietz A, Jakobsson U, Midlöv P, Eriksson A. Firearm deaths in Sweden. *European Journal of Public Health*. 2019;29(2):351-358. https://doi.org/10.1093/eurpub/cky137.

15. Thomsen AH, Leth PM, Hougen HP, Villesen P. Gunshot homicides in Denmark 1992-2016. *International Journal of Legal Medicine*. 2021;135(4):1507-1514. https://doi.org/10.1007/s00414-021-02548-5.

16. Solarino B, Nicoletti EM, Di Vella G. Fatal firearm wounds: a retrospective study in Bari (Italy) between 1988 and 2003. *Forensic Science International*. 2007;168(2-3):95-101. https://doi.org/10.1016/j.forsciint.2007.01.023.

17. Resnick S, Smith RN, Beard JH, et al. Firearm Deaths in America: Can We Learn from 462,000 Lives Lost? *Annals of Surgery*. 2017;266(3):432-440. https://doi.org/10.1097/SLA.0000000000002376.

18. Kumar A, Sachan R, Verma A. Medico-legal evaluation of firearm injuries-an original study from India with review of literature. *Journal of Forensic Sciences*. 2015;60(s1):S83-S86. https://doi.org/10.1111/1556-4029.12593.

19. Kohli A, Aggarwal NK. Firearm fatalities in Delhi, India. *Legal Medicine*. 2006;8(5):264-268. https://doi.org/10.1016/j.legalmed.2006.06.001

20. Shashikant VK, Dayanand VD, Bhalge U, Pandey SK, Pathak M. Pattern of Fatal Firearm Injuries Pertaining to Manner of Death: An Original Research Article. *Indian Journal of Forensic Medicine & Toxicology*. 2020;14(1):38–43. https://doi.org/10.37506/ijfmt.v14i1.9.

21. Myint S, Rerkamnuaychoke B, Peonim V, Riengrojpitak S, Worasuwannarak W. Fatal firearm injuries in autopsy cases at central Bangkok, Thailand: A 10-year retrospective study. *Journal of Forensic and Legal Medicine*. 2014;28:5-10. https://doi.org/10.1016/j.jflm.2014.09.002.

22. Ptaszyńska-Sarosiek I, Filimoniuk K, Cwalina U, Niemcunowicz-Janica A. Review of fatal gunshot cases in the files of the Department of Forensic Medicine in Białystok, Poland, in the years 1964-2015. *Archiwum Medycyny Sądowej* i *Kryminologii*.2016;66(4):211-219. https://doi.org/10.5114/amsik.2016.68097.

23. World Health Organization. *Small arms and global health -2001*. Available at: https://apps.who.int/iris/handle/10665/66838 [Accessed 22th September 2022].

24. Jeffery A, Hulewicz B, Langlois N, Little D, Ellis P. Firearm fatalities in Western Sydney 1994-2003. *Forensic Science, Medicine and Pathology*. 2007;3(4):252-257. https://doi.org/10.1007/s12024-007-0035-0.

25. The American Society for Photogrammetry and Remote Sensing. *Definition.* Available at: https://www.asprs.org/a/society/about.html [Accessed 24th January 2023].

26. Thali MJ, Braun M, Brueschweiler W, Dirnhofer R. "Morphological imprint": Determination of the injury-causing weapon from the wound morphology using forensic 3D/CAD-supported photogrammetry. *Forensic Science International*. 2003;132(3):177-181. https://doi.org/10.1016/S0379-0738(03)00021-5.

27. Urbanová P, Hejna P, Jurda M. Testing photogrammetry-based techniques for three-dimensional surface documentation in forensic pathology. *Forensic Science International*. 2015;250:77-86. https://doi.org/10.1016/j.forsciint.2015.03.005.

28. MATLAB & Simulink. *What Is Deep Learning? - How It Works, Techniques & Applications*. Available at: https://www.mathworks.com/discovery/deep-learning.html. [Accessed 24th January 2023].