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# LETTER TO THE EDITOR

## COVID-19: UNRAVELING THE EVOLVING PANDEMIC

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**ABSTRACT**

The coronavirus disease (COVID-19), which originated at Wuhan, China in December 2019, has been named as a pandemic by the World Health Organization (WHO). According to the perspective of the author and many others, it is much more than a health crisis. In addition to its impact on human health, it also can be characterized as an issue having several aspects including social, political, economic, human rights, logistical and global peace and security. The outbreak affects all segments of the population and is particularly damaging to the vulnerable groups including poor, immunosuppressed, with terminal illnesses, pregnant women, people with chronic medical conditions, persons with disabilities, elderly living alone and displaced people. Evidence indicates that the health and economic impacts of the outbreak are being borne disproportionately by poor and many in middle class with their misery compounded by the strict actions taken by the governments in good faith. It is also becoming clear that the effect of COVID-19 upon systems brings an enormous challenge, since in many situations the systems do not have organized plan to face a pandemic of this nature, but it can be expected the resilient human race to come up with various innovations, mainly technological to face the current challenge despite apocalyptical predictions.

***Keywords:*** *COVID-19 pandemic, Socioeconomic impact, Human rights, Healthcare and forensic services, Global peace and security*

## INTRODUCTION

Pandemics of infectious diseases have altered human history since the beginning of time. Spanish Flu, Ebola virus disease, SARS, and H1N1 influenza are examples of just a few of those pandemics. Present day human population face a threat of dissemination of novel coronavirus fueled by the ease of international travel which has become commonplace, with the pandemic continuing to grow exponentially infecting over 2,845,859 people and at least 197,846 fatalities globally, until now. Coronaviruses are enveloped RNA viruses belonging to the family of Coronaviridae, genus betacoronavirus. The human coronavirus types 229E, NL63, OC43, and HKU1 commonly infect the people around the world[1]. Sometimes coronaviruses that infect animals can mutate and become a new human coronavirus. Though the coronaviruses generally cause mild respiratory infections in humans, over the past 18 years, three animal-derived coronaviruses have emerged namely, SARS-CoV (civet cat), MERS-CoV (dromedary camel) and SARS-CoV-2 (probably bat), causing much more severe acute and potentially fatal respiratory disease[2]. Those emergent zoonotic viruses cause substantially higher death rates than common coronavirus infections and the current estimate of the overall case fatality proportion due to COVID-19 syndrome caused by SARS-CoV-2 appears to be closer to 3 %[3]. The human to human transmission in COVID-19 is most likely from the direct contact with the patient, by respiratory droplets and by contact with the contaminated surfaces and objects. The development of this new epidemic is largely due to the fact that the humans has no natural or acquired antibodies against this virus. Main challenges in addressing the new coronavirus-associated outbreaks are lack of suitable anti-viral medication to treat active disease and appropriate vaccines to prevent disease.

The initial symptoms of COVID-19 are fever, dry cough, sore throat, shortness of breath and breathing difficulties. For some patients, the disease can progress to pneumonia, acute respiratory distress syndrome, renal failure and even death[4]. Comorbidities like lung diseases, diabetes mellitus, hypertension and cardiovascular disease are potential risk factors to patients with severe COVID-19 infection compared with non-severe patients[5]. As of 7th May 2020, Sri Lanka has 800 confirmed cases with nine deaths.

### Global timeline of the Pandemic

The first reports of an outbreak came on 31st December 2019 in Wuhan, capital of Hubei Province of China, a city of 11 million people. On 7th January 2020 the WHO confirmed a novel coronavirus (SARS-CoV-2) was spreading[6]. There had been no deaths linked to the virus, at that point; but by 11th January, China announced its first death from the virus, a 61-year-old man who had purchased goods from the Huanan Seafood Wholesale Market at Wuhan[7]. Within weeks, the number of fatalities was rising rapidly, and China became the epicenter of the new global epidemic. On 13th January, the WHO reported the first case outside China, a woman who had arrived from Wuhan to Thailand.

Officials in USA, Nepal, France, Australia, Malaysia, Singapore, South Korea, Vietnam and Taiwan confirmed cases over the following days. China placed Wuhan and 15 other cities in Hubei province under strict quarantine after the area was overwhelmed with the infection by 23rd January 2020. The Chinese government drafted healthcare workers from the whole country, and two hospitals were built in just over a week to care for the patients.

The decision to quarantine Wuhan presented unprecedented challenges as it was dealing with a city about eight times bigger than Hong Kong and five times the size of

London. The lockdown of the province affected more than 50 million people. Public transport services were shut down, and in Wuhan, the airport, railway station and metro transit system were closed, and no one could leave the city without permission. Soon after, the factories, offices, and schools were also closed. Some of the most effective steps China has taken for reducing the transmission rate are, encouraging work from home, closing schools and prohibiting large gatherings.

On February 2, the Philippines reported the first death outside China, the victim being a Chinese man from Wuhan. With the infection spreading around the globe like a wildfire, the WHO on 11th March declared on the coronavirus outbreak a pandemic, as a long-anticipated move. By mid-March 2020, Italy and Spain became the epicenters of the pandemic, reporting thousands of infected cases and fatalities, with health, social and economic infrastructure of the countries overwhelmed by alarming levels of severity and spread of the infection and deaths. The USA, with approximately 1/3rd of the confirmed COVID-19 cases (1,263,142 as of 07th May 2020) worldwide, and a total death toll of 74,809 (28% of the world deaths), is now the global epicenter.

**Sociopolitical and socioeconomic impact: Novel coronavirus versus the world**

Throughout the human history, epidemics not only destroyed the lives but also had a devastating impact on countries affected by them. According to Prof. Frank M. Snowden, a professor emeritus of history and the history of medicine at Yale, the disease outbreaks have shaped politics, crushed revolutions, and entrenched racial and economic discrimination[8]. He mentions that, "stretching across centuries and continents, the epidemics have also altered the societies in which they have spread through, affecting personal relationships, the work of artists and intellectuals, and the man-made and natural environments". He also writes, "epidemic diseases are not random events that afflict societies capriciously and without warning. On the contrary, every society produces its own specific vulnerabilities. To study them is to understand that society's structure, its standard of living, and its political priorities."

Further research along the lines of his theory showed, when a six-month cholera outbreak, which was part of a widespread pandemic that affected parts of Asia, Europe, and the Americas struck Paris in 1832, eventually killing nearly 19,000 Parisians, a conspiracy theory spread that the unpopular government under King Louis Philippe was poisoning many kinds of food and wine[9]. The police and Municipal guard were barely able to contain the ensuring violence. The institutional memory of those events probably fueled the dread of the 'dangerous classes' or the poor people and violent crushing of 1848 revolution and Paris Commune. Napoleon Bonaparte's colonial conquest in nineteenth-century across the Atlantic Ocean was halted by yellow fever[10], which ravaged his army in France's Caribbean colony of Saint-Domingue, the modern Haiti. His eastern ambitions were blunted by dysentery and typhus[11]. The Spanish flu was one of the deadliest disasters in history, lasting for two years, between 1918 and 1920, killing estimated 50 million people[12]. It was thought the early cases originated in the United States before spreading in an alarming rate to Europe. The rat-infested trenches of the First World War, with poor sanitation and squalid living conditions probably had affected the immune systems of soldiers and war affected populations, making them more vulnerable to illness. The COVID-19 outbreak also has capacity to unfold in a similar way to a worldwide calamity.

Parallel to the actions taken by China, more countries across the world have significantly curbed public life in order to halt the spread of the COVID-19 outbreak. The

Government of Sri Lanka also initiated several strict measures to help the country prevent, detect, and respond to the COVID-19 pandemic and strengthen its public health preparedness. Some key actions implemented include;

- Establishment of National Operation Centre for Prevention of COVID-19 Outbreak (NOCPCO), which has effectively coordinated with the health services in containment, quarantine and contact tracing efforts and appointing Acting Chief of Defence Staff and Commander of the Army Lt. Gen. Shavendra Silva as its Head.
- Implementing travel bans to other affected countries and closing of harbours and airports.
- Quarantining the sea and air passengers arriving in Sri Lanka at the quarantine centres managed by the Armed Services.
- Vigorous tracing of contacts and absconding returnees with the assistance of the Special Task Force and intelligence operatives of the Tri-services and police.
- Locking down entire towns and villages when it is impossible to move large number of people to quarantine facilities.
- Implementing strict island wide police curfews to facilitate aggressive "social distancing" process in the entire country with closing down educational establishments, public and private institutions, business premises etc.
- Taking legal action against those who break curfew, public health laws or attempt to spread fake news.

The actions taken by the governments may lead to unnecessary social and economic disruption. Millions of under-paid, daily wage earners like laborers who hold supply and sanitary chains which are critical to everyday life and many in the middle class, all over the world may get affected by the strict measures taken in good faith to contain the infection. Both public and private sector organizations are challenged by the need to promote health and health practices among their employees while, at the same time, maintaining their operations. An economic slowdown as the result of the pandemic, may result in worldwide recession with wider repercussions on the Global economy and security. Predictions of the global impact vary: Bloomberg hypothesizing $2.7 trillion in lost output, the Asian Development Bank releasing scenarios from $77 billion to $347 billion, and an Organisation for Economic Co-operation and Development (OECD) report talking about a halving of global economic growth[13,14,15]. Similar to the desolate situation predicted at the global level, the outbreak is likely to worsen the economic situation in Sri Lanka further with wider repercussions due to severe blow sustained by major income generators like tourism, apparel, foreign employment, construction, retail, banking and finance sectors, due to global economic turmoil combined with local public health concerns and economic vulnerabilities.

**Human Rights Perspective of containment**

The 'lockdowns' can sometimes result in inappropriate, excessive and counterproductive measures that may sometimes hinder coordination of outbreak response. As public health authorities increase efforts to address the COVID-19 pandemic, rumours, misinformation, racism and xenophobic theories appear to be spreading world over faster than the virus. Fear, stigma and misinformation have direct implication on the implementation of effective public health measures to control the pandemic. Respecting human rights and protecting public health have to go hand-in-hand as those measures are taken in everyone's best interest in mind.

Office of the United Nations High Commissioner for Human Rights has emphasized the need to respect for human rights across the spectrum, including

economic, social, and cultural rights, and civil and political rights as fundamental to the success of the public health response and recovery from the pandemic[16]. It is of paramount importance to introduce person/family centric care for the health and well-being of the wider community and especially for the vulnerable groups like those with COVID-19 or other respiratory conditions, immunosuppressed, with terminal illnesses, pregnant women, people with chronic medical conditions, persons with disabilities, elderly living alone and displaced people, in time of a challenge to the established system, which is taxed maximally during the pandemic outbreak. It is of particular significance to address the situation of prisoners and others in detention institutions as they are at a heightened risk of infection due to the inability to achieve physical distancing and poor standards of hygiene at prisons and detention centres[17,18].

The World Health Organization (WHO) declaration of the COVID-19 outbreak as a public health emergency of international concern (PHEIC) included recommended, evidence-based measures for detection, containment and control, based on available data[19]. These measures adhere to International Health Regulations (IHR) principles concerning human rights, proportionality, and unnecessary interference with trade and travel[20].

**Burden on Healthcare systems including Forensic services**

As health workers around the world put their lives on the line to save others in the fight against the pandemic, many have died and some of the others have tested positive[21]. A global shortage of personal protective equipment (PPE) has also added a huge toll on their physical and mental wellbeing. It is becoming clear that the effect of COVID-19 upon healthcare systems brings an enormous challenge, since in many situations the systems do not have organized plan to face a pandemic of this nature and cannot cope with the volume of patients needing care, especially combined or even without calls to manage disorders associated with cardiovascular, pulmonary, metabolic and malignant conditions. During an infectious disease outbreak, public and other health leaders have to work diligently to contain its spread, manage the medical and social impact, and try to counter misinformation and prevent discrimination. In an event of 'explosion' of the number of cases, the under-resourced and under-staffed health services may not be able to cope up with the challenge as it was seen in the early period of the infection in China, Iran, Italy, Spain and now in USA. The health workers may get exhausted due to continuous work or may simply go down with the infection. There is a high likelihood of health staff workers not reporting to work at all. A new guidance issued by Royal College of Nursing[22] states, that if sufficient PPE cannot be supplied and treatment cannot be delayed or carried out in another format, nurses should decline to work. COVID-19 is taking a significant toll on front-line healthcare providers[23]. In addition to the stress and anxiety the doctors may have to make the despondent choice of deciding who is going to survive and who is going to die, who is going to get a monitor, a ventilator and the medical attention they need, when the system is overwhelmed[24].

In addition to above, the supply chain disruptions and shortages that medical/ pharmaceutical industries may have to face in the near future due to the strategic hoarding by suppliers and panic buying by consumers are a major concern.

According to the 'Briefing on COVID-19' by The Royal College of Pathologists, UK[25], SARS-CoV-2 is categorized under hazard group 3 agents (HG3). HG3 are defined as "agents which can cause severe human disease and may be a serious hazard to employees". It is considered that agents categorized in HG3 can spread to the community, but there is usually effective

prophylaxis or treatment available (though it is not so in COVID-19). SARS, MERS, Rabies, Dengue, Japanese Encephalitis, HIV and Hepatitis B, C, D and E viruses are some of the infectious biological agents included under HG3. The briefing further mentions that, the HG3 infections can be acquired in the mortuary via, percutaneous inoculation, skin contamination without inoculation, ingestion, inhalation and contamination of mucosal surfaces. It underscores the importance of the preparation for the possible presence of an infection in a deceased, drafting of appropriate protocols on what to do, the proper state of the mortuary and its equipment, universal precautions, appropriate PPE and preventive prophylaxis through vaccination of staff, in managing HG3 infections in mortuary.

In Sri Lankan context[26] and in most of the other countries, if a death is due to confirmed COVID-19 infection, there is no need to do a post-mortem examination and the Medical Certificate of Cause of Death can be issued for the disposal of body. However, in the cases of deaths due to suspected or possible corona viral infections which needs laboratory confirmation, inquests and limited autopsy examinations are required exposing the forensic pathologists and ancillary staff for potential infection. Unlike in the case of developed countries, some of the medico-legal morgues in Sri Lanka lack basic facilities like adequate ventilation, lighting, running water, refrigerators and proper autopsy instruments in addition to the shortage of PPE and properly trained mortuary attendants with knowledge in mortuary maintenance and health and safety, heightening the concerns of the forensic community.

**Threat to Global Peace and Security**

In a close video-conference with the members of the Security Council, the UN Secretary-General António Guterres mentioned[27], "while the COVID-19 pandemic is first and foremost a health crisis, its implications are more far-reaching and could threaten global peace and security". He outlined his concerns calling the crisis as the "gravest test since the founding of this Organization".

He indicated eight potential ways COVID-19 could undermine global peace and security;

- Erosion of trust in public institutions if people perceive that their authorities had mishandled response or were not transparent.
- Impact of pandemic in fragile societies or less developed countries, leading to economic instability and discrimination in accessing health services with devastating consequences for vulnerable groups.
- Rise in political tensions and undermining of legitimacy due to postponing or proceeding with electoral processes.
- Escalation of violence which could further entrench ongoing wars in some conflict settings which may complicate efforts in fighting the pandemic leading to further division and turmoil.
- Terrorist groups could see "a window of opportunity to strike" with most Governments focused on managing the pandemic.
- The risk of bioterrorist attack to countries by non-state groups who could gain access to virulent strains of microorganisms.
- Stalling of many peace processes and conflict resolution efforts in countries with conflict situations, triggering or worsening numerous human rights challenges and growing manifestations of authoritarianism, including limits on the media, civic space and freedom of expression.
- Rise of hate speech and stigma with white supremacists and other extremists seeking to exploit the situation.

## CONCLUSION

Since a sudden, large-scale pandemic like COVID-19 poses substantial threats to human lives and the world order, how to mitigate such impacts is a key issue which needs serious consideration. It is of utmost importance to note that effective epidemic/ pandemic logistical response and planning is vital to secure health, economy, social security, peace and prosperity, for now and the future. The challenges posed by the outbreak should invigorate the governments and private sector to investigate and develop the appropriate logistical strategies and solutions, since there is a serious scarcity of knowledge on how the logistical system can adapt and tackle the impacts in an epidemic/ pandemic outbreak.

True to the idiom 'every cloud has a silver lining' it can be expected the resilient human race to come up with various innovations, mainly technological to face the current challenge despite apocalyptical predictions. The pandemic is compelling the societies to turn toward digital technologies to respond to the crisis and in the medical field, the post-COVID-19 world is likely to be remembered as the time when the provision of primary care or the management of non-communicable diseases shifted to digital modalities. It can be expected that, the most impactful innovations in technologies to come from developments related to artificial intelligence (AI) as well as to health technologies. In developed nations like UK and USA, the strategy of forward triaging of patients suspected of COVID-19 or other disorders has been already firmly established with the assistance of telemedicine and online screening before they are directed to the emergency departments.

Sri Lanka will also likely to get benefitted by global developments in addition to technological advancements made by her own professionals. Recently, the Director General of the World Health Organization, praised the actions taken by the Government of Sri Lanka so far to contain the pandemic and offered continued support to fight against the outbreak. Additionally, the nation should commend and appreciate the efforts taken by the State, and the dedication, commitment and high level of responsiveness of the healthcare workers, government officials, the armed forces and police in carrying out their duties to manage the present crisis.

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# SEX DETERMINATION BY MANDIBULAR RAMUS - A DIGITAL PANORAMIC STUDY -

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## ABSTRACT

Sex determination becomes the main part in the procedure of identification of a person by forensic investigator in a case of mishaps, chemical and nuclear bomb explosions, natural disasters, crime investigations and ethical studies. In human remains, next to pelvis, mandible is used as the best key for the sex determination. Aim of the study was to evaluate the sex dimorphism in measurements of mandibular ramus by using orthopantamographic (OPG) images. The retrospective study was conducted using digital OPG images of 175 males and 175 females between age group of 20 and 60. The measurements were taken by using tools fetched with "APL software v8.1". Discriminant analysis was done using SPSS (version 23) software. Statistically significant relationships were found between sex and maximum ramus breadth ($p=0.000$), minimum ramus breadth ($p=0.024$), condylar height ($p=0.000$), projective height ($p=0.000$), coronoid height ($p=0.000$). Furthermore, condylar height showed highest sex differentiation in its measurements (Wilks' lambda = 0.659), followed by Projective height. The study revealed higher identification rates for males (77.1%) and females (73.7%) with a total accuracy rate of 75.4% (Table 5.0). These results justify that the above said parameters can produce reliable results in sex determination from OPG. According to our results there is a relationship between maximum ramus breadth, minimum ramus breadth, condylar height, projective height, coronoid height. From all the parameters condylar height was found to be more reliable to determine sex.

## INTRODUCTION

Sex determination is a main part of the forensic odontology and its essential when the evidences are not sufficient enough to identify the dead body. Sex determination becomes the main part in the procedure of identification of a person by forensic investigator in a case of mishaps, chemical and nuclear bomb explosions, natural disasters, crime investigations and ethical studies (Ayesha *et al*., 2015).

Identification of the skeletal remains is a very important step in medico-legal investigations. Most of the time parts of the pelvis and skull are used for the sex determination. Presence of a dense layer of compact bones makes it durable and well preserved than many other bones (David *et al*., 2012). In human remains, next to pelvis, mandible is used as the best key for the sex determination (Jambunath *et al*., 2016).

Skeleton has always aided in genetics, anthropological, odontological and forensic investigation of living and non-living individuals (John *et al*., 1998). So far in sex determination pelvis region and the skull bones have been played a major role.

When the entire adult skeleton is available for analysis, sex can be determined up to 98% accuracy (Krogman *et al*., 1986), but in a vast disaster or fatal incident where the loss of the pelvic region, the skull is playing a vital role in sex determination. Skull is the most dimorphic and easily sexed portion of skeleton after pelvis providing accuracy up to 92%. But in cases where intact skull is not found mandible may play a vital role in sex determination as it is the most dimorphic, largest and strongest bone of the skull (David *et al*., 2012).

Mandible is a bone which forms an articulation with the cranium. It is the one and only bone in the entire skull which is not fused with its adjacent cranium bones via sutures. It also articulates with the neurocranium via the temporal bone, forming the temporomandibular joint (TMJ). Mandible is a single bone and it is symmetrical on both sides and aid in movements of the mouth and chewing process of the foods. The lower set of teeth in the mouth is rooted in to this bone and muscles are attached to it to facilitate the movements of the bone. Some of the muscles that mandibular ramus is surrounded are the masseter, the temporalis, the medial pterygoid, and the lateral pterygoid (Healthline.com, 2015).

There are several types of dental X-rays. Mainly it divides in two categories as extra oral and intra oral. Bitewing radiography, Periapical radiography and occlusal radiography are known as the intra oral radiography. OPG, lateral oblique projection and cephalograms comes under the extra oral radiography.

Orthopantamography (OPG) is a technique which is used to image upper and lower jaws of the human body. It's also known as rotational panoramic radiography, dental panoramic tomography and panoral. Panoramic equipment is based upon a simultaneous rotational movement of the tube head and the film cassette in equal but opposite directions around the patient's head, which remains stationery. OPG images are taken for orthodontic assessment of the absence and presence of the teeth, to detect fractures of the mandible, to assess large pathological lesions such as tumor and cysts and to assess third molar before surgery.

The panoramic radiograph is one of the complementary exams most required by dentists for diagnostic purposes. Among all the periapical images, OPG has been playing an important role in dental radiography. OPG is popular due to the wide visualization of dental arches, mandibular and maxillary bones. Most of the extra oral radiographic equipment does not provide exposure settings compatible with unique situation.

This can be easily overcome by using digital OPG machine as well as OPG manipulate the image for quality enhancement (Beaini *et al*., 2016).

Primarily, the present study was planned to determine the sex using mandibular ramus with the help of maximum ramus breadth, minimum ramus breadth, condylar height, projective height and coronoid height measured on OPG image. Specifically, to assess the usefulness of mandibular ramus in sex determination and to evaluated the most significant mandibular ramus parameter to determine sex in Sri Lankan population.

## MATERIALS AND METHODOLOGY

The study was conducted in Army hospital, Narahenpita, Sri Lanka from 1st of July to 30th of November 2017. The study sample includes 175 OPG images of male patients and 175 OPG images of female patients among the age group of 20–60 years. VERA VIEW POCS X-550 OPG machine was used to take the OPG images.

Images of female and male patient between the age group of 20-60 ages were only taken for the study. Blurred images, images which were taken from the patients who had not a natural permanent dentition and OPG images of patients with any syndromes like: cleft lip, palate or other craniofacial pathology were rejected.

Technically erroneous OPG images according to the standard imaging criteria were also excluded. All OPG images have been taken by a one qualified radiographer.

This cross-sectional study mainly focused on the determination of the sex by the measurements of mandibular ramus. Each measurement was rechecked by all the researchers. "APL software V8.1" software was used to measure the parameters which were saved in the database.

As illustrated in Figure 1, maximum ramus breadth, minimum ramus breadth, condylar height, projective height and coronoid height were measured on the OPG image. 137.9% magnified image will be used to measure the parameters. The most significant parameter for the determination of the sex has been assessed statistically. SPSS software (version 23) was used for the statistical analyzing purposes.

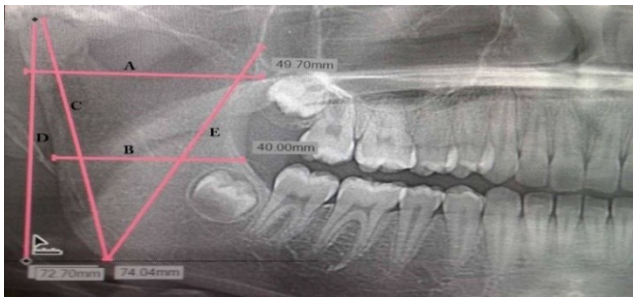


*Figure 1: Measurements of the Mandible*

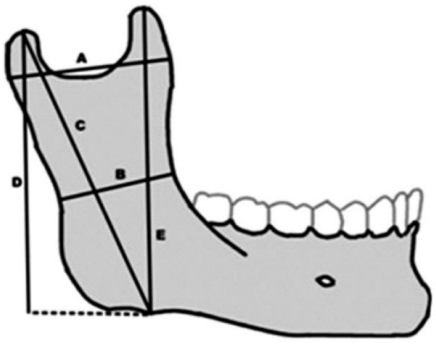


*Figure 2: Lateral view of the Mandible*

A — Maximum ramus breadth: Distance between most anterior and line connecting most posterior part of condyle and angle of jaw.
B — Minimum ramus breadth: Distance between smallest anterior to posterior of ramus.
C — Condylar height: Height of ramus from most superior part on condyle to the tubercle or most protruding portion of the inferior border of the ramus.
D — Projective height: Distance between highest part of condyle and lower margin of mandible.
E — Coronoid height: Projective distance between coronion to lower margin of mandible.

## RESULTS

**Table 1: Age descriptive statistics**

| | Range | | Mean | | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Statistics | Std.error | | |
| **Age** | 20 | 58 | 30.01 | 0.446 | 1.180 | 1.004 |

With regards to age groups, highest number of male patients (112/350, 32%) were aged between 20-30 years and highest number of female patients (109/350, 31.14%) were aged between 20-30 years while the minimum number of male patients (3/350, 0.86%) were aged between 51-60 and minimum number of female patient were aged between 51-60 (Fig. 2).

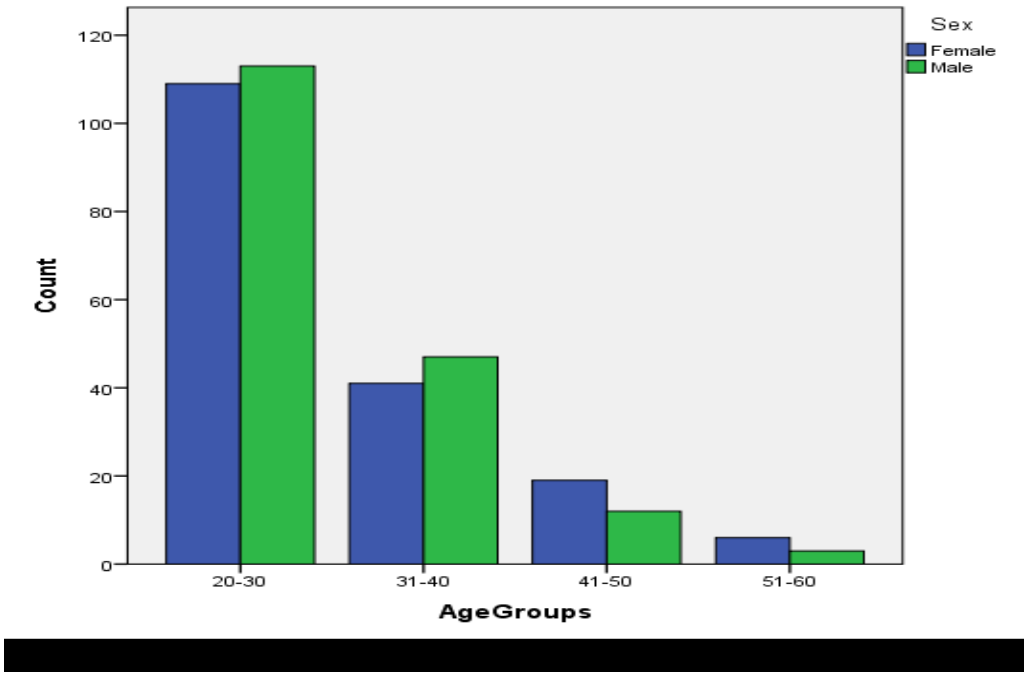


*Figure 3: Age distribution with number of patients*

Distribution of the age range were tested by normality test and the data were not normally distributed ($p$<0.05) as shown in Table 2.

**Table 2: Tests of normality for age**

| Tests of Normality | | | | | | |
|---|---|---|---|---|---|---|
| | Kolmogorov-Smirnov | | | Shapiro-Wilk | | |
| | Statistic | Df | Sig. | Statistic | Df | Sig. |
| Age | .154 | 350 | .000 | .893 | 350 | .000 |

Measurements of maximum ramus breadth, minimum ramus breadth, condylar height, projective height and coronoid height were taken for every patient from the hospital data base. Distributions of these measurements were tested by normality test and determined that data were normally distributed. ($p$> 0.05).

**Table 3: Tests of normality for mandibular ramus measurements**

| | Sex | *p*-value |
|---|---|---|
| Maximum ramus breath (mm) | Female | 0.100 |
| | Male | 0.213 |
| Minimum ramus breath (mm) | Female | 0.195 |
| | Male | 0.053 |
| Condylar height (mm) | Female | 0.006 |
| | Male | 0.619 |
| Projective height (mm) | Female | 0.720 |
| | Male | 0.637 |
| Coronoid height | Female | 0.765 |
| | Male | 0.414 |

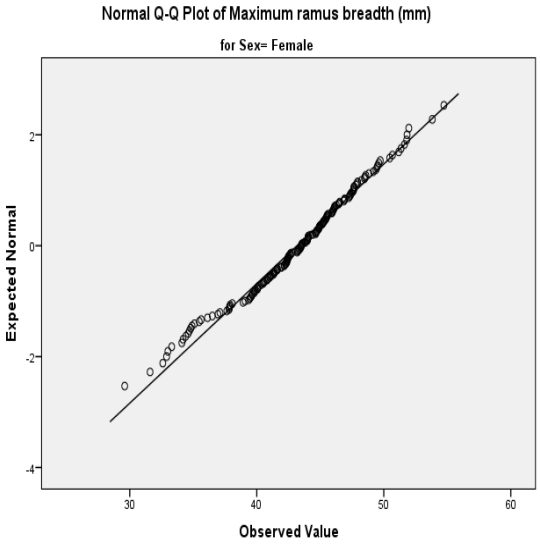


*Figure 3: Normal Q-Q plot of Maximum ramus breadth (mm) for female*

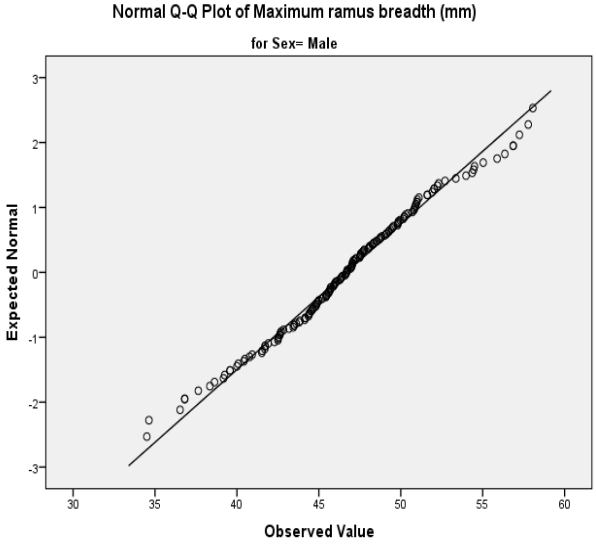


*Figure 4: Normal Q-Q plot of Maximum ramus breadth (mm) for male*

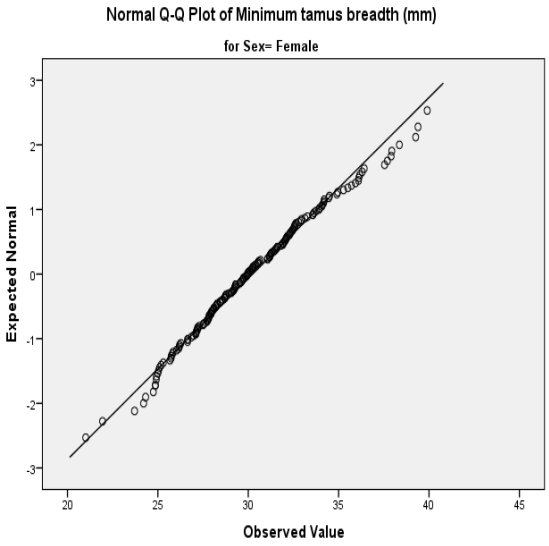


*Figure 5: Normal Q-Q plot of Minimum ramus breadth (mm) for female*

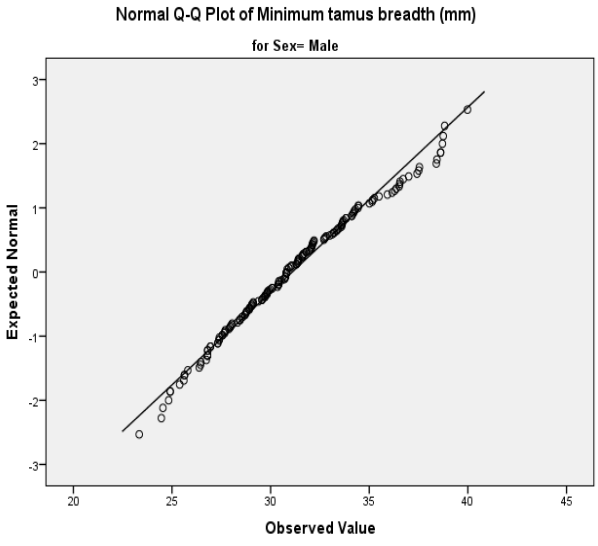


*Figure 6: Normal Q-Q plot of Minimum ramus breadth (mm) for male*

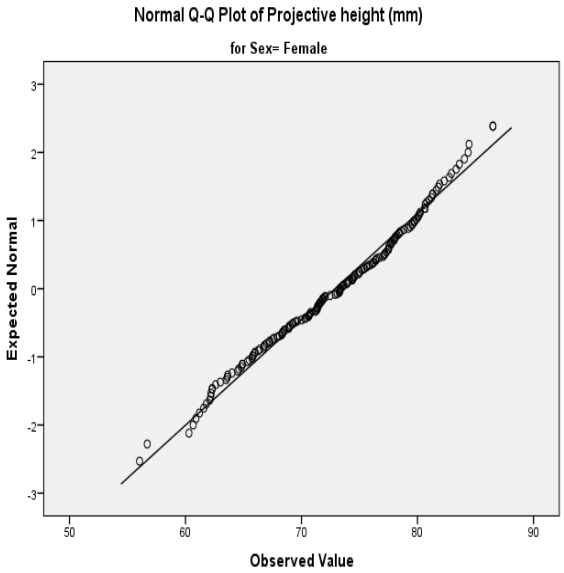


*Figure 7: Normal Q-Q plot of Projective height (mm) for female*

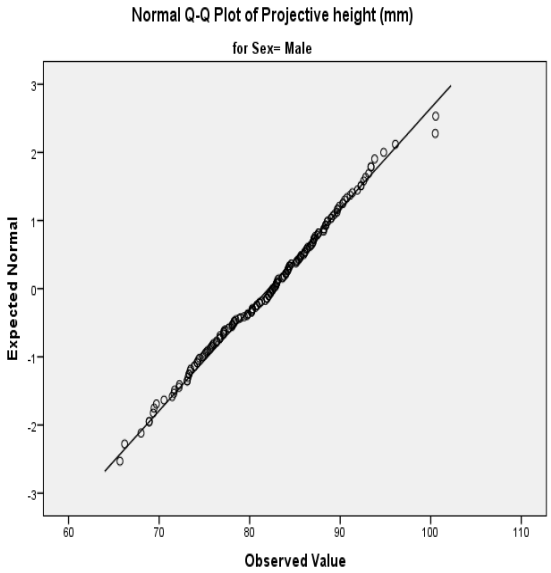


*Figure 8: Normal Q-Q plot of Projective height (mm) for male*

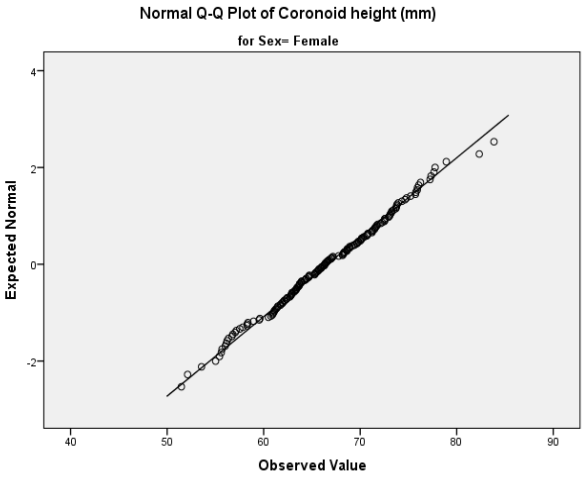


*Figure 9: Normal Q-Q plot of Coronoid height (mm) for female*

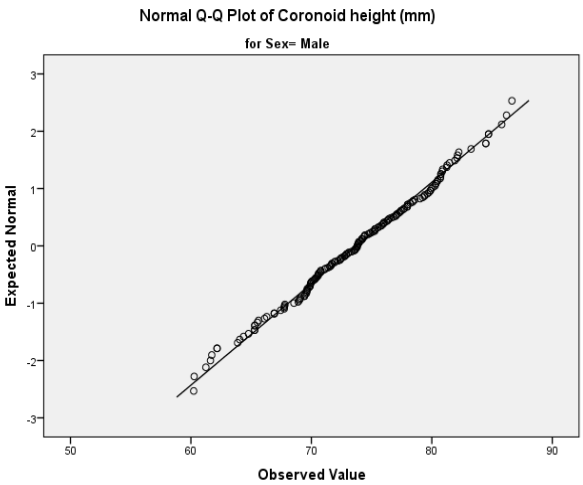


*Figure 10: Normal Q-Q plot of Coronoid height (mm) for male*

All the five measurements were subjected to statistical analysis. There is a specific difference between all five mandibular ramus measurements at 5% level of significance. (Maximum ramus breadth p=0.000), (minimum ramus breadth p=0.024), (condylar height p=0.000), (projective height p= 0.000), (coronoid height p=0.000).

**Table 4: For mean and std deviation of coefficient in original sample**

| | Sex | N | Mean | SD | Wilks` Lambda | p- value |
|---|---|---|---|---|---|---|
| Maximum ramus breadth (mm) | Female | 350 | 43.17 | 4.637 | 0.870 | 0.000 |
| | Male | 350 | 46.68 | 4.461 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Minimum ramus breadth (mm) | Female | 350 | 30.24 | 3.570 | 0.985 | 0.024 |
| | Male | 350 | 31.09 | 3.465 | | |
| Condylar height (mm) | Female | 350 | 75.59 | 6.404 | 0.659 | 0.000 |
| | Male | 350 | 85.21 | 6.989 | | |
| Projective height (mm) | Female | 350 | 72.89 | 6.404 | 0.671 | 0.000 |
| | Male | 350 | 82.10 | 6.759 | | |
| Coronoid height (mm) | Female | 350 | 66.60 | 6.092 | 0.730 | 0.000 |
| | Male | 350 | 73.73 | 5.649 | | |

A statistically significant difference was observed in the mean values of maximum ramus breadth, minimum ramus breadth, condylar height, projective height, coronoid height. The results show a definite dimorphic feature in these measurements, which help in sex differentiation using these parameters. Of all the parameters the condylar height showed highest sex differentiation in its measurements (Wilks' lambda = 0.659), followed by projective height (Table 4).

**Table 5: Test of Equality of group means**

| | **Maximum ramus breadth (mm)** | **Minimum ramus breadth (mm)** | **Condylar height (mm)** | **Projective height (mm)** | **Coronoid height (mm)** |
|---|---|---|---|---|---|
| **Wilks` Lambda** | 0.870 | 0.985 | 0.659 | 0.671 | 0.730 |

Discriminant analysis was done using sex as a grouping variable and maximum ramus breadth, minimum ramus breadth, condylar height, projective height, coronoid height as independent variables and the discriminant equation was obtained for sex determination.

$D_{female}$= 0.947 Maximum ramus breadth + 1.197 Minimum ramus breadth + 0.253 Condylar height +0.584 Projective height + 0.976 Coronoid height – 102.586

$D_{male}$ = 1.030 Maximum ramus breadth +1.126 Minimum ramus breadth +0.325 Condylar height + 0.665 Projective height + 1.071 Coronoid height – 122.882**.** "D" is the discriminant score.

The study revealed higher identification rates for males (77.1%) and females (73.7%) with a total accuracy rate of 75.4% (Table 5). These results justify that the above said parameters can produce reliable results in sex determination from OPG.

In this study the sectioning point was found to be 0 (zero). Values greater than this sectioning point indicate male and the values lesser than sectioning point indicate female.

**Table 6: Prediction Accuracy**

| | Predicted male | Predicted female | Total |
|---|---|---|---|
| **Male** | 135 | 40 | 175 |
| | 77.1% | 22.9% | |
| **Female** | 46 | 129 | 175 |
| | 26.3% | 73.7% | |

## DISCUSSION

Sex determination is playing an extremely important role in identification of an individual. This study was aimed to determine the sex by mandibular ramus. 175 OPG images of males and 175 OPG images of females were selected for the study from the data base of the Army Hospital, Narahenpita, Sri Lanka. The sample was consisted of total number of 350 images of patients among 20-60 years of age.

Mandible rami can be used for sexual dimorphism as it is a reliable tool for gender prediction.

All the mandibular ramus measurements (maximum ramus breadth, minimum ramus breadth, condylar height, projective height and coronoid height) were subjected to the discriminant analysis.

According to the study, the measurements (maximum ramus breadth, minimum ramus breadth, condylar height, projective height and coronoid height) were shown a significant sex difference between both genders. Condylar height was showed as the most significant variable for the Sri Lankan population (Table 5).

A study conducted by Saini et al., 2009 showed that coronoid height possessed the best potential for sex determination of Indian people, but according to the current study best potential sex predicting parameter for the Sri Lankan population is condylar height (Table 5).

According to a research conducted in India (More et al., 2017) has shown that each of the five variables measured on mandibular ramus were statistically significant ($p<0.05$). The current study also showed that there is a significant relationship between sex and the mandibular ramus measurements (maximum ramus breadth, minimum ramus breadth, condylar height, projective height and coronoid height).

Furthermore, it has shown that maximum ramus breadth and the projective ramus height has the highest sexual dimorphism, which did not stimulate with the results of the current study. The condylar height has the highest sexual dimorphism according to the current study. The study has got 68% of accuracy rate for males, 70% accuracy rate for females and total accuracy rate of 69% and also another study conducted by Jambunath et al. has shown that the sexual dimorphism can be found from the mandibular ramus up to an accuracy level of 72%. According to the current study there was a 77.1% of accuracy level for males, 73.7% accuracy level for females with a total accuracy rate of 75.4% (Table 6).

## CONCLUSION AND RECOMMENDATIONS

OPG has been proven to be a valuable tool for the determination of morphological dimensions of the mandible ramus. Through the use of mandibular ramus parameters such as maximum ramus breadth, minimum ramus breadth, condylar height, projective height and coronoid height, sex can be determined. The implications of such correlations have numerous applications in

the fields of forensic identification and orthodontic analysis.

According to our overall findings, significant relationship between sex and mandibular ramus measurements were found. ($p< 0.05$). Similarly, condylar height showed a marked significant difference (Wilks' lambda = 0.659) than maximum ramus breadth, minimum ramus breadth, projective height, coronoid height. From the results obtained within the Army hospital population; Males had a larger condylar height than females.

The results of this study will be helpful for medico-legal practices in Sri Lanka since this is the first research study done on sex determination using mandibular ramus for a Sri Lankan population.

Finally, further studies are encouraged to conduct on a large scale in various population groups to estimate the significance of mandibular ramus measurements in sex determination.

## ACKNOWLEDGEMET

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# REVISING CURRICULAR ON MEDICAL ETHICS: A WAY FORWARD

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## ABSTRACT

In this modern era practicing medical ethics has become more demanding. The advancement of science with new technologies, new therapies and complex clinical trials has resulted in a situation where the current principles and concepts of medical ethics alone are not adequate in situations. Therefore, teaching ethics to medical students in a broader way as medical bioethics would cover the implications that result following treatment or research and is more beneficial for patients or participants. This paper illustrates the need of transforming the teaching of medical ethics to medical bio ethics as a way forward.

***Keywords:*** *Medical ethics, Medical bio ethics, practice, transformation*

## INTRODUCTION

Medical ethics is a collection of moral principles that applies values and better judgment to the actions taken in the practice of medicine[1]. Medical ethics in the Hippocratic era had recognized values such as confidentiality, impartiality and do no harm which are still valid in present context[2]. After world war two there was rapid advance in medical research, new approaches in treatment and introduction of new medical devices[3]. In such situations the Nuremburg code, Belmont principles and Declaration of Helsinki etc. have provided useful guidelines to safe guard patients' rights and doctors' values. However, in some critical situations where decision making is vital these principles conflict with each other[4]. On the other hand, those principles provide indirect immunity to the treating doctor from allegations of medical negligence[5] and preserves the rights of patients[6].

During the last few decades medical and biotechnological fields have expanded extensively. Traditional moral values of the physicians are challenged in various situations of decision making and patient management[7]. With the health care inequalities specially in limited resource settings and emergence of new methodologies such as high-risk therapeutic measures, in-vitro fertilization, complex medical devices and genetic and embryonic research, traditional medical ethics have become inadequate and cannot totally be relied upon to assist physicians[8].

Further these situations may warrant immediate action with inadequate time for ethical evaluation. In such instances, especially the vulnerable populations are at risk. The twenty first century demands more advanced ethical norms to face new developments in science and technology. Therefore, understanding and application of bio ethics plays an important role in medicine.

The objective of this paper is to discuss the necessity of widening the scope of medical ethics into bio medical ethics in medical fields with the view of teaching it to the professionals and personnel who are involved in caring for patients.

## DISCUSSION

The main ethical principles described in Belmont principles are namely respect for persons, beneficence, and justice[9,10]. Even with its' limitations those principles helped the clinicians to take decisions in conflicts situations, research with human subjects accordingly and mostly limited to applied ethics. Within last few decades' complexity of ethical dilemmas faced by doctors in the ward has rapidly increased and became more complex due to advances in medicine[11]. The values of individuals including doctors are challenged frequently due to reasons, such as changes of social norms and values, prioritisation of materialistic aspects associated with technological and economic development, political influence and social media. Therefore, learning medical ethics not only assists doctors in managing ethical dilemmas but also helps in defining personal values.

Bio ethics does not have a single definition but encompasses a broader spectrum which is used to explain the application of moral principles to biomedical aspects considering humans nature[12]. The notion of bio ethics was first introduced by Potter in 1970 describing it as humanistic ethics resulting from biology and medicine[13]. Within months Helleger and Sargent Shriver independently stated that ethical scrutiny of precise problems raised by medicine and the biological sciences by professionals as bio ethics[14]. In 2010 Dawson represented it as "all ethical issues rising from the creation and maintenance of the health of living things"[15]. Brassington re-emphasizes the purpose of bioethics as being "to produce action-guiding advice to given concerns for

morality"[16]. In these explanations scope of bio ethics is much broader than the medical ethics.

Medical ethics has been expanded in universal declaration on bioethics and human rights in 2005 [17,18] generating new bio ethical principles recognized by UNESCO and incorporating rights of the human and animal, environment, life sciences and progress in technology. It recognizes elements which were not directly spelled out in Belmont principles. Attributes such as human dignity and freedom over the science, non-discrimination and non-stigmatization, regards on cultural diversity and pluralism are among them. Further UNESCO recognizes solidarity among human and international cooperation, promotion of health and social development as a responsibility of all sectors and importance of sharing benefits of scientific research. It gives due repute on future generations and genetic constitution, protection of environment, biosphere and bio diversity. Compulsorily these aspects of bio ethics offer multi sectoral approach in development of health, taking responsibility, involvement and collaboration in resolving health related conflicts and better future out comes in providing health facilities while upholding ethical norms[19].

Recognition and application of these bio ethics principles is more relevant to us in the present-day, since Sri Lanka is part of bio bank research, genetic studies, drugs and vaccine multi-center clinical trials. Ethical aspects related to handling of biological samples, disposal of clinical waste and handling of human subjects in complex research trials are few examples where the application of bio-ethics would be needed. In addition, every day health care activities of medical personnel are challenged in diverse aspects while intertwined with media. As an answer to those challenges' bio ethics has allowed scrutiny of health-related activities by non-medical personnel such as lawyers, philosophers and lay people. Multi sectorial approaches strengthen accountability, transparency and feeling of professionals for legitimacy of their activities[20]. This aspect is practiced in recognized ethics review committees in Sri Lanka, which include members from multiple disciplines. Non-medical participants look into the matters from the lay persons angle and represents public interest in those committees.

Bio ethics is not merely a subject dealing with life sciences but also consider future outcomes of action in an ethical angle and move forward with other humanistic disciplines.[16] Contribution from many fields take the responsibility not only to resolve conflict situations but to strengthen the right outcome at the end[21,22]. Therefore other fields such as law, science and philosophy recast the medical ethics generating better solutions in the field[23]. It provides present and future frame work for physical as well as moral advances in medicine. It has connections with application ethics and philosophy in a cultural dimension[24]. Bio ethics demands not only ethical approach but also novel solutions to existing problems such as inadequacy of resources, ecological disasters, rights of under-privileged, political and economic disadvantages on health issues[25]. Therefore, medical ethics which are taught as an indispensable part of the medical curricula as a module or strand and its teaching methods such as lectures and tutorials which give basic knowledge on ethical principles and its application are not sufficient to cater to the needs of the day and future and need transformations[26].

Present day teaching of medical ethics should be emphasized and expanded into bio ethics, be included in different subjects from the beginning of medical education and should be reinforced with clinical exposure[17]. Then only the teaching process will help the learners to convert the assembled knowledge into practice[18].

### A. Present day situation of teaching medical ethics

A student who has had 13 years of school education in diverse social and cultural backgrounds needs to be transformed into a practitioner, scientist and to a professional after 5 years of medical education in Sri Lanka. To accomplish these out comes they should develop basic knowledge in medical science, clinical and patient management skills, communication skills, interpersonal skills, professional values and attitudes. Today medical ethics is taught in Sri Lankan medical schools with inclusion of topics such as basic ethical principles, consent, confidentiality, medical negligence, medical council and professional misconduct. Professionalism is discussed in some medical faculties. Most topics are delivered as lectures or tutorials while some faculties use case-based scenarios in small group discussions. With the clinical exposure students learn ethics from role models. However, it appears that the expected behavioural change following 'taught ethics' is not adequate at the time of starting their career as a doctor and thereafter[27]. There have been several reported instances where concerns were raised by the public and media in relation to the doctor- patient relationship, acts of medical negligence and violation of rights of patients. The present medical curricula can be transformed to incorporate a multi-disciplinary ethical approach to conflict resolution with problem solving and policy making in health, citing the new trends in bioethics.

### B. Integrating bio ethics into medical teaching

UNESCO bio ethics curriculum[28] can be used as a guide with adaptations to suite the socio- cultural dimensions of the country. Different facets of bio ethics can be brought to the notice of the pre-clinical students before clinical exposure specially using films and television series with ethical dilemmas building on their gut feeling and on moral values. Discussions can be initiated during preclinical teaching on their perceptions on ethical issues even without a theoretical background. It will help them to mould into a socially responsible, accountable person with humanistic values and empathy towards the patient even prior to clinical learning.

Traditional methods of teaching are not adequate in bio ethics[17]. During para clinical years' small group discussions on ethical issues, case-based seminars and dramas, reflective writing on ethical issues experienced during clinical attachments help students to identify, asses and arrive at a conclusion on how to act in case of an ethical dilemma[29]. Focused issues such as consent taking, confidentiality of information can be taught using audio and video clips and role plays. Culturally and socially appropriate concerns can be assimilated to the case discussions giving more relevance with panel discussions to clear doubts. There should be a common virtual platform where teachers can share the learning material with other university teachers and students across the country. It will provide a solution to the lack of socio-culturally relevant learning material on bio ethics. A more practical elective module can be offered for students who are interested in broadening their knowledge and application in bio ethics.

Further, gathered knowledge and skills of a medical student on ethics should be strengthened every day in the ward setting. Bed side teaching of bio ethics in each discipline gives holistic attitude to the problems where the learner can interact with the patient while learning emotional, social and cultural attributes of ethics[30]. Continuous professional development programmes for academics and clinicians have to be strengthened by providing training with the aim of integrating ethics teaching routinely at the bed side. This is essential because unlike in any other discipline role models and the hidden

curriculum plays an important part in learning ethics[31]. More advanced concepts can be discussed highlighting intrinsic ethical issues during post graduate training relevant to each field. Universities should be given the task of developing short modules on bioethics and making it a mandatory short appointment, will be the answer to build knowledge, attitudes and practices of future doctors. However, converting the knowledge into a practice in the real world is determined by several factors and more difficult to accomplish. Adequate and suitable continuous assessment of bio ethics is mandatory to achieve the objectives of learning. Using video and audio clips and simulated patients with communication stations increase the validity of practical assessment.

A strong bio ethics curriculum not only prepares a medical student and post graduate student for future practice as a professional but also teaches on how to reflect on their own views and potential biases in health management. Further it gives an opportunity to interact with other fields and recognizes the expectations of patients and public[27].

### B. Integration of bio ethics into other health related fields

Health care is team work and there are several other disciplines and personnel that closely work with physicians in patient management. Administrators who make public policies on health, paramedical personnel, therapists, nurses, social workers, scientists and hospital minor staff are involved in various situations of patient management and care. Bio ethics has its wider use in such situations addressing ethical aspects in many fields related to human rights, life sciences, environment and technology, making it more applicable to them. Therefore, the time is ripe to address the necessity of introducing concepts of bio ethics and relevant applications in learning curricula of fields allied to medicine and health.

## CONCLUSION

Medical ethics is based on moral values that helps in making judgments and decisions in the practice of Medicine. Whereas bioethics encompasses a broader spectrum which is used to explain the application of moral principles to biomedical aspects of humans and nature. Learning bio ethics in comparison to medical ethics helps medical personnel improve their professional ethics by developing critical thinking, allowing application in ethical dilemmas and guidance to consider implications of health polices to society and patients. In an era where public demand on executive bodies and administration, who implement health related decisions are increasing, bio ethics is more relevant than medical ethics. Therefore, introducing bio ethics into medical fields replacing applied medical ethics is a need of the day.

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# A SHORT REVIEW ON THE USE OF SHORT TANDEM REPEAT BASED DNA PROFILING IN SEXUAL ASSAULT

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## ABSTRACT

Forensic DNA evidence can convict perpetrators who would otherwise have escaped, hence the reason for its growth in case evidence over the years. Short Tandem Repeat (STR) profiling, continues to be the mainstay for forensic DNA testing due to its robustness and high power of discrimination. The 'core STRs' in forensics, are highly polymorphic, and unique to an individual, therefore proven as important investigative leads in cases of identification of perpetrators in sexual assault, thereby ensuring justice. The common STRs used to date are autosomal STRs, Y-STRs, mini STRs and recently, Deletion Insertion Polymorphism-STRs. This article reviews current literature and discusses the advantages and limitations of each STR marker and their targets in different challenging samples. It aims to provide intuition on minimising ambiguous profiles for case evidence in sexual assault and thereby, reduce the chances of wrongful conviction by DNA evidence.

***Keywords:*** *DIP-STR, mini STR, sexual assault, short tandem repeat, Y-STR*

## INTRODUCTION

The method of ''DNA fingerprinting'' discovered by Sir Alec Jeffreys in 1980s is used globally by forensic scientists, for exonerating innocent and convicting guilty individuals. DNA evidence for sexual assault has led to numerous successful convictions, but has also led to a few wrongful convictions[1,2].

During the first decade of DNA forensic testing, STR profiling was evolving fast due to the small amounts of DNA required for testing, its robustness and high discrimination power[3,4]. Thus in 2011, it was reported that 77% of sexual assault cases were resolved successfully by STR profiling[3].

STRs are made up of 2-7 base pair repeating units, found mostly in the non-coding region of DNA and spans extensively across the human genome. STR profiling in forensics involves isolation of DNA from biological samples collected, most commonly by either swabs off skin, body fluids or 'touch DNA' found at a crime scene. The STRs are then amplified by polymerase chain reaction (PCR) and analysed by polyacrylamide capillary or slab gel electrophoresis and the results are matched with the suspects samples, or from profiles gathered from a national DNA database[4,5].

Since autosomal STRs were the initial STR markers developed, they occupy the largest established national DNA databases to date, which far exceed Single Nucleotide Polymorphisms (SNP's) and any other STR marker[4,6]. Novel STR methods such as Y chromosome STR profiling, mini STR profiling and during the recent years, Deletion Insertion Polymorphism (DIP)-STRs analysis' have been implemented into case evidence. Each of these markers target different challenging samples, to generate profiles for case evidence in sexual assault, which will be discussed in this review[7,8].

### Analysis of the types of STR profiling used in case evidence in literature

#### *Autosomal Chromosome STR Profiling*

Autosomal STR typing was used in the 1990s, and in 2002, an interesting rape case used autosomal STR analysis to generate profiles without evidence samples from the crime scene itself. The case involved a rape of a girl who conceived after rape. The crime was investigated four months later, and sperm typing was unable to confirm the perpetrator. Therefore, DNA was extracted from blood of the victim, 4 suspects and skin tissue of the foetus. Analysis of 6 STR loci were done, and the allele types for one locus are shown here (Table 1) [9].

**Table 1: Results for one STR locus analysed on 4% polyacrylamide gel [9]**

| *Locus* | *Victim (mother)* | *Foetus* | *Suspect 1* | *Suspect 2* | *Suspect 3* | *Suspect 4* |
|---|---|---|---|---|---|---|
| **CSF1PO** | 10 | 10 (m) | 11 | 10 | 11 | 11 |
| | 10 | 11 (p) | 13 | 10 | 13 | 12 |

Taking the first locus (CSF1PO) as an example; the foetus has alleles 10 and 11, with 10 arising from the mother since she is homozygous for allele 10. The suspect 2 can be excluded since the individual is also homozygous for allele 10 and cannot be the donor of allele 11 of the foetus. Different genotype at one locus at least, is the rule for exclusion in any STR profiling work as highlighted in this particular case. The individual specific nature of STRs prove to give this technique high discriminatory power over other techniques[6].

In contrast to only making exclusions, inclusions of suspects in a criminal case involve autosomal STR profiling at multiple loci, regardless of the number of suspects. Blood samples from a suspect were obtained, along with the semen stain recovered from the victim's dress. The use of 9 autosomal STR loci confirmed the perpetrator was the suspect[4].

### *Y Chromosome STR Profiling*

Y-STR profiling specifically resolves male components in a mixture to generate a DNA profile allowing a match or exclusion of an individual in a crime investigation[6,10]. When evidence contains both male and female DNA, autosomal STR typing has male DNA detection sensitivity at a male to female ratio of 1:50, whereas Y-STR typing can detect male DNA at a ratio of 1:2000[6].

However, a rare case of wrongful conviction by Y-STR profiling took place after an innocent individual was convicted for 2 years due to a coincidental match of a 17-loci Y-STR profile in an alleged case of sexual assault. Re-evaluation was carried out after the conviction, using 23 loci, where 2 loci did not match the suspect, and the guilty verdict for the alleged suspect was reversed[11].

This shows that a match profile alone, cannot determine guilt or innocence. Since Y-STR is not sufficiently discriminatory, it is best advised to perform both autosomal and Y-STR profiling and increase the number of loci to increase the validity of the test[12,13]. Use of combination of the two, provided highly informative profiles for 21% of the cases[14].

Another major drawback of routine Y-STR profiling kits, is the inability to differentiate paternally related males[15]. To overcome this, Ballantyne and colleagues proposed the use of 13 Rapidly Mutating (RM) Y-STRs where the mutation rate is $1x10^{-2}$ and in comparison to Y-STR mutation rate $1x10^{-3}$. [16] Studies into RM Y-STRs in 2012, by Ballantyne and colleagues confirmed a 4.4-fold increase of average male differentiation in comparison to Y-STRs[16]. This notion was further supported by Adnan and colleagues in 2016, when a 7-fold increase of differentiation of paternal relatives in comparison to Y-STRs, highlighting the importance of their use[17].

Other successful Y-STR profiling studies and the age of evidence samples used are given in (Fig. 1) [6,10,13,18,19,20]. Typically, most cases fall between 3-9 days out of the time frame of one year. But samples that exceed 3-9 days, are less procured by Y-STR profiling. Hence the need for mini STR profiling arises.

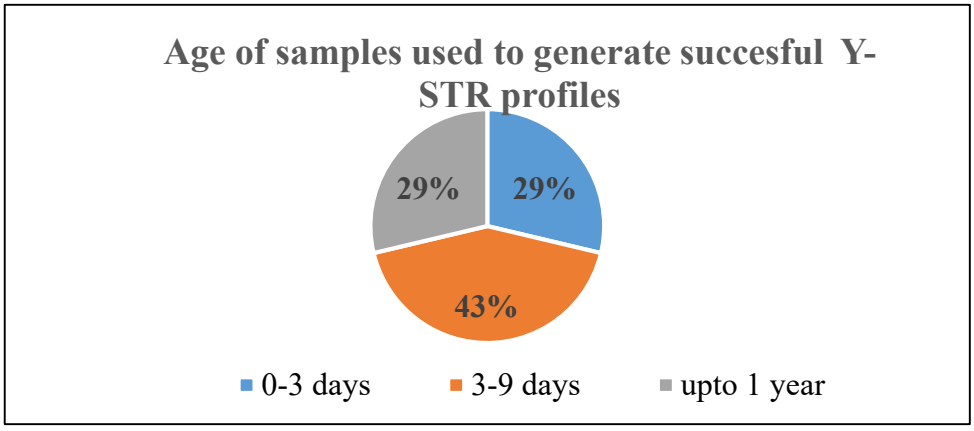


***Figure 1: The age of the sample used, and the respective number of cases for each age category***

### *Mini STR profiling*

Mini STR profiling involves primers which target the DNA sequence closer to the repeat region unlike conventional STR primers; thus, generating shorter amplicons[7,21]. Since only about 31% of the sexual assault offenses are reported at the time of the incident, mini STRs' as shown in (Fig. 2), are known to be effective in processing aged samples with low template/degraded DNA[22,23].

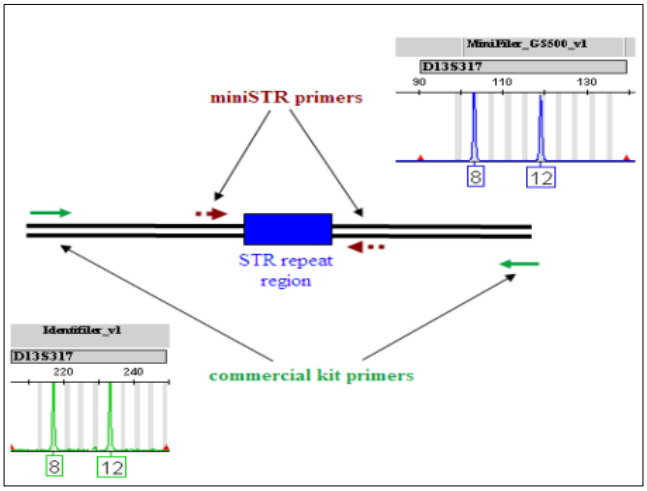


***Figure 2: D13S317 Locus: Conventional STR primer (green) generate amplicons of 200-250bp, Mini STR primer (blue) generate amplicons of 100-150bp, closer to the repeat region.[24]***

DNA evidence in court has been doubtful since it depends on the age and volume of sample to generate successful profiles, and it is understood that vaginal pool evidence reduces after one day[22,23]. Avoiding the DNA extraction steps and increasing PCR cycles is essential when DNA is degraded/ present in trace amounts[25,26]. However, direct STR profiling or increasing the number of PCR cycles would generate more PCR non-specific amplifications, since other cell contaminants are also amplified. Moreover, using mitochondrial DNA profiling is not time and cost effective, thus the growth of mini STR profiling in case evidence[21].

A case of sexual assault was re-analysed twelve years after the incident occurred, and a sample of 2ng/µl was collected from a stained slide. Analysis by conventional autosomal STR profiling revealed only the victim's profile. But, when mini STR profiling was proceeded, two profiles were generated, one from the victim and the other from the prime suspect in the case, highlighting the mini STRs' higher efficacy in generating profiles for all the contributors[24].

In addition to the type of sample used, the age of the samples and their degradation index ratios (DI) are also a key determinant of generating successful profiles. Seminal stains from the study by Bini and colleagues in 2015, were samples three decades after the crime, with different degradation ratios. Mini STR profiling yielded full profiles for most of the samples, in comparison to autosomal, Y-STR and RM Y-STR profiling[27].

A study by Hara and colleagues in 2015, used seminal stains of different ages (33,50 and 60 years) and different degradation ratios. For the DI ratio of 0.0044, autosomal and Y-STR profiling had extremely low

success rates in comparison to the impeccable sensitivity of mini STR's which gave a minor decrease (8/9) in successful profiles, which outlines that the age of the sample alone, doesn't govern the successful profiles generated, rather, the DI ratio does and the volume of the sample available also contribute. Thus, in low DI ratios, mini STR proves advantageous over autosomal and Y-STR profiling[28].

***Deletion Insertion Polymorphism STR Profiling***

Genetic identification of DNA using autosomal or Y-STR profiling is a major problem when the DNA of interest is a minor component in the mixture. (Table 2) [6,7,29,30]. Hence, the reason for the implementation of DIP-STRs into casework recently. They are deletion/ insertion polymorphisms linked to a microsatellite to selectively identify minor DNA fraction even at a very low minor DNA to major DNA ratio[29,31,32].

**Table 2: The ability of STR profiling techniques identify minor DNA in mixtures. [6,7,29,30]**

| STR profiling technique | Minor DNA: Major DNA ratio |
|---|---|
| **Mini STR** | 1:10 |
| **Autosomal STR** | 1:20 |
| **Autosomal STR with fluorescent** | 1:50 |
| **cell sorting** | |
| **Y-STR** | 1:2000 |
| **DIP-STR** | 1:16000 |

In 2017, Oldoni, Castella and Hall demonstrated the first use of DIP-STRs in sexual assault evidence, when both, Y-STR and autosomal STR couldn't identify minor DNA in mixtures. In one of their cases described, the sample was taken from the defendant's tracksuit crotch area, to test if the complainant's DNA was present. Y-STR profiling would not have been able to distinguish female DNA, and autosomal STR profiling only gave a profile for the male. Hence three DIP-STRs were used and identified the female DNA which was the minor DNA in the mixture, illustrating that DIP-STRs can be used in challenging sample mixtures to analyse minor DNA components[29]. In another case described by the same authors, a vaginal swab was collected three days after the assault and analysed with ten DIP-STRs, where the major DNA component was in 16,000-fold excess. The full Y-STR profile was generated for the defendant, and seven DIP-STRs provided informative leads and

correlated with the Y-STR profile. However, the three other DIP-STRs generated non-specific PCR amplifications, leaving its sensitivity comparable to Y-STR profiling. Suggestive that, further validation is desired for DIP-STR profiling for extremely low DNA components in mixtures[29].

## CONCLUSION

In consideration with the cases discussed, the analysis of a higher number of Y-STR loci should be implemented, since this will yield additional discriminatory power and statistical grounding to confirm if it is a coincidental mismatch or not. Since Y-STR profiling is not individual specific, autosomal or DIP-STRs should be used in parallel, if one method fails.

Retrieval of samples shortly after the crime, cannot always be expected. Therefore, the development of a 'mini RM Y-STR' marker can be suggested to be used in combination with autosomal STRs or DIP-STRs to target degraded DNA and specifically resolve male components in mixtures. This would help counteract the disadvantages of each STR marker, and have great promise in minimising the chances of wrongful conviction in the future.

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# THE PATTERN OF MEDIAL CLAVICULAR EPIPHYSEAL OSSIFICATION : PRELIMINARY STUDY OF A SRI LANKAN POPULATION

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## ABSTRACT

Forensic Age Estimation (FAE) in living is required in many civil and criminal circumstances where documentary proof of age is unavailable. In Sri Lanka, 16-21 age range has many statutory age limits. Though international guidelines recommend CT scanning of medial clavicular epiphyses for forensic age estimations within this age range, Sri Lanka does not have any population-specific reference standards for this modality.

The objective of this study was to describe the pattern of medial clavicular epiphyseal fusion among Sri Lankans aged 15-30 years.

Chest, neck and pulmonary angiography CT scans of patients between 15-30 years performed in two tertiary hospitals were reported independently by two radiologists using the five-stage classification for medial clavicular ossification by Schmeling et al. (2004). Interobserver reliability was assessed using Cohen's Kappa coefficient. A preliminary descriptive analysis of the first 46 cases was done using SPSS.

There were 25 males and 21 females. Majority (80%) were 18 years and above. The oldest with stage 1 was 16 years. The youngest for stages 2 and 3 were both 17 years. Stages 4 and 5 were seen in 67% of cases and none were below 20 years. This trend was similar to previously published studies.

From the preliminary results, it appears that only stages 4 and 5 can be used reliably to determine if a person is >18 years. Stages 2 and 3 are likely to indicate that the person is >16 years. Clavicular epiphyseal fusion shows good potential to be a reliable FAE method in Sri Lanka.

***Key words:*** *Forensic age estimation; population-specific reference databases; skeletal maturation; legal age limits*

## INTRODUCTION

Estimation of the age in living adolescents and young adults has significant importance both in civil and criminal legal matters. In many western countries, the emphasis on Forensic Age Estimation has mainly been on illegal immigrants seeking refugee status without proper birth records[1,2]. In a variety of criminal and civil proceedings, different age limits have forensic importance. In Sri Lanka, the age range 16 to 21 years include many statutory age limitations such as the age of consent for sexual intercourse (16 years), age of marriage (18 years), fitness for driving (18 years) and the sale of intoxicants (21 years)[3]. Often it is to determine whether an individual is an adult or a minor and the commonly used age limit for adulthood in most jurisdictions is 18 years.

The medical assessment of a person's age is based primarily on determining the maturity of the dentition and skeletal system[4]. A person's growth and development, cognitive and intellectual maturity as well as development of secondary sexual characteristics can also be used but have a lesser reliability on their own. The updated recommendations of Study Group on Forensic Age Diagnostics for age estimations in living individuals in criminal proceedings by the German Group for Forensic Age Diagnostics published on 2008[5], recommends that a physical examination, x-ray examination of the left hand, dental status and x-ray of dentition be performed in each case. It further recommends a radiological evaluation of clavicle, if the skeletal maturation of hand is completed[5].

The lack of population specific reference standards on skeletal maturation has been a controversial issue in forensic age estimations. Available studies on major populations have shown that skeletal maturation takes place in identical, defined stages. However, the rate of ossification could be affected by numerous factors including socioeconomic status, environment, and ethnicity[6,7]. Though ethnicity was mentions as one of the factors, the studies mainly concentrated on the populations of different regions. Therefore, application of European reference standards on an individual from a lower socio-economic background would lead to underestimation of that person's age[8]. Therefore, it is recommended that repositories of population-specific databases from lower socio-economic countries are established and used as reference material for forensic age estimation when individuals from that ethnicity or region are being investigated[9].

The imaging methods used to assess the maturity of hand and wrist found to be one of the reliable methods for age estimation in children up to 14 to 15 years[10]. The Study Group on Forensic Age Diagnostics recommends evaluation of medial epiphyses of the clavicles by thin-section computed tomography (CT) in adolescents and young adults because sexual maturation, hand bone ossification, and third molar tooth growth has already been completed during the adolescent period.[11] Recent studies have shown that this method has a higher level of reliability in forensic age estimations in adolescents and young adults within the age ranges of 16-21 years[12-14].

However, the fusion pattern of medial clavicular epiphysis has not been explored previously in a Sri Lankan population. Therefore, this study is aimed to develop population-specific reference standards for 15 to 30-year-old Sri Lankans. This paper presents a preliminary analysis of the data obtained during the first year of the study to

evaluate the feasibility of expanding into a larger nationwide reference database.

## MATERIALS AND METHODS

A retrospective analysis was done of all retrievable CT scans of patients between 15 to 30 years who have undergone chest CT, CT pulmonary angiography and CT neck performed at the Department of Radiology at National Hospital Sri Lanka (NHSL), and Colombo South Teaching Hospital (CSTH) over a one-year period commencing from August 2018. The chronological age was confirmed by hospital records. Exclusion criteria included scans with improper chronological age records, diagnosis of any significant bone disease such as osteogenesis imperfecta, endocrinological disorders, chronic illness or long-term medications that may affect the bone development, presence of artefacts or significant anatomic variations, fractures of the clavicle or sternum and CT evidence of bone dysplasia.

High-resolution thin-slice CT images were used for analysis. The stages of clavicular maturation were reported by two radiologists experienced in age estimation, blinded to the chronological age and to each other. Images were reported on Vitrea 2 work advanced visualization workstation.

The five-stage classification system by Schmeling et al. 2004 was used in the current study to evaluate the clavicular ossification[12].

- Stage 1: non-ossified epiphysis
- Stage 2: isolated ossified epiphysis
- Stage 3: partial bony fusion between epiphysis and metaphysis
- Stage 4: complete bony fusion between epiphysis and metaphysis with definable epiphyseal scar
- Stage 5: complete bony fusion between epiphysis and metaphysis without visible epiphyseal scar

Data analysis were carried out using Statistical Package for the Social Sciences (SPSS) version 23. The age distribution and inter-observer agreement on the ossification grade were assessed. The ossification grade at each age was expressed as a minimum, maximum mean and median range. The age-ossification relationship was visually evaluated using a box-whisker plot analysis.

The Inter-observer agreement between the radiologists with regard to the ossification grade of medial clavicular epiphysis was calculated using kappa statistics in 31 cases. The following criteria were used to interpret the agreement: kappa value of less than 0.20 indicated poor agreement; a kappa value of 0.21–0.40, fair agreement; a kappa value of 0.41–0.60, moderate agreement; a kappa value of 0.61–0.80, substantial agreement; and a kappa value of more than 0.81, excellent agreement[15].

The ethics clearance was obtained from the ethics committees of all selected hospitals.

## RESULTS

There were 46 patients included in the study.

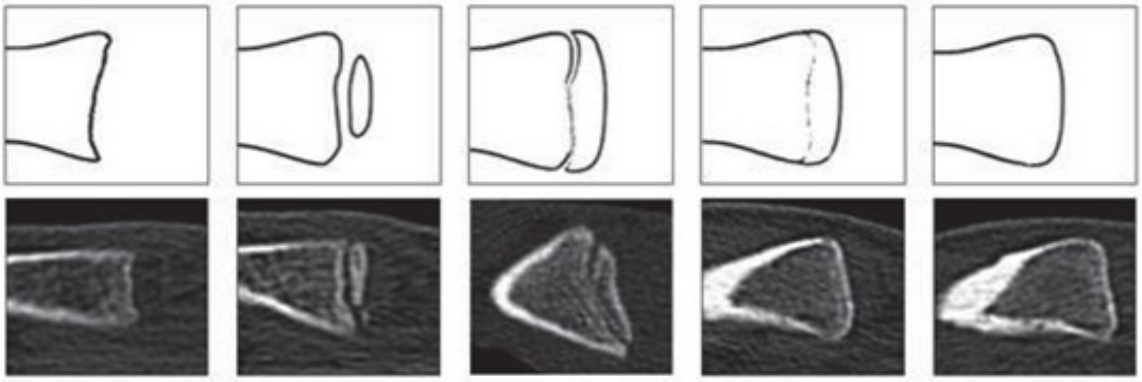

***Figure 1: The stages of maturity status of edial clavicular ossification*** [9]

❖ Figure 2 - Cases by age and sex.

| Male | | | | Female | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 5 | 5 | 1 | | | | | |
| | 7 | 7 | 6 | 1 | 6 | 7 | 7 | | |
| | 9 | 9 | 8 | 1 | 8 | | | | |
| | 1 | 1 | 0 | 2 | 0 | 1 | | | |
| | | | | | | | | | |
| | | 3 | 2 | 2 | 2 | 3 | | | |
| | | | | 2 | 4 | 4 | 5 | 5 | 5 |
| 7 | 6 | 6 | 6 | 2 | 7 | 7 | 7 | | |
| 9 | 9 | 8 | 8 | 2 | 8 | 9 | 9 | | |
| | 0 | 0 | 0 | 3 | 0 | 0 | | | |

Key: 6|2|7 means 26-year-old male 27-year-old female

***Figure 2: Stem-leaf plot of cases by age and gender (n=46)***

Twenty-five (54.3%) were female and 21 (45.7%) male. There were 9 patients below the age of 18 years.

❖ Figure 3 - Distribution of ages within each clavicular maturation stage.

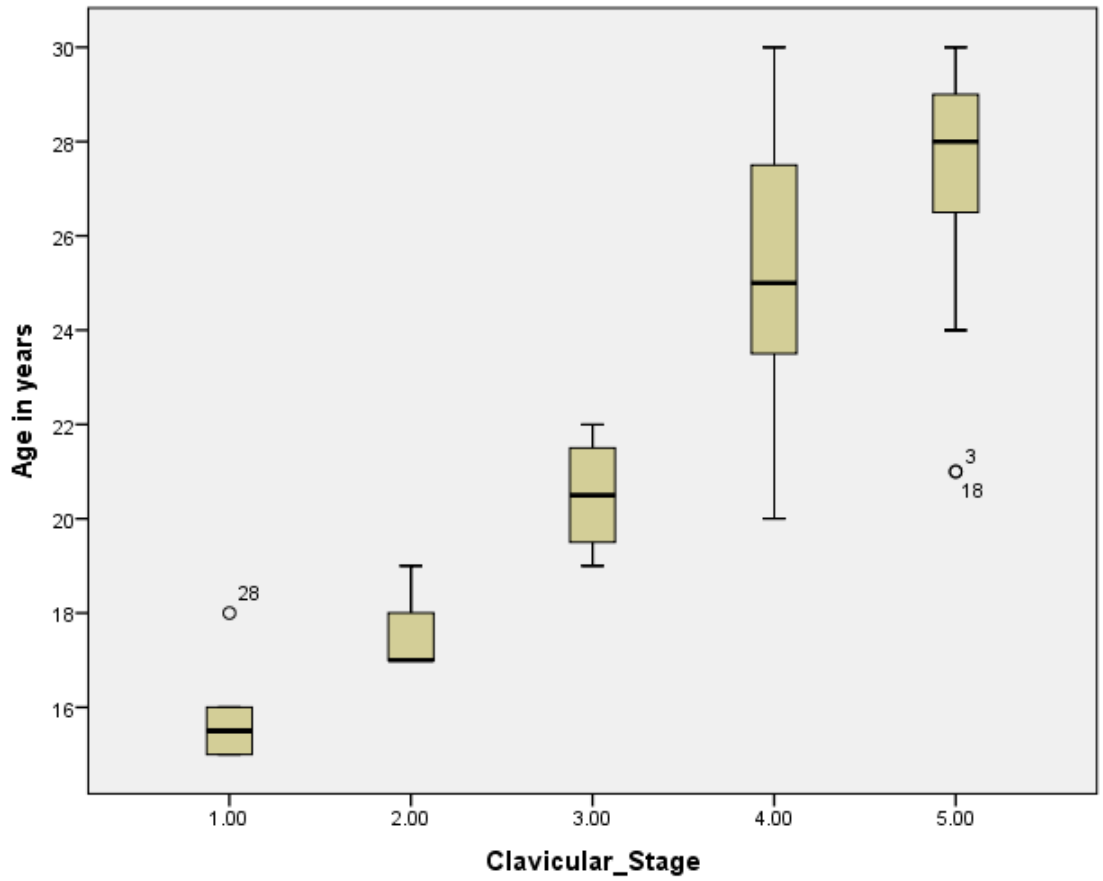


***Figure 3: Scatter plot graph showing the relationship between age and averaged ossification grades.***

One outlier data was noted at the age of 18 on stage 1, and two outlier data was noted on at the age of 21 on stage 5. Those data were excluded from further analysis.

Table 1 shows the descriptive statistics of the clavicular stages with the maximum, minimal age limits mean and median values of each ossification stages after removing the outlier data on tested samples.

**Table 01: Statistical parameters by gender for ossification stages 1–5 after removing the outlier data.**

| Stage | No. | Min.-Max. | Mean | Median |
|---|---|---|---|---|
| 1 | 5 | 15.0-16.0 | 15.4 | 15 |
| 2 | 6 | 17.0-19.0 | 17.5 | 17 |
| 3 | 4 | 19.0-22.0 | 20.5 | 20.5 |
| 4 | 15 | 20.0-30.0 | 25.81 | 25.5 |
| 5 | 13 | 24.0-30.0 | 27.83 | 28 |

Stage 1 was seen in five patients between 15 and 16 years. There were 6 patients in Stage 2, where the minimum age of appearance was 17 years, and was not seen beyond 19 years. Stage 3 was seen in 4 patients between 19 to 22 years. Stage 4 was seen in 15 patients where the youngest was 20 years. Stage 5 was seen in 13 patients and the minimum age of appearance was 21 years.

When comparing the trends of maturation of our study population with other published studies, we found that earliest appearance of stage 3 is 16 years, whereas it is 19 years in our study.

There were 31 cases which were reviewed by both radiologists (Table 2). Discrepancies were seen in 7 cases one involving stages 2 and 3 and six involving stages 4 and 5. The Cohen Kappa score for inter-observer agreement was 0.626.

**Table 2: Interobserver variation between the two radiologists**
(The numbers in bold indicate cases where there were discrepancies)

| | | Radiologist_B | | | | | |
|---|---|---|---|---|---|---|---|
| | Clavicular stage | 1 | 2 | 3 | 4 | 5 | Total |
| Radiologist_A | 1 | 3 | | | | | 3 |
| | 2 | | 4 | 1 | | | 5 |
| | 3 | | | 2 | | | 2 |
| | 4 | | | | 6 | 3 | 9 |
| | 5 | | | | 3 | 9 | 12 |
| Total | | 3 | 4 | 3 | 9 | 12 | 31 |

**Table 03: Review of some CT studies on different population with medial clavicular ossification stages**

| Study | Number of samples | Study population | Age (years) | | |
|---|---|---|---|---|---|
| | | | Stage 3 | Stage 4 | Stage 5 |
| Schulz et al.[16] | 629 | Germany | 16-28 | 21-30 | 21-30 |
| Schulze et al.[19] | 100 | Germany | 16-25 | 19-25 | - |
| Franklin et al.[20] | 388 | Australia | 17-24 | 20-36 | 24-35 |
| Pattamapaspong et al.[21] | 409 | Thailand | 15-27 | 18-29 | 20-29 |
| Zhang et al.[22] | 752 | China | 16-26 | 19-26 | - |
| Ufuk et al.[18] | 300 | Turkey | 16-26 | 18-26 | 21-30 |
| Kreitner et al.[17] | 279 | Germany | 16-26 | 22-29 | - |
| Present study | 46 | Sri Lankan | 19-21 | 20+ | 24+ |

## DISCUSSION

This study presents a preliminary finding of an ongoing research intended to develop a population specific reference standard for the use of medial clavicular epiphyseal fusion staging for forensic age estimation in the living. We evaluated the ossification of the medial clavicular epiphysis in chest CT scans of Sri Lankans between the ages of 15 and 30 years. The averaged ossification grades had a positive correlation with increasing age which were consistent with those of previous studies[16-22].

In our preliminary analysis of 46 individuals, stage 1 was seen between 15-16 years except for one outlier who was 18 years. The earliest appearance of stage 2 was 17 years and stage 3 was 19 years. The youngest with stage 4 was aged 20 years and except for two outliers who were 21 years old, the minimum age of stage 5 was found to be 24 years. Both stages 4 and 5 were seen at 30 years indicating that though complete fusion of the medial epiphysis occurs the presence of the scar could persist even beyond 30 years in our population. Table 3 compares our results with several studies conducted in different populations. The closest comparable trend is from an Australian population study[20]. A notable difference was that the earliest appearance of stage 3 was seen in much older individuals than in other studies and was not seen beyond 21 years. Based on the criteria used to interpret the kappa score value[23], substantial agreement was achieved between the two radiologists in assessing the clavicular stages.

According to Sri Lankan law, the minimum age of consent for sex is 16 [24]. Studies on German, Chinese and Turkish populations[16-19,22] showed that stage 3 first appears at the age of 16. However, in Thailand population, it appears at the age of 15, and in Australian populations, it appears at the age of 17 [20,21]. In this study, only stage 1 was seen in those less than 16 years old. With larger numbers it may be possible to use stages 1 and 2 to clearly distinguish the probability of being above or below 16 years. Stage 3 however, appeared much later in our study and has the potential to be a reliable indicator of a person being above 16 years. This would be a very useful tool when age is disputed in alleged sexual abuse cases in the adolescent period.

Except for the two outliers (who were also 21 years), the minimum age of stage 5 could be considered as 24 years which could be considered as a safe indicator of a person being above 21 years. Age 21 is the legal age limit for selling and consuming of intoxicants in Sri Lanka. Since conventional dental and hand radiographic methods have no value over the age of 18, this could be safely used to estimate the age of 21 in legal cases.

The test for inter-observer error showed substantial agreement between the two radiologists which suggests that this method of age estimation is highly reproducible.

Many previous studies based on CT scan were not divided by sex. Sex was compared in two studies and showed a significant difference in sex[16,25]. In both studies, the difference was noted in stage 2, and females found to reach the stage earlier than males. However, the study conducted on the Turkish population did not find any significant difference between male and females on ossification stages[18]. Due to the small sample size, we did not attempt comparison between the sexes during this preliminary analysis.

## LIMITATIONS

The generalizability of these findings is limited due to the small sample size. With a large sample size, the trends noted here could change significantly. Although we identified and excluded the outlier data in the further analysis, given the small sample size there is a possibility that they may even be normal occurrences in the population.

We did not have the necessary resources to consider the socio-economic status of the individual patients through this study which may influence the results. There are significant differences in socio-economic standards within Sri Lanka[26] and differences in nutritional status have been reported even within a single urban locality[27]. This factor would be taken into consideration when developing the larger database for the country.

As this was a retrospective study the chronological age of the participants was obtained only from hospital records. However, it was verified by contacting them over the phone. No discrepancy was noted in the obtained ages.

## CONCLUSION

The preliminary results of our study revealed that there is good potential for the medial clavicular epiphysis ossification stages to be reliably used to diagnose important legal age limits in Sri Lanka. Stage 3 is likely to be a reliable indicator that an individual has reached the age of 16 years. Stages 4 and 5 could be used to indicate an age above 18 years with stage 5 being highly suggestive of being older than 21 years.

## RECOMMENDATIONS

There appear to be notable differences in the trends of clavicular epiphyseal ossification when compared with published studies in other populations and therefore it would be extremely important to develop and use a reference database specific to Sri Lanka.

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# MEDICO-LEGAL INTERPRETATION OF CASUALTIES PRESENTING WITH TRAUMA TO A TERTIARY CARE HOSPITAL IN SRI LANKA

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## ABSTRACT

### Background

Even though traumatic injuries are the leading cause of hospitalization in Sri Lanka, demographic profile, causes, and severity of injuries sustained have not been reported. This data will be of assistance to policy makers in the effective prevention of violence and health care costs

### Results

Of the 626 casualties, 535 (85.5 %) were due to assault, and 72 % of them were assaulted with a blunt weapon. Of the assaults, 75 % were in the 20 – 49year age group and 53.5 % occurred between 4 pm and 10 pm. Of 55 (8 %) casualties with accidental injuries, 38.2 % were caused by falls and 38.2 % by burns. Of 18 (2.9 %) child abuse cases, 61.1 % were sexually abused. The highest frequency of, both, assaults and accidents was between 6 pm and 8 pm, while all instances of child abuse occurred between 8 am and 8 pm. Abrasions were seen in 45.4 %, contusions in 40.7 %, lacerations in 29.2 % and fractures in 21.6 %, while 12.3 % did not have any injuries. Injuries sustained were non-grievous in 65.5 %, grievous in 30.7 %, endangering life in 1.4 % and fatal in the ordinary course of nature in 2.4 %.

### Conclusion

Being aware of the types, weapons, time of day, age and sex of victims, subjected to violence will be beneficial to reduce these and thereby reduce the economic, physical and psychological burden to the country.

***Keywords:*** *Assault; Child abuse; Grievous; Medico-legal examination; Traumatic injuries*

## BACKGROUND

Trauma is defined as a deeply distressing or disturbing experience, which may be caused due to a physical injury or a stressful situation[1]. Injuries are a leading cause of death, hospitalization, and disability throughout the world and according to the World Health Organization (WHO) accounting for 9 % of all deaths annually[2]. According to the Ministry of Health in Sri Lanka, trauma and other injuries were the leading cause of hospitalization since 1995. The trauma burden is felt across all districts. It was ranked as the number one reason for admissions in 18 of the 25 districts. In the seven other districts, it was always among the top five[3]. Trauma is commonly seen in assaults, accidental and self-inflicted injuries.

Assault is an act, which creates an apprehension of an imminent harmful or offensive contact with a person[4]. Section 342 of the penal code of Sri Lanka declares that "Whoever makes any gesture or any preparation, intending or knowing it to be likely that such gesture or preparation will cause any person present to apprehend that he who makes that gesture or preparation is about to use criminal force to that person, is said to commit 'an assault'[5]. Assault is a common problem worldwide and a major contributor to death, disease and disability. According to the WHO report 2014, almost half a million are murdered around the world each year. Homicides are one of the leading causes of death in males and intimate partner violence is the leading cause in women[6]. Physical assaults vary from minor assaults such as shoving and pushing which may not result in any physical harm, to serious assaults which may leave temporary or permanent physical damage. This may include using a firearm, any sharp or blunt weapon or just using physical force. Assault patterns differ in various parts of the world according to the economy, laws prevailing in the area and weapon accessibility[7].

Accidental injuries (unintentional injuries) can be subdivided into injuries due to falls, road traffic, fires, poisoning, and drowning[8]. Most of the accidental injuries occur due to unsafe conditions of living, working, traveling and lack of preventive efforts[9].

Self-inflicted injuries are one of the leading causes of death worldwide and is a significant public health problem. It can cause death as well as cause ill-health and disability.

An abortion is defined as the deliberate termination of a human pregnancy, most often performed during the first 28 weeks of pregnancy before the foetus is able to survive independently[1]. Illegal abortions can lead to acute life-threatening complications, as well as long term disability and morbidity.

Numerous studies have been conducted both globally and in South Asian countries, exploring factors related to assault injuries and other injuries separately. However, there is a paucity of information on all types of traumatic injuries sustained and the medico-legal category of hurt (severity of injuries). This study analyzed the circumstances of the incident, injuries and causation of the victims of all forms of trauma who underwent medico-legal examination at the Teaching Hospital Peradeniya, Sri Lanka. This institution is one of two tertiary care hospitals in the Central Province of Sri Lanka, serving a population of 2.5 million, and which receives referrals from several other areas of the country.

The main objectives of this study was to highlight the pattern and profile of medico-legal cases of trauma presenting to the hospital, which not only highlights the value system among individuals in the community, but also provides vital data for administrators, health officers, philanthropists, social workers, non-

governmental organizations to devise strategies in order to reduce these incidents.

## METHODOLOGY

A retrospective descriptive study was conducted on casualties that were admitted to the Teaching Hospital Peradeniya, Sri Lanka during a five-year period, following injury. All those who were issued a Medico-legal Examination Form (MLEF) and consented for examination were included, while those who did not consent for examination were excluded; all road traffic accident casualties were also excluded, as this subset had been studied separately.

The information gathered from the patients included age, gender and history of the incident; and subdivided into assault, accident, self-inflicted, child abuse, abortion, animal attack or produced by the police for examination. Following examination, the types of injuries present were classified and the severity (which is referred to as the 'category of hurt') assessed in accordance with the penal code of Sri Lanka. Injuries which cause an existing threat to life and which may result in death are classified as EL, while those injuries which will result in death without prompt and proper medical care are classified as FIOCN. All injuries that do not fall under grievous or above is classified as non-grievous.

To reduce observer and record bias in the study, history taking and examination was done by the first author only, who is a board-certified specialist in forensic medicine.

The documented findings were entered to a Microsoft Excel spreadsheet. The data was analyzed using SPSS version 22.0.

## RESULTS

### Demographic profile related to casualties

Among the 630 medico-legal cases registered and a MLEF issued during the study period, four did not consent for examination. -, There were 465 (74.3 %) males and 161 (25.7 %) females.

The majority of the victims of assault (77.8 %), those produced by the police for examination (75 %), victims of animal attacks (66.7 %) and accidents (61.8 %) were males, while self-inflicted injuries were seen in both females and males in equal proportions. Most of the child abuse victims were females (72.2 %).

The mean age of the study sample was 34 years. Of the assaults, 75 % were in the 20–49 year age group, while 66.7 % of those that had self-inflicted injuries were in the 30–39 age group, 60 % of those arrested by the police were in the 40–49 year age group and all child abuse cases were less than 19 years of age (Table 1). One of the two cases of illegal abortion was 22 years old while the other was 44 years old.

**Table 1: Types of incidents according to the age group**

| Age group | Assault | *Accident | Child Abuse | Self-inflected | Police examination | Animal attack |
|---|---|---|---|---|---|---|
| 0-9 | 4 (0.8%) | 11 (20%) | 8 (44.4%) | - | - | 2 (40.0%) |
| 10-19 | 44 (8.2%) | 9 (16.4%) | 10 (55.6) | - | - | 1 (20.0%) |
| 20-29 | 158 (29.5) | 12 (21.8%) | - | 2 (33.3%) | 1 (20%) | - |
| 30-39 | 141 (26.4%) | 8 (14.5%) | - | 4 (66.7%) | - | - |
| 40-49 | 103 (19.3%) | 4 (7.3%) | - | - | 3 (60.0%) | - |
| 50-59 | 56 (10.5%) | 7 (12.7%) | - | - | 1 (20%) | 2 (40.0%) |
| 60-69 | 16 (3.0%) | 2 (3.6%) | - | - | - | - |
| 70-79 | 11 (2.1%) | 2 (3.6%) | - | - | - | - |
| 80-89 | 2 (0.4%) | - | - | - | - | - |

*Accidental injuries were due to falls, burns, blunt weapons, explosives and exclude RTA

**Type of incident and injuries sustained**

Of the 626 patients presented for medico-legal examination, 535 (85.5 %) were due to assault, 55 (8.8 %) were victims of accidents, 18 (2.9 %) were victims of child abuse, 6 (1.0 %) had self-inflicted injuries, 5 (0.8 %) were attacked by animals, 5 (0.8 %) were produced by the police for examination and two were following illegal abortion.

Of the injuries listed in the MLEF, the presence, and not the quantity, of the commonest eight types of injuries (i.e. abrasions, contusions, lacerations, fracture, cut, burn, gunshot and stab) were documented. Individuals with more than one type of injury were included under each type of injury, and therefore the total of all injuries exceeds the sample size.

Of the 626 persons examined 284 (45.4%) had abrasions, 255 (40.7 %) had contusions, 183 (29.2%) sustained lacerations, 135 (21.6 %) had fractures, 66 (10.5 %) had cuts, 28 (4.5%) sustained burns, 18 (2.9%) had gunshot injuries and seven (1.1%) had stabs. Seventy-seven (12.3 %) of those examined did not have any injuries.

**Time of the incident**

The time of assault was available in 528 of the 535 cases. Majority of the assaults (76%) were observed between 10 am and 10 pm whilst the highest number of assaults (26%) were observed between 6 pm and 8 pm. The lowest frequency of assaults (1.1 %) were between 2 am and 4 am.

The time of accident was known in 53 of the 55 cases. The number of accidents between 10 am and 10 pm were 35 (66 %) with the highest incidence (18.9%) observed between 6 pm and 8 pm. The lowest number of accidents (5.7 %) were between 2 am and 6 am, with none occurring between 2 am and 4 am.

All cases of child abuse had occurred between 8 am and 8 pm.

**Assaults**
Of the 535 victims of assault, 385 (72 %) were assaulted with a blunt weapon, 53 (10 %) with a sharp weapon and 16 (3 %) with both blunt and sharp weapons. In 54 (10 %) the weapon was not known. Explosives were used to assault 14 (2.6 %) persons, of whom, twelve were with firearms, while two were with bombs. Poison was used in four (0.8 %), while four (0.8 %) were bitten. In addition, there were three (0.6 %) cases of sexual assault and two (0.4 %) were burns caused by acid.

The injuries seen were abrasions (48.2 %), contusions (45.9 %), lacerations (29.3 %), fractures (21.3 %), cuts (11.6 %), gunshot injuries (2.4 %), stab injuries (1.3 %) and burns (0.4 %). Fifty-nine (11.0 %) had no injuries.

**Accidents**
Of the 55 casualties with accidental injuries, 21 (38.2 %) were accidental falls and 21 (38.2 %) were burns. There were five casualties each, who sustained accidental injuries due to blunt weapons and explosives. Accidental collapse of a wall caused two casualties while one accidental sharp weapon injury was seen. Of those who had fallen, 12 had fallen from a height, while 9 was at ground level. Among the 21 accidental burns, 14 (66.7 %) were due to flame, six (28.6 %) were due to hot liquids and one (4.8 %) was due to hot solids. Of the five who had accidental firearm/explosive injuries, two were due to the discharge of a firearm, two due to explosion of cartridges and one due to a gas cylinder explosion.

The type of injury sustained were, burns (40 %), lacerations (36.4 %), fractures (32.7 %), abrasions (18.2 %), gunshot injuries and contusions (7.3 %), and cuts (3.6 %). Three persons (5.5 %) did not have any injuries.

**Child abuse**
Of the 18 children who were abused, 11 (61.1 %) were sexually abused and seven (38.9 %) physically abused. Of the seven who sustained injuries, all had abrasions, two had contusions and lacerations, while one each had cut, fractures and burn injuries. Eleven (61.1 %) did not have injuries.

**Self –Inflicted**
Of the six self-inflicted injuries, three were flame burns. There was one caused by a firearm, one poisoning and one by both sharp and blunt weapons. Three (50.0 %) had burn injuries, while injuries from blunt and sharp weapons, poisoning and shot gun injury had one (16.7 %) patient each.

**Produced by police for examination**
Of the five casualties brought for medico-legal examination three were those arrested by the police while two were produced for alcohol level examination. Of them two had old abrasions and three had no injuries.

**Animal attacks**
Of the five animal attacks four sustained dog bites while one was attacked by an elephant. All patients had abrasions; three had lacerations while two had contusion and one had fractures.

**Abortion**
Neither of the abortion victims had sustained injuries.

**Category of injuries**
The injuries were classified as either non-grievous, grievous, endangering life or fatal in the ordinary course of nature, based on their severity in accordance with the penal code of Sri Lanka[5]. Amongst the 626 casualties 410 (65.5 %) had non-grievous injuries, 192 (30.7 %) had grievous injuries, nine (1.4 %) had injuries endangering life and 15 (2.4 %) had sustained injuries that were fatal in the ordinary course of nature.

When the 535 victims of assault were considered, 359 (67.1 %) had non-grievous injuries, 160 (29.9 %) had grievous injuries, 4 (0.8 %) had injuries endangering life and 12 (2.2 %) had injuries fatal in the ordinary course of nature. The injury was non-

grievous in 25 (45.5%) of those who had an accidental injury and a similar number was grievous. Three (5.5 %) were endangering life while two (3.6 %) were fatal in the ordinary course of nature.

Both the abortion victims had no injuries while 15 of child abuse victims had non-grievous injuries (83.3 %) and three (16.7 %) had grievous injuries.

Of the 6 self-inflicted injuries two each (33.3 %) were non-grievous and endangering life while one each (16.7 %) was grievous and fatal in the ordinary course of nature. All those produced by the police for examinations had non-grievous injuries while two (40 %) animal attack patients had non-grievous injuries and three (60 %) had grievous injuries (Table 2).

**Table 2: Category of hurt**

| | NG (%) | G (%) | EL (%) | FIOCN (%) |
|---|---|---|---|---|
| Assaults | 359 (67.1%) | 160 (29.9%) | 4 (0.8%) | 12 (2.2%) |
| Accidents | 25 (45.5%) | 25 (45.5%) | 3 (5.5%) | 2 (3.6%) |
| Self-Inflicted | 2 (33.3%) | 1 (16.6%) | 2 (33.3%) | 1 (16.6%) |
| Abortions | 2 (100%) | - | - | - |
| Child Abuse | 15 (83.3%) | 3 (16.7%) | - | - |
| Produced by police for examination | 5 (100%) | - | - | - |
| Animal Attacks | 2 (40%) | 3 (60.0%) | - | - |
| Total | 410 (65.5%) | 192 (30.67%) | 9 (1.44%) | 15 (2.4%) |

*NG – Non-grievous, G – Grievous, EL – Endangering life, FIOCN – Fatal in ordinary course of nature.

## DISCUSSION

Of the 1367 medico-legal cases registered over the five-year period, 42.4 % were road traffic accidents. Since these were analyzed and published in 2017, all road traffic accidents were excluded in this study. The present study analyzed all other casualties presenting with trauma to Teaching Hospital, Peradeniya, over the five years. It has become a massive burden to the world economy, costing billions of dollars each year. Therefore, there is a need of effective violence prevention interventions to reduce these avoidable injuries.

Once the road traffic accident casualties were excluded, the majority (85.5 %) were due to assault, followed by accidents (8.8 %), child abuse (2.9 %), self-inflicted injuries (0.95 %), animal attacks (0.8 %), produced by the police for examination (0.8 %) and abortions (0.3 %).

According to studies done in India[10] and Scotland[11], the percentage of male victims of assault were found to be 85.4 % and 80 % respectively which was similar to this study. Males dominate over females in almost all the types of casualties, with the percentage of males of accidents, animal attacks and

produced by the police for examination being 61.8 %, 66.7 % and 75 % respectively.

This may be due to the aggressive behavior, prevalent outdoor activities, more active lifestyle in the society and inclined to engage in riskier behavior[12]. Self-inflicted injuries were seen equally in both females and males. However, the majority of victims of child abuse, were female (72.2 %) which is similar to the finding of a study done in Anuradhapura, Colombo South and Ratnapura districts in Sri Lanka.

There was a greater proportion (27.6 %) of all the casualties between the ages of 20-39 years with a mean age of 34 years. However, in a study done in Nigeria, 70.4% of cases were from the age groups of 20-39 years[13]. This may be due to the fact that, young people in this age group tend to be more aggressive and impulsive and marred by array of problems starting from unemployment to newer exposure of responsibilities to establish a new domain or identity in their respective work of life having cut-throat competition[4]. Considering two abortion cases one was 22 years old and other was 44 years old. In Sri Lanka, induced abortions are illegal and restricted to cases in which the mothers' life is in danger. Therefore, most of the induced abortion cases are not reported to the Government sector. Most of the women tend to have unsafe abortion due to lack of reliable source of information during decision making. Moreover, some other reasons such as poor knowledge, positive attitudes on its safety, a smaller number of affordable abortion services and their economy instability may cause to have illegal abortions[14].

Among the assault casualties, the majority (72 %) were assaulted by a blunt weapon which is similar to the study done in Australia where the majority of the assault injuries were due to blunt weapons[15]. Frequently, the assault incidents followed small arguments and the assailant tends to assault with bare hands as well as objects nearby. Weapons used in assault depends on its availability, intention of the assailant and the level of aggressiveness. The socio economic and geographical influences increase the level of impact[16]. Moreover, most of the assault incidents occurred during the evening, which may be due to their more exhaustible, irritable and irresponsible nature along with more man to man interaction after the working period[10]. This behavior is totally altered after midnight as it involves fewer human activities[10].

Among victims who - sustained injuries caused by explosive objects, the majority (40 %) were injured by discharge of a trap gun. A trap gun is an illegally and locally manufactured smooth bore, long barreled, muzzle loading firearm in Sri Lanka. It has a victim activated trigger mechanism and is usually used to protect crops and livestock from wild animals. This is commonly seen in the dry zone in Sri Lanka, which includes Ampara, Anuradhapura, Kurunegala, Monaragala and Vavuniya[17]. According to the firearm ordinance in Sri Lanka, people need a license to keep a gun which is issued in limited numbers. Therefore, firearms are not readily accessible in Sri Lanka[18]. This may be the reason for a small number of firearm related injuries compared to other countries such as US where the total number of gun violence incidents in 2018 was 57235, (including 340 mass shooting incidents), causing 14746 deaths and 28202 injuries[19].

Burn injuries are very common and is the fourth most common type of trauma observed in the world[20]. Interestingly all the burns in this study caused by assault, were due to acid. Acid burns in Sri Lanka commonly occur due to assaults[21] and there is an increasing occurrence of acid attacks compared with other countries in Asia and Africa which has moderate industrialization[22]. This is an alarm for medical, social and government authorities to explore solutions to prevent such acts and

mitigate further complications to their victims.

Of accidental injury victims, highest proportion was injured by accidental falls and burns. Among the accidental falls, more than half had fallen from a height. Falls are the second leading cause of accidental injury deaths worldwide and each year 646 000 individuals die from falls and 37.3 million are hospitalized[23]. Considering accidental burns, the majority (66.7 %) were flame burns while 28.6 % were from hot liquids and 4.8 % were due to hot objects. Burn injuries are one of the major health problems that cause prolong physical and mental disabilities[24]. Interestingly all the accidental blunt injuries occurred at the work place. The only sharp weapon injury, was a penetrating injury which had occurred while climbing a tree.

There is a decreasing trend of suicide in Sri Lanka since 2011[25]. In this study, of the self-inflicted injuries, half (50 %) had burn injuries and all were flame burns. It was followed by in equal numbers of firearm/explosive injuries (16.7 %), poisoning (16.7 %) and both sharp and blunt injuries (16.7 %). All explosive injuries were caused by firearms and a gas cylinder. According to a study conducted in 2013, agrochemical poisoning was the most common method of suicide in the Eastern province of Sri Lanka, followed by poisonous seeds, hanging, deliberate train injury and self-drowning. However, according to the Sri Lankan Police 2018 report, the commonest mode of suicide in the entire country was hanging, followed by agrochemical poisoning, train injury, self-drowning and self-immolation[26]. The difference in our study is probably due to the fact that we are considering the victims who survived after attempting suicide.

Among those who were produced by the police for examination, were those apprehended for crimes committed and drivers of vehicles for alcohol level examination. In Sri Lanka, according to motor traffic act to charge drunken drivers, police are required to prove that the accused had consumed alcohol and has a concentration of alcohol in blood above 80mg/dl. The police officer may use a breathalyzer or produce the driver to a government medical officer for examination. Alcohol consumption is one of the major risk factors for interpersonal assaults and road traffic injuries. Majority of the assaults occurred during night hours, mostly on weekends with the street and drinking bars being the commonest venues similar to the study done by Charles and Oberaifo[13]. A study done in West Midland showed that 60 % - 70 % of victims who were suffering from physical violence had a positive blood alcohol level at the time of the attack[27]. Moreover, the risks associated with assault injuries are similar in men and women without intake of alcohol. It has also been shown that alcohol consumption can increase the impact of an assault[28].

Among all casualties, there were few animal attacks; among them, dog bites were the commonest type of animal attack. Canine rabies causes approximately 59,000 human deaths globally, over 3.7 million disability-adjusted life years, and 8.6 billion USD economic losses annually[29]. The high prevalence of dog bites in Sri Lanka, coupled with poor knowledge and dog bite management practices and the high cost of prophylactic treatment should be addressed by the policy makers and relevant authorities.

Approximately two-thirds (65.5 %) of the casualties we studied had injuries that amounted to non-grievous injuries. Among all casualty's, the majority of assault, abortion, child abuse and produced by police, had non grievous injuries. Most of the assaulted victims were assaulted by blunt weapons and among the child abuse victim's majority were sexually abused.

The commonest injuries were abrasions followed by contusions. Lacerations were the third commonest and fractures were the fourth commonest injuries. Among the assault victims, the majority had abrasions and contusions, which was due to the majority being assaulted with blunt weapons. Considering the accidental injuries, majority had burns and lacerations. This finding may be due to the fact that most of the accidental injuries were burn and fall injuries. Half of the self-inflicted injuries were flame burns. All the abortions had no significant injuries. Most of the child abuse victims had no injuries. Since more than half of the victims were abused sexually, these findings can be expected. Majority of the animal attack victims had abrasions while one person attacked by an elephant sustained fractures.

## CONCLUSION

There was a high proportion of assaults among the reported cases, in which, males were the predominant group of victims. In contrast, the majority of the child abuse victims were females. Most of the casualties were observed within the age group of 20-39 years.

Proper education, awareness programs and implementing employment opportunities for the youth may reduce the number of incidents. In order to manage trauma casualties, it is important to identify the most common locations of assault and establish well equipped emergency departments with trained medical personnel. There is a need to establish Clinical Forensic Medicine Units in Sri Lanka, as proper examination, documentation and reporting is imperative to implement laws and obtain a successful conviction in a court of law.

**List of Abbreviations**

| | | |
|---|---|---|
| WHO | - | World Health Organization |
| MLEF | - | Medico Legal Examination Form |
| NG | - | Non-grievous |
| G | - | Grievous |
| EL | - | Endangering Life |
| FIOCN | - | Fatal in the ordinary course of nature |

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