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INTRACORONARY TRANSPLANTATION OF AUTOLOGOUS HAEMATOPOIETIC STEM CELLS IN ISCHAEMIC END-STAGE LEFT VENTRICULAR FAILURE

P M Athauda arachchi ^{1,2}

General Sir John Kotelawala Defence University¹,
Durdans Hospital, Colombo²

ABSTRACT

The prevalence of end-stage heart failure is rising despite presence of successful reperfusion strategies for treating acute myocardial infarction and advancements made in pharmacological and device therapy optimized for heart failure management. The non-availability of a mature cardiac transplantation programme and absence of left and right ventricular assist devices in many parts of the world has renewed interests in potential alternative options.

We demonstrate the preliminary observational data (not a trial) of a beneficial effect of intra coronary autologous bone marrow derived peripheral haemopoietic stem cell transplantation to improve myocardial contractility.

Systematic and cellular level analysis on these cells will be required to optimize therapeutic utility of this emerging regenerative medical speciality.

ABBREVIATIONS:

PCI -Percutaneous Coronary Intervention, CABG -Coronary Artery Bypass Grafting, TVD – triple vessel disease, LV EF -left ventricular ejection fraction, DHM -Dynamic Heart model, MR-Mitral Regurgitation, NSTEMI- Non-ST elevation myocardial infarction, STEMI- ST elevation myocardial infarction, LAD-Left anterior descending, NYHA – New York Heart Association

KEYWORDS: End-Stage Heart Failure, Intra-Coronary Transplantation, Autologous Bone-Marrow-Derived Peripheral Haematopoietic Stem Cells.

1. INTRODUCTION

Worldwide, the prevalence of heart failure is estimated at 64.34 million cases (8.52 per 1,000 inhabitants), accounting for 9.91 million years lost due to disability [Lippi, 2020]. Deaths attributed to heart failure exceed the combined death toll for lung cancer, breast cancer, prostate cancer, and HIV/AIDS (Chen-Scarabelli, 2015) even in countries with developed medical facilities. Prognosis of the heart failure patients is poor, worse than that for many cancers (Kirkpatrick, et al 2007). Patients with NYHA class II symptoms are at a proportionally higher risk of sudden cardiac death while those with NYHA class IV symptoms have a one-year mortality as high as 75% with a significantly higher risk of dying of progressive heart failure characterized by worsening shortness of breath, orthopnea, hypotension, and decreasing level of consciousness. This illustrates the need for developing new therapeutic options in advanced heart failure.

Autologous bone marrow derived hematopoietic stem cells have been used for experimental or small-scale trials or registries in the context of heart failure or myocardial infarction since 2007 (Assmus et al, 2007 & Mills et al 2007) and more recently in dilated cardiomyopathies (Amoozgar H et al). Our group has previously reported one case of successful adaptation of intracoronary autologous transplantation of such cells in ischaemic end-stage heart failure, with subsequent ability to proceed for Rotablation assisted high risk PCI revascularization of the last remaining calcific coronary artery (Athauda arachchi et al, 2018). Multiple medical comorbidities, heterogeneous quality of cell harvesting, and delivery systems used, makes it difficult to systematically evaluate the benefit of this new therapy in end stage heart failure or long-term prognosis, as many organ dysfunctions have already set in at this stage.

We therefore evaluated our own collective experience of utilizing such stem cells, and we describe the safety aspects and immediate efficacy noted in left ventricular function, the detailed studies of which are ongoing.

2. METHODOLOGY

This was a simple observational study evaluating end stage heart failure patients with NYHA IV symptoms with LVEF <30% on maximal tolerable heart failure medications and unsuitable for device therapy or further revascularization.

Following haematological evaluation, patients were administered intravenous GCSF X 2-3 doses, with review of blood counts. Stem cells were harvested within set time periods using a haemocath dialysis catheter, placed in femoral vein, with the support of intravenous inotropes, and stem cells were harvested using Haemonetics MCS 971E kit. One (1 ml) stem cell harvest was sent for immediate sample analysis for CD34 count by nearest Flow cytometric facility on ice, and the remaining harvest (ranged from 25 ml to 35 ml, on average 30 ml), was delivered on ice for immediate intra coronary transplantation, after gentle warming. Cath lab procedure was undertaken within 15 minutes and intracoronary slow injection of stem cells was given using a microcatheter based injection system over 15 minutes. Pre and post echocardiographic assessment of LVEF was done using dynamic heart model (DHM), Simpson's biplane and strain pattern on Phillips Epic CVx echocardiographic platform.

The patients were observed after the index procedures, with their standard heart failure therapy being continued as appropriate, and the long-term outcome noted over a year.

3. RESULTS

Of a typical case, following GCSF, the total WBC count of the stem cell harvest was 303.4×10^3 per microlitre and the CD34+ cell count was 3276 per microlitre. These CD34+ve cells constituted 24% of the CD45 negative cells (see Figure 1 annexed). This would suggest that approximately 9×10^9 of CD34+ve haemopoietic stem cells should have been contained in total in the intracoronary injection (Figure 2).

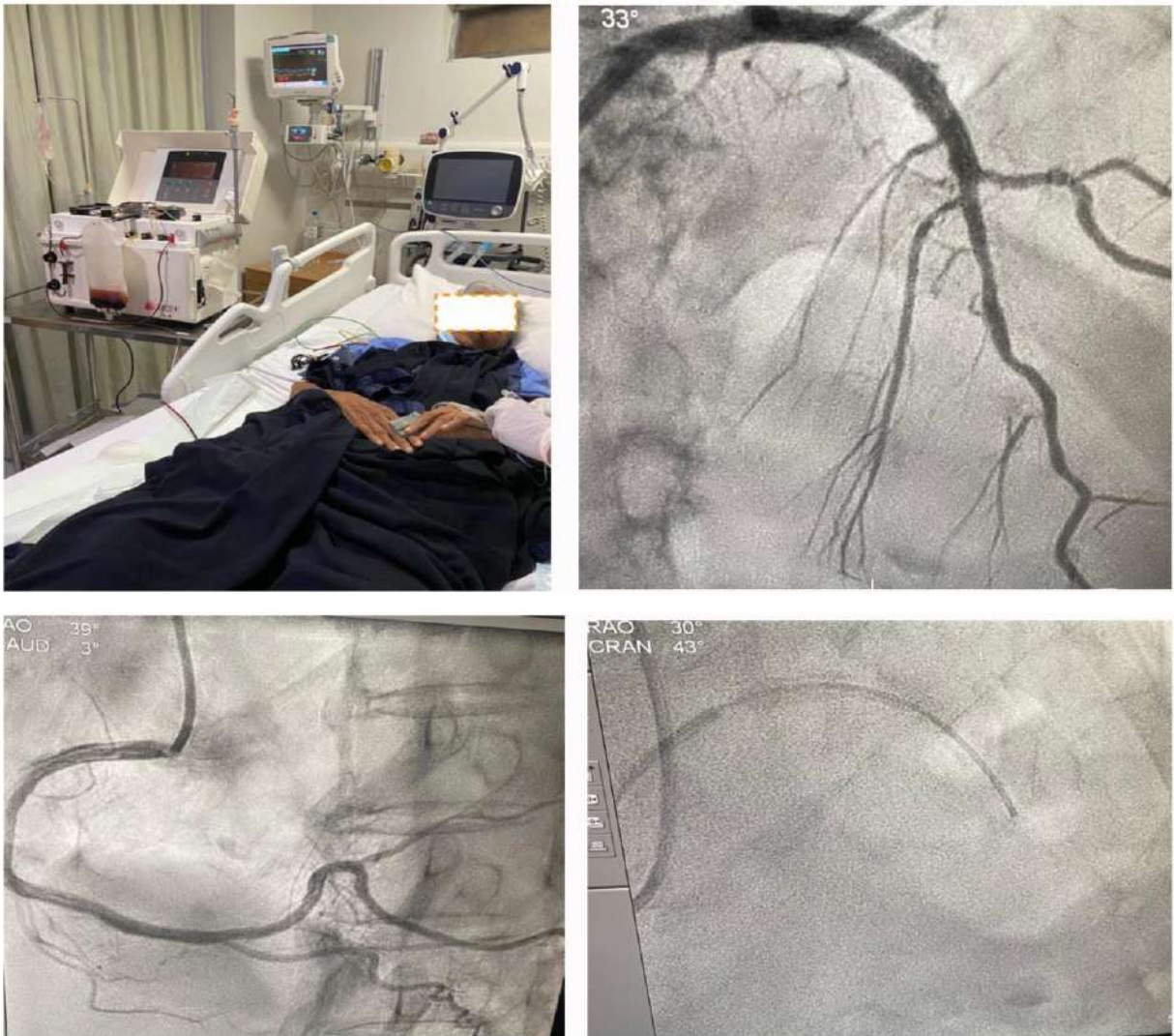


Figure 1: harvesting autologous haemopoietic stem cells in a coronary care unit , with monitoring facilities. Coronary angiogram: patent stent in previously infarcted LAD territory, recrossed with coronary microcatheter (standard interventional technique) to transplant the autologous stem cells

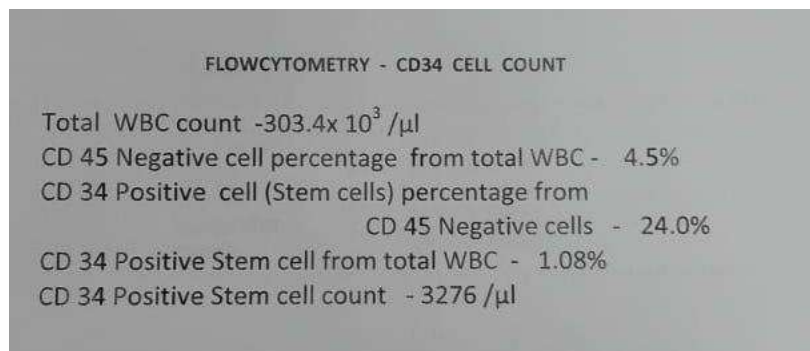


Figure 2: Flow cytometric analysis of cells derived using the Haemonetics kit, to calculate CD34+ve cell counts in the harvest



Figure 3: Intracoronary stem cell transplantation and Echocardiographic (DHM) LVEF assessment pre- and post-transplant (Illustrated above is the post-operative echocardiogram of subject 4).

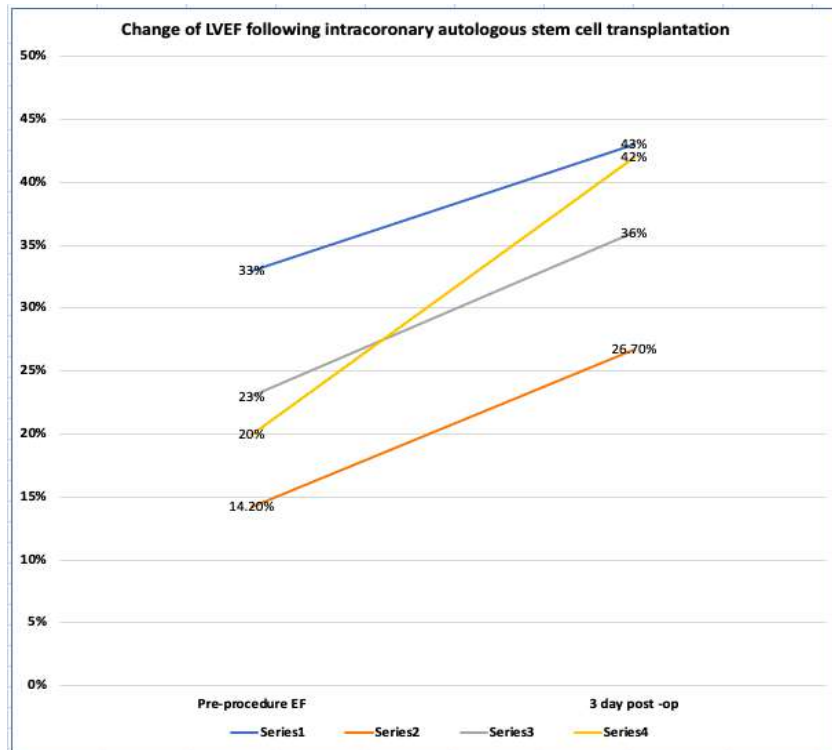


Figure 4: Observed early Change of LVEF following intracoronary autologous haematopoietic stem cell transplantation (0 and 3 days)

The average age was 63.75 years and Preoperative LVEF was 22.55%+/-7.9%. Post procedure day 3, LVEF was 37%+/-7.5%, with an average increase of LVEF post procedure by 14%+/-5.25% (Figure 3).

In hospital major adverse cerebral or cardiac events (MACCE) was 0%, and all 4 patients reported improvement of their symptom of breathlessness corroborating with improvement of calculated LVEF noted within 72 hours of procedure in all the patients, with variable degrees (Figure 4).

On long term follow up of survival of these relatively ill patients, the eventual cause of death in 3 patients was deemed non-cardiac, and one patient is still alive being followed up in heart failure clinic (Figure 5). However, the study being an observational finding of cases and having a very limited number of end-stage heart failure patients, no inferences could be drawn on mortality from this data. However, in all the cases listed as above, no immediate or late cardiac or extra-cardiac complications were noted.

Patient details	Indication	Pre-op LVEF	Day3 post -op LVEF	Intra op or in-hospital complications	Long term outcome
Male, 74 years	CABG post MI, poor LVEF, narrow QRS, repeated and frequent hospitalization despite maximal tolerable medical therapy	33%	43%	No	Survived 1.5 years(non-cardiac death-?(CVA). Had only 1 heart failure hospitalization till time of death .
Female, 63 years	Severe calcific TVD, turned down for CABG, repeated NSTEMI, severe SOB and HF hospital admissions	14.2%	26.7%	No	Improved EF and less SOB, could then proceed to Rotablation assisted PCI to LAD (last remaining vessel), improving LVEF further to 36.1%. No recurrent hospitalizations. Survived 2 years (non-cardiac death? GI bleed)
Male, 38 years	Late(>4d) presenting Ant STEMI, severe TVD, complicated PCI to LAD and severe residual LVSD , with no response to maximum tolerated medical therapy>1 year and primary prevention AICD in place. Repeated hospital admissions with pulmonary oedema	23%	36%	No	Improved physical activity and return to previous occupation. No further emergency hospital admissions. Survived for 18 months before sudden death during Covid lockdown after a respiratory illness.
Female,80 years	Late(>4d)presenting Ant STEMI, Late PCI, severe residual LVSD with MR, with no response to maximum tolerated medical therapy>1 year, considered but not suitable for CRT and unable to offer surgery or Mitra clip, repeated hospitalizations with heart failure	20%	42%	No	Less SOB and able to perform ADL better. Follow up ongoing. Patient alive.

Figure 5: Summary table of characteristics and long term outcomes of 4 subjects with end-stage heart failure, undergone intracoronary stem cell transplantation once and followed up in clinic.

4. DISCUSSION

In our patients with end stage ischaemic cardiomyopathy, the intracoronary transplantation of autologous bone marrow derived haematopoietic stem cells harvested from peripheral blood resulted in the improvement of the symptoms of heart failure and left ventricular systolic function without significant immediate peri-procedural complications.

This was a consistent finding in all the patients studied irrespective of age or sex, albeit with a very small number of subjects. However, it is not clear how long the effects would last and whether repeated therapy would improve function further or if adverse events would increase in subsequent attempts. The mode and cellular mechanisms of the benefits noted above requires further analysis at cellular and molecular level.

5. CONCLUSION

The intracoronary transplantation of autologous, bone marrow derived haematopoietic stem cells, harvested from peripheral blood, offers another investigative therapeutic option for improving symptoms or echocardiographic features of end stage heart failure once all other therapeutic options have been tried maximally. This is important, as the supply of cadaveric heart transplants are in short supply. This new regenerative therapy should be assessed further for identifying ways to improve long term outcomes in end-stage heart failure.

6. ACKNOWLEDGEMENTS

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PLANKTON DIVERSITY IN COASTAL WATERS NEAR KALU GANGA RIVER MOUTH; SRI LANKA

Batugedara B.D.I.M.¹ and Senanayake S.A.M.A.I.K.¹

Department of Zoology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka¹

ABSTRACT

The plankton community plays a significant role in the stability of coastal ecosystems. They serve as key players in marine food webs. The present study investigated the plankton diversity in coastal waters near Kalu Ganga river mouth. Six sampling locations were chosen randomly, three along the right side of the coastline (CR₁-CR₃) and three along the left-side (CL₁-CL₃) from the river mouth. Zooplankton and phytoplankton at each location were sampled from September 2020 to February 2021 using a 55µm plankton net in surface waters on a monthly basis. Plankton were morphologically identified to the nearest possible taxonomic level. The Shannon-Weiner diversity index (H) and Simpson's Index of Diversity (SID) were calculated to determine plankton diversity. The number of phytoplankton species found during the wet months (September-October) and dry months (January-February) were 62 and 68 respectively, while a similar number of zooplankton species (43) were recorded in both periods. Altogether, 81 phytoplankton species and 53 zooplankton species were identified during the research period. Bacillariophyta (72%) and Copepods (68%) were identified as the dominant phytoplankton and zooplankton groups respectively. Dinoflagellates including, *Peridinium* sp., *Protoperidinium* sp., *Ceratium* sp., *Noctiluca* sp., *Gonyaulax* sp., and *Alexandrium* sp., which are well-known to form harmful algal blooms (HABs) accounted for 17%. Chlorophyta and Cyanophyta were less dominated and found only during wet months at nearest sampling locations (CL₁ and CR₁) to river mouth. Rotifera (11%), foraminifera (9%), protozoa (10%) and ichthyoplanktons (<1%) were also reported. The H and SID values for plankton were recorded to be between 2.7 to 3.1 and 0.90 to 0.96 respectively. The both values were not significantly different ($p>0.05$) between wet months and dry months at each location. According to the H and SID values, the study area has a moderate-high level of plankton diversity. Further research should be conducted to determine the temporal and spatial variation of plankton diversity in the study area.

KEYWORDS: Kalu Ganga river mouth, Coastal waters, Plankton diversity, Shannon-Wiener diversity index, Simpson Index of Diversity

Corresponding Author: Senanayake S.A.M.A.I.K. Email- indunil@sci.sjp.ac.lk

1. INTRODUCTION

Plankton are aquatic organisms that are unable to swim against the currents of the water (Suthers et al., 2019). They play a critical role in marine life and in supporting fisheries (Batten et al., 2019). Plankton are classified according to their food requirements, size, habitat, and life cycle.

They are primarily classified as phytoplankton or zooplankton based on their dietary requirements. Prokaryotes that are capable of photosynthesis commonly referred to as phytoplankton contribute greatly to biomass and primary production in aquatic settings. These organisms are crucial for aquatic life because they serve as the basis of the food chain. The other significant component is zooplankton, which acts as primary consumers in energy transmission between phytoplankton and higher trophic levels (Imoobe and Adeyinka, 2009; Kusuma et al., 1988).

Biodiversity affects ecosystems' functioning and services (Duffy, 2009). Changes in the plankton community's structure directly affect the ecosystem's function (Gao et al., 2018; Yuan et al., 2014). The abundance of zooplankton and phytoplankton is determined by a wide array of abiotic factors (such as light availability, temperature, salinity, heavy metals, pH and nutrient concentrations) and biotic factors (predators, parasites) that jointly influence the structure of plankton communities (Harris and Vinobaba, 2012; Rocha et al., 1997). Plankton reacts at the slightest variation of surrounding ecosystems (Araujo et al., 2022). Therefore, plankton communities are frequently used as bioindicators to monitor ecological changes in aquatic ecosystems (Paul et al., 2016). They can be used as management tools to monitor the quality of the ecosystem by preventing algal blooms and identifying harmful contaminations from unknown sources. These variations are studied through ecological data and can be utilized by policymakers, such as in circumstances where the plankton population changes due to the rapid growth of harmful plankton species due to the surplus of nutrients in the water (Anderson et al., 2014).

Diversity indices are used to quantify the general characteristics of communities (Morris et al., 2014). The Shannon-Weiner Species Diversity Index (H) is one of the most applied diversity indices in aquatic communities which considers the species richness and evenness. The number of species present in a community is referred to as its species richness. Species evenness is a parameter which indicates relative abundance of given species among all the species in a community (DeJong, 1975). This index gives a numerical assessment of the number of component groups and the relative abundance of these groups within the community (Cook, 1976). The Simpson index of diversity (SID) is a dominance index because it gives more weight to common or dominant species. As developed by Simpson, the index ranges from 0 to 1, where 0 indicates the absence of diversity and 1 indicates maximum diversity (Guajardo, 1999).

According to Krakstad et al., (2018), in Sri Lankan waters, plankton dynamics from the central Indian Ocean are poorly known. In Sri Lanka, several studies have been carried out on the plankton diversity of coastal and brackish waters (Jayasiri et al., 2007; Jitlang et al., 2008; Wijetunge et al., 2015; Wimalasiri et al., 2021). Fernando (1980), has stated that the limnetic zooplankton of Sri Lanka is typical of tropical limnetic zooplankton in species composition. Warusawithana and Yatigammana (2019) reported 85 phytoplankton species and 38 zooplankton species in Kotmale reservoir while Silva (2007) has identified nearly 150 taxa of phytoplankton belonging to nine taxonomic groups from Sri Lankan inland water bodies. However, such studies in coastal waters near the river mouths of Sri Lanka are scanty. Environmental conditions in river mouth areas fluctuate widely, according to river water discharge and the effects of oceanic water intrusion (Sakami et al., 2003). These fluctuations can affect on the biological community. Land-based pollutants discharged into waterways finally end up at the coast with a risk of contamination. Therefore, identifying plankton diversity in coastal waters near river mouths can reveal important ecological data. The Kalu Ganga basin is Sri Lanka's second largest river basin, comprising 2766 km², and a substantial portion of its catchment is located in the country's greatest rainfall region. The river originates from the Adam's peak in the central hills at an altitude of 2250

m and falls in to the Indian ocean at Kalutara after flowing through Rathnapura and Kaluthara districts. The basin's average annual rainfall is approximately 4000mm, resulting in a yearly flow of 4000 million m³. It accounts for the country's most significant amount of discharge to the sea (Ampitiyawatta and Guo, 2010; Panditharathne et al., 2019). Hettige et al., (2014) have studied the water quality status of Kalu Ganga coastal waters. Since the river flows through rapidly developing cities there's a possible risk of nutrient contamination. Therefore, it will be essential to examine the plankton population in the Kalu Ganga river mouth's coastal waters to determine the potential threat of algal blooms to coastal fisheries and recreational activities in the neighbouring beach park. With a focus on identifying the major zooplankton and phytoplankton taxa in the study area, the current study was conducted to evaluate the plankton assemblage in coastal water near the river mouth of the Kalu Ganga. The Shannon-Wiener diversity index (H) and Simpson's Index of Diversity (SID) for plankton were calculated to determine the impact of precipitation on the plankton population. That involved calculating the variation of H and SID between wet and dry months in the study area.

2. METHODOLOGY

2.1 Study site and sampling locations

The current study was carried out in the adjacent coastal water of Kalu Ganga river mouth. Sampling was carried out at six randomly selected and independent sampling locations, including three (CR1, CR2, CR3) along the river mouth's right-side coastline and three (CL1, CL2, CL3) along the river mouth's left-side coastline (Figure 2.1). Each sampling point's GPS coordinates were recorded using a handheld GPS (Garmin eTrex H Handheld GPS Navigator). Monthly sampling was carried out from September 2020 to February 2021. September and October of 2020 were considered as wet months while the January and February of 2021 were considered as dry months based on the average monthly rainfall (Meteo.gov.lk., 2021).

2.2 Sample collection and analysis of plankton composition

At each sampling location, 50L of surface water (0-1m) was filtered through a typical plankton net (HYDRO-BIOS, KIEL plankton net : 55 µm mesh size) to analyze phytoplankton and zooplankton. The samples were immediately transferred to labeled 100mL opaque plastic bottles and preserved with acidified Lugol's solution and 4% formalin. The plankton samples were kept for 24hours for the natural sedimentation. After removing the supernatant, known dense sample was vigorously shaken to ensure homogeneity. A Sedgewick-rafter counting chamber was used (Pysler-SGI, S52, glass cell) to enumerate the plankton.

Identification and enumeration of plankton was carried out under binocular compound light microscope (Optika, Italy, B-159) with the magnification of 40x (APHA,2017). Using standard plankton identification keys and guides, zooplankton and phytoplankton were identified to the lowest possible taxonomic level (Cupp, 1943; Dand et al.,2015; Faust and Gulledege, 2002; Newell and Newell,1963; Perry,2010; Razouls et al., 2021; Yamaguchi and Bell, 2007). Magnus Live USB 2.0 viewer of the Microscopic Image Projecting System was used to process the images (Magnus MIPS, India).

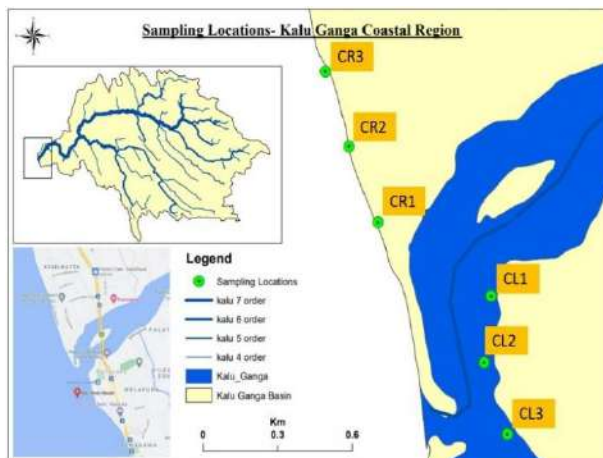


Figure 2.1- Sampling locations of Kalu Ganga river mouth coastal are

2.3 Calculation of Shannon-Wiener Diversity Index (H) and Evenness

The Shannon-Wiener diversity index was calculated to determine the plankton diversity. The following formula was used for the calculations (Gao et al., 2018; Pielou, 1966).

$$H = - \sum_{i=1}^s p_i \ln p_i$$

$$\text{Evenness} = \frac{H}{\ln(S)}$$

Where,

H = Shannon- Wiener diversity index

P_i = fraction of the entire population made up of species i

S = number of species encountered

Σ = sum from species 1 to species S

2.4 Calculation of Simpson's index of diversity (SID)

The Simpson index was calculated (Hossain et al., 2017; Simpson, 1949) using the following equation.

$$SID = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where,

D = Simpson's diversity index

n = number of individuals of each species

N = Total number of individuals of all species

2.5 Secondary data collection

Monthly total and average rainfall data of the Kalu Ganga catchment area for the study period was collected from the Meteorological Department, Sri Lanka. Digital maps of the study area were collected from Survey Department, Sri Lanka.

2.6 Map generation, Data analysis and Statistical Analysis

The study area's map generation was performed using

Arc GIS 10.5 version. Statistical analysis was carried out using Minitab 17 statistical software package along with Microsoft Excel 2016 version. Paired T test was performed to determine the significance difference of H value and SID values separately, between wet months and dry months for zooplankton diversity and phytoplankton diversity. p < 0.05 was regarded as statistically significant. All the statistical tests were performed with a significance level of 95%.

3. RESULTS AND DISCUSSION

3.1 Plankton identification

The number of recorded phytoplankton species was 62 and 68 respectively during wet and dry months. A similar number of zooplankton species (43) was recorded during the wet months as well as during the dry months. A total of 81 phytoplankton and 53 zooplankton species were recorded during the study period. The identified phytoplankton groups were bacillariophyta (72%), dinophyta (17%), chlorophyta (7%) and cyanophyta (3.5%). As the major zooplankton groups, copepoda (68%), rotifera (11%), foraminifera (9%), protozoa (10%) and ichthyoplankton (<1%) were recorded (Table 3.1 and 3.2). In a similar manner, Perumal et al. (2009) identified Bacillariophyta as the main phytoplankton group and copepod as the dominating zooplankton group in Kaduviyar estuary, southeast coast of India, and the percentage contribution of each phytoplankton group was as follows: In the phytoplankton community, Bacillariophyta > Dinophyta > Cyanophyta > Chlorophyta predominate. Also mentioned is a similar descending arrangement of zooplankton groups. Bacillariophyta has been found as the main phytoplankton group in the southeast coast of India (Rajkumar et al., 2009) and northern Bay of Bengal (Prakash and Raman, 1992). Diatoms predominated the phytoplankton population, followed by dinoflagellates (Achary et al., 2014; Madhav and Kondalarao, 2004; and Yasmin et al., 2021). Microscopic photographs of some of the observed plankton are included in Figure 3.1(phytoplankton) and 3.2 (zooplankton).

Table 3.1: Recorded phytoplankton, their distribution and percentage of occurrence during the study period

Phytoplankton group	Phytoplankton sp.	No. of recorded species in the genus	Sampling location ID						No. of recorded species in the group	Percentage %
			CL1	CL2	CL3	CR1	CR2	CR3		
Bacillariophyta (Diatoms)	<i>Acknanthes</i> sp.	1	+					+	59	72
	<i>Amphiprora</i> sp.	1		+	+					
	<i>Amphora</i> sp.	1						+		
	<i>Asterionellopsis</i> sp.	1	+	+	+	+	+	+		
	<i>Biddulphia</i> sp.	2	+					+		
	<i>Campylodiscus</i> sp.	1	+							
	<i>Cerataulina</i> sp.	1		+	+	+	+	+		
	<i>Chaetoceros</i> sp.	4	+	+	+	+	+	+		
	<i>Cocconeis</i> sp.	1			+					
	<i>Coscinodiscus</i> sp.	1	+			+	+	+		
	<i>Cyclotella</i> sp.	1	+	+	+	+	+	+		
	<i>Cylindrotheca</i> sp.	1	+	+		+	+	+		
	<i>Cymbella</i> sp.	1				+		+		
	<i>Detonula</i> sp.	1		+				+		
	<i>Diatoma</i> sp.	1	+							
	<i>Diploneis</i> sp.	1	+	+				+		
	<i>Ditylum</i> sp.	2	+	+	+	+	+	+		
	<i>Fragilaria</i> sp.	1	+					+		
	<i>Guinardia</i> sp.	1								
	<i>Gyrosigma</i> sp.	2	+		+			+		
	<i>Helicotheca</i> sp.	1	+					+		
	<i>Lauderia</i> sp.	1	+	+		+		+		
	<i>Leptocylindrus</i> sp.	1			+	+	+			
	<i>Lioloma</i> sp.	1			+					
	<i>Melosira</i> sp.	1	+			+				
	<i>Navicula</i> sp.	3	+							
	<i>Nitzschia</i> sp.	5	+	+	+	+	+	+		
	<i>Odontella</i> sp.	1			+					
	<i>Pinnularia</i> sp.	1	+		+	+		+		
	<i>Planktoniella</i> sp.	1		+						
	<i>Pleurosigma</i> sp.	2	+	+	+	+	+			
	<i>Proboscia</i> sp.	2	+	+						
	<i>Pseudonitzschia</i> sp.	1	+	+	+	+	+	+		
	<i>Rhizosolenia</i> sp.	3	+					+		
<i>Skelotonema</i> sp.	1	+	+	+	+	+	+			
<i>Streptotheca</i> sp.	1	+		+			+			
<i>Synedra</i> spp.	2	+	+		+		+			
<i>Tabellaria</i> sp.	1			+			+			
<i>Thalassiothrix</i> sp.	1	+	+		+					
<i>Thalassionema</i> sp.	1		+				+			
<i>Thalassiosira</i> sp.	1	+			+					
<i>Tribonema</i> sp.	1						+			
Dinophyta (Dinoflagellates)	<i>Alexandrium</i> sp. *	1		+					13	17
	<i>Ceratium furca</i> *	1	+	+	+	+	+	+		
	<i>Ceratium fusus</i> *	1		+	+	+	+			
	<i>Ceratium lineatum</i> *	1	+		+		+	+		
	<i>Ceratium longipes</i> *	1		+	+	+	+	+		
	<i>Ceratium tripos</i> *	1	+	+	+					
	<i>Dinophysis tripos</i> *	1						+		
	<i>Gonyaulax</i> sp. *	1						+		
	<i>Gymnodinium</i> sp. *	1				+	+			
	<i>Noctiluca scintillans</i> *	1	+			+	+			
	<i>Peridinium</i> sp. *	1	+	+						
	<i>Protoperidinium divergens</i> *	1	+	+	+	+	+	+		
	<i>Pyrocystis noctiluca</i> *	1	+	+		+	+	+		
	Chlorophyta (Green algae)	<i>Ankistrodesmus</i> sp.	1	+						
<i>Closterium</i> sp.		3	+	+			+			
<i>Scenedesmus dimorphis</i>		1	+							
<i>Scenedesmus quadricauda</i>		1	+							
Cyanophyta (Blue green algae)	<i>Chroococcus</i> sp.	1	+				+	3	3.5	
	<i>Spirogyra</i> sp.	1	+				+			
	<i>Spirulina</i> sp.	1	+							

+: Presence of species at each location
*: Dinoflagellates known to form algal blooms

Table 3.2: Recorded zooplankton, their distribution and percentage of occurrence during the study period

Zooplankton Group	Zooplankton	Nu. of recorded species	Sampling location ID						Nu. of recorded species	Percentage (%)
			CL1	CL2	CL3	CR1	CR2	CR3		
Copepoda	<i>Acartia</i> sp.	2	+		+		+	+	36	68
	<i>Acartiella</i> sp.	2						+		
	<i>Acrocalanus</i> sp.	1			+		+			
	<i>Candacia</i> sp.	1		+						
	<i>Centropages</i> sp.	2		+	+		+	+		
	<i>Chiridius</i> sp.	1			+					
	<i>Clanopia</i> sp.	1					+	+		
	<i>Cyclops</i> sp.	4		+	+		+	+		
	<i>Dioithona</i> sp.	1		+						
	<i>Euchirella</i> sp.	1	+				+	+		
	<i>Heterorhabdus</i> sp.	2				+	+			
	<i>Isias</i> sp.	1	+					+		
	<i>Microsetella</i> sp.	1	+	+				+		
	<i>Nauplius</i>	4	+	+	+	+	+	+		
	<i>Paracalanus</i> sp.	4	+		+	+	+	+		
	<i>Pontella</i> sp.	1								
<i>Pseudodiaptomus</i> sp.	6		+		+					
<i>Rhincalanus</i> sp.	1	+		+	+	+				
Rotifera	<i>Keratella</i> sp.	2	+			+			6	11
	<i>Lecane</i> sp.	2	+			+				
	<i>Testudinella</i> sp.	2	+			+		+		
Foraminifera	Foraminifera	5		+			+		5	9
Protozoa	Tintinnids	3		+	+	+	+		5	10
	<i>Arcella</i> sp.	2		+	+	+	+			
Ichthyoplankton	Fish eggs	1	+						1	<1
+: presence of species at each location										

The plankton diversity as well as the number of reported freshwater phytoplankton were increased towards the river mouth along the coastline. *Nitzschia* sp. was found at every sampling location as a tolerant phytoplankton species with highest abundance and highest species richness. The genus *Nitzschia* contains species found in clean water as well as in polluted water. *Nitzschia* sp. can be easily found in almost any water body in the world (Martin and Fernandez, 2012). Ariyasinghe et al., (2016) has reported highest abundance of *Nitzschia* sp. in all salinity levels. Nauplius larvae are an important food source for fish and predatory invertebrates. The abundance of these species could be attributed to the abundant food supply, reproductive activity, and the ecosystem's favourable environmental conditions (Ramaiah and Nair, 1997). Their recorded highest abundance is essential information for the coastal fisheries of the area. However, most of the species

found in the study area were marine. Since some of the bloom-forming dinoflagellates were reported it is important to analyze the nutrient content of the coastal waters in the study area.

3.2 Variation of plankton composition between wet months and dry months

During the wet months 48 Bacillariophyta species, 5 dinophyta species, 6 chlorophyta species and 3 cyanophyta species were recorded. But during the dry months, only bacillariophytes and dinoflagellates were reported in 56 and 12 respective number of species. During the wet months the number of recorded species of copepods, rotifers, foraminifera and protozoa were 31, 6, 2 and 4 respectively. During the dry months 35 copepod species, no rotifers, 5 foraminifera species, 2 protozoa species and 1 ichthyoplankton were reported (Figure 3.3 and 3.4).

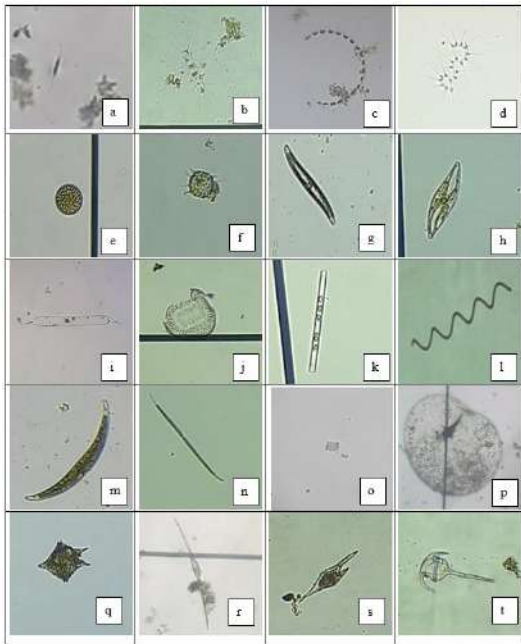


Figure 3.1: Some of the recorded phytoplankton: Bacillariophyta (a-k), Chlorophyta (l-o), Dinophyta (p-t)



Figure 3.2: Some of the recorded zooplanktons: Rotifera (a-c), Protozoa (d-g), Foraminifera (h-i), Copepoda (j-p)

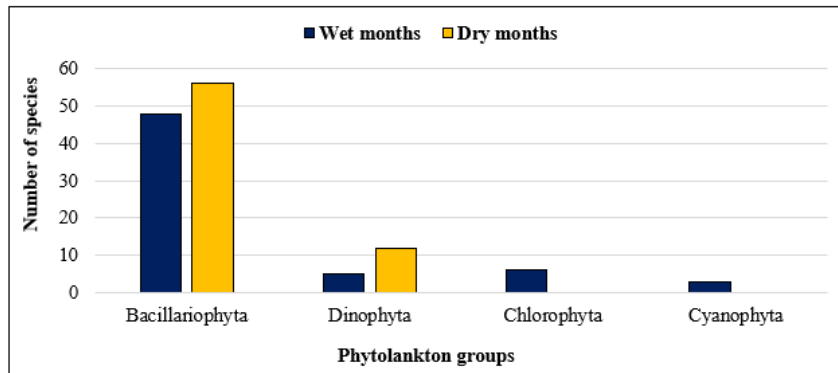


Figure 3.3: Variation of Phytoplankton composition

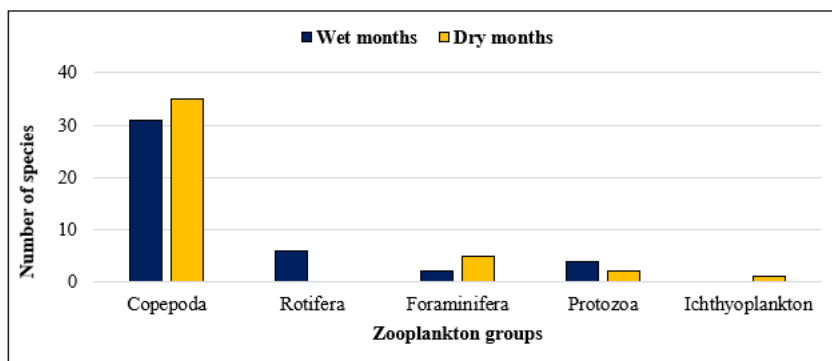


Figure 3.4: Variation of Zooplankton composition

Compared to the dry months, Kalu Ganga catchment area receives a high amount of rainfall during the wet months [The average monthly rainfall at Rathnapura station was reported as >575mm, >400mm, <200mm, <75mm respectively during September (2020), October (2020), January (2020) and February (2020)] (Meteo.gov.lk., 2021). Therefore, the volume of freshwater discharge through the river mouth into adjacent coastal waters is higher during wet months compared to the dry months. Salinity fluctuates in response to seasonal variation of freshwater inflow into adjacent areas from the rivers (Stoker et al., 1992).

Rathnayaka et al., (2013) has observed a saltwater intrusion in Kalu Ganga up to 11 km from the river mouth. Larson and Belovsky (2013) has stated salinity as a dominant factor which influence the diversity of phytoplankton communities in aquatic ecosystems. Therefore, the changes of salinity levels between wet months and dry months can influence the plankton diversity. Due to high amount of freshwater inflow into coastal areas can allow freshwater chlorophytes and cyanophytes to tolerate at the nearest sampling locations (CL1 and CR1) to the river mouth during wet months. The freshwater green algae *Closterium* sp. is sensitive to water quality (Wang et al., 2018). Low salinity levels can allow them to tolerate. Perumal et al. (2009) observed the presence of freshwater algae in the Kaduviyar estuary, located on the southeast coast of India, during the monsoon season when there is considerable rainfall and low salinity. Freshwater phytoplankton found in estuaries during the wet months can be used as an indicator of the presence of freshwater conditions. But due to the decreasing dilution effect of saltwater along the coastline from the river mouth, they tolerate only at the nearest sampling locations to the river mouth.

But less freshwater discharge during the dry months can increase the saltwater conditions at same locations (CL1 and CR1) making these freshwater species hard to survive at these locations. Harris and Vinobaba (2012) observed decrement of chlorophyta and cyanobacteria abundance with the increasing salinities. Freshwater phytoplankton do

not survive at these higher salinities (Harris and Vinobaba., 2012). Therefore, they only present during the wet months. Also, the flow variations can change the nutrient levels, primary production and make changes in the ecosystem (Alexander et al., 1996).

3.3 Variation of Shannon-Wiener diversity index value between wet months and dry months

During the research period, H value was recorded between 2.7 to 3.1. In terms of zooplankton and phytoplankton diversity, the CR1 and CL1 locations reported the highest H value (H=3.1). There was no significant difference in H values between wet and dry months for phytoplankton ($t= 0.00$, $p=1.00$) and zooplankton ($t=2.24$, $p=0.076$). The Figure 3.5 and Figure 3.6 are regarding the variation of H value (\pm Standard deviation) between wet months and dry months respectively for phytoplankton and zooplankton.

3.4 Variation of Evenness between wet months and dry months

The calculated species evenness values during the research period for zooplankton and phytoplankton are displayed in Figure 3.7 separately. Although there were no significant differences in zooplankton species' evenness ($t=1.31$, $p=0.247$) between wet and dry months, a significant difference was recorded for the phytoplankton species evenness ($t=6.97$, $p=0.001$) between wet months and dry months. Species evenness was higher during the wet months compared to the dry months for phytoplankton.

3.5 Variation of Simpson's Index of Diversity (SID) values between wet months and dry months

SID value was recorded between 0.90 to 0.96 in the study area during the research period. The highest SID value (0.96) was reported at CL1 location. There was no significant difference in SID value for phytoplankton ($t=2.10$, $p=0.09$) and zooplankton ($t=2.44$, $p=0.06$) between wet and dry months. Figure 3.8 and Figure 3.9 are regarding the variation of SID value (\pm Standard deviation) between wet months and dry months, respectively, for phytoplankton and zooplankton.

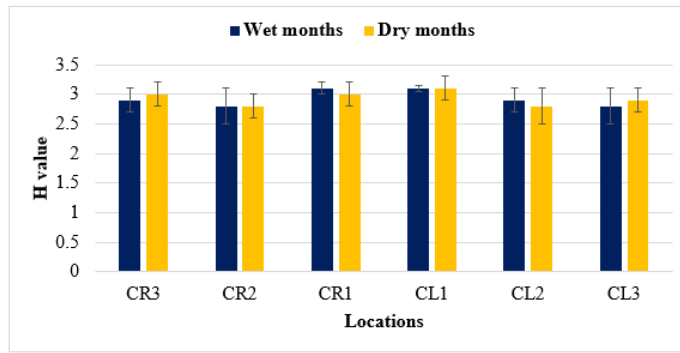


Figure 3.5: Variation H value for phytoplankton between wet months and dry months

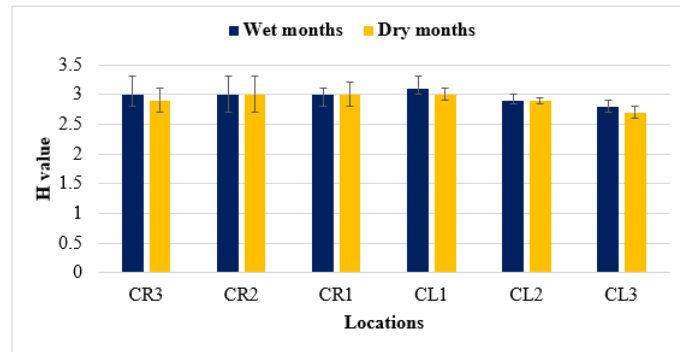


Figure 3.6- Variation H value for zooplankton between wet months and dry months

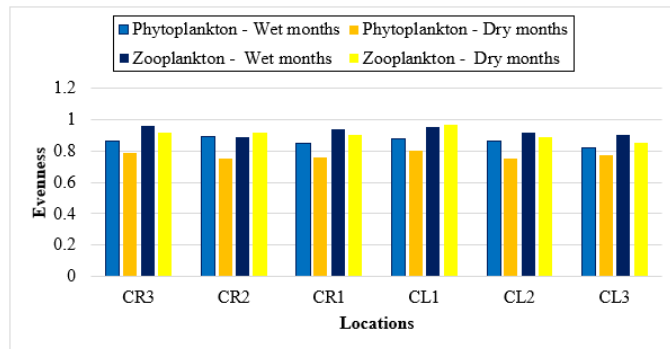


Figure 3.7- Variation of species evenness between wet months and dry months

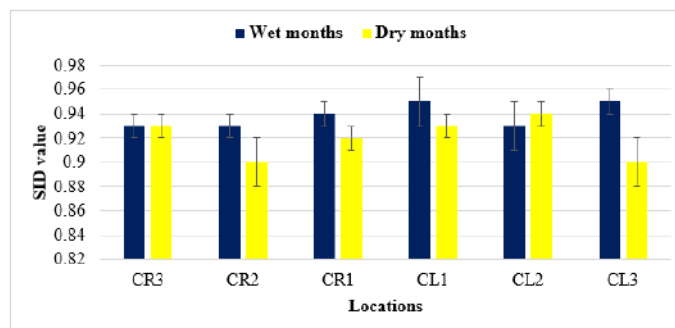


Figure 3.8- Variation of SID value for phytoplankton between wet months and dry months

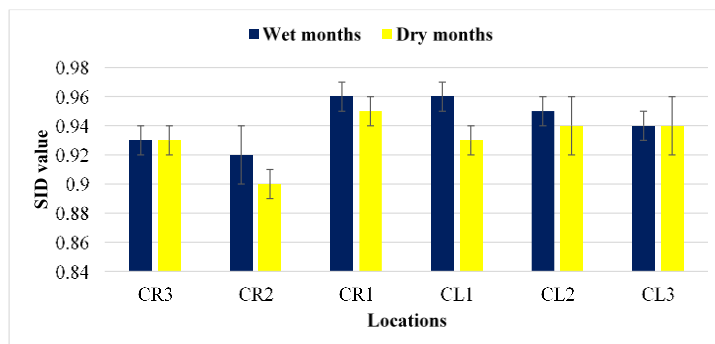


Figure 3.9- Variation of SID value for zooplankton between wet months and dry months

Shannon-Wiener index is strongly influenced by species richness as well as by rare species, while Simpson index gives more weight to evenness and common species. The effect of the sample size is generally negligible for both of them. According to the classification scheme for the Shannon-Wiener Diversity index as described in Fernando et al., (1998), the relative level for the zooplankton and phytoplankton diversity of the study area is moderate to high (H value range- 2.7-3.1). According to the classification system of Simpson's Index of Diversity in Guajardo (2015), study area can be classified as a high diversity area of plankton (SID value range - 0.90-0.96). The reported high evenness values can be contributed to the high SID values. In coastal areas near river mouths, nutrient-rich river water is mixed with coastal water (Romero et al.,2007). Therefore, it increases phytoplankton diversity. In aquatic environments, phytoplankton plays a significant role in supplying the dietary needs for filter-feeding zooplankton (Peltomaa, et al., 2017). With a sufficient food supply, zooplankton community becomes stable and diverse. The ability of freshwater plankton, brackish water plankton, and marine planktons to tolerate at nearest sampling locations to the river mouth (CL1 and CR1) can increase species richness towards the river mouth. Therefore, diversity increases towards the river mouth. Ariyasinghe et al., (2016) have reported greater species diversities at low salinities than at high salinities in Batticaloa lagoon, Sri Lanka.

Low salinity levels closer to the river mouth can attribute to this high diversity value at CL1 and CR1 locations. Interactions between marine and river

water result in ecosystems with wide fluctuations in salinity and a variety of other physical, chemical, and biological water characteristics (Morris et al.,1995). Therefore, studying plankton community structure at these areas are crucial. This study's findings about the distribution and abundance of plankton would serve as a valuable tool for future ecological assessment and monitoring of the coastal ecosystems of Sri Lanka's River mouths.

4. CONCLUSION

Bacillariophyta was the dominant phytoplankton group while copepods were identified as the dominant zooplankton group during the study period. Although the number of recorded plankton species was almost similar in both periods, a variation of species composition was observed between wet months and dry months. The plankton diversity as well as the number of reported freshwater phytoplankton were increased towards the river mouth along the coastline. The highest species diversity was reported at the nearest sampling locations (CL1 and CR1) to the river mouth. Although the hazardous algal bloom conditions were not reported in the study area it can be concluded that there is a risk of bloom formation due to the presence of dinoflagellates which are well known for bloom formation. There was no significant difference in H and SID values between wet months and dry months. There is a moderate-high level of plankton diversity in the area. Future research is highly recommended regarding the spatial and temporal distribution of plankton community of the study area with long-term continuous assessments.

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AUTONOMY IN ENGLISH LANGUAGE TEACHING AND LEARNING DURING SECONDARY EDUCATION: A STUDY OF AUTONOMOUS LANGUAGE LEARNING EXPERIENCE RECOLLECTIONS AMONG ENGINEERING STUDENTS IN A SRI LANKAN STATE UNIVERSITY

Saumya Batuwatta¹ and C.D.H.M. Premarathna²

Department of English Language Teaching, University of Ruhuna, Matara, Sri Lanka¹,

Department of Linguistics, University of Kelaniya, Kelaniya, Sri Lanka²,

ABSTRACT

Autonomy is a central concern of language teaching and learning that has various sources and wide-ranging implications. There are several advantages of autonomous learning practices in a country like Sri Lanka, where the English language learning contexts are non-egalitarian. Autonomy is a concept that impacts both teachers and learners. It does not mean that the learners are fully independent and alone in this practice. In reality, teachers have a prominent role in fostering autonomy among learners, and it is a process to be started at the secondary education level. Mainly the teachers' willingness to shift the English as a Second Language (ESL) pedagogy from teacher-centered to learner-centered mode is significant in this context. This basis the learners get from the school makes them lifelong and independent learners, which also minimizes the reluctance and difficulties of using the English language among people from all walks of life. Realizing the importance of the teacher's role in teaching autonomous learning, this study focuses on collecting data through the recollections of 300 engineering undergraduates in a state university in Sri Lanka who had their secondary education from various schools island-wide. A questionnaire was distributed via a link, and the collected data were thematically and statistically analyzed. The data were collected on multiple language learning experiences the learners had from the autonomous learning point of view and the impact of the teachers' involvement in this regard. The study concludes that most learners are unsatisfied with their secondary ESL education and emphasize the importance of increasing speaking practices. Most importantly, the respondents suggest that even though the teachers assigned them various extra activities, the outcome and teachers' awareness of autonomous teaching and learning practices are questionable. Significantly, all the participants emphasized the importance of learning the English language and being independent learners.

KEYWORDS: *Autonomy, Independent learner, Second language learning, Secondary education*

Corresponding Author: Saumya, Batuwatta, Email: saumya@eltu.ruh.ac.lk

1. INTRODUCTION

Decolonization and globalization are two significant reasons that have increased the demand for English language proficiency among Sri Lankans for years until today. Since the early 1950s, all successive governments have made several efforts to facilitate English education in all Sri Lankan schools without discrimination Perera, (2010b). Currently, English language proficiency and the need to achieve this skill have increased with the widespread use of Information Technology (I.T.). Further, it is understood that the learners of urban areas were motivated to master English due to various privileges accorded to English-educated people, such as a promising career, higher education, social recognition, and economic success Prasangani Kariyawasam and Nadarajan Shanthi (2015) On the flip side, this language proficiency has also reasoned to broaden the social gap as creating discrimination among the people who are with and without English language skills. The learners have also found English language proficiency a significant barrier to personal development and professional success. Overall, ESL proficiency is still a challenge for most Sri Lankans.

As a solution to this deficiency, it was identified that practicing Learner Autonomy (L.A.) or self-directed learning strategies and principles in language learning would bring more positive outcomes in any language learning situation.

Meanwhile, looking at the LA concept through a theoretical lens, the idea of autonomy in education is based on constructivist learning theories. According to Audrey Gray (1997) in (Wang 2011), the constructivism theory that Jean Piaget introduced is a method of learning which believes that knowledge is not something that the teacher can transform from standing in front of the classroom to the students who are sitting on their chairs. Instead, learners raise knowledge through active mental development; students are the builders and creators of meaning and knowledge. Furthermore, the constructivism theory holds that students are active constructors of knowledge, meaning, and learning subjects.

On the contrary, the theory of constructivism is not only for learners but also for teachers. Further, according to Audrey Gray (1997) (Wang, 2011), the qualities of a constructivist teacher and the organization of a constructivist classroom are as the learners are actively involved, the environment is democratic, the activities are interactive and student-centered, and the teacher facilitates a process of learning in where the students are encouraged to be responsible and autonomous. Further, in a constructivist-related classroom, the instructions are learner-centered and active; the teacher provides students with experiences that allow them to hypothesize, predict, manipulate objects, pose questions, research, investigate, imagine, and invent. Ultimately, the teacher's role is to facilitate this process. Moreover, as mentioned by Dörnyei and Csizér (1989) in (Fernando, 2005), among the commandments for motivating language learners for teachers to set a personal example with their behavior, create a pleasant and relaxing atmosphere in class, develop a good relationship with the learners, increasing the learner's linguistic self-confidence; and promoting learner autonomy has also given priority. Furthermore, it is understood that L.A. has several other aspects to enhance the effectiveness of the ESL teaching and learning process. According to (Perera, 2010a), L.A. can also positively cater to the heterogeneity in the classroom and resource-poor learning environments (Fonseka, 2003a).

Moreover, providing an answer to the non-egalitarian nature of the Sri Lankan English education system through a critical eye (Fonseka, 2003b) states, "the learning tasks and reading materials presented in the textbooks can be described through the famous metaphor in Sinhala: *Ballantö leli pol denöwa wage*; "Like giving unhusked coconuts to dogs." Although dogs like to eat the kernels of coconuts, they cannot extract them when they are covered with a husk" (p 2-3). This expression suggests how much the government attempts to provide the opportunity to learn English. Still, the actual outcome is questionable, especially among learners of underprivileged families and teaching backgrounds. With that understanding, it is evident that fostering autonomous learning practices among almost all Sri

Lankan learners of English would bring many positive outcomes.

However, it is understood that there is a shortage of local studies based on autonomous teaching and learning practices. Thus, among the existing literature Fonseka (1996, 2003a) are two notable empirical studies focusing on how children's songs can promote learner autonomy. These studies are written as solutions for a society where learners carry out their studies in circumstances that are far from easy. Factors such as geographical distance, timetable disagreement, limited classroom accommodation, and lack of teaching personnel are some common examples of practical complications of this situation. However, it is notable that despite the said negative factors, the learners from the urban areas also find it challenging to achieve English language proficiency due to a lack of authentic language exposure and opportunity to practice English outside the classroom, financial issues, low education level of parents, limited time allocation for English in the school timetable, and non-conducive classroom learning environment caused by lack of L.A. Apart from these negative impacts, mother tongue influence, teacher dependency, fear and anxiety, internalization of the idea that English is a complex language, and that English grammar is difficult to study; have also detached learners from learning and speaking English, Seefa, (2017).

Due to the lack of equality in English language teaching, such as demographical, social, and administrative reasons, in the local ESL education system, it is worthwhile implementing autonomous practices among local ESL learners and teachers. Further, as L.A. is not very popular in the local education context, it is essential to brief the concept first.

The term 'autonomy' has been diversely interpreted by scholars over time. However, Dayananda and Yapar, (2020) state that L.A. has no universal definition. The concept is diversifying with the research findings in L.A. Largely, L.A. is perceived as learners taking responsibility and developing the capacity to take control of their learning.

However, among many other definitions, Benson's (2006) thoughts on autonomy are as follows: "people

taking more control over their lives - individually and collectively. Thus, autonomy in learning is about people taking control over their learning both in and outside the classrooms, while autonomy in language learning is about people taking more control over the purposes for which they learn languages and how they learn them". This definition is more similar to the famous description given by Henri Holec (1981), considered as the father of autonomy: "... the ability to take charge of one's learning, and to take charge of one's own learning is to have, and to hold, the responsibility for all the decisions concerning all aspects of this learning". Further to Holec, an autonomous learner can determine learning objectives, define the contents and progressions, select methods and techniques to be used, monitor the procedure of properly speaking (rhythm, time, place, etc.), and evaluate what has been acquired (Yang, 2005). Further to Dickinson (1993) in (Yang, 2005), autonomous learners can identify what has been taught, formulate their learning objectives, select and implement appropriate learning strategies, identify ineffective strategies, and monitor their learning. However, according to many scholars' (H. Holec, D. Little, D. Nunan, D. Thanasoulas, H. Reinders, B. Sinclair, M. Usuki, A. Ikonen, etc.) points of view, in (Pichugova Inna, Stepura Svetlana, and Pravosudov Matvey, 2015), there should be the following conditions to implement learner autonomy: choice, goals and needs, support, emotional climate, learning strategies, learner attitude and motivation, and self-esteem.

Further, it is notable that L.A. cannot be achieved without teachers' involvement, and it is a two-way process for both learners and teachers. A learner cannot be autonomous without the support of a teacher. The teachers' multiple roles as facilitators, counselors, resource suppliers, evaluators, organizers, designers, managers, cooperators, inspires, supporters, monitors, and atmosphere creators are crucial in developing an autonomous learner, Yan (2012). This fact suggests that the teacher has a significant and prominent role in this context. However, the teachers' identification of their responsibilities and importance is questionable. Further, unawareness of the L.A. concept, institutional rules and regulations, attitudes, and cultural issues are common negative causes of promoting L.A. in most educational

contexts.

Similarly, the learners also have negative aspects of L.A. due to a lack of understanding of the L.A. concept. They do not know how to learn and study, are unable to think outside the box, and are not critical thinkers; most do not have goals, no research skills, and lack motivation Borg Simon and Alshumaimeri Yousif, (2019). Especially in a country like Sri Lanka, where the teaching and learning contexts are conservative, these features among learners and teachers are widespread. Further, learners' over-dependency on teachers, and on the other hand, the teachers' targets on preparing the students for examinations, hinder the promotion of L.A. However, the concern Bowman (2011) in Kariyawasam and Shanthi (2015), teachers should facilitate three human requirements of autonomy as follows: freedom for choices and determine the future, mastery (ability to learn and expertise), and purpose (search for the use of learning to the life). However, Kariyawasam and Shanthi (2015) state that L.A.'s expectations of students from teachers are high, as 90% for both in and outside learning. Especially the students expect great support from the teachers to motivate their learning. According to the referred literature, it is clear that Sri Lankan learners expect a very close relationship with their teachers. Therefore, Breen and Man (1997) in Yang (2005) list some essential factors required to be a teacher of autonomous learners as follows: self-awareness as a learner, belief in each learner's capacity to learn, and trust in each learner's ability to assert their autonomy, and the desire to foster L.A. However, Borg Simon and Al- Busaidi Saleh, (2011) show that most language teachers' understanding of this concept is shallow. This reason further represents a gap in the literature because teachers' instructional behaviors influence student learning, and teachers' beliefs impact these behaviors.

Fostering autonomy is a responsible task where the teachers' thorough understanding and positive attitudes are required. As Sara, (1998) mentions, autonomous language learners are charged with designing their own language programs, are encouraged to clarify what they want to learn, set goals, identify problems, and propose and implement solutions. Further, reflection is an

essential aspect of the learner's new role. Therefore, the assistance of the teachers in adopting these new autonomous behaviors among ESL learners is efficient and necessary. Thus, the responsibilities of learners and teachers will facilitate a smooth transfer between each other. However, Raya, Lamb, and Vieira, (2007); Al-Saadi, (2011b) point out an obstacle that directly disadvantages learners. According to them, "both teachers and student-teachers may show some resistance to innovative pedagogies that assign the teacher a new role as a facilitator of autonomy-oriented processes" (p.1). On the other hand, transferring some of the tasks the teacher traditionally holds to their learners may be viewed as losing control over learning and discipline to some teachers.

Nonetheless, it is unavoidable that teachers and learners encounter several drawbacks, challenges, and negative experiences in adapting to this novel process of fostering and teaching L.A., especially in a country like Sri Lanka.

Considering the ESL context in Sri Lanka, English has been given recognition as a foreign language rather than a second language. Further, it is being taught as an academic language rather than a part of their regular lives. Additionally, the local ESL context is very different from that of the countries like Canada, Australia, and the U.K., where formal English language learning is primarily interactive with an authentic learning environment. The Sri Lankan ESL education system is more classroom centered, and the students are extrinsically motivated to learn English to get through higher examinations, get foreign job opportunities, etc. Perera, (2010a).

The existing literature provides ample examples of teachers' and learners' drawbacks in teaching and learning English. Mainly heterogeneity of the language classroom is a vivid challenge in most ESL contexts. Here the textbooks and the syllabuses are commonly prepared, and the learner outcomes and the effectiveness of lessons are questionable. Furthermore, the learners engaged in higher studies also find it challenging as most local primary and secondary education is conducted in the vernacular media, and almost all higher studies are in English. This sudden transition of the medium of

instruction significantly affects most learners, simultaneously mastering language and subject knowledge.

Establishing learner autonomy is essential for a society where learners carry out their studies in circumstances that are far from easy, such as geographical distance, timetable disagreement, limited classroom accommodation, and the lack of teaching personnel. Further investigation Fonseka Gamini, (1996) gives prominence to songs. It explains how songs enhance learner autonomy with multiple features such as a sense of responsibility, self-direction, metacognition, and motivation amalgamated into operation in a carnivalesque spirit.

However, suppose a particular society does not have enough resources to cater to every individual's learning needs. In that case, individuals must develop the autonomous capacity to acquire the necessary knowledge Al-Saadi, (2011b). This argument is very much applicable to a country like Sri Lanka. Thus, the development of autonomy and independence of present learners have become essential as an answer to various changes which have taken place in recent times, not only in the field of language teaching but also in worldly affairs Al-Saadi, (2011b).

Finally, considering the current study, the main focus has been given to a group of Engineering undergraduates in a state university in Sri Lanka. In reality, graduates should be able to apply knowledge when working with people, and they need the skill to work independently, become efficient problem solvers, do self-evaluation, and enhance higher-order skills to become lifelong learners in an increasingly globalized and technological world. Therefore, the need to become autonomous learners during secondary education is highly beneficial, especially in ESL. Hence, directing the learners toward new dimensions of learning and introducing new pedagogies of teaching English has become a significant concern.

2. METHODOLOGY

Observing most undergraduates' struggle with the

English language in following an English medium Engineering degree program and their teacher-dependent nature with lack of self-motivation in ESL learning, the researchers realized the pressing importance of introducing autonomous language learning practice. Since fostering independent learner qualities is a time-consuming and lengthy process, determination, motivation, and patience on the part of teachers and learners are very important. Therefore, this study sought to answer first the question of teachers' readiness to foster learner autonomy in the classroom, secondly, that of Sri Lankan ESL learners' autonomous learning exposure at the school, and thirdly, that of students' satisfaction with the English education during school time, and what suggestions they have to improve the local ESL school education.

The present study is based on the experiences and the recalling of 300 engineering undergraduates, and the study employed an online structured questionnaire. The questionnaire was designed to gather data in three sections: teachers' understanding of autonomous teaching strategies and the concept, the learners' experiences and exposure to independent learning strategies, and the students' suggestions and comments on the ESL education they had during the school time. The questionnaire was distributed among 327 first-year engineering students, and 300 were considered, excluding the non-received and unanswered questions. The data were gathered from male and female students studied in various schools island-wide. The collected data were both qualitatively and quantitatively analyzed.

Considering the general questions of the first section of the survey, all the participants, 100%, agreed that learning English as a second language is essential; 92% mentioned that learner autonomy is vital in this learning process, while 8% said no. Initially, answering the question on what learner autonomy means to you, the highest percentage of 41.3% of participants have chosen L.A. means learners' right to take control of their own learning. Accordingly, 32.7% state it is the same as self-study, and 29.7% state it is a situation where learners are responsible for their education. In comparison, 12.7% believe L.A. is a capacity for teachers to help learners develop in the learning

process, and 12.3% mentioned that it is a teaching methodology that focuses on learners. In contrast, 0.7% to 0.3% of participants said they do not have any idea or understanding of the L.A. concept.

Based on the given answers, most students believe L.A. substantially impacts self-studies, which is essential. Analyzing their responses, it was categorized into three themes: L.A. is a responsibility of the learners, it is self-learning, and I have no idea about fostering autonomous behaviors among learners.

The most common misunderstanding of autonomous learning is that it can be achieved without the teacher's support. The learner is fully independent within this process, and the teacher has no role to perform. However, in reality, a teacher has to play a prominent role, and especially the teacher has to create an autonomous learning environment and guide the

learners by providing necessary activities and monitoring their work with essential feedback. Likewise, a monitored scaffolding provided by the teacher until the learner develops confidence is required.

3. RESULTS

To inculcate L.A. in students, the teachers should also understand and be willing to shift their role from teacher-centered to learner-centered while sharing the responsibilities of the classroom activities.

Therefore, in the second section of the questionnaire, the following questions were forwarded to the participants to identify whether the teachers had given them enough opportunities to develop L.A. Also, the answers convinced to what extent the teachers are aware and familiar with the concept of L.A.

NO	Items	Yes	No
1	Have your English teachers talked about autonomy and its values?	117	183
2	Have you been allowed to decide your study goals at the beginning of each year regarding English language learning?	147	153
3	Have you been allowed to check how much progress you have made in English language learning by the end of the year?	205	95
4	Have you been given a chance to decide on the textbooks and extra learning materials to be used in the class for English language learning?	160	140
5	Have you been given a chance to decide on the topics and activities used in the class to learn English?	139	161
6	Have you been given the freedom to decide on classroom management, such as seating arrangement and class rules?	142	158
7	Have you been asked to keep a diary in English?	106	194
8	Have you been asked to watch and listen to T.V. and radio programs in English?	233	67
9	Have you been asked to practice speaking English with your friends?	220	80
10	Have you been encouraged to use the library for extra reading in English?	161	139
11	Have you been encouraged to have cooperative and peer learning activities in the class?	196	104
12	Have you been advised to be more responsible about what you do to improve your English language learning skills both in and outside the classroom?	208	92
13	Were the students given a chance to explain the lesson or to express ideas about the lesson to peers?	183	117
14	Who had the most authority during the English lesson in the class?	Teacher 90% (270)	Student 10% (30)
15	Who did the most speaking in the class, is your English teacher or the students?	287	13

The selected sample of the study is currently following an Engineering degree program in English medium. Therefore, it is essential to get their opinion on the English education they had during school time, its effectiveness, their ideas, and most importantly, their suggestions to improve the effectiveness of the process.

It is also noteworthy that, in response to the question, are you satisfied with the education you gained regarding English language proficiency from your school? among the respondents, 59% of 177 participants mentioned that they were not content with the ESL education they received. In comparison, 41% of 123 participants said they were comfortable.

Accordingly, the students have given various suggestions to enhance school ESL education's quality, effectiveness, and expectations. Thematically analyzing the given answers, three main themes emerged: giving more priority to practical language usage, effective learning environment, and teaching methods.

With the thought of giving priority to the practical use of language and assigning more interactive sessions, the participants said, *“Not only grammar and writing but speaking also should be improved by giving them more group activities and presentations,”* *“Try to encourage students to talk in English. They will gain confidence in the language. Otherwise, it will be challenging to face the future”* *“Practice speaking should include a separate period for spoken English.”* *“Becoming more interactive between teacher and students may be the way to give more knowledge and proficiency in the English language among school learners.”* *“Drama, speaking activities, writing poetry, reading stories, watching YouTube videos with English subtitles ...”*

Meanwhile, *“emphasizing to study the English language along with other subjects,”* the participant highlighted the importance of creating an effective physical and mental learning environment. As per the suggestions, *“teachers have to make a better environment to practice English for students”*; therefore, *“first teachers have to change the mentality of students.”* The following answer is an example that

highlights the need for understanding among teachers on establishing a suitable mindset to learn English. *“Teachers speak like there is nothing more important than English, you are going to die without English, so every kid in the school like, no, I am not going to do it because you are forcing me to do it...”*

Thus, the participants have mentioned that the allocated time to study in the timetable is also insufficient to get a significant level of language proficiency. Meanwhile, one participant noted, *“teachers only care about the completion of textbooks, not to teach us even the basic grammar.”* At the same time, another said, *“most teachers tried to cover the syllabus but not to develop the language skills of students.”*

Interestingly, the participants who had education in private schools were fully content with their general education in English.

4. DISCUSSION

Considering the gathered information, it is understood that several aspects of ESL pedagogy must be improved to make the process more fruitful and efficient. Focusing on *the Sri Lankan ESL learners' autonomous learning exposure in the classroom*, the collected data indicates that, even though the teachers assign certain activities to learners, which are partially reasons to enhance their autonomous qualities in them, it is still questionable whether the teachers do these with a fundamental understanding of the values of independent learning and the exact necessity of inculcating autonomous behaviors among the learners. Moreover, it is questionable whether these activities are supportive enough to enhance the language requirements of the learners, as most of the assigned activities do not have the guidance and monitoring of the teachers.

Thus, Ellis (1999) in Al-Saadi, (2011b) also emphasize that the collectivity of language awareness, learning awareness, social awareness, cultural awareness, and metacognitive awareness are interrelated with autonomous learning. Therefore, teachers' thorough understanding and clear vision are crucial in fostering

autonomy among learners.

Considering the *teachers' readiness to foster learner autonomy in the classroom*, the identification that the teachers have not discussed the importance of L.A. with the students, continuing more teacher talk time, and maintaining the authority in the class among the teachers themselves indicates that the teachers do not encourage or create an autonomous supportive learning environment. Further, it suggests that the teachers are unaware of independent learning principles and are not ready to share the teaching and learning process responsibilities with the learners.

Finally, exploring *the student's satisfaction with the English education during school time and what suggestions they have to improve the local ESL school education*, it is understood that the teacher's primary concern is to complete the syllabus and prepare the students for the examinations. Therefore, the need to convince the learners that learning the English language is not a mere subject but a study throughout their life has not been fulfilled. This situation has further reason to neglect speaking and practical usage of the English language both in and outside the classroom. As a result, many students are backward in using English.

5. CONCLUSION

The pedagogical practices must be modified and changed with time, especially in language teaching and learning. Especially in a country like Sri Lanka, where primary and secondary education is being conducted in vernacular media and higher educational streams are being taught in English, the learners find it more challenging to study both language and the particular subject contents simultaneously.

However, the learners are not ready to accept responsibility for their learning automatically or at once. Therefore, the teachers have to play a significant role in helping the learners to perceive their new roles as active and independent learners by designing tasks and activities which will gradually assist learners in accepting responsibility and taking control over their learning.

Moreover, implementing autonomous skills will also bring awareness to minimize significant difficulties that most Sri Lankan learners have, such as limited resources, lack of space, limited hours allocated for a course, and union strikes. These challenges are typical for learners from school to higher education levels in Sri Lankan education.

Finally, the study's findings imply that now the time has come to shift from 'brick houses' to 'click houses,' which is to move from traditional bounds to modern out-of-bounds to do self-explorations and expand the horizons of wisdom. Especially the responsible authorities have to pay attention to designing the school curriculums for the English language and the teaching practices to be more student-centered like in many other developed countries. These amendments would make the local learners more autonomous in mastering the English language as lifelong learning.

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RELEVANCE OF ECONOMICS TEACHER EDUCATION CURRICULUM CONTENTS IN THE TEACHING OF SENIOR SCHOOL ECONOMICS IN NIGERIA

Bello, Muhinat Bolanle¹,

Department of Social Sciences Education, Faculty of Education,
University of Ilorin, Nigeria¹

ABSTRACT

No one subject is better than another. However, numbers and figures play a large role in how societies function. Economics is the study of the facts and figures that affect government, households, families, businesses, and the overall state of the world's resources. Thus much importance is attached to the learning and teaching of economics in our educational system, and the performance of students in secondary schools in Nigeria in this subject has remained an issue of concern to all stakeholders. This calls for why this study investigated the relevance of pre-service education economics curriculum contents in teaching senior school Economics in Nigeria. The study adopted a descriptive form of survey. Teachers of Economics in senior schools constituted the target population. They were sampled from private and public senior schools in Kwara state. There is a total of 302 economics teachers in Kwara State out of whom 217 were purposively sampled. Researchers designed a marching items questionnaire with psychometric properties of content validity, and a reliability index of 0.69 was used to elicit the needed data from the sampled respondents. The data collected were analysed using frequency and percentage mean. The finding revealed that the teacher education curriculum contents were very relevant in the teaching of senior school Economics. It was recommended that the content of economics education should remain as it is since it has catered well for the effective teaching of senior schools' Economics content.

KEYWORDS: *Relevance, Private, Economics, Teacher, Content and Senior-School*

Corresponding Author: *Bello, Muhinat Bolanle*, Email: bello.mb@unilorin.edu.ng

1. INTRODUCTION

Over the years, Economics has been one of the elective social science subjects taught in senior secondary schools in Nigeria. The need for Economics as a secondary school subject resulted from an increase in economic problems in modern society, and it was introduced to the Nigeria curriculum in the year 1966 and was first taken in the West African Examinations Council (WAEC) in the year 1967. It has witnessed an increase in enrolment since its introduction to secondary school because it is one of the prerequisites for gaining admission to social sciences and management courses in higher educational institutions.

Economics is concerned with human behaviour such as how people earn their living and make a choice between alternatives to satisfy their wants. It focuses on the study of firms and the government whose activities are geared to the production of goods and services for the satisfaction of human wants since economics is concerned with human behaviour. So, economics is a social science, and like any science subject, the reasoning procedure in economics is methodological, its analysis is systematic, and the validity of its various theories can be tested. Bernard in Adekeye (2021) described economics to be the study of how people and societies make decisions in the production, exchange, distribution and consumption of goods and services. Economics according to Kenton (2021) is concerned with how individuals, government, businesses and other organizations make choices that affect the allocation and distribution of scarce resources. Thus, an attempt has been made to integrate the theoretical foundations of the subject with their practical applications. The guiding principle of the Economics curriculum is based on the need to better equip graduates of secondary schools with the basic knowledge and skills that will enable them to better appreciate the nature of economic problems in any society. The underlying philosophy of this is to present Economics as a subject that has relevance to everyday life. This curriculum according to Osunnaiye in Adekeye (2021) has been designed by the Comparative Education Study and Adaptation Centre (CESAC) to meet the requirements of Economics in the new

system. This means that no subject of the present day is so important as economics. Economics governs the life of the individual, society and modern states. The subject plays a significant role in international affairs. The knowledge of economics helps in solving many problems and the study has practical advantages as follows in the curriculum as stated by the Nigerian Educational Research and Development Council as presented in table one.

Table 1: Contents of the Senior school economics curriculum (NERDC (2021)

S/No	Contents
1	DEFINITION AND SCOPE OF ECONOMICS: Scarcity and Choice, Scale of Preference, Opportunity Cost, Production Possibility Curve. Economic activities – Production, Distribution and Consumption. Classification of economic activities - Primary, Secondary and Tertiary and their relative contributions in terms of output /income, employment, savings, investment and foreign exchange.
2	FACTORS OF PRODUCTION Land, labour, capital and entrepreneurship-meaning, characteristics and importance.
3	TYPES AND BASIC FEATURES OF ECONOMIC SYSTEMS Types – capitalism, socialism and mixed economy. Basic features of each advantage and disadvantages of each. Economic problems of society and the approaches for solving them under each of the systems.
4	BASIC TOOLS OF ECONOMIC ANALYSIS Tables, graphs and charts. Some basic statistical measures and representations – arithmetic mean, median, mode and their simple applications.
5	DEMAND Concept of demand and law of demand, the demand schedules and curve, reasons for exceptional demand curves, types of demand (derived, composite, joint and competitive); factors determining the demand for goods and services – the price of the commodity, prices of other commodities, income, tastes, price expectation, etc. The distinction between a shift of and movement along a demand curve; is the concept of elasticity of demand. Types of elasticity of demand and their measurement – price, income and cross elasticities of demand: the importance of the concept of elasticity of demand to consumers, producers and government.
6	SUPPLY Concept of supply and law of supply, supply schedules and curve, types of Supply– composite,

	complementary and competitive. Factors determining supply – input prices, technology, prices of other commodities, climatic factors, etc. The distinction between the shift of and movement along the supply curve. Concept and measurement of elasticity of supply and its importance to producers and government
7	THEORY OF CONSUMER BEHAVIOUR The utility concepts- total utility, average utility, marginal utility and the calculation of utility schedules. The law of diminishing marginal utility, the relationship between total utility, average utility and marginal utility. The concept of equilibrium of a consumer. Determination of consumer equilibrium. The effects of changes in price on consumer equilibrium. The relationship between marginal utility and the demand curve.
8	THEORY OF PRICE DETERMINATION The Concept of the market; interaction between demand and supply. Price determination under free and regulated markets. Equilibrium price and quantity in product and factor markets. The effects of changes in supply and demand on equilibrium prices and quantities. Introduction to the algebraic determination of equilibrium price and quantity. Price controls: maximum and minimum price regulations- meaning and their effects; rationing, black market (parallel market)
9	THEORY OF PRODUCTION Production: division of labour and specialization: Scale of production (Internal and External economies), the concept of the total, average and marginal productivity and law of variable proportions.
10	THEORY OF COST AND REVENUE Cost concepts: total cost, average cost, marginal cost, variable cost, fixed cost; short-run and long-run costs. The distinction between economist's and accountant's views of cost (opportunity cost and money cost). Revenue concepts: total, average and marginal revenue; Marginal revenue Product.
11	MARKET STRUCTURES Concept of a market, characteristics of various market structures, determination of price and output under different structures - perfect competition and imperfect competition (monopoly and monopolistic competition). Review of cost and revenue concepts. Price discrimination.
12	BUSINESS ORGANIZATIONS Types and basic features of business enterprises – Sole Proprietorship; Partnership, Joint- Stock companies (Private and Public), Co-operatives; Statutory Corporation, Joint ventures. Sources of funds. General and basic problems of business enterprises. Privatization and Commercialization as solutions to problems of public enterprises. Indigenization and nationalization policies.
13	DISTRIBUTIVE TRADE Process of distribution, the role of producers, role

	of wholesalers, retailers and co-operatives: the role of government agencies in product distribution and the problems of distribution and their solutions.
14	POPULATION AND LABOUR MARKET Population - determination and implication of size and growth of population, Rural-urban migration, Malthusian theory of population Geographical, age, sex and occupational distribution. Importance and problems of the census. Population and economic development (under-population, optimum population and over-population). Labour Market, Concept of the labour force and human capital, efficiency and mobility of labour, factors affecting the size of the labour force, particularly the population characteristics (age, sex, occupation, education, etc.) supply of and demand for labour: wage determination. Concept of unemployment and underemployment, Trade Unions, Employers' association and Government policies on labour and wages.
15	AGRICULTURE: Structure (e.g. food crops, export crops, livestock, fisheries): systems of agriculture (peasant, commercial, co-operative and state farming); the importance of agriculture to the national economy: marketing of agricultural products (commodity boards). Agricultural policies (minimum agricultural prices) problems of agriculture and remedies.
16	INDUSTRIALIZATION Meaning and types of industry. Definition of industrial concepts: plant, firm, industry and industrial estates. Location of industry, localization, the role of industrialization in economic development. Strategies of industrialization. Problems of industrialization. The link between agricultural and industrial development.
17	NATIONAL INCOME Meaning of major national income concepts e.g. Gross Domestic Product, Gross National Product. Net National Product, etc. Different ways of measuring national income and their problems. Uses and limitations of national income data; trends and structure of national income.
18	MONEY AND INFLATION Money – definition and historical development- barter and its problems, types, characteristics functions. Supply of and demand for money, the value of money and the price level. Inflation: meaning types, causes, effects and control.
19	FINANCIAL INSTITUTIONS Types (traditional, Central Bank, Commercial Bank, Development Bank, Merchant Bank, Insurance Companies, Building Societies): development and functions of financial institutions. Money and capital markets; meaning, types and functions

20	PUBLIC FINANCE Fiscal policy and objectives of public finance: Sources of government revenue. Taxation -types (direct and indirect), objectives, merits, demerits and incidence; Principles/canons of taxation; Rates of taxation (proportional, progressive and regressive) direct and indirect taxation: incidence and effects of taxes, composition/ structure of public expenditure (recurrent and capital expenditure): effects of public expenditure. Government budget and the national debt.
21	ECONOMIC DEVELOPMENT AND PLANNING Meaning of economic development, the distinction between economic growth and development, characteristics and problems of developing countries, elements of development planning (objectives of planning, and problems of planning). Types of plans (short term, medium term, perspective or long term, rolling plan etc.).
s22	INTERNATIONAL TRADE AND BALANCE OF PAYMENTS International Trade: differences between domestic and international trade, the basis of international trade, absolute and comparative cost advantage, terms of trade (definition and measurement) commercial policy (objectives) and instruments – tariffs (types) and direct control. Trend and structure of West African countries’ external trade. Balance of Payments: role of money in international transactions, meaning and components of the balance of payments, the balance of payments disequilibrium, the balance of payments adjustments (exchange rate policy exchange control, monetary and fiscal policies) and financing (the use of reserves and international borrowing)
23	ECONOMIC INTEGRATION Economic Integration (objectives, levels of and features). Development and problems of economic integration in West Africa- ECOWAS
24	INTERNATIONAL ECONOMIC ORGANIZATION Development and role of: - Organization of Petroleum Exporting Countries (OPEC) - Economic Commission for Africa (ECA) - International Monetary Fund (IMF) -International Bank for Reconstruction and Development (IBRD) - African Development Bank (AfDB) - United Nations Conference on Trade and Development (UNCTAD) etc. relevance of such organizations to West African Countries.
25	MAJOR NATURAL RESOURCES Development of major natural resources (petroleum, gold, diamond, timber, groundnut etc) effects on West African economies (positive and negative)

These senior school economics curriculum contents are capable of equipping students with an in-depth understanding of core economic theory and with the ability to apply it to the real business world. Further, they help in developing in students a range of transferable skills, in communication, problem-solving, research, numeracy and time management (Jad, 2021).

It is said that economics comes after the English language and Mathematics (Azamosa, 2022). Therefore, when it is appreciated that economics became a secondary school subject in Nigeria in 1966, it may be said that the growth in its popularity as a subject in secondary schools in Nigeria has been great. When economics was introduced into the secondary school curriculum, its popularity grew rapidly because the first few schools which offered it in the West African School Certificate Examination [WASCE] had unexpectedly good results. There was a positive relationship between the quality of results in economics and the number of candidates that offered it in subsequent years in the WASCE.

Since 2012 there has been a concern raised by education stakeholders on the rate at which the performance of senior school students in public school dropped from high to low in external examinations such as the West African Examination Senior School Certificate and National Examination Senior School as well. Referring to the roadmap of education by a Non-Governmental Organisation named “the youth of Nigeria,” there was a report that West African Examinations Council (WAEC) 2011 results show an overall poor performance with only 26% per cent obtaining a credit pass in Mathematics and English (Waecdirect. com, 2011). In the same vein, the National Examinations Council (NECO) November/December 2011 results show 98% failing to clinch five credits, including Economics, English and Mathematics. Only 1.8% got five credits, including Economics, English and Mathematics. The subject of economics was not left out. The course of this development could not be curtailed but different researchers have come up with studies trying to find out factors that could be responsible for the poor performance. Some of their findings have pointed out that factors such as schools with poor structures,

inadequate facilities, inadequate textbooks, and inadequate instructional materials (Obiakor and Oguejioffor, 2019; Kpolovie, Ololube & Ekwebelem, 2017; Tsinidou, Gerogiannis, & Fitsilis, 2016 and Hansel, 2012). Another study revealed inadequate teachers teaching economics, that economics has not been handled by teachers who are professionals in the field (Boyd, Landford, Loeb, Rockoff, & Wyckoff, 2018; Aaronson, Barrow & Sander, 2017). Other researchers did not see the teacher as a contributing factor, and instead they pointed at the poor attitude of the Government, the poor interest of the students to study economics as well as the parents not giving adequate support to their children, as factors responsible for the poor performance of students in economics (Wentzel (2018).

This present study shifted from some of the factors already researched to looking at the curriculum that is produced by senior school economic teachers. Could it be that what the students were taught is at variance with the content is? That could be because the contents of the curriculum produced by the senior school economics teachers are not relevant to the contents they are to be taught to senior school students.

Economics teacher's education content over the years has been usually assumed to be that which can cater for the teaching of economics in Post basic schools, but it poses a challenge how the Economics teachers complain about how to get materials for teaching senior school economics students after completing their course of study in economics education (Melichar, 2018).

The concept of relevance according to Al-Bahrani, Holder, Patel and Sheridan, (2016) is the concept of one topic being connected to another topic in a way that makes it useful to consider the second topic when considering the first. The concept of relevance is studied in many different fields such as social sciences, and education among others.

Ajeyalemi (2010), reported that most of the teachers who graduated within the last 15 years were incompetent in the knowledge of the subject matter or content as well as in teaching. Two years after the foregoing report, Adeosun (2012), stressed that

teacher training institutions in Nigeria have been criticized for their inability to produce teachers who are properly grounded in subject matter, pedagogy and the ability to collaborate professionally in a working environment. Thus, Economics teacher trainees require specialized training in some aspects of Mathematics and Statistics education. These two studies are part of what motivated the present study, to confirm if truly the teacher training curriculum is a contributing factor to poor performance in economics. The curriculum of economics trainee teachers is presented in table two.

Table 2: Economics Education Curriculum Contents (National University Commission Benchmark 2020)

S/N	Contents
1	ECN 101: Principles of Economics I Nature and scope of economics. Production and exchange. Location and localization of industries. Price theory and its application. National income.
2	ECN 102: Principles of Economics II Analysis of money and banking. Elementary models of income and employment. Introductory concepts in international trade theory. Taxation and public expenditure. Introduction to budgeting and national development planning.
3	ECN 103: Introduction to Statistics I: Definition and scope of statistics. Basic concepts in statistics. Statistics in everyday life. Measurement and types of data in Economics. Sources, nature, uses and limitations of published economic and related statistical data in Nigeria. Methods of data collection: census and survey
4	ECN 104: Introduction to Statistics II: Techniques of data presentation: frequency distribution, tables, curves and cumulative frequency. Measures of central tendency and dispersion. Elementary probability theory. Standard and normal distributions.
5	ECN 105: Introductory Mathematics for Economics I: Mathematical Concepts in the Social Sciences. Set theory. Factors, surds and indices. Logarithms, equations, inequalities and functions. Sequences and elementary matrix algebra. Trigonometry: trigonometric functions and their inverse. Implicit functions. Permutations and combinations.
6	ECN 106: Introductory Mathematics for Economics II: Co-ordinate geometry. Introduction to calculus, differentiation and integration.

	Economic applications of differentiation and integration.
7	ECN 201: Microeconomics I: Basic concepts in microeconomics. Tools of economic analysis. Problems of scarce resources. Allocation of resources in product and factor markets. Equilibrium analysis. Demand and supply theory. The elasticity of demand and supply. Cobweb theory.
8	ECN 202: Microeconomics II: Introductory Dynamics. Utility approach to consumer behaviour. General equilibrium of exchange. Production theory. Theory of costs. Equilibrium under different market structures. Pricing of factors of production.
9	ECN 203: Macroeconomics I: Scope and Methodology. National income accounting. Macroeconomic aggregates of the classical and Keynesian systems. Monetarist system. Domestic economic stabilization.
10	ECN 204: Macroeconomics II: Macroeconomic theory of consumption, savings and investment. Money supply and demand. Monetary and fiscal policies. Price control and inflation.
11	ECN 205: History and Structure of the Nigerian Economy I: Analysis of the development of economic and social organizations in the pre-colonial and post-colonial periods. Role of agriculture, industry, money and banking, and international trade in Nigeria's economic development. Growth of income, employment, wages and prices. Public development institutions.
12	ECN 206: History and Structure of the Nigerian Economy II: National income and expenditure. Monetary and fiscal policies in Nigeria. Monetary institutions. Trade and transport systems. Contribution of sectors of the Nigerian economy to national output and their interrelationship. Role of national institutions. Economic development and social change.
13	ECN 301: Microeconomics III: Mathematical treatment of microeconomic theory using Linear programming. Advanced treatment of price and output determination under perfect competition, oligopoly, and monopoly.
14	ECN 302: Microeconomics IV: Mathematical treatment of the general equilibrium microeconomics. Exchange theory, offer and contract curves. Introduction to capital theory. Types of the production function.
15	ECN 303: Macroeconomics III: Concept of national income. Comparison of classical, Keynesian and monetarist system approach. Introduction to macro-rational expectation proposition and the Ricardian

	Equivalence hypothesis.
16	ECN 304 Macroeconomics IV: Problems of unemployment and inflation. ISLM analytical apparatus. Relative effectiveness of monetary and fiscal policies.
17	ECN 305: Econometrics and Research Methods: Definition and scope of econometrics. Stages of econometric research. Simple linear econometric model. Ordinary least squares estimator: multicollinearity, homoscedasticity and autocorrelation. Identification problem. Simultaneous equation models and the two-stage least squares method.
18	ECN 312: Public Policy 1: The general theoretical framework of public policy. Concept of the public sector. Pricing, investment and financing of public sector enterprises. Role and determinants of the size of the public sector.
19	ECN 314: Financial Institutions: Importance of money in the modern economy. Financial institutions. Relationship between central authority and financial institutions. Commercial, development and merchant banks. Non-bank financial institutions. Money and capital markets in less developed countries. International financial organizations.
20	ECN 401: Microeconomics V: Fundamental quantitative relationships. Optimization in theories of consumption and production. Dynamic analysis. Theory of the firm and its application to monopoly, oligopoly, monopolistic and perfect competition.
21	ECN 402: Microeconomics VI: Theories of determination of wages, rent, interest and profit. General equilibrium and disequilibrium. Welfare economics and notions of efficiency and equity. Externalities, social and private costs. Other areas of market failure.
21	ECN 403: Macroeconomics V: Statics, dynamic and general equilibrium. Models of income determination. Advanced theories of consumption, saving and investment. Theories of money and interest. General equilibrium in the product and money markets. Effectiveness of economic policy.
23	ECN 404: Macroeconomics VI: The Classical-Keynesian models of employment and output. Theories of inflation. Philips relation. Models of economic growth. Keynesian and monetarist interpretation of the trade cycle. New Classical macroeconomics.
24	ECN 410: Public Finance II: Areas of market failure. Taxation and resources allocation. Taxation: income inequality and equity. Tax structure, public expenditures, public debt, and public enterprise pricing. Inter-governmental fiscal relations. Budgeting and planning. Fiscal stabilization.

25	ECN 413 Issues in Development Development and under-development. Development theories. Economic and non-economic factors in development experience. Role of the state in promoting development. Problems and Policies of development. Prospects of Nigeria's development.
26	ECN 414: Econometrics: Introduction to the algebra of econometrics. General linear model and generalized least
27	ECN 416 Petroleum Economics Petroleum and the economy. Petroleum resources around the world. Optimum rate of oil extraction. Cost analysis. Price fixing. Role of Multinational Corporations in Nigeria's oil sector.
28	ECN 417 International Finance Coverage and measurements of the balance of payments in Nigeria. Adjustment policies. Foreign exchange market, exchange rate and key currencies. Transfer problems and capital movements in international services. International monetary systems.
29	ECN 418 International Economic Relations Structure and direction of Nigerian trade. Nigeria's policy on trade and payments. Export instability and consequences on the balance of payments. Payments adjustment in Nigeria. Nigeria and international organisations: Commonwealth, OECD, EU, IMF, World Bank. Nigeria and the ECOWAS.
30	ECN 419 Demography Definition of terms. Sources of data. Fertility measures and trends. Family planning. Mortality measure and trends. Life table. Migration: internal and international. Population: composition, growth, measurement and trends.
31	ECN 420 Public Policy II Relationship between the size of the public sector and economic development. Analysis of selected public policies in Nigeria: monetary, exchange rate, public debt, developmental, industrial and other policies.
32	ECN 421 Nigerian Public Finance Main issues in Federal finances. Structure of public revenue and expenditure. Intergovernmental transfer and regional/state revenues. Problems of public debt in Nigeria. Budgetary processes of Nigerian governments.
33	ECN 423: Economic Planning I: The rationale for planning. Origin and types of planning. Planning machinery and processes. Planning data. Plan implementation and performance. Development planning in Nigeria. Planning experiences of other countries.
34	ECN 424: Economic Planning II: Planning models and social accounting framework. Planning techniques: input-output analysis and linear programming. Resource projection and consistency test. Programme balancing.

From the curriculum, highly qualified senior school teachers are expected for effective teaching of economics. The relevance of economics teachers' education curriculum contents to senior school economics curriculum contents was, therefore, examined in this work to establish if the content of teachers' education content successfully takes care of all topics in the senior school economics content.

Purpose of the Study

The study investigated the relevance of economics teacher education contents for teaching senior school economics in Nigeria.

Research Questions

The research question for this research was to investigate: How relevant are the contents of economics teachers' education to teaching senior school economics?

Literature Review: Concept of Economics

Economics is a social science that studies how individuals, governments, firms and nations make choices on allocating scarce resources to satisfy their unlimited wants. Economics can generally be broken down into macroeconomics, which concentrates on the behaviour of the aggregate economy; and microeconomics, which focuses on individual consumers (Brinia & Vikas, 2014). When teaching Economics in Senior High School, teachers are facing various problems in trying to make their students understand basic economic terms and their application in everyday life. As a result, to overcome such problems, teachers need to discover and apply new teaching methods that are compatible with the needs and abilities of their students. One teaching method that seems to appeal to students' interests is teaching through art.

Economics is one of the subjects taught at the higher secondary school level. As it can be understood in its most basic description by Robbins, it is significant to both students and civilization since it cuts across all axes of human endeavor. It can be understood in its simplest definition by Robbins, "...thus economics as

a science which studies human behaviour as a relationship between ends and scarce means which have alternative uses....” By this definition, Robbins (1935) emphasized economics as a science and that economic investigation would be based on positive and logical methods rather than normative with vague judgments. The important ideas of teaching and learning economics in the classroom are to help the basic stage student master the principles vital for understanding financial problems and precise economic issues. The policy alternatives help the students understand and then apply the economic perspective and also reason accurately and empirically about economic matters. This promotes lasting student interest in economics and the economy (McConnell, Brue, & Flynn, 2010).

According to the National Council of Educational Research and Training, India (NCERT, 2005) “the answer to the question; why economics is taught in schools is not only essential in answering students but also for the teachers when they teach economics in schools. Teachers are likely to understand why economics is taught so that they can plan the classroom activities effectively”. The details of opinions would also help in understanding the content topics and subtopics and why they are included in the curricular content. The aims of teaching economics at the higher secondary stage are: making students understand some basic economic concepts and developing economic reasoning so that learners can apply it to their daily lives as citizens, workers and consumers; enable learners to realize their role in the country building and sensitize them to the economic issues that the nation is facing today, to equip learners with the basic tools of economics and statistics to analyze economic issues. This is pertinent to even those who may not pursue this course of the higher secondary stage; and to develop an understanding among students that there can be more than one view on any economic issue and to develop the skills to argue logically with reasoning (NCERT, 2005).

Concept of Economics Teacher Education

Economists believe that the decisive input in the economic development matrix of any nation is human

capital development through the education of the citizenry. Education is activities that deal with teaching and learning practice in schools or colleges to inculcate knowledge and develop skills (Hornby, 2006). Education is deemed to have been a crucial factor in the growth and development index of advanced economies of the world. Teacher education is an investment in human capital and should be thorough and qualitative. According to Akindutire and Ekundayo (2012), every nation labours for the provision of quality education for its citizens, and education is needed to engineer and consolidate any nation’s development process. One of the goals of teacher education in Nigeria is to update teachers especially Economics teachers with the intellectual and professional background adequate for their duty and make them versatile to changing situations (the Federal Republic of Nigeria, (FRN), 2004). As if in a refrain, Utulu, (2010) noted that it is not enough to produce teachers who collect facts but teachers who find meaning in facts and help students to do so. As per the teaching practices programme which is a core part of teacher preparation, Mahamud (2017) investigated the dependability of pre-service teachers’ scores in teaching practices courses in a Nigerian University. The study submitted that the quality of pre-service teachers’ scores in teaching practice scores I and II was not relevant to the reality of the teaching profession, thereby recommending an increase in the number of occasions and raters for better teaching practice programmes.

Colander (2001) posited that Economics deals with how human beings coordinate their wants and employ the decision-making mechanisms, customs and socio-political actualities of the society, stressing that economic reasoning once learned is infectious and offers one the possibility of making rational decisions even in things that do not concern the scope of Economics. Economics noted by Hall (2013) is the study of how individual firms and whole societies identify their most important needs and allocate and manage scarce resources to satisfy as many needs as possible. This means that a well-trained Economics teacher should not merely furnish students with the knowledge of Economics education; the teacher should be able to help the student make an appropriate transfer of learning from theoretical

abstraction to real-life situations. When this becomes possible, Economics will make the desired impact on the Nigerian economy. Presently, its impact is significantly negligible relative to the myriad of economic challenges facing Nigeria in this millennium of the global quest for increased growth and development.

Economics is also plagued by other factors responsible for the state of falling standards witnessed in almost all subjects taught at the post-basic schools level in Nigeria. According to the WAEC Chief Examiner's Report (2015), the result of Nigerian students in post-basic schools during the May/June 2014 West African Secondary School Certificate Examination (WASSCE) showed that out of the 1,705,976 candidates that sat for the exam, 1,176,551 had their results below the minimum requirements for admissions into the University (Dike, 2014). Economics teacher trainees require intensive and extensive training to enable them to improvise the needed instructional materials. In the same vein, Economics teacher trainees require adequate knowledge and applicability of Information and Communication Technologies (ICTs) in Economics instructional delivery in recent times. Financial difficulties also face not only Economics teacher trainees but the Nigerian Education industries and the entire country. Nigeria is suffering from perennial poverty, which underscores the character of contemporary global development (Umezurike, 2013).

Besides, the globalization and technological competitiveness of this present millennium presuppose that Economics teacher trainees encounter challenges due to innovation and technology. According to Akindutire and Ekundayo (2012), globalization is a big challenge to teachers in this present age and for teachers to operate effectively, teachers need to update themselves on new technologies and methodologies of the advanced countries of the world.

Theoretical Framework

The study is based on Weiner's (1992) attribution theory. The concept of attribution describes the

cognitive process by which a person perceives the cause of what has happened to him/ her either as caused by himself/herself or by others (Kahn 2001). According to the attribution theory, we tend to explain the causes of success or failure to either internal or external factors. That is, we succeed or fail because of factors that we believe have their origin with us or because of factors that originate in our surroundings. An important assumption of the attribution theory is that we will interpret our environment in such a way as to maintain a positive self-image. That is, we will attribute our successes or failures to factors that will enable us to feel as good as possible about ourselves. For example, when learners succeed in an academic task, they are likely to attribute the success to their efforts or abilities and when they fail, they will attribute failure to factors over which they have no control, such as lack of resources.

Weiner's attribution theory applies to this study in that senior school economics students are most likely to attribute their high failure in Economics to external factors like, their economics teachers are incompetent and not serious when teaching and to internal factors like not working hard or having a negative attitude towards Economics.

2. METHODOLOGY

The study adopted a descriptive form of survey to investigate the relevancies of the curriculum contents of economics teachers' programmes to the effective teaching of senior school economics contents. The population for the study were Economic teachers, teaching economics in senior schools. They were sampled from both private and public senior schools in Kwara state. There is a total of 302 economics teachers in Kwara State out of which 217 were purposively sampled. A marching items questionnaire was designed by the researcher, which was used to elicit the needed data from the sampled respondents. It was validated for contents validity and a split-half reliability approach was employed and a reliability index of 0.69 was obtained. The data collected was analysed using a percentage mean.

3. RESULTS

The acceptance relevancy level of the economics education curriculum contents in this study is 70%. Therefore, economic education curriculum content that is less than 70% was regarded as irrelevant while that which is above 70% was regarded as relevant. This is in line with Mahamu's (2017) submission on the benchmark for acceptable generality level for the generalizability coefficient and dependability coefficient.

Table 3: Percentage response of Relevant Economics Education curriculum to the teaching of senior school economics

Contents	Relevant (%)	Not Relevant (%)	Remark
ECN 101: Principles of Economics I	92.3	7.7	Relevance
ECN 102: Principles of Economics II	80.8	19.2	Relevance
ECN 103: Introduction to Statistics I	75.0	25.0	Relevance
ECN 104: Introduction to Statistics II	82.7	17.3	Relevance
ECN 105: Introductory Mathematics for Economics I	86.5	13.5	Relevance
ECN 106: Introductory Mathematics for Economics II	86.5	13.5	Relevance
ECN 201: Microeconomics I	92.3	7.7	Relevance
ECN 202: Microeconomics II	86.5	13.5	Relevance
ECN 203: Macroeconomics I	92.1	7.9	Relevance
ECN 204: Macroeconomics II	78.1	21.9	Relevance
ECN 205: History and Structure of the Nigerian Economy I	84.6	15.4	Relevance

ECN 206: History and Structure of the Nigerian Economy II	73.1	26.9	Relevance
ECN 301: Microeconomics III	81.2	18.8	Relevance
ECN 302: Microeconomics IV	89.9	13.1	Relevance
ECN 303: Macroeconomics III	73.1	26.9	Relevance
ECN 304: Macroeconomics IV	86.9	13.1	Relevance
ECN 305: Econometrics and Research Methods	82.7	17.3	Relevance
ECN 312: Public Policy 1	90.4	9.6	Relevance
ECN 314: Financial Institutions	88.5	11.5	Relevance
ECN 401: Microeconomics V	84.6	15.4	Relevance
ECN 402: Microeconomics VI	82.7	17.3	Relevance
ECN 403: Macroeconomics V	86.8	13.2	Relevance
ECN 404: Macroeconomics VI	75.0	25.0	Relevance
ECN 410: Public Finance II	75.0	25.0	Relevance
ECN 413 Issues in Development	67.3	32.7	Irrelevance
ECN 414: Econometrics	81.1	18.9	Relevance
ECN 416: Petroleum Economics	74.2	25.8	Relevance
ECN 417: International Finance	82.0	18.0	Relevance
ECN 418: International Economic Relations	90.3	9.7	Relevance
ECN 419: Demography	74.1	25.9	Relevance
ECN 420: Public Policy II	83.1	16.9	Relevance
ECN 421	80.0	20.0	Relevance

Nigerian Public Finance			
ECN 423: Economic Planning	88.6	11.4	Relevance
ECN 424: Economic Planning II	91.0	9.0	Relevance
Grand Mean			80.53

Table 3 shows respondents' responses on the relevance of the economics education curriculum to the teaching of senior secondary economics curriculum in Nigeria. It is clear from the data that only ECN 413: Issue in Development, which was regarded irrelevant in this study, had 67.3 percent of respondents agree among the 34 economics courses that economics education trainees are exposed to at the university. While all other courses (33 of them) are thought to have a relevant level of greater than 70. It is also noted that the grand mean for the relevancy of the economics education curriculum to senior school economic curriculum is 80.53%. Therefore, it could be said that the economic education curriculum is relevant to teaching senior school economics in Nigeria.

4. DISCUSSION

Findings from the study indicated that teacher education contents were very relevant for the effective teaching of senior school economics. It means that the curriculum contents of the University Commission prepared in the preparation of economics teachers is close to being perfect in the production of qualified and well-trained teachers to handle effective teaching of economics content at senior school in Nigeria. This is because to teach senior school economics contents the teacher is required to have the knowledge of the disciplines in terms of their subject areas, which will consist of an understanding of key facts, concepts, principles, and the frameworks of a discipline, as well as the rules of evidence and proof that are part of that discipline. All of these are embedded in the teacher education programme as revealed by the study. This finding contradicts Mahamud's (2017) submission that the quality of pre-service teachers' scores in teaching practices courses I and II is not relevant to the reality of the teaching profession. And also the findings of

Omosewo (1991) revealed there is a lack of relevance between the curriculum contents of the Physics teacher education programme and that of the senior school contents, which means that the content of Physics education that is being run in teacher education programmes cannot help in the production of physics teachers required to teach Physics effectively in Nigerian senior schools, which means that the poor performance of senior school students in Economics has nothing to do with the preparation of economics teachers. Teachers' quality through their training and the courses they are exposed to is very relevant and highly related to helping them in the effective teaching of a senior school student. So other factors or a combination of factors may be responsible for the poor performance.

5. CONCLUSION

A good teacher education content would lead to the production of good and competent teachers as was evident in the present study. It was based on this that the study recommends:

- a. Economics teacher education content as it is at the moment can cater to effective teaching of senior school's economics content. Therefore, the content of economics education should remain as it is since it catered well to the needs of senior schools' economics content.
- b. The modifications that could be done to the teacher education contents should be to include recent happenings in the world's economics in relevant courses to make the teaching and learning of economics relevant and timely to students and teachers.

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HEART DISEASE RISK IDENTIFICATION USING MACHINE LEARNING TECHNIQUES FOR A HIGHLY IMBALANCED DATASET: A COMPARATIVE STUDY

Fernando C.D.¹ Weerasinghe P.T.² and Walgampaya C.K.³

Computing Centre, Faculty of Engineering, University of Peradeniya,
Peradeniya, Sri Lanka¹

Department of Statistics and Computer Science, Faculty of Science,
University of Peradeniya, Peradeniya, Sri Lanka²

Department of Engineering Mathematics, Faculty of Engineering,
University of Peradeniya, Peradeniya, Sri Lanka³

ABSTRACT

Heart disease has become one of the most prevailing universal diseases in the world today. It is estimated that 32% of all deaths worldwide are caused due to heart diseases. One of the major causes for this is that its extremely difficult even for medical practitioners to predict heart diseases as heart attacks as it is a complex task which requires a great amount of knowledge and experience. The number of deaths caused by heart diseases has hugely increased in the recent past. Machine learning has become one of the most popular areas in computer science where many complex problems have been addressed successfully specially in the field of medicine. In this study we trained multiple supervised classifiers namely; Naïve Bayes, LightGBM, Decision Trees, Random Forest, XGBoost, K Nearest Neighbours and ADABOOST and we compared the accuracies and identified what models perform better for heart disease prediction. We used the Behavioral Risk Factor Surveillance System (BRFSS) 2015 Heart Disease Health Indicators Dataset which was highly imbalanced and in order to address the class imbalance problem we used methods such as Synthetic Minority Over Sampling Technique (Smote) Sampling, Adaptive Synthetic Sampling, Random Over Sampling, Random Under Sampling, TomekLink, SmoteTomek, Smoteen and Cluster Centroid. According to the results obtained, we can conclude that the hybrid models such as Smoteen and SmoteTomek performed better than the other sampling methods.

KEYWORDS: *Heart Disease, Machine Learning, Class Imbalance, Sampling methods*

Corresponding Author: Fernando C.D. Email: fchanna2853@gmail.com

1. INTRODUCTION

Cardiovascular diseases (CVD's) have been the leading cause of death globally with an estimate of 17.9 million dying every year as mentioned by the World Health Organization (WHO). CVDs are a group of disorders of the heart and blood vessels and include coronary heart disease, cerebrovascular disease, rheumatic heart disease and other conditions. One of the major reasons for such an increase in the number of deaths can be caused due to unhealthy diet, physical inactivity, tobacco use and harmful use of alcohol. The behavioral risk factors might show up in people due to raised blood pressure, raised blood glucose, raised blood lipids, and overweight and obesity. The risk factors can be measured in primary care facilities and indicate an increased risk of heart attack, stroke, heart failure and other complications. Prevention of tobacco use, reduction of salt in diet, eating more fruits and vegetables, regular physical exercises and avoiding harmful use of alcohol have shown to reduce the risk of cardiovascular disease. Identifying people at highest risk of CVD's and making sure that early symptoms are detected and treated can prevent premature deaths. But, diagnosis is a major problem for practitioners as the nature of the symptom is similar to other conditions and are often confused with signs of aging.

The growth of data in the field of medicine has given new opportunities for physicians to improve patient diagnosis.

There is a great deal of interest in employing computer technologies to enhance decision support and offer solutions to challenging issues in the field of medicine, especially with the development of computer science and the quick rise of Artificial Intelligence, Machine Learning, and Computer Vision. Machine learning has become one of the most popular methods used to diagnose, detect and forecast many cardiovascular disorders. This has given the opportunity to identify new ways to predict heart diseases by detecting and treating symptoms at an early stage. In this study, we train multiple classifiers both supervised and unsupervised and compare the accuracies to identify which machine learning algorithms perform better in heart disease detection.

The main contributions of our study are given below:

- Address the class imbalance problem of real world medical datasets by applying many statistical methods on sampling techniques in order to obtain higher accuracies for our models.
- Identify which classification algorithms are suitable for corresponding statistical sampling methods.
- Identifying the statistical sampling methods used to address the class imbalance problem that are able to obtain the highest accuracies.

2. LITERATURE REVIEW

Boshra Bahrami (2015) evaluated a standard dataset acquired from a hospital in Iran containing 209 records and 8 features with different machine learning classifiers in heart disease diagnosis. Since this dataset doesn't contain missing values, they have straight away selected features using both Gain Ratio Attribute Evaluated and Ranker Search methods. Then using the WEKA data mining tool, the data set was applied to four machine learning algorithms by using 10-fold cross-validation. (J48 Decision Tree classifier, K Nearest Neighbor classifier, Support Vector Machine classifier, and Naive Bayes Classifier) Finally, they measured the accuracy, precision, sensitivity, specificity, F-measure, and the area under Receiver Characteristic Operator (ROC) curve. The J48 Decision Tree classifier showed the best results by achieving higher values for the above-mentioned parameters.

Asha Rajkumar (2022) employed the "Tangara" data mining tool which comes in handy with a graphical user interface to compare the performance of selected supervised machine learning algorithms. The training dataset consists of 3000 samples and 14 features for each instance. Naive Bayes Classifier, K Nearest Neighbor classifier, and Decision List algorithms were applied to the above data set using the Tangara data mining tool. As for the analysis results, the Naive

Bayes algorithm showed the best performance in terms of the computation time, the accuracy, the left ventricle hypothesis, the normal and the stress abnormal statistical parameters.

Choosing the best features out of the dataset is one of the important facts that decide the accuracy of the data analysis results Jian Ping L (2021). In this study he proposed a fast conditional mutual feature selection algorithm (FCMIM) to select the best features out of the raw dataset. In this method, by applying Conditional Mutual Information (CMI), each feature is given a score with respect to the output class and other features and selects the best features out of them. The newly developed feature selection method and existing feature selection methods (Relief Algorithm, Minimal Redundancy Maximal Relevance Algorithm, Least Absolute Shrinkage Selection Operator Algorithm, Local Learning Based Features Selection Algorithm) were applied to the “Cleveland Heart Disease “dataset which consists of 303 instances with 75 features. The preprocessed outputs of each algorithm are then fed to selected machine learning classifiers and calculated by several statistical parameters to compare the performance of each feature selection method. The Proposed feature selection method (FCMIM) with Support Vector Machine Classifier showed the highest accuracy compared to the other mentioned algorithms.

Selecting the best features and balancing the output classes can greatly improve the data analysis results of a dataset. Abid Ishaq (2020) used a heart failure dataset to improve the heart disease patient survivor prediction. They employed Decision Tree (DT), Adaptive boosting classifier (AdaBoost), Logistic Regression (LR), Stochastic Gradient classifier (SGD), Random Forest (RF), Gradient Boosting classifier (GBM), Extra Tree Classifier (ETC), Gaussian Naive Bayes classifier (G-NB), and Support Vector Machine (SVM) machine learning algorithms and compared output results. In the proposed approach, the Random Forest Algorithm is used to select features and the Synthetic Minority Oversampling Technique (SMOTE) is used to balance the output class and then analyzed the outputs of the selected machine learning algorithms. In comparison to the original data set, the findings demonstrated that

the ETC classifier had the maximum accuracy when the suggested data pretreatment technique was used.

Norma Latif Fitriyani (2020) proposed an Effective Heart Disease Prediction Model (HDPM) as a Clinical Decision Support System (CDSS) to identify heart diseases in the earlier stages. In this system, they used a Density-Based Spatial Clustering of Applications with Noise (DBSCAN) to remove outliers from the dataset. Then applied Synthetic Minority Oversampling Technique-Edited Nearest Neighbor (SMOTE-ENN) algorithm to solve the class imbalance problem. As for the data analysis algorithm, they employed Extreme Gradient Boosting (XGBoost) to train the dataset. Applying the proposed system with the “Statlog” and the “Cleveland” dataset they achieved 95.90% and 98.40% accuracies respectively. To help medical professionals better diagnose patients, this proposed system has been implemented as a Heart Disease Clinical Decision Support System (HDCDSS).

3. METHODOLOGY

Behavioral Risk Factor Surveillance System (BRFSS) is one of the major surveys conducted in the United States of America (USA). BRFSS interviewed around 400,000 adults each year and remotely over the telephone. The questions are based on health-related risk behaviors, chronic health conditions, and the use of preventive services. This survey is conducted in all states of U.S.A., the District of Columbia, and three other U.S. territories (Snead 2020).

The data set used in this study is the data from the 2015 BRFSS report. The original data contains 441,455 responses regarding risk factors for heart disease with 330 features. The cleaned data set contains 253,680 instances with 21 quantitative features. This data set doesn't contain any missing values. The output is a binary class containing 229,787 responses from people who didn't have heart disease and the rest of 23,893 responses from those who suffered from heart disease.

The features of this dataset are given in table 2 below. The following are the final outputs of the dataset.

0 = No high blood pressure

1 = High blood pressure

Class Imbalance

A data set is considered “imbalanced” when the output classes show a skew distribution. The output classes with a higher number of samples are called “majority classes” while the classes which have a fewer samples are called “minority classes”. But this class imbalance does not affect the results of the classification algorithms (M Galar 2012).

In this dataset, the number of people who haven’t suffered from heart disease is very high compared to the people who have. The ratio between those two is 9.62%.

Table 1: Dataset Output Classes

Category	Number of Samples
Had not suffered from heart disease (0)	229,787
Suffered from heart disease (1)	23,893

Since the machine learning classification algorithms expect a balance between minority and majority classes, this class imbalance has to be addressed before fetching the dataset into any machine learning algorithm. If the class imbalance is not addressed properly, the classification algorithms will show higher accuracy for the majority classes and poor accuracy for the minority classes.

The results of the algorithm will be biased towards the majority class, while the minority class will be almost neglected (Sing A. 2015). There are mainly three methods to solve class imbalance.

- Over Sampling.
- Under Sampling.
- Hybrid Sampling (Combination of Over Sampling and Under Sampling).

Over Sampling.

Oversampling methods try to increase the number of samples in the minority class by adding new synthetic samples into the minority class. This will improve the ratio between minority and majority classes thus balancing both classes equally. To achieve this, there are a lot of methods that are being used in many studies. Some of the techniques just replicate existing samples and balance classes and some techniques generate synthetic samples by creating new samples with different strategies (Rančić S. 2021). These oversampling methods can help to improve the performance of the machine learning models (Kovács G. 2019). In this study, we have used the following over sampling techniques on the dataset.

ROS: Random Over Sampling.

This is a simple process to increase the minority class size by duplicating randomly selected data samples from the minority class depending on the amount of oversampling that is needed. Since it just duplicates existing samples, this might lead to an increase in the overfitting of the classification algorithm (Ling. 1998).

SMOTE: Synthetic Minority Over-Sampling Technique.

This is a synthetic minority over sampling technique. Here, the minority class samples are artificially generated by considering the “feature space” of the dataset and its nearest neighbours. These synthetic samples balance the ratio between the minority and majority classes without changing the majority class. SMOTE first identifies the feature vector and its nearest neighbours and then takes the difference of the distance between them. The number of nearest neighbours can be selected depending on the amount of oversampling required. Then the difference is multiplied by a random number and is identified as a new data point on the line between them. The same procedure follows until both classes are balanced (Chawla 2002).

Table 2: Features of the Data Set

Feature	Data Type	Data Range
High Cholesterol	Binary	0 = No high cholesterol 1 = High cholesterol
Cholesterol Check	Binary	0 = Hasn't checked cholesterol within past five years 1 = Has checked cholesterol within past five years
BMI	Numeric	[12,98]
Smoking	Binary	0 = Has smoked more than 100 cigarettes. 1 = Hasn't smoked more than 100 cigarettes
Stroke	Binary	0 = Hasn't suffered from a Heart Stroke 1 = Has suffered from a Heart Stroke
Diabetes	Numeric	0 = No Diabetes 1 = Diabetes 2 = Only during the pregnancy
Physical Activity	Binary	0 = Hasn't exercised during the past 30 days 1 = Has exercised during the past 30 days
Fruit	Binary	0 = Hasn't consumed at least 1 fruit per day 1 = Has consumed at least 1 fruit per day
Vegetable	Binary	0 = Hasn't consumed at least 1 vegetable per day 1 = Has consumed at least 1 vegetable per day
Alcohol Consumption	Binary	0 = Men: Less than 14 drinks per week Women: Less than 7 drinks per week 1 = Men: more than 14 drinks per week Women: more than 7 drinks per week
Health Care is covered by a Health Insurance.	Binary	0 = No 1 = Yes
Did not meet a doctor during the past 12 months due to financial issues	Binary	0 = No 1 = Yes
General Health Rating	Numeric	[0,5]
Mental Health Rating	Numeric	[0,30]
Physical Health Rating	Numeric	[0,30]
Difficulties in walking	Binary	0 = No 1 = Yes
Sex	Binary	0 = Female 1 = Male
Age	Numeric	[1,6]
Education	Numeric	[0,30]
Income	Numeric	[1,8]

ADASYN: Adaptive Synthetic Sampling.

ADASYN is also a nearest neighbour based algorithm which is similar to the SMOTE algorithm.

The main difference between them is the ADASYN focuses more on the minority data samples which are

harder to learn rather than easier to learn data samples. And also, in the SMOTE, it just picks new data points along the straight lines between neighbours. But the ADASYN algorithm looks deeper into the nearest neighbour region by considering the majority class data points inside the region. ADASYN generate synthetic samples only if there are majority samples

inside the neighbour region (Bai 2008).

Under Sampling.

Under sampling techniques focus on the majority class and try to balance both classes by eliminating samples from the majority class. But this might lead to losing important data about the dataset. Hence, this causes to reduce the performance of the machine learning models (Kotsiantis, 2006). If the ratio between minority and majority classes is high, this can cause a lack of data for the analysis. Since these methods drop samples from the majority class, the randomness of the dataset no longer exists. Thus, the representation of the original target distribution cannot be expected by that the sample.

RUS: Random Under Sampling.

In this under sampling technique, the class imbalance problem is solved by removing samples randomly from the majority data set until two sets are balanced. This can lead to loss of valuable information about the dataset hence reducing the accuracy of the predictions (Yen S.J. 2006).

TOMEK: Tomek Link Under Sampling

Tomek links (Tomek I. 1976) can be defined as follows: given two examples E_i and E_j belonging to different classes, and $d(E_i, E_j)$ is the distance between E_i and E_j . This pair is called a Tomek link if there is not an example E_l , such as that $d(E_i, E_l) < d(E_i, E_j)$ or $d(E_j, E_l) < d(E_i, E_j)$. These Tomek Links can be used as a Under Sampling method to remove the majority class samples to balance the data set. If we want to use this approach as a data cleaning method, we can remove both samples from the majority and minority classes if the above condition for Tomek Link is satisfied.

Cluster Centroid Under Sampling

As per Cluster Centroid Under Sampling method, first the whole data set is divided into some distinct clusters using k means clustering algorithm. Then those clusters are classified by considering the ratio between minority class samples and majority class samples. Initially, the number of cluster samples was set equal to the number of samples in the minority class. Then

by using the k mean algorithm, cluster centroids are calculated over the majority class. The calculated cluster centroids are used to replace the entire majority class. This procedure continues until both classes are balanced (Yen, 2009).

Hybrid Sampling

Hybrid Sampling is a combination of the Over Sampling and Under Sampling techniques. Over Sampling increases the data size by adding synthetic information to the minority class while Under Sampling removes data points from the majority class causing a loss of information. A portion of the sampling in the hybrid approach is carried out using oversampling techniques, and the remaining piece is carried out using undersampling techniques. This approach leads to improving the strengths of each technique by reducing the drawbacks (Seiffert, 2009). Many studies have shown that this approach improves the overall performance of the classification algorithm drastically.

SMOTETomek: SMOTE + Tomek Link

This hybrid approach combines SMOTE as an over sampling method and Tomek Link as an Under Sampling method (Wang Z.H.E. 2019). First, the SMOTE sampling is used to generate a new synthetic sample set. Then the newly created data set is processed with Tomek Link to remove Tomek Link pairs from the dataset. The resulting dataset is a balanced dataset with a reduced overlapping between data points.

SMOTEEN: SMOTE + ENN

This is also a hybrid version of the SMOTE over sampling method and the Edited Nearest Neighbour (ENN) under sampling method. In this method, the minority class and the majority class are balanced by using SMOTE technique. Then the balanced dataset is applied to ENN under the sampling process as a cleaning mechanism to eliminate noises generated by the SMOTE while introducing new synthetic samples (Srivastava, 2022).

Data Classification

Applying different Sampling methods discussed in the above section on the BRFS dataset, we obtain

different balanced datasets for each sampling method. All the generated sample sets are divided into two portions. 70% for training and 30% for testing. Then we employed the following supervised machine learning algorithms to evaluate and compare the performance of each sampling technique.

1. K Nearest Neighbour (KNN) Algorithm.
2. Gaussian Naïve Bayes (Gaussian NB) Algorithm.
3. Decision Tree (DT) Algorithm.
4. eXtreme Gradient Boosting (XGBoost) Algorithm.
5. Light Gradient Boosting Machine (LGB) Algorithm.
6. Adaptive Boosting (ADABOOST) Algorithm.
7. Random Forest (RF) Algorithm.

4. RESULTS

In order to analyze the results of our study and to compare the accuracies we will use the confusion matrix and also metrics such as precision, recall, and f1-score.

We will analyze the performance of each machine learning algorithm by evaluating the following statistical parameters.

Confusion Matrix.

The confusion matrix has four important parameters to summarize the performance of the machine learning classifier.

1. TP (True Positive): The total number of data samples where the model correctly predicts the positive class.
2. TN (True Negative): The total number of data samples where the model correctly predicts the negative class
3. FP (False Positive): The total number of data samples where the model incorrectly predicts the negative class
4. FN (False negative): The total number of data samples where the model incorrectly predicts the positive class

Accuracy.

This represents the baseline performance of the classification model. This is calculated by taking the

ratio between correctly predicted classes (TP + TN) and the total number of samples.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

Precision.

This is referred to as the false positive rate. This is calculated by taking the ratio between correctly predicted positive class (TP) and the total number of positive predictions (TP + FP).

$$Precision = \frac{TP}{TP + FP}$$

Recall:

Recall or Sensitivity is calculated by taking the ratio between correctly predicted positive class (TP) and the total number of actual positive samples.

$$Recall = \frac{TP}{TP + FN}$$

Mathews Correlation Coefficient (MCC)

This is a balanced method of all the parameters of the confusion metrics. This can be used even when the class sizes are not equal.

MCC

$$= \frac{TP * TN - FP * FN}{\sqrt{(TP + FP)(TP + FN)(TN + FP)(TN + FN)}}$$

F1 Score:

This is a mean indicator of the precision and recall of the dataset. This is calculated by taking the harmonic mean of both parameters.

$$F1\ Score = \frac{2 * Recall * Precision}{Recall + Precision}$$

The preprocessed dataset was applied to the above machine learning algorithms in Python version 3.8. The following libraries were utilized in the classification process.

- Pandas version 1.4.4.
- Sklearn version 1.1.2.
- Seaborn version 0.12.
- Matplot version 3.5.3.
- Imbalanced learn 0.9.1.

By applying all the sampling methods mentioned earlier in the dataset with above mentioned machine learning algorithms, we calculated the accuracies,

recall values, MCC values, and F1 values for each case and presented them in the following tables:

Table 3: Confusion Matrix

		Predicted Value	
		Has/had a heart disease	Doesn't have/ Didn't have a heart disease
Actual Value	Has/had a heart disease	True Positive (TP)	False Negative (FN)
	Doesn't have/ Didn't a heart disease	False Positive (FP)	True Negative (TN)

Table 4: Accuracy values for Sampling methods.

Algorithm	SMOTE	ADSYN	ROS	RUS	TOMEK	CLUSTER	SMOTEK	SMETEEN
KNN	0.8573	0.8524	0.8772	0.7208	0.8970	0.6300	0.8595	0.9543
GNB	0.7512	0.7437	0.7279	0.7244	0.8240	0.8000	0.7513	0.8128
DT	0.9155	0.9166	0.9497	0.6737	0.8532	0.9349	0.9177	0.9441
XGBOOST	0.9477	0.9478	0.7969	0.7661	0.9052	0.9669	0.9487	0.9607
LGBOOST	0.9436	0.9446	0.7780	0.7700	0.9072	0.9685	0.9445	0.9576
ADABOOST	0.9050	0.9046	0.7698	0.7678	0.9091	0.9601	0.9070	0.9389
RF	0.9466	0.9467	0.9710	0.7607	0.9022	0.9623	0.9476	0.9650

Table 5: Precision values for Sampling methods.

Algorithm	SMOTE	ADSYN	ROS	RUS	TOMEK	CLUSTER	SMOTEK	SMETEEN
KNN	0.8853	0.8826	0.8986	0.7210	0.8655	0.6440	0.8861	0.9572
GNB	0.7521	0.7444	0.7288	0.7249	0.8834	0.8019	0.7520	0.8197
DT	0.9156	0.9167	0.9538	0.6738	0.8597	0.9349	0.9177	0.9440
XGBOOST	0.9507	0.9510	0.8001	0.7678	0.8790	0.9672	0.9515	0.9610
LGBOOST	0.9466	0.9479	0.7811	0.7748	0.8828	0.9687	0.9473	0.9580
ADABOOST	0.9053	0.9053	0.7703	0.7678	0.8857	0.9609	0.9072	0.9389
RF	0.9484	0.9487	0.9724	0.7625	0.8743	0.9632	0.9476	0.9652

When considering Table 3 accuracy results, we can see that the Random Forest algorithm has obtained an accuracy higher than 0.9000 for all sampling methods except Random Under Sampling Method. SmoteTomek, Smoteen hybrid random sampling methods, and the Cluster Centroid method have shown an accuracy greater than 0.9000 for Decision Tree, XGBoost, LGBoost, ADABOOST, and

Random Forest algorithms. These hybrid algorithms have shown an accuracy above 0.75 for all the classification algorithms employed in the study.

As shown in Table 4,5,6,7 XGBoost, LGBoost, and ADABOOST algorithms have shown above 0.92 values for precision, recall, MCC score, and F1 score for the cluster centroid algorithm. And also, SmoteTomek and Smoteen hybrid algorithms have shown values

above 0.90 for precision, recall, MCC, except F1 score, which is also above 0.80. TomekLink

algorithm has shown the poorest performance in terms of the MCC value for all the machine learning algorithms as shown in table 6.

Table 6: Recall values for Sampling methods.

Algorithm	SMOTE	ADSYN	ROS	RUS	TOMEK	CLUSTER	SMOTEK	SMETEEN
KNN	0.8573	0.8524	0.8772	0.7208	0.8970	0.6300	0.8595	0.9543
GNB	0.7512	0.7437	0.7279	0.7244	0.8240	0.8000	0.7513	0.8128
DT	0.9155	0.9166	0.9497	0.6737	0.8532	0.9349	0.9177	0.9441
XGBOOST	0.9477	0.9478	0.7969	0.7661	0.9052	0.9669	0.9487	0.9607
LGBOOST	0.9436	0.9446	0.7780	0.7700	0.9072	0.9685	0.9445	0.9576
ADABOOST	0.9050	0.9046	0.7697	0.7678	0.9091	0.9601	0.9070	0.9389
RF	0.9466	0.9467	0.9710	0.7607	0.9022	0.9623	0.9476	0.9650

Table 7: MCC values for Sampling methods.

Algorithm	SMOTE	ADSYN	ROS	RUS	TOMEK	CLUSTER	SMOTEK	SMETEEN
KNN	0.7420	0.7343	0.7756	0.4410	0.2002	0.2748	0.7450	0.9079
GNB	0.5033	0.4880	0.4566	0.4492	0.3058	0.6020	0.5034	0.6240
DT	0.8312	0.8332	0.9035	0.3475	0.1985	0.8698	0.8354	0.8842
XGBOOST	0.8985	0.8988	0.5970	0.5340	0.2512	0.9341	0.9001	0.9193
LGBOOST	0.8902	0.8925	0.5592	0.7700	0.2444	0.9372	0.8917	0.9129
ADABOOST	0.8102	0.8099	0.5402	0.5362	0.2777	0.9210	0.8142	0.8738
RF	0.8950	0.8954	0.9434	0.5232	0.2401	0.9255	0.8970	0.9650

Table 8: F1 values for Sampling methods

Algorithm	SMOTE	ADSYN	ROS	RUS	TOMEK	CLUSTER	SMOTEK	SMETEEN
KNN	0.8547	0.8494	0.8756	0.7204	0.8741	0.6222	0.8570	0.9539
GNB	0.7511	0.7434	0.7275	0.7242	0.8475	0.7997	0.7512	0.8140
DT	0.9155	0.9166	0.9496	0.6736	0.8564	0.9349	0.9177	0.9440
XGBOOST	0.9476	0.9478	0.7963	0.7658	0.8806	0.9669	0.9486	0.9607
LGBOOST	0.9435	0.9445	0.7774	0.7693	0.8792	0.9685	0.9445	0.9577
ADABOOST	0.9049	0.9046	0.7697	0.7677	0.8869	0.9601	0.9070	0.9389
RF	0.9465	0.9467	0.9710	0.7603	0.8775	0.9623	0.9475	0.9650

Receiver Operating Characteristic (ROC Curve) is another common technique to compare the performance of the classification algorithms. A ROC curve represents a trade off between the true positive

rate and the false positive rate.

Following figures show the ROC curves for each sampling method for all 7 machine learning algorithms.

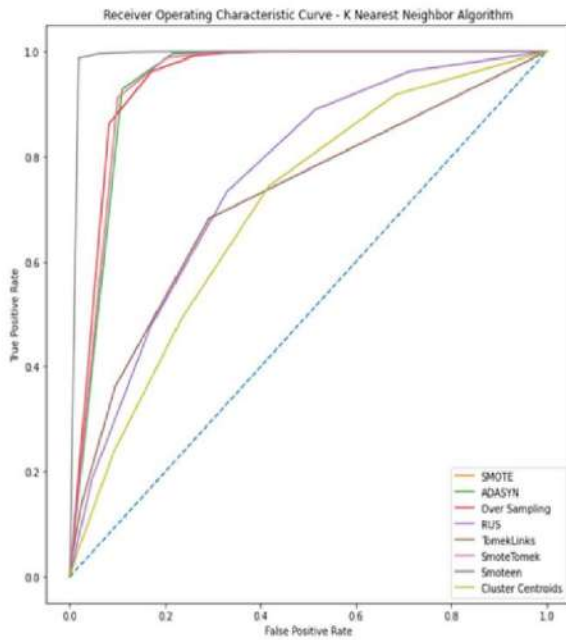


Figure 1: ROC Curves KNN

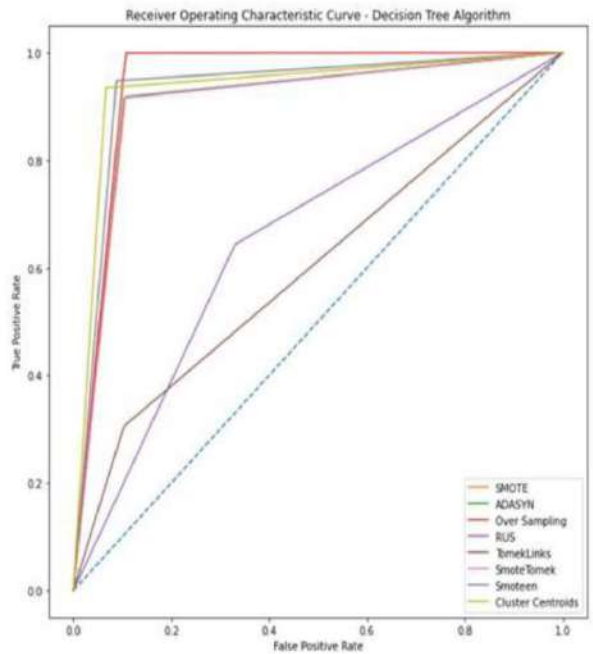


Figure 2: ROC Curves Decision Tree

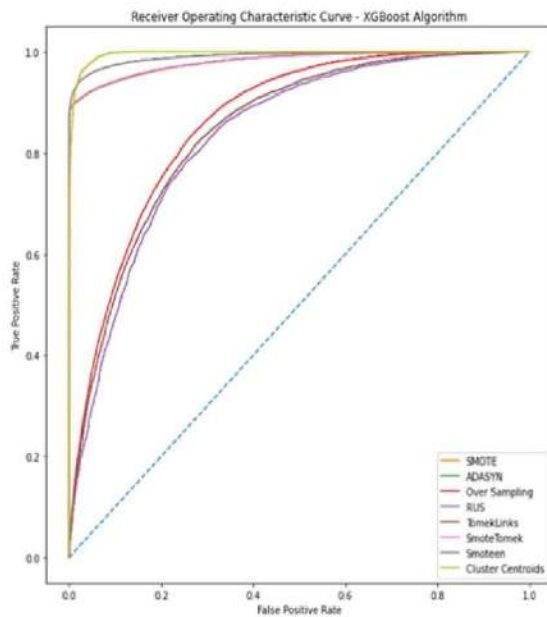


Figure 3: ROC Curves XGBoost

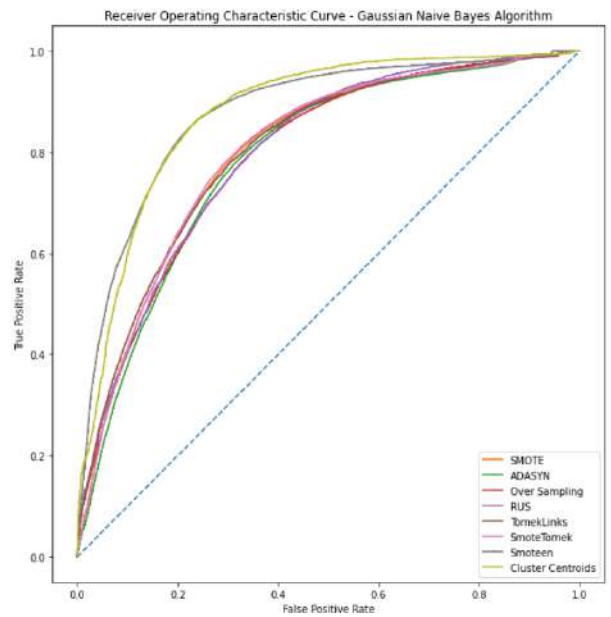


Figure 4: ROC Curves Gaussian Naïve Bayes

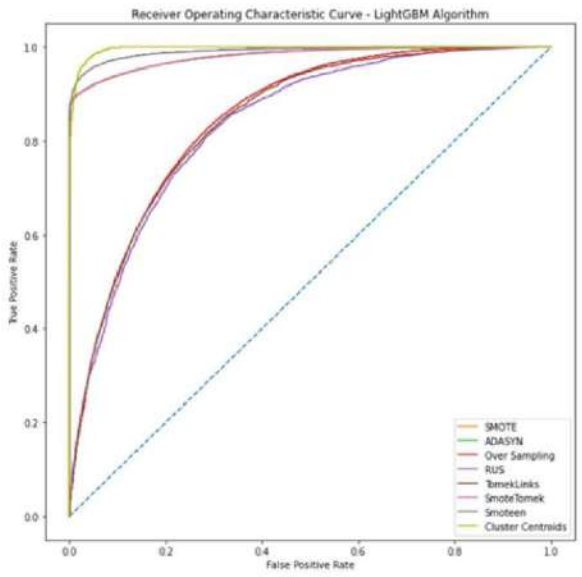


Figure 5: ROC Curves LGBost

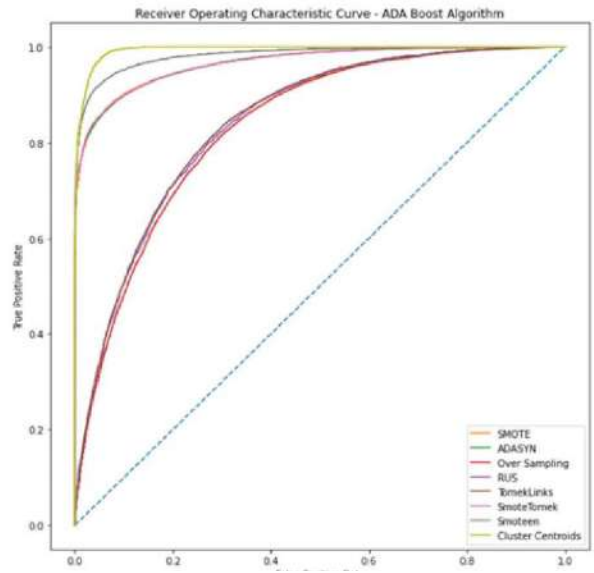


Figure 6: ROC Curves ADABost

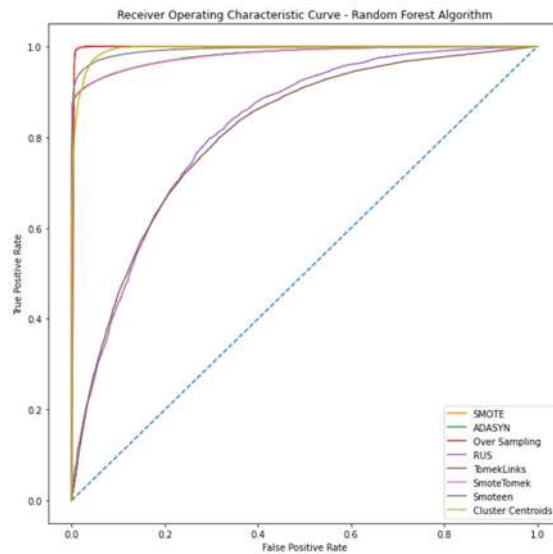


Figure 7: ROC Curves Random Forest

5. DISCUSSION

In this study, we observed that the Random Forest algorithm has shown accuracy above 90% for all the sampling techniques except the Random Under Sampling method. This is because it is an ensemble method, and performed very well on every class

imbalance method. All the hybrid methods SmoteTomek and Smoteen show the best performance for all classification algorithms specially for Decision Tree, XGBoost, LGBost, ADABost, and Random Forest algorithms. These hybrid methods show above 90% accuracy for all the machine learning algorithms except for k nearest neighbor and Gaussian Naive

Bayes algorithms. This is not only for accuracy, but also valid for other measured statistical parameters as well. From the analysis of all the class imbalance methods, it is evident that Over Sampling followed by Under Sampling methods can improve the performance of the classifier drastically because of its behavior. In the presented work, heart disease detection compares eight class imbalance methods over seven classifiers.

6. CONCLUSION

The performance of ensemble classifiers AdaBoost, Random Forest, and XGBoost is better than the base classifiers mainly due to their ensemble behaviour; somehow, KNN and Decision Tree classifier also performed very well. In all base classifiers, the performance of the Gaussian Naive Bayes classifier was the least in each class imbalance method. In this study we have shown that in heart disease prediction not only the classification algorithm but also the sampling techniques are important when dealing with a class imbalanced dataset. Because if you have an imbalanced dataset it will result in very low accuracies for the respective classification algorithms and as a result will not be able to detect heart diseases accurately. We also showed that for validation, only considering the accuracy metric is not sufficient.

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BELT AND ROAD INITIATIVE (BRI) AND SRI LANKA: A REVIEW OF LITERATURE

Tharindu Udayanga Kamburawala¹ and Dilmini Hasintha Abeyrathne²
Department of Economics, University of Sri Jayewardenepura, Sri Lanka¹,
Department of Economics, University of Kelaniya, Sri Lanka²

ABSTRACT

Belt and Road Initiative (BRI) project is one of the most dominant trade policies initiated by the Chinese government. It connects one hundred and forty-six countries occupying more than fifty per cent of the world's gross domestic product. Thus, BRI has become an indispensable perspective of forecasting trade performance between regions in the coming years. This study employs an evidence-based approach and critically evaluates the existing arguments on the BRI project and the possible strategies to mitigate the negative impacts of the project with special reference to Sri Lanka. Further, it attempts to summarize some key facts related BRI's engagement in the regions such as the South-East Asia, Europe, Indo-Pacific, and the South Asia. The findings of the study discover the heavy domestic focus of the BRI objectives. Existing financial incompetence, lack of physical capital, and technology gap are the main motives for developing economies to engage with the project. Geopolitical repercussions, security problems, and the debt trap are the highlighted adverse impacts of BRI. Several developing countries like Nepal have adequately accomplished the BRI projects domestically. Sri Lanka has benefited from BRI in several aspects and experienced several difficulties in power rivalry, autonomy and independence, growing debt burden, transparency and corruption. The study concludes the higher potential of BRI to approach developing countries' growth-related shortages and the possibility of emerging geopolitical repercussions. Thus, it recommends implementing a practical government framework to manage BRI domestically. This study recommends governments to enhance transparency and accountability related to the project's affairs, while maintaining economic feasibility and environmental sustainability. Furthermore, practicing a rational process for project selection and implementing efficient evaluation are recommended.

KEYWORDS: *BRI, Developing Countries, Economic Development, Geopolitical repercussions, Sri Lanka*

Corresponding Author: Tharindu Udayanga Kamburawala, Email: kktudayanga@sjp.ac.lk

1. INTRODUCTION

BRI, the most determined China's foreign trade and investment project, has implicitly converged on uplifting the connectivity and cooperation among regions; especially Asia, Africa, and Europe. The project consists of two divisions called the Silk Road Economic Belt (The Belt) and the 21st Century Maritime Silk Road (The Road). The Belt covers China's land area to Europe through Central Asia, whilst the Road extends China to Southeast Asia, the Middle East, East Africa, and Europe. It operates along the Mediterranean, the Indian, the Atlantic, and the Pacific attaching over 20 countries (Igbinoba, 2017). Chinese engagement through financial investments and contractual cooperation for the first half of 2022 in the 147 countries of the Belt and Road Initiative was about US\$28.4 billion (Nedopil, 2022).

The Asian Infrastructure Investment Bank (AIIB) and the Silk Road Fund which account for US\$40 billion are mainly funding the BRI. Thus, the BRI project is vital in anticipating trade performance between regions in the coming years. Critical evaluation of the objectives, opportunities, and risks of BRI will discover the existing research gaps and indicate the way forward.

BRI has consisted of different kinds of objectives. Even though policy coordination, connectivity, unimpeded trade, financial integration, and people-to-people bonds are the theoretical five fundamental aspirations, the project's expected outcomes could be different in reality. The real intentions of the project are related to the causes of the origin of the project.

Cai (2017) has examined the profound reasons for the implementation of BRI. Although China has already enhanced itself as a country with a higher economic growth rate, it has exhibited substantial income disparities among its domestic regions. On the other hand, Chinese construction firms and industries account for a significant excess capacity. This remaining excess capacity is an indirect result of the government's actions to boost the economy during the period of economic recession in 2008. The overall

context of the country reveals two main intentions of proceeding with BRI. Addressing China's deepening regional disparity and investing country's chronic excess capacity could be the project's favourable objectives (Peter, 2017). Thus, the objectives of the BRI will have a heavy domestic focus.

Identifying the real focus of executing the BRI is vital to foretelling the challenges and possibilities that the participating countries could face. Even though the project's theoretical aspect has immensely highlighted economic cooperation, the long-term concentration of the BRI goes beyond that. It has emphasized that the BRI project is a geopolitical plot than a purely economic one (Peter, 2017). The reason for this implication could be the geostrategic attention of the project than the geo-economic focus. Several studies have classified the strategic priorities of the BRI that prove the above-discussed argument. Strengthening China's "Go Global" policy, Expanding Chinese exports to BRI participating countries, promoting the structural changes of the Chinese firms, strengthening China's geopolitical role, and managing the industrial oversupply of Chinese firms have been highlighted as the strategic priorities of the BRI (Mckenzie, 2017). Most significantly, these strategic priorities have extensively influenced to determine the extent of the benefits and risks that are going to be experienced by the participating countries.

2. METHODOLOGY

The primary objective of this study is to investigate the existing arguments on the BRI project and the possible strategies to mitigate the negative impacts of the project with special reference to Sri Lanka. Secondly, this study has summarized some key facts related to BRI's engagement in the regions such as South-East Asia, South Asia the Europe. Therefore, an evidenced-based approach was utilized to analyze the existing literature. This study is analytical and explanatory in nature based on a literature review. Secondary data sources such as journal articles, book chapters, and reports were used for a narrative analysis to review and analyze the findings of several researchers.

3. RESULTS AND DISCUSSION

3.1 International Experience of BRI

Most countries have already admitted and cooperated in the Chinese BRI project. The Belt and The Maritime Road have evolved as the key pillars of connecting economies to the BRI. The Belt has emerged as the significant logistics corridor and the transshipment hub for Central Asia and Eastern Europe while the Maritime Road has been linking Southeast Asia, South Asia, the Middle East, and East Africa. Consequently, there are already more than 1700 BRI projects, either completed or in progress (Mckenzie, 2017). Cumulative BRI engagement since the announcement of the BRI in 2013 is US\$932 billion, about US\$561 in construction contracts, and US\$371 in non-financial investments (Nedopil, 2022).

Moreover, BRI has developed six main trade corridors such as China-Indochina, China-Myanmar, Bangladesh-India, China-Pakistan, China-Central Asia-Western Asia, New Eurasian Land Bridge, and China-Mongolia-Russia (Mckenzie, 2017). Although the project has been widely spreading its partnerships, one of the main obstacles the BRI faces is India's inactive participation (Wijayasiri & Senaratne, 2018). Nevertheless, BRI is substantially engaging in trade and spreading its partnerships with Pakistan, Bangladesh, and Sri Lanka discounting India's inactive engagement.

Most developing economies have engaged in BRI, due to the existing financial incompetence, lack of physical capital, and the technology gap. BRI projects align with several sectors such as transport, energy, water and sanitation, urban development, and information and communications. Mineral resources are among the primary sectors that receive most Chinese investment, especially in the Central Asian region.

3.1.1 BRI and South-East Asia

Indonesia, a Southeast Asian country, has involved itself in BRI and encountered both positive and negative impacts. Indonesia has profited from the BRI, especially with foreign direct investment (FDI). One of the crucial examples of this is the High-Speed

Rail Project (HSRP) which links Jakarta to Bandung. Even though land ownership issues have arisen, these development projects have filled the technology gap and financial burdens. A comprehensive investigation of FDI to Indonesia exhibits that before 2013 China has a small proportion.

Nevertheless, after 2013 China has become the third-largest investor in Indonesia (Tarmidi & Gammeltoft, 2013). Furthermore, Indonesia has introduced an investment plan to the BRI forum, and the plan proposes to develop four economic corridors in the country. The plan is called "Regional Comprehensive Economic Development Corridors", and the four corridors are located in the islands such as North Sumatra, North Kalimantan, North Sulawesi, and Bali. The whole investment plan consisted of 30 projects worth US\$ 91.1 billion (Pratiwi, 2020). These development projects are expected to boost the economic growth of the country.

Even though there are massive opportunities for Southeast Asian countries, there are several challenges (Cox, 2018). Pratiwi (2020) has investigated two types of negative impacts of BRI in Indonesia: security problems and the debt trap. With the implementation of the BRI projects in Indonesia, the grass root level people have been becoming vulnerable, and they could receive ill treatment and injuries due to the lack of a safe work environment. Furthermore, Indonesian workers could lose their jobs due to increasing imports of textiles and steel. There is a tendency to increase Chinese workers in the Indonesian labour market. Hence, human security issues, land ownership issues, and labour market issues are the significant concerns of Indonesia's security problems with BRI. Although Indonesia accounts for a considerable volume of debt to China, it has not yet been recorded as a debt trap. However, countries such as Tajikistan, Kyrgyzstan, Maldives, Laos, Pakistan, Montenegro, Mongolia, and Djibouti are highly vulnerable to debt distress (Hurley, Morris, & Portelance, 2018).

Exporting China's technological and engineering standards is one of the intentions of BRI (Breznitz & Murphree, 2013). Even though the BRI has been filling the technology gap, Indonesia has experienced increasing dependency, since it has to hire experts

from China (Pratiwi, 2020). However, it is possible to identify several policies that can mitigate the adverse effects of BRI to Indonesia. Indonesia should transfer BRI investment into the domestic industry with great advantage and something that Indonesia cannot do. Significantly, 270 BRI infrastructure projects in the Southeast region are on hold because of the lack of funding (Greer, 2018). Thus, Indonesia can guarantee the technology transfer from China so that Indonesia could work independently when the Chinese leave in the middle of the underway project. Furthermore, promoting environmental sustainability, considering the communities surrounding the project, and employing domestic workers at the maximum proportion could be effective policy solutions to manage the harmful effects of BRI projects. Therefore, if the economy is engaged in BRI projects, necessary policy adjustments should be formulated to deal with diverse effects.

3.1.2 BRI and the Indo-Pacific Region

Similarly, China's rapid economic growth and massive investment capability have created substantial geostrategic repercussions in several regions. Most of these geopolitical consequences have been generated in the areas where there are existing geopolitical conflicts between China, and the USA are already on the rise (Gong, 2019). The Indo-Pacific region has become one of those significant regions. Gong (2019), examined how the dynamics between BRI and the United States impact the Indo-Pacific region. Although China interprets the BRI as an economic cooperation and development platform, most Western countries, especially the USA, have observed and highlighted the Chinese geostrategic intention. According to the US National Security Strategy, BRI was a Chinese attempt to "displace the United States in the Indo-Pacific region" (Wuthnow, 2018). Thus, the USA has taken several actions to control China's involvement in the Indo-Pacific region. As an example, the United States (US) has become more determined to promote the free and open Indo-Pacific Strategy (FOIP) (Department of Defence, 2019). If it needs to control the BRI engagement to the Indo-Pacific region, the USA should facilitate its existing financial and

technological gap. Hence, the United States has initiated financial arrangements in cooperation with associates to counter China's BRI financing. The US Chamber of Commerce and the US-India Business Council and the US-Japan Business Council have launched the Indo-Pacific Infrastructure Trilateral Forum to facilitate India's private sector (The Economic Times, 2018). Furthermore, the ASEAN minister-level meetings in August 2018 have launched an investment package of US\$ 113 million for technology, energy, and infrastructure initiatives (CNBC, 2018). Within this context, the BRI engagement has caused the rise of geopolitical repercussions. However, if the developing economies' governments promote a balanced foreign policy, they would potentially obtain economic development from the Western (US) and Eastern (China) world.

3.1.3 BRI and the Europe

BRI involvements in the European Union are diverse. Although the BRI has played a vital role in the Indo-Pacific region's geopolitical context, it has not yet substantially engaged in economic cooperation agreements with the European Union (EU) and EU countries. Most significantly, the European think tanks have reviewed a significant modification of the BRI targets between the initial and present stages. At the initial stage, BRI targeted to create successful projects for reviving the ancient Silk Road through improved connectivity and infrastructure. Nevertheless, in the second BRI forum in 2019, it was highlighted that BRI supports free-market principles and macroeconomic policy coordination.

Further, BRI has started to keep opening up the Chinese economy to foreign investors and increasing its imports (Roctus, 2020). In reality, China has not yet opened its economy to foreign investors, especially European stockholders. Based on the context, the EU's participation in the BRI is still inactive. Nevertheless, the European Union can play a vital role in the BRI since, according to the Chinese perspective, the EU is the "final destination" of BRI. As the first EU member state to sign a joint statement on BRI, Hungary might play such a pioneering role in Europe. Moreover, the EU and the western European member states would be the only potential

economies for BRI because of China's worsening relations with most developed countries such as Japan, South Korea, Australia, Canada, and the United States. Thus, it concludes that the EU and the Western European member countries would be the high potential states that can determine future BRI performance.

3.1.4 BRI and South Asia

BRI linkages with South Asian countries have already gained global attention. Though India, the robust regional economy, is inactive in the BRI discussions, smallest South Asian countries – Sri Lanka, Maldives, Nepal, and Bangladesh – have made significant BRI connections. These countries have been obtaining the benefits of BRI through trade and infrastructure development projects. According to most Indian and US analysts, the BRI linkages with small South Asian countries have aimed to strengthen Chinese military bases. However, Samaranayake (2019) has provided a deeper understanding of South Asia's smaller countries and their developing engagement with China. The region's trade statistics reveal that the United States is the most favourable export destination for many South Asian countries, especially Sri Lanka and Bangladesh, whilst China remains one of the top sources of imports. Nevertheless, the Maldives is the only small South Asian country engaged in a free trade agreement with China. Based on the context, analyzing the risks and opportunities obtained by the South Asian countries from BRI has become much more complicated. However, the literature highlights two main drawbacks for South Asian countries from the BRI. Emerging geopolitical security risks and the foreign debt trap are the most critical issues.

Analyzing the country-wise situations reveals different settings. As an emerging economy with a higher population, Bangladesh has mostly been connected with BRI for development projects in sectors such as power, infrastructure, information, and communication, and technology. In October 2016, Bangladesh received US\$ billion for 27 development projects. Furthermore, Bangladesh has been negotiating with China to obtain loan terms for other projects under BRI. These loans cover six projects in Dhaka; two power plants (\$3 billion), the

Padma Bridge rail link (\$3.1 billion), Info Four broadband network (\$1.56 billion), a telecommunication network project (\$1.6 billion), and a single-point mooring terminal to supply fuel (\$5 billion) (Kallol, 2017). Even though Bangladesh has engaged in various development loans with China and BRI, it is not vulnerable to a debt trap (Samaranayake, 2019). Thus, Bangladesh involves in a progressive way of achieving development tasks with BRI.

Nepal, a small South Asian country, has concerned China as an alternative option that facilitates possibilities beyond India. The BRI investment in Nepal has mainly motivated the transportation, tourism, and energy sectors. The literature confirms that Nepal is associated with both loans and donors from BRI. One of the recent agreements between Nepal and China was signed in 2018, and it has facilitated BRI cooperation on railway connectivity between Kathmandu and the Tibetan border point of Kerung. Further, the country has engaged in several loans such as US\$ 156 million for the Pokhara Airport project (the second international airport), and US\$55 million for general economic and technical cooperation (Ministry of Finance, 2017). Even though Nepal has already obtained development loans from BRI, Nepal does not indicate a debt risk (Samaranayake, 2019). Moreover, Samaranayake (2019) has emphasized that Nepal has obtained more BRI benefits than the other countries in the region since it is the highest recipient of grants and foreign direct investment. Though Nepal is a small country, it has substantially managed the BRI domestically and attempted to obtain maximum benefits.

3.2 BRI and Sri Lanka

As a South Asian country, Sri Lanka has received more attention than other countries due to its geographical location. This location is critical in the BRI project since it could be a hub that provides facilities for the easy transformation of Chinese exports and imports. The cumulative value of Chinese infrastructure investment in Sri Lanka between 2006 and 2019 is US\$ 12.1 Billion (Wignaraja, Panditaratne, Kannangara, & Hundlani, 2020). China's energy imports from the Middle-East and Africa's mineral exports go through Sri Lanka

(Palit & Spittel, 2013).

Several studies have examined the opportunities and risks from BRI in Sri Lanka. Sri Lanka has benefited from BRI for various development projects, especially in transport, water and sanitation, urban development, and information and communication. Among the number of BRI projects in Sri Lanka, Hambantota Port, Norochcholai Power Station, Colombo Port City project, and the Mattala International Airport project have taken significant attention. Wijayasiri and Senaratne (2018) identified trade, investment, hard and soft infrastructure, the economic hub, development of the global value chain, growth in tourism, discovery, and utilization of marine resources, technology, and knowledge transfer employment opportunities as essential assistance. Jayamaha (2017) has discovered regional connectivity via ports, airports, roads, and transmission towers; increased foreign investments into the country, easy access to new exports markets, exploration of marine resources and the exclusive economic zone, and participation in the digital revolution in the financial services as the positive outcomes of BRI in Sri Lanka.

However, there are several various kinds of drawbacks discussed in the Literature. Sri Lanka has spent the last decade balancing precariously while pursuing BRI-related economic and other benefits from China. The participation of Sri Lanka in the BRI has raised concerns over potential power struggles. This is mostly due to Sri Lanka's participation in the BRI and India's absence from it. Since the BRI has sparked concerns about China's plans in the Indian Ocean, India, Japan, and Western nations have paid close attention to Sri Lanka's involvement with the BRI Chinese investment in Sri Lanka, particularly in the ports of Colombo and Hambantota. Therefore, Sri Lanka is caught in a power struggle involving powerful economies like the United States, India, China, and Japan due to its strategic location at the heart of the Indian Ocean. (Wijayasiri & Senaratne, 2018).

The US\$ 1.2 billion Hambantota Port Development project is one of the major high-profile infrastructure projects that Sri Lanka pursued with BRI funding. Several reports and articles in newspapers have

criticized the Sri Lankan government engagement in this development project. The main argument for the criticism is obtaining Chinese BRI loans and investing in unproductive projects. It has emphasized that feasibility studies of the project had not recommended the constructions. However, some studies have indicated that though the development planning experts have criticized the Hambantota Port Development project, there are several reasons for the justification. In 2005, the government presented the initial project proposal, and President Chandrika Kumaratunga requested a bunkering system and a tank farm project (Samaranayake, 2019). Furthermore, Rebuilding Hambantota after the devastating tsunami in 2004 was another necessity. Moreover, the Hambantota-salt-producing region of the Southern Province of Sri Lanka has been underdeveloped. Thus, the domestic stability and security obtained after the civil conflict has drawn the government's attention to constructing the project to position Sri Lankan ports as regional and global trade hubs within Asia and East Africa (Mariyathas, Perera, & Yehiya, 2016). However, on 29 July 2017, the government of Sri Lanka and China Merchants Port Holdings Ltd signed a Public-Private Partnership Agreement to develop Hambantota Port under a 99-year lease. Even though most studies have highlighted that this is due to Chinese BRI's Sri Lankan debt trap, some studies have discovered this as a common challenge that low-income countries experience when transitioning to middle-income status (Samaranayake, 2019). However, a common critique against both Hambantota Port and Norochcholai Power Plant is that those projects have not met international standards concerning feasibility studies and domestic legislation processes (Hundlani & Kannangara, 2020).

There are concerns that Sri Lanka would lose some autonomy in how it manages these assets because ownership of important state infrastructure is linked to such firms. China's ownership of the troubled Hambantota port in Sri Lanka aroused concerns about a possible loss of sovereignty. Infrastructure development initiatives are frequently motivated more by political than by economic factors. It is highly doubtful whether future project profits would be sufficient to fully satisfy repayments to Chinese

creditors due to the lack of financial imperatives driving BRI initiatives. The Mattala Rajapaksa International Airport is a prime example. Based on these circumstances, Wijayasiri & Senaratne (2018) have outlined potential issues with BRI for Sri Lanka including power struggles, independence and autonomy, a mounting debt load, transparency and corruption, low investment returns, public perception and opposition, pollution and sustainable growth, and changes in government and policy.

The argument put up by Wijayasiri & Senaratne (2018) when analyzing the debt diplomacy in Hambantota port investment has been backed by Wibisono (2019). It has been established that China engaged in debt diplomacy with Sri Lanka in three stages and was successful in acquiring the Hambantota Port through the signing of a 99-year lease. The three phases are: (1) the investment phase; (2) the construction and operating phase; and (3) the expropriation and debt collection phase. In the case study of the Hambantota Port, China was able to ensnare Sri Lanka with loans that had high-interest rates and terms that were advantageous to China, like the hiring of Chinese firms for port expansion projects. Political interference, such as full support for the China-friendly Mahinda Rajapaksa regime, serves to amplify China's influence over development initiatives. Due to high-interest foreign debt bondage in significant infrastructure projects that ensnared Sri Lanka in China's debt diplomacy, Sri Lanka was compelled to adopt a \$ 1.12 billion debt relief deal in exchange for handing over the 99-year lease of Hambantota Port (Wibisono, 2019). Chaudhury (2019) provided additional evidence in support of this claim by pointing out the growing geo-economic significance of the Indian Ocean and the so-called Malacca Dilemma that China has been obliged to work around as a result of its reliance on energy supplies. It has been underlined that as Sri Lanka is already heavily indebted, China's expanding investments will have a negative long-term effect on that nation (Chaudhury, 2019).

Weerakoon & Wijayasiri (2019) presented a different viewpoint on debt and diplomacy associated with the BRI when talking about the Opportunities and Challenges for China-Sri Lanka Economic Relations.

It has been underlined that only a small number of "important" infrastructure projects from the huge portfolio of Chinese-funded initiatives have attracted significant international attention. The Hambantota port, which lies at the southernmost point of Sri Lanka, is the most disputed. The notion that Sri Lanka is likewise burdened and overwhelmed by its debt to China has not been supported by the data on debt, which has been highlighted as being the most relevant point. After making up 0.5% of the total debt in 2006, Chinese loans made up slightly over 9% of Sri Lanka's entire foreign debt in 2018. Furthermore, as part of a larger "Asian pivot" strategy to benefit from growing trade and finance flows, emerging Asian economies like Sri Lanka stand to earn significantly from participation in the BRI process (Weerakoon & Wijayasiri, 2019).

The idea presented by Weerakoon & Wijayasiri (2019) has been supported by Hundlani & Kannangara (2020). The debt trap is a significant issue discussed among these drawbacks. However, most analytical studies have revealed that Sri Lanka's debt issue goes beyond one country – China. Most significantly, Sri Lanka's debt to China has accounted for only 6% of the GDP, whilst 27% of the GDP has owed to the international financial markets and multilateral lenders like the World Bank (Hundlani & Kannangara, 2020). Furthermore, Sri Lanka's debt to China is 5.5 per cent of the country's total debt, and 94.5 per cent of Sri Lanka's debt is not to China (Samaranayake, 2019). Thus, even though Sri Lanka's foreign debt to China is significant, its debt issue has gone far beyond that of any country.

Various studies have looked at potential solutions for addressing the negative effects of Sri Lanka's participation in the BRI and measures to maximize the positive effects on the country's economy. Wijayasiri & Senaratne (2018) draw the conclusion that the BRI will need to do more than merely construct physical infrastructure if it is to be successful in fostering ties between China and Sri Lanka. To more effectively integrate into global value chains, the country must implement structural changes, better trade policies, and an improved investment climate. Soft infrastructure is also essential. The underlying difficulty of identifying

environmentally friendly and economically successful initiatives cannot be solved simply by providing financing. Additionally, it has been underlined that as Sri Lanka participates in the BRI, it must balance its relations with China and other significant powers that have an interest in the Indian Ocean (Wijayasiri & Senaratne, 2018).

Weerakoon & Wijayasiri (2019) emphasized that more has to be done to solve flaws in Sri Lanka's FDI framework if benefits from the BRI are to be realized and debt accumulation is to be controlled more efficiently. Additionally, improved connection between China and Sri Lanka is fostering not only commercial ties but also other forms of intercultural contact in industries like tourism. Sri Lanka will be in a better position to approach the ASEAN for a dialogue partnership and eventually link up with the China-led Regional Comprehensive Economic Partnership (RCEP) process taking shape in the Asian neighborhood if it has bilateral FTAs with China and India in addition to some selected Southeast Asian economies (Weerakoon & Wijayasiri, 2019).

Jayathilaka (2022) has also stressed the importance of these tactics. Policies including increasing export performance to reduce the country's trade deficit with China, luring more Chinese investment through improved bilateral ties, and luring more Chinese visitors have all been promoted. Additionally, Ruwanpura, et al. (2020) have looked at the presence and absence of underdetermined components that indicate existing narratives do not sufficiently consider potential ruptures that may exacerbate the effects of mega infrastructure and related environmental degradations. Thus, the requirement for greater regional study on the BRI is highlighted.

4. CONCLUSIONS AND RECOMMENDATIONS

The analytical review of existing literature confirms that the Chinese BRI project has influenced various countries in different aspects. It emphasizes the possibility of occurring geopolitical repercussions,

especially in the South and East Asian regions. Power rivalry, autonomy and independence, growing debt burden, transparency and corruption, low investment return, public perception and opposition, pollution and sustainable growth have been identified as the potential concerns around BRI for Sri Lanka. Even though there are several positive impacts, governments should implement effective frameworks to mitigate the adverse effects.

Governments must share information on planned projects more openly and honestly. This applies not only to the terms and conditions of loan disbursements, but also to the protocols for environmental protection, economic feasibility analyses, population displacement, and other issues. The idea that expensive Chinese loans are funding political vanity projects or fostering a corrupt climate will endure in the absence of openness and accountability systems. To securely traverse the new funding landscape, solid national debt management processes and protections on project selection and evaluation are required at the national level.

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ARTIFICIAL DEPRIVATION OF HUMAN LIFE: THE LEGAL, MORAL AND RELIGIOUS CONTROVERSY OF EUTHANASIA AND ASSISTED SUICIDE

Ruwini Uthpala Nissanka
Attorney-at- Law of Supreme Court, Sri Lanka

ABSTRACT

Euthanasia or assisted suicide could be defined as the practice of artificial deprivation of human life to end unbearable and incurable suffering of a terminally ill person. Medical Historians believe that ancient Greeks and Romans were in support of the concept of mercy killing rather than denying the whole notion. While opponents and proponents of euthanasia have not arrived at a mutual understanding yet, Oregon, USA was the first state to decriminalize euthanasia while Netherlands and Belgium were the first nations to legalize assisted suicide. While many countries across the globe comprising a few in Asia including Japan, have adopted similar means, Sri Lanka remains inflexible when it comes to this subject. Any sort of intentional taking of human life is considered an offence in Sri Lanka and Article 296 of the penal code prescribes death penalty for such actions which amount to the offence of murder. Suicide is also considered an offence under article 299 of the penal code and a person who aids and assists suicide could be penalized with capital punishment though Sri Lanka has adopted a de-facto moratorium on executions since 1976. The only instance where Sri Lankan law allows wilful ending of human life is under section 303 of the penal code where medical termination of pregnancy is possible strictly under the condition of preservation of mother's life. This qualitative research was carried out as a literature-based, comparative study, and it concentrates on the concept of euthanasia, assisted suicide, the legal, moral, and religious controversy it has led to with examples from other countries while considering the possibility of decriminalizing physician-assisted suicide in Sri Lanka for terminally ill patients, under stringent conditions and suggesting in favour of voluntary passive euthanasia.

KEYWORDS: *Euthanasia, Physician-assisted Suicide, Decriminalizing, Legal Aspects*

Corresponding Author: R.U. Nissanka, Email: ruvirun@gmail.com

1. INTRODUCTION

In sickness, the most natural human norm is to take care of the sick with best possible care and medication until that person becomes fit again. But when it comes to a hopeless situation like a life-threatening, terminal illness or a cureless unbearably painful situation, there are two options to take on: either to let the patient sustain under prevailing despair or let the patient die a dignified death. The dilemma caused by these two alternatives has created endless debate and much controversy throughout centuries. While the subject matter beholds its own medical, ethical, legal, political, religious, moral, and emotional perspectives, the affected stakeholders such as medical practitioners, legal professionals, policymakers, politicians, the public, religious leaders, and victims of terminal illnesses themselves bring up constant arguments both in agreement and in utter disagreement of assisted suicide or euthanasia. The topic itself poses many inbuilt problems, such as what if a patient wants to die and the system would not allow it, what if the system allows mercy killing but the patient wants to live and has lost the ability to communicate, whether it is fair for a third party to take a life terminating decision on behalf of a person in vegetative state, whether euthanasia is legal, where the world stands on the topic and what Sri Lanka's standpoint is.

2. METHODOLOGY

With the objective of considering the possibility of legalizing voluntary passive euthanasia in Sri Lanka, this paper attempts to critically analyze the debatable issue of euthanasia giving special attention to legal and medical aspects associated with it. This research was carried out as a literature-based research and a comparative study giving special attention to an array of domestic, regional, and international research instruments, judicial decisions, conventions, and legislative enactments both

published, and internet based. The paper is intended to deliver a comparative study of different other nations and Sri Lanka on the case of euthanasia or physician assisted suicide.

ORIGINS OF EUTHANASIA

The term "euthanasia" derives from the Greek words "eu" which means 'good' and "thanatos" which means 'death'. Traces of evidence of euthanasia date back to the 5th century B.C where ancient Greeks and Romans supported intentional ending of life in good faith rather than ignoring the suffering of a person. Evidence suggests that mercy killing to end the lives of incurably injured animals have farther origins of existence in civilizations than human euthanasia or assisted suicide. Even before the concepts of modern medical science started getting shaped by the time of ancient Greek physician Hippocrates¹ who is commonly considered as the father of medicine, euthanasia had been carried out as a medical procedure by physicians back in the days. Before Hippocrates, euthanasia was a routine procedure and physicians assumed that they had the authority to end the lives of patients for whom they gave up the hope of recovery, without asking for their permission (Ney, cited in Gandhi 2017). Hippocrates seemed to have had a rather different opinion about the matter than his colleagues and considered killing a patient without his consent and solely on the judgement of his physician is wrongful and not transparent, which led to mould the words in Hippocratic Oath. Grover (2022) mentions that the oath says that, a doctor must not refuse treatment to any patient and among many things a line states, "A Doctor will neither give a deadly drug to anybody who asked for it nor will the Doctor make a suggestion to this effect."

During the Nazi regime which governed Germany from 1933 to 1945, the concept of Euthanasia was used against various sections of the community considered as undesirable², an attitude that ultimately led to the further atrocities and genocide

¹ Considered to be born c. 460 BCE, island of Cos, Greece and died c. 375 BCE, Larissa, Thessaly

² Michalsen A, Reinhart K. "Euthanasia": A confusing term, abused under the Nazi regime and misused in present end-of-life

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of World War II.³ Gandhi (2017, p.106) states that the euthanasia programme called Aktion T4 authorized by Hitler led to the killings of about 70,273 people against their will for the supposed “good of the country”.

Ever since its origin, euthanasia has always set-off much dilemma in society, and the debate remains argued to the date. Euthanasia or assisted suicide has created a medical--legal -- ethical matter with its own moral, religious, emotional, and even political viewpoints. Many countries remain obstinate on not allowing mercy killing while

some countries openly practice it in specific circumstances. The Northern Territory of Australia was the first jurisdiction to decriminalize Euthanasia in 1996 while Oregon was the first state in the USA to do so in 1997. Netherlands was the first country to legalize Euthanasia in 2001 followed by Belgium. Switzerland, Canada, Luxemburg, Columbia, and New Zealand also took upon the same path in later years. Meanwhile, euthanasia remains illegal in the UK and is punishable by law, and in the USA, laws which govern the matter differ from state to state. Even though euthanasia is not decriminalized in France, passive euthanasia is allowed to a certain extent as the law allows doctors to culminate heavily invasive medical care and life-support of patients in vegetative state. The concept of assisted suicide is not widely accepted in Asia; however, a recent Indian Supreme Court Judgement has recognised passive euthanasia.⁴ With religiously backed-up mind set-ups, euthanasia in Sri Lanka is yet far from legal even though certain arguments have been brought up especially by legal and medical practitioners in support of legalizing euthanasia under dire circumstances.

Where is Euthanasia/Assisted Suicide Legal?

Country	Euthanasia	Physician-Assisted Suicide	Minimum Age Requirement	Diagnosis Required?	Progression Of Illness
Switzerland	✗	✓	None	✗	N/A
Netherlands	✓	✓	12	✗	Late stage with no signs of improvement
Belgium	✓	✓	None	Only for minors ✓	Illness needs to have progressed to the late, and “unbearable” stage
Luxembourg	✓	✓	18	✗	Condition needs to be defined as incurable with unbearable suffering and no potential for improvement
Canada	✓	✓	18	✗	Incurable illness with unbearable suffering
Columbia	✓	✓	6	✓	Only in the terminal/final stage of the illness
New Zealand	✓	✓	18	✓	Incurable, death within six months, visible decline

● Euthanasia/Physician-Assisted Suicide allowed ● Only Physician-Assisted Suicide allowed



Figure. 1: Willis (2022), Present situation

EUTHANASIA V. PHYSICIAN ASSISTED SUICIDE (PAS)

The terms euthanasia and Physician assisted suicide are often used reciprocally or understood mutually even though the two terms contain slight differences.

Clowes (2020) defines “euthanasia” as an action committed or omitted for the purpose of causing or hastening the death of a human being after birth, usually for the alleged purpose of ending the person’s suffering. Euthanasia could therefore be an act (active euthanasia), or an omission (passive euthanasia). Willis (2022) states that, physician assisted suicide has only one key difference, and that is that the terminally ill person elects to end his own life, typically by taking an oral dose of medication.

³ Grodin MA, Miller EL, Kelly JI. The Nazi Physicians as Leaders in Eugenics and “Euthanasia”: Lessons for Today. *Am J Public Health*. 2018 Jan;108(1): 53-57.doi:10.2105/AJPH.2017.3 04120. Epub 2017

Nov 21. PMID: 29161068; PMCID: PMC5719686.

⁴ *Common Cause (A Regd. Society) v. Union of India*, (2018) 5 SCC 1.

Willis (2022) further states that, assisted suicide, when it is specified as such, means that a doctor must either inject the dose, be present during the procedure, or be hands-on with the process in a key way. Though the two terms contain slightly different connotations, the consequence, and the objective of both are similar as they result in termination of a person's life to give a merciful ending to an incurable and unbearably painful suffering.

Active Euthanasia – It refers to the deliberate merciful act, usually through the intentional administration of lethal drugs, to end an incurably terminally ill patient's life (Bartels and Otolowski cited in Patil, 2013). Therefore, active euthanasia creates an act of commission where physician's role as a life preserver is highly debated.

Passive Euthanasia – This is action withheld for the purpose of causing or hastening death (Clowes, 2020). Therefore it is an act of omission where deliberately letting the patient die takes place by stopping patient's life extending medication or treatment, i.e. not carrying out a certain surgical life extending procedure, not giving certain life prolonging medication, or disconnecting feeding tube or life support equipment such as ventilators. Patil (2013) states that, "Letting Die" means to give way to an ongoing inner organic process of disintegration, without supporting or substituting vital functions. Therefore, it could be considered that, even though the term 'Passive Euthanasia' is often used, such omission does not constitute a lethal act of killing but only an influence on the life expectancy of the patient.

Voluntary Euthanasia – According to Morrow (2022), in voluntary euthanasia, the sick person asks the doctor for help and the doctor agrees, and therefore both act willingly. Hereby, an authorized medical person performs a merciful act or an omission which could amount to death only at the request of the patient. Switzerland is a country where voluntary euthanasia is legalized and commonly used.

Involuntary Euthanasia – This is where someone causes a sick person's death without the sick person

giving permission (Morrow, 2022). This concept, which has led to much controversy, simply means performing euthanasia without the consent or request of the patient with the intention of relieving his painful suffering. This procedure carried out against or without the will of the patient amounts to homicide, and this has created much legal, medical, and ethical dilemma.

Non-voluntary Euthanasia – This is committed when the subject is unconscious or otherwise cannot give consent (Clowes, 2020). Often called as 'suicide by proxy', it is commonly practiced when the patient is in a vegetative state or in a state where he or she cannot possibly communicate. There are instances that next of kins are allowed to decide whether to continue or halt patient's life support with the recommendation of medical or sometimes legal authority.

Legitimate Medical Euthanasia – According to Gandhi (2017), it is based on the doctrine of "dual effect" and concerns the use of lethal dosing or terminal sedation by some medical professionals. In this, administration of medication or a treatment which has the side effect of speeding the patient's death is carried out in-order-to lessen the pain he or she is going through. Gandhi (2017) further states that, lethal dosing, to a competent, terminally ill patient by the physician, which by its "Dual effect" may hasten the patient's death, is both ethical and legal as long as the terminal treatment is intended to relieve the pain and suffering of an agonizing terminal illness.

COUNTRIES AND REGIONS WHERE EUTHANASIA OR ASSISTED SUICIDE ARE LEGAL

Victoria, Australia – Australia's Northern Territory was one of the first regions in the world to legalize assisted suicide back in 1996 by passing *Rights of Terminally Ill Act of 1995*. After much debate Australia's federal court overruled the territory law in 1997. Willis (2022) states that, 'nearly 20 years later, as public perception shifted,

so did this region's attitude toward the practice. In 2019, the **Voluntary Assisted Dying Act** came into effect in the region again, and with it, a very large area of Australia legalized physician-assisted suicide.'

Netherlands - Being the first country in the world to legalize euthanasia, Netherlands passed ***Termination of Life on Request and Assisted Suicide (Review Procedures) Act*** in 2002 allowing active voluntary euthanasia and physician assisted suicide under specific provisions. The specialty in Netherlands is that the law allows not only adults but also children as young as 12 years and above to request for assisted suicide under strict conditions of having a fatal illness or a permanent psychiatric illness, leaving the debate whether children are matured enough to take such an immense decision in life or not, unsolved.

Belgium - With almost no exception, Belgium has the most permissive laws when it comes to legal suicide. (Willis, 2022) The law was introduced in 2002 making Belgium the second country in history to legalize PAS. Euthanasia by administration of lethal injection for minors who are suffering from terminal illnesses was allowed in 2014 and Belgium remains one of the very few nations which allows a physician to administer lethal dose of drugs to a mentally ill person

Luxembourg – This is the third country in line to legalize euthanasia by passing ***Palliative Care/Euthanasia Act 2009***. Doctors need to consult with a colleague to assess whether patients are terminally ill and are suffering from a "grave & incurable condition" and have repeatedly requested to die. (Ebhrhimi, cited in Patil, 2013)

USA – Even though US federal law has not legalized euthanasia or assisted suicide yet, several states have passed laws decriminalizing physician assisted suicide. Oregon was the first state to introduce the law with ***The Death with Dignity Act*** in 1997 followed by Washington, Vermont, California, Colorado, District of Columbia, Hawaii, Maine, and New Jersey.

Canada – Both assisted suicide and euthanasia were legalized in Canada in 2016. Even though the law is very much similar to those of other countries, one key difference that Canadian law holds is that it is not mandatory to have a definite time frame for patient's death diagnosed by professionals. Therefore, patients with unbearable and long-term illnesses where death may not take place for some time are still entitled to assisted suicide if they voluntarily decide that death is in their best interest.

Switzerland – Switzerland could be known as the country with most permissive and the most accommodating setting for assisted suicide. The specialty in Switzerland is that its law criminalizes every form of euthanasia, but legalizes an individual to administer a lethal dose of medication. According to Willis (2022), the only stipulation of the law states that the medications may not be administered for "selfish", or profitable, reasons. She further states that Non-profit organizations (Dignitas, Eternal Spirit, and Pegasos Association) allow non-nationals to voluntarily check-in and die on the premises. The Swiss e-news site, The Local (2021) reported that some 1,282 seriously ill people ended their lives using the services of Swiss assisted organisation EXIT in 2020, which is 68 more people than in 2019.

Soon to be the latest addition to Swiss PAS system, Swiss inventor Philip Nitschke of Exit International has designed a self-operated suicide pod from bio-degradable raw material most recently. It is a portable capsule designed for use in assisted suicide and has already been authorized by Switzerland's medical review board, therefore it could be available within the year 2022. Suicide pod known as the "**Sarco**" is made with 3D-printing technology by the company Exit International (Jackson, 2021). The pod is reported to have been designed to bring the oxygen levels down carefully, so that death takes place painlessly and peacefully. This innovation has developed countless debate between opposers and proposers of euthanasia or assisted suicide around the world.

India – India is the newest addition to the list of countries to recognize passive euthanasia and is the first in the South Asian region to do so. Indian

courts have considered the legality of euthanasia or assisted suicide on several occasions since decades. Indian supreme court made history in 2018 by recognizing passive euthanasia by the judgement *Common Cause (A Regd. Society) v. Union of India*.⁵ According to Kulkarni (2021), the *Common Cause* verdict has further held that the absence of acknowledgement of advance medical directive in terms of a patient in a permanent vegetative state to be an unnecessary gridlock preventing the smooth functioning of a right embodied in Article 21.

ARGUMENTS PROPOSING AND OPPOSING EUTHANASIA

There are many arguments that propose and oppose euthanasia or PAS. Many argue that, right to life itself comprises the right to self-determination, right to relief from suffering and autonomy of patient, therefore a patient has the right to decide whether to live with pain or to die with dignity. Kondrashova (cited in Sumachev, 2021) mentions that, since the law provides for the right to life, and the right to a good life implies the disposal of this good at one's own discretion, and this presupposes the existence of the right to death. According to research carried out by Castillo et al. (2020) using medical students in European countries, certain articles have argued that the relatives of a terminally ill patient themselves also have a right to be free from emotional suffering and burden of caring so that the relatives should be vested with power to decide on the life of a patient in vegetative state.

On the other hand, opposition of euthanasia brings out justifiable arguments as well. Kovalev MI, et al. (cited in Sumachev, 2021) argue that euthanasia should be banned based on the possibility of error of diagnoses, the fact that terminal and pre-terminal stages are often associated with a special state of the human body and due to the rapid development of medicine and pharmacology and some diseases and conditions which were previously fatal or created a poor quality of life are now curable or treatable for

survival with a high quality of life. According to Castillo et al. (2020), these clashing opinions have made the controversy of euthanasia even more contradictory and hard to arrive at a common understanding. the most common arguments against euthanasia were religious and personal beliefs, the "slippery slope" argument and the risk of abuse and the physician's role in preserving life. These clashing opinions have made the controversy of euthanasia even more contradictory and hard to arrive at a common understanding.

SRI LANKAN PERSPECTIVE

In Sri Lanka euthanasia or assisted suicide has no lawful existence. Any sort of practice of euthanasia is considered a clear act of offence. Sri Lanka's penal code prohibits any sort of abetment or aiding in suicide. Article 299 PC states that, 'If any person commits suicide. whoever abets the commission of such suicide shall be punished with death.' Article 300 PC, under sub-heading 'Attempt to murder', further mentions that whoever does any act with such intention or knowledge and under such circumstances that if he by that act caused death, he would be guilty of murder. Therefore, a physician could be convicted for the offence of murder, if he assists a patient in an act of euthanasia by any mean, even in good faith in Sri Lanka.

And if a patient attempts suicide with or without the assistance of a physician and does not die, he or she could be punished under Article 302 for attempting to commit suicide in which it is described as, 'Whoever attempts to commit suicide, and does any act towards the commission of such offence, shall be punished with imprisonment of either description for a term which may extend to one year, or with fine, or with both.' Although the penal code takes steps to control aiding and abetting suicide, it does not provide for the prevention of suicide (Jayalath and Gunawardena, 2021).

The only instance where Sri Lankan law allows the artificial deprivation of human life is the medical

⁵ Ibid 4

termination of the life of an unborn child under the strict condition of saving mother's life. Even if the mother is pregnant due to rape, she has no legal authentication to abort the unborn by herself or request for an abortion. Laws pertaining to abortion in Sri Lanka remain restrictive and abortion is illegal unless the life of the mother is at risk. (WHO 2018) Articles 303-306 of penal code provides that, causing the death of a fetus is a criminal act and is punishable with imprisonment ranging from three to ten years, with or without fine if mother's life was not at risk.

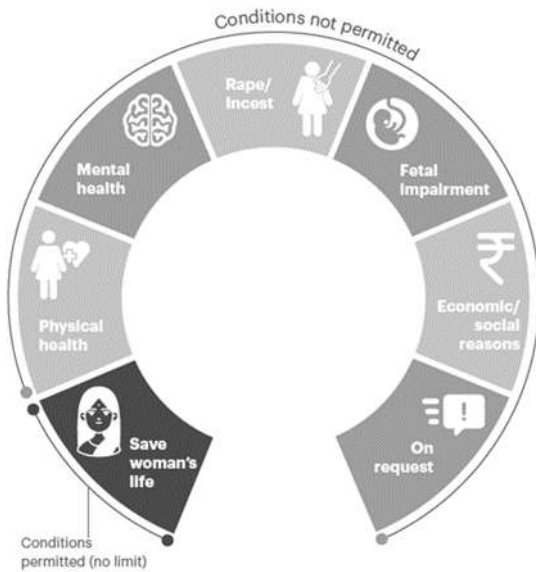


Figure 2: Conditions and gestation limit for which abortion is permitted in Sri Lanka. (WHO 2018)

The constitution of Sri Lanka does not explicitly recognize 'right to life' as a fundamental right even though 'right to life' is a universally accepted human right. Article 3 of Universal Declaration of Human Rights (UDHR)⁶ reads as 'Everyone has the right to life, liberty, and the security of a person.' Any other human right would be nothing but mere words if a person does not possess the right to life as no qualification attaches to this specific right. The law's legitimate interests in protecting that right thus justifies legal intervention to prohibit (or at least control) involuntary and non-voluntary

euthanasia. Brazier (1996, p. 318) Despite the absence of right to life in the constitution, the supreme court of Sri Lanka has recognized right to life in several landmark judgements. In *Rathnayake Tharanga Lakmali v. Niroshan Abeykoon*⁷ it has been held that 'Article 11-freedom from torture' read with 'Article 13(4) freedom from arbitrary punishment recognizes a right to life by necessary implication. The court further stated that the constitution is a living document and subjected to be interpreted in a comprehensive manner. In *Sriyani Silva v. Iddamalgoda, Officer-in-Charge, Police Station Paiyagala Others*⁸ it was ruled that, Article 11 guarantees freedom from torture and from cruel and inhuman treatment or punishment. Hence, unlawful deprivation of human life, without a person's consent or against a person's will, amounts to inhumane treatment under Article 11 of the constitution of Sri Lanka.

According to a recent research carried out in Sri Lanka, using a group of healthcare professionals of the Accident Service at the National Hospital of Sri Lanka including medical officers and nursing officers, 66.6% of the sample have been in agreement with legalizing euthanasia in Sri Lanka. Researchers, Silva, Samarakoon A.S., Samarakoon M.A.S.C. (2019) state that the majority (80%) were aware about the concept of Euthanasia, 75% of them believed it is ethical, whereas 66% of them knew it is legalized in Western countries and among the nursing professionals 87% mentioned that they themselves would accept Euthanasia if they were chronically ill.

The last and the most recent census in Sri Lanka was carried out in 2012 and according to census data, 70.2% of the Sri Lankan population consists of Buddhists, while there are 12.6% Hindus, 9.7% Muslims and 7.4% Christians. Buddhism is a religion which promotes non-harm, compassion and finding out the ultimate truth of life. The first precept (Sheela) of the Buddhist conception of

⁶ UDHR was proclaimed by the United Nations General Assembly in Paris on 10 December 1948.

⁷ SC/ FR Application 577/2010

⁸ (2003) 2 Sri LR 6 pp 76 - 77

Pancha-Sheela disallows killing or abetting to kill any sort of living being including humans and animals. Therefore, Buddhist philosophy does not accept the core ideals of euthanasia or assisted suicide.

When it comes to Hinduism, unlike Buddhism there are beliefs which support euthanasia under special circumstances. According to Koodamara et al. (2018), in Hinduism the purity of one's rebirth and the future of one's soul depends on one's actions in the present life, hence euthanasia is not an act of sin to reach moksha and one can be permitted to end his life. Therefore, it could be considered that it is not a sin for a patient to request assisted suicide to end pain and find eternal peace.

Unlike in Hinduism, Islamic view on life unconditionally denies euthanasia or PAS. According to holy Qur'an 16.61 God (Allah) is the creator of life and life is a gift of God. Therefore, only Allah himself possesses the right to give life or take it back. No matter what a patient's condition is, still there is hope as God could gift him or her cure at some point according to Islam.

Even though almost all the countries where euthanasia or assisted suicide is legal consist of Catholic or Christian majority, Christianity and Roman Catholicism thoroughly refuse any act of taking life as they believe life is made by God and human's duty is to preserve and make the life fruitful with the love of God. God's power is eternal and divine, so no human authority could authorise to end life.

It could be assumed that a great disagreement would arise from religious leaders and religious activists in Sri Lanka if an attempt is made to decriminalize euthanasia or physician attempted suicide in Sri Lanka. Vidanapathirana (2017, p.3) suggests euthanasia to be legalized in Sri Lanka to uphold the rights of terminally ill patients to die with dignity as physicians could misuse euthanasia to perform illegal and unethical malpractices such as DNR (Do Not Resuscitate) orders misusing medical paternalism. Vidanapathirana (2017, p.3)

further describes physicians' orders not to resuscitate if patient goes into cardiac arrest as a type of involuntary passive euthanasia which amounts to homicide.

Even if Sri Lanka decriminalizes PAS, whether doctors be able to get the moral or ethical decision to let a terminally ill patient die as a part of their daily duty remains questionable with the notion of physician's responsibility as a life preserver in mind, and it calls for further research.

3. DISCUSSION

End-of-life care will continue to be a subject of debate due to the struggle between biomedical principles, the different existing legal frameworks, and the general population's beliefs. (Picón-Jaimes et al., 2022) Medically educated and especially trained to cure sicknesses and save lives, physicians play a vital role when it comes to the subject of euthanasia or assisted suicide. Affected and shaped by religion, morality, and general ethics of civilization, it is highly doubtful that a physician without special training on euthanasia or PAS would carry out such a procedure even if legally allowed or ordered or requested so. Turillazzi and De Paolo (cited in Picón-Jaimes et al., 2022) states that, medical education, and preparation in the perception of death, especially of a dignified death, seems to be the pillar of the understanding of the need to develop medical-legal tools that guarantee the integrity of humans until the end of their existence. If the new generations of physicians are given special training and education on bioethics, euthanasia, and PAS, it would be of very much assistance for them to overcome possible future ethical conflicts during their professional lives.

On the other hand, life is a natural phenomenon that exceeds the human created notions of biology, medicine, and law. Life is associated with the concept of dignity. Self-satisfaction and self-esteem are unavoidable demands of a thriving life. Even though birth is not a choice, life becomes a choice in dire circumstances. Picón-Jaimes et al. (2022) suggests that a person's treatment must be individualized in bioethics since each individual is

a unique unit so that medical paternalism must be abandoned. Therefore, it could be argued that medical and legal intervention in life requires certain limitations since perception on life and death differs from one human being to another. Unbearable pain and low quality of life should indeed be considered when deciding on a patient's life. Terminally ill persons should be considered as a special group of society who require extra chances and opportunities.

4. RECOMMENDATIONS

After careful and critical analysis of much research, it could be suggested that voluntary passive euthanasia shall be legalized in Sri Lanka under stringent conditions:

- The patient must be diagnosed terminally ill and be suffering from unbearable pain.
- A panel of medical specialists should confirm the diagnosis to be correct and a competent legal body should accept the request.
- The patient must be fully aware of his condition and death shall be requested by the patient himself without any force from a third party.
- The death should only be for the best interest of the patient and not for the best interest of any other party.
- Any other reasonable alternative should not be available.
- The illness could not be treatable in any other way. (If there is treatment anywhere in the world, the patient should not be granted with his death wish even if the treatment is not affordable or acquirable.)
- Patient should give his consent in the presence of a competent panel of witnesses and shall be allowed to prepare his living will.
- Consent of next of kin should be considered.
- Euthanasia must be the remedy of last resort and never to be carried out actively with or without the consent of the patient.
- Euthanasia should be carried out passively only by terminating life prolonging treatment and

never to be carried out in an active manner.

“We, in the process of evolution, should acknowledge quality of life over quantity. The physician's duty is to alleviate pain and suffering. If there is no other option, the doctor, in fulfilling this duty, should be allowed to passively end the patient's life. This statement is not based on autonomy, but on beneficence.” (Goel, cited in Gandhi 2017).

5. CONCLUSION

Euthanasia or assisted suicide is yet an antagonistic subject in the society and will always be, while a patient's quality of life and his right of self-determination remains the heart of the debate. The purpose of this paper was to discuss the concept of artificial deprivation of human life addressing the legal, moral, religious, and other aspects associated with it and to consider the possibility of decriminalizing physician assisted suicide in Sri Lanka under extreme circumstances.

It was suggested that it would be of a patient's best interest if voluntary passive euthanasia could be legalized in Sri Lanka in life threatening cases where the patient has no hope of surviving and where dying is the solitary will of the patient. Major issues associated with assisted suicide needs to be addressed cautiously and wisely as the concept itself could be used in ulterior motives of relatives and as some diagnosis could be turned wrong and as cures keep on getting invented in the field of medicine continuously.

Sri Lanka is a country which has been battered for decades by a civil war, by social, economic, and political issues and quite recently by COVID-19 outbreak and economic recession and political instability. It is more likely that certain individuals may argue that a developing nation like Sri Lanka should not pay much attention to a topic like 'Euthanasia or Assisted suicide' as Sri Lanka has greater problems to solve than considering a problem of a small group of society. There arises a question. What if you or a loved one turns terminally ill, and if a doctor verdicts that there is

not the slightest hope left? What if the unbearable pain becomes your own? We humans tend to analyze a problem quite philosophically as long as it is not our own. I am of the view that it is high time for Sri Lankan authorities to get into the shoes of the victims and have a view from their perspective rather than bearing a rigid opinion just because it is against morality or religion.

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EVALUATION OF SET-UP ERRORS AND SET-UP MARGIN IN THREE-DIMENSIONAL CONFORMAL RADIOTHERAPY FOR PELVIC TUMOURS BY USING ELECTRONIC PORTAL IMAGING DEVICE

V Ramanathan¹, K Gunarathne¹, DC Sampath^{1,2} and MM Rizwy^{1,3}

Department of Radiography & Radiotherapy, Faculty of Allied Health Sciences, General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka¹

Apeksha Hospital, Maharagama, Sri Lanka²

Teaching Hospital-Batticaloa, Sri Lanka³

ABSTRACT

A set-up error is defined as any deviation between the predetermined and actual treatment positions, and is determined by measuring the displacement of the treatment field position by comparing the treatment image to its reference image. Dose distribution in the target volume is dependent on setup margins. It is important to assess the setup errors for each radiotherapy unit to reduce the treatment errors. The aim of this study was to evaluate the systematic and random setup errors using electronic portal imaging device (EPID) for pelvic tumour patients treated by 3D-CRT (conformal radiotherapy) and also to assess set-up margin. 115 pelvic tumour patients were included in this study in which 1150 portal images were assessed. The displacements between DRR (digitally reconstructed radiograph) and the portal images were measured in the direction of right to lateral, superior to inferior in anterior images by matching rigid bony landmarks. Moreover, the displacements between anterior to posterior and superior to inferior were measured in lateral images. The estimated systematic errors were 0.242, 0.255 cm in right to lateral and superior to inferior direction in anterior images, and 0.227, 0.220 cm in anterior to posterior and superior to inferior in lateral images. The estimated random errors were 0.404, 0.367 cm in right to lateral and superior to inferior in anterior images, 0.313, 0.337 cm in anterior to posterior and superior to inferior in lateral images. The determined margins for CTV to PTV based on ICRU were 0.4711, 0.4465, 0.3870, 0.4026 cm in the order of the above mentioned directions. A 0.5 cm safety margin is suggested for all pelvic tumour patients treated with 3D-CRT in Varian 2300CD linear accelerator unit, Apeksha Hospital, Maharagama.

KEYWORDS: Radiotherapy, 3D-CRT, EPID, Pelvic tumours, Linear accelerator, DRR.

1. INTRODUCTION

Radiotherapy is one of major treatment option in cancer treatment and about 50% of cancer patients receive radiotherapy in radical or palliative intent during their course of treatment (Ramanathan et al., 2022). Radiotherapy uses high-energy radiation to destroy and control the spread of cancer cells. The genetic material (deoxyribonucleic acid, DNA) of cells can be damaged by high-energy radiations and the ability of further division and proliferation can be blocked (Jackson et al., 2009 & Ramanathan, 2021). The rate of repairing and retaining its normal function status of normal cells is usually better than that of cancer cells. Differential cell killing can be induced by high-energy radiation because of this inefficient rate of repair mechanism of cancer cells (Begg et al., 2011).

At present, many newest teletherapy modalities are available such as three-dimensional conformal radiotherapy (3D-CRT), Intensity Modulated Radiotherapy (IMRT), Image Guided Radiotherapy (IGRT), Stereotactic Body Radiation Therapy (SBRT), Stereotactic Radiotherapy (SRT), Stereotactic Radiosurgery (SRS), Particle therapy, etc. (Ramanathan 2017). And, 3D CRT is the most basic modern technique in which 3D anatomic information is used by sophisticated treatment planning system to generate conformal treatment fields sufficient enough to cover the target volume with 3D dose distribution while minimizing the normal tissue irradiation. There are some limitations to achieve the definition of 3D CRT. The knowledge of Clinical Target Volume (CTV) is the major barrier when conforming the radiation dose to the target volume as imaging modalities reveal mostly gross tumour extent only. Possible microscopic extensions also should be included in the target volume to achieve the goals of 3D CRT (Khan and Gibbons, 2014).

The International Commission on Radiation Units and Measurements (ICRU) has provided useful guidelines and the definitions of target volume delineation. The gross demonstrable extent and the location of a malignant and the location of a malignant growth are defined as Gross Tumour Volume (GTV). The Clinical Target Volume (CTV) is acquired by adding a margin around GTV to include the microscopic spread of malignant disease that must be eliminated. The dose

distribution in CTV may deviate from the intended plan due to geometrical uncertainties. ICRU has considered three sources of geometrical uncertainties respectively patient setup variation, organ motion and deformation, and machine-related errors. ICRU recommends two margins (internal margin and setup margin) for avoiding the deviation of CTV coverage due to anatomical and geometrical uncertainties. Internal margin (IM) is added to compensate for the variation due to the movements of internal organs because of their physiological functions (breathing, bladder filling, rectum filling, etc.). The CTV plus IM is called internal target volume (ITV). Setup margin (SM) is added to ITV to compensate for the deviation of intended CTV coverage due to the uncertainties in patient positioning and the alignment of therapeutic beams during the treatment planning and throughout all treatment sessions. The ITV plus SM are together called the planning target volume (PTV) (Landberg et al., 1999).

The set-up error is defined as any deviation between the predetermined and actual treatment position, and is determined by measuring the displacement of the treatment field position by comparing the treatment image to its reference image. Setup errors consist of two components namely systematic and random errors. The systematic component of the setup error describes the errors which occur during the treatment preparation while the errors during the treatment execution are described by the random component. The systemic errors make the dose distribution deviate away from the CTV, and the random errors blur the dose distribution around the CTV (van Herk, 2004). The process of radiotherapy verification helps us to ensure that targeting volume is the same as in the treatment plan (RCR 2008). Because of the possibility to detect and reduce setup errors for a large number of patients, portal imaging to measure set-up errors is the standard practice in a large number of institutions among various types of verification methods. This has made it possible to detect and reduce the setup errors for a large number of patients (Noghreiyani et al., 2019). During the portal imaging, visual comparison between the reference image and the image taken in the treatment position of the patient is performed. The DRR created by the planning system or digitized simulated film produced by a treatment simulator is used as a reference image. This deviation is measured relative to

the isocenter or field borders. The translational uncertainties in the three-dimensional can be detected, and if necessary, the correction can be made according to the correction protocol followed in the institute. The rotational uncertainties can also be detected with modern devices but the possibility of correction is limited according to the available couch movements. The setup error and the geometric PTV margin are interrelated. This margin is defined during the treatment planning process. The margin recipes are formulations that calculated the required PTV margin to provide adequate CTV dose coverage in the presence of errors for specific patient populations (Ecclestone et al., 2012). Several margin recipes have been published by some authors considering the dose coverage probabilities, physical and biological considerations (Landberg et al., 1999, Stroom et al., 1999, van Herk et al., 2000).

Image review at the first fraction of radiotherapy treatment and then periodically is necessary to ensure the treatment accuracy and reproducibility. The limitation of couch positional changes (setup uncertainties), which requires setup review or change before treatment delivery, should be determined for each institution specifically (Goyal et al., 2014). Generating data on its setup accuracy in every department is much better and recommended than using a published margin regarding the setup accuracy (Gupta et al., 2007). The deviation detected by comparing the reference image and treatment position image by using an electronic portal image device (EPID) can be used for evaluating the margin added to the CTV according to the margin recipes published under guidelines provided by ICRU (RCR 2008).

Varian 2300CD is the first linear accelerator installed in 2008 at Apeksha Hospital-Maharagama, which is the main treatment centre for cancer in Sri Lanka. After five years of installation, research was done by Loganathan et al. to evaluate the 3D setup errors of pelvic irradiation using EPID. 100 first two-day pre-treatment portal images of 50 patients have been evaluated and it has been shown that there were significant 3D displacements. The author has suggested that weekly portal images additional to the first two-day pre-treatment portal need to be performed for better treatment delivery. Currently, the workload has doubled that of 2014 at Apeksha

Hospital, Maharagama. The increase in the number of patients will reduce the time spent with a patient. This will cause an increase in the frequency of errors. Even after 10 years of installation, no review had been done about margin calculations. Therefore, it was very important to perform the evaluation of set-up errors and set-up margin due to the age of the machine and higher workload. The aim of the study was to evaluate setup errors and setup margin in 3D-CRT for pelvic tumours by using an electronic portal imaging device.

2. MATERIALS AND METHODS

A retrospective study was conducted among 115 patients treated for pelvic cancer, and all patients completed their course of 3D-CRT treatment during the period from July 2019 to June 2020 in Varian 2300CD linear accelerator unit, Apeksha Hospital, Maharagama. The permission was obtained from the hospital authority to conduct this study. The ethical approval for this study was exempted as there was no involvement with patients' routine treatment steps. The patients aged 18 to 80 years were included in this study. Data were collected from ARIATM oncology information system of Varian Linac.

Generally, radiotherapy is given as fractionated treatment over several weeks, and it is usually given five days per week. Orthogonal images of five fractions were selected from each patient for the assessment including the first two fractions, and other three fractions were randomly selected from the remaining fractions of their course of radiotherapy. Totally, 1190 portal images were assessed using the image review option provided with the ARIATM oncology information system. Each portal image was compared with a digitally reconstructed radiograph (DRR) as a reference image generated by the treatment planning system during the treatment planning process.

DRR is an image generated by the treatment planning system by using imported images from the CT simulator. DRR can be created in any plane other than the image acquisition plane. The quality of DRR can be adjusted up to some extent by the treatment planner, but it mostly depends on CT data. Clear

visualizing of bony anatomy ridges in DRR depends on the quality of the DRR. Clear bony anatomy ridges in DRR helps to give a good comparison result with portal image. DRRs were generated by Varian Eclipse™ treatment planning system in the present study setting. Portal image is an essential tool used to verify the patient set-up with respect to the position of the radiation beam. Isocentrically mounted Varian Portal Vision™ aS1000 electronic portal imaging device was used to acquire electronic portal images (EPI). Typically, a radiation beam with energy 6 MV is used to deliver 1 MU (Monitor Unit) of exposure at 300 MU/min dose rate for the acquisition of portal image. Visual comparison between EPI and DRR is performed by matching clearly visible rigid bony landmarks in the interested area. EPI software gives details of shifts required to correct detected uncertainties. All images are stored in the database automatically for review purposes and can be reviewed using offline image review option in ARIA™ oncology information system as shown in figure 1.

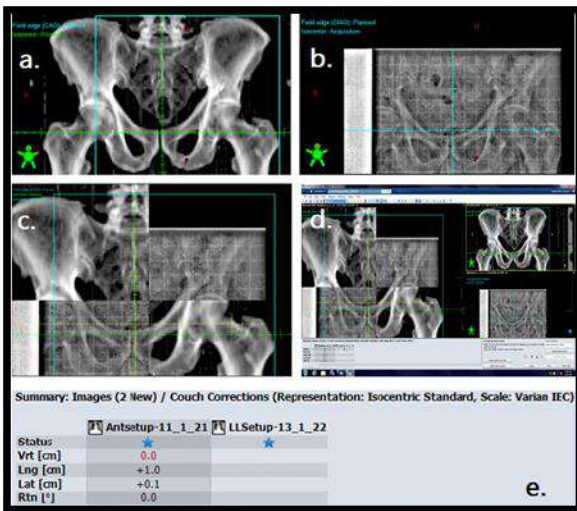


Figure 1: Visual comparison of bony land marks in DRR and EPI by using offline image review option in ARIA™ oncology information system [a- DRR generated by treatment planning system, b- EPI obtained just prior to delivery of treatment, c- superimposed DRR and EPI to correct the deviation with split window tool, d- user interface of offline image review option provided with ARIA™ oncology information system, and e- calculated couch

corrections according to the comparison of images a and b].

Displacements between DRR and portal images were estimated in the direction of right to lateral and to superior to inferior using image obtained at 0° gantry angle by matching rigid bony landmarks. Moreover, the displacements were obtained in the direction of anterior to posterior and superior to inferior using a lateral image obtained at 90° gantry angles. Superior, anterior, and left-sided shifts were implied as positive shifts, and inferior, posterior, and right-sided shifts were implied as negative shifts for the analysis of this study. The method used in the report published by the Royal College of Radiologist (RCR, 2008) was used to calculate the individual and population-based random and systemic errors in the direction of right to lateral, superior to inferior from anterior image at gantry angle 0°; anterior to posterior and superior to inferior from lateral image at gantry angle 90° (table 1).

Table 1: Methods demonstrated to calculate population based systematic and random errors. SD stands for standard deviation.

Component	Method of calculation
$m_{\text{individual}}$ (individual systematic error)	Mean setup error for an individual patient
M_{pop} (Overall mean setup error)	Overall mean of population
$\Sigma_{\text{set-up}}$ (Systematic error for population)	SD of the individual mean set-up errors about the overall population mean (M_{pop})
$\sigma_{\text{individual}}$ (Individual random error)	SD of the set-up errors of corresponding individual ($m_{\text{individual}}$)
$\sigma_{\text{set-up}}$ (Population random error)	Mean of all the individual random errors

The CTV to PTV margin calculations were performed according to the popular margin recipe formulae which were published by van Herk et al., 2000, Stroom et al., 1999, and Landberg et al., 1999 (ICRU 62) based on various assumptions shown in

table 2. Calculations and analysis were performed using Microsoft Office Excel (MS Office 2007) spreadsheets and Minitab19 Statistical Software.

Table 2: Formulae used for CTV to PTV margin calculation.

Formulae	Author	Assumptions
$2.5\sum+0.7\sigma$	van Herk et al., 2000	90% of patients in the population receive a minimum cumulative CTV dose of at least 95% of the prescribed dose
$2\sum+0.7\sigma$	Stroom et al., 1999	Average 99% of CTV receives more than or equal to 95% of the prescribed dose
$\sqrt{\sum^2 + \sigma^2}$	Landberg et al., 1999 – ICRU 62	Systemic and random part of set-up error have the same contribution to the dose distribution

3. RESULTS

1190 images of 115 patients were selected for analysis in this study. Details of the patients are listed in Table 3. The majority of patients were female (56.52%) and most of the patients were in the range of 66-80 years (43.48%). Carcinoma in cervix, prostate, rectum, endometrium, anus and bladder were included in this study. All patients were treated in supine position with the support of a head cushion and foot rest.

Table 3: Patients and treatment characteristics.

Characteristics	No. of patients	Percentage	
Age (years)	18-30	2	1.74
	30-42	7	6.09
	42-54	17	14.78
	54-66	39	33.91
	66-80	50	43.48
Gender	Male	50	43.48
	Female	65	56.52
Diagnosis	Cervix	32	27.83
	Prostate	37	32.17
	Rectum	8	6.96
	Endometrial	26	22.61
	Anus	1	0.87
	Bladder	11	9.57
Dose (Gy)	Median	50.0	
	Mean	51.1	
	Minimum	19.8	
	Maximum	72.0	
Fractions	≤ 10	0	0
	10<&≤20	10	8.70
	20<&≤ 30	100	86.96
	> 30	5	4.35

Measured displacements in ranges for all directions were summarized and are shown in table 4, and those for individual directions are shown in table 5. The distribution of the measured displacement is shown in figure 2 in each direction, right to lateral, superior to inferior using anterior image, anterior to posterior and superior to inferior using lateral image.

Table 4: Summary of displacements in all directions

Range	In all directions
Displacement ≤0.3cm	49.04%
0.3cm < Displacement ≤0.5cm	29.13%
0.5cm < Displacement ≤0.7cm	18.83%
0.7cm < Displacement ≤1cm	2.96%
Displacement > 1cm	0.04%

Table 5: Summary of displacement in individual directions.

Range	R- L(Ant)	S- I(Ant)	A- P(Lat)	S- I(Lat)
Displacement $t \leq 0.3\text{cm}$	41.57 %	46.09 %	55.13 %	53.39 %
0.3cm < Displacement $t \leq 0.5\text{cm}$	29.57 %	29.22 %	27.30 %	30.43 %
0.5cm < Displacement $t \leq 0.7\text{cm}$	24.70 %	21.04 %	16.00 %	13.57 %
0.7cm < Displacement $t \leq 1\text{cm}$	4.17%	3.65%	1.39%	2.61%
Displacement $t > 1\text{cm}$	0%	0%	0.17%	0%

Table 6: Summarized results of population systematic ($\Sigma_{\text{set-up}}$) and random ($\sigma_{\text{set-up}}$) error, overall mean setup error (M_{pop}), Minimum deviation and Maximum deviation along each direction.

Field	Anterior image		Lateral image	
	R-L	S-I	A-P	S-I
Minimum deviation (cm)	-0.9	-0.9	-1.1	-0.9
Maximum deviation (cm)	0.9	0.9	0.9	0.9
Overall mean (cm)	0.0158	0.0261	-0.0762	0.0313
$\Sigma_{\text{set-up}}$ (cm)	0.242	0.255	0.227	0.220
$\sigma_{\text{set-up}}$ (cm)	0.404	0.367	0.313	0.337

Table 7: CTV to PTV margin generated in present study

Recipe	Anterior		Lateral	
	R-L (cm)	S-I (cm)	A-P (cm)	S-I (cm)
$2.5\Sigma + 0.7\sigma$ Van Herk	0.8871	0.8940	0.7868	0.7866
$2\Sigma + 0.7\sigma$ Stroom	0.7663	0.7665	0.6733	0.6764
$\sqrt{\Sigma^2 + \sigma^2}$ ICRU 62	0.4711	0.4465	0.3870	0.4026

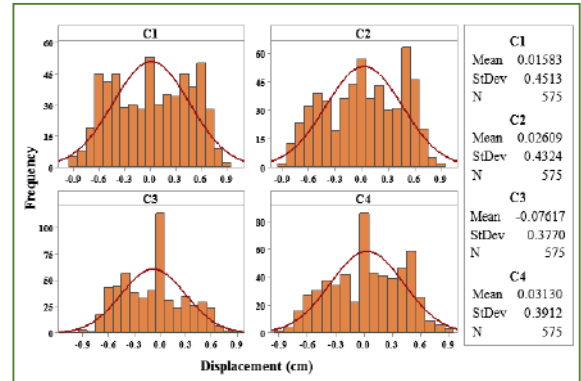


Figure 2: Distribution of measured displacements (C1- right to lateral direction, C2- superior to inferior (from anterior image); C3- anterior to posterior direction, C4- superior to inferior direction (from lateral image).

Population systematic ($\Sigma_{\text{set-up}}$) and random ($\sigma_{\text{set-up}}$) error and overall mean setup error (M_{pop}) were calculated according to the methods shown in Table 1. The mean displacements were 0.0158, 0.0261, 0.0762, and 0.0313 cm in the direction of right to lateral, superior to inferior (anterior), anterior to posterior and superior to inferior (lateral) respectively. Systematic errors were 0.242, 0.255, 0.227, 0.220 cm and random errors were 0.404, 0.367, 0.313, 0.337 cm respectively along the relevant directions (table 6).

The calculated CTV to PTV margin values in the direction of right to lateral and superior to inferior from anterior image, anterior to posterior and superior to inferior from lateral image are shown in table 7.

4. DISCUSSION

The present study setting is a busy radiotherapy centre where an average of 80 patients are treated daily including 3D-CRT, IMRT, and electron beam therapy within 12 to 16 hours by VARIAN 2300CD linear accelerator. Patient positioning is a challenging task as the number of radiotherapy patients is high. Daily image verification is performed for IMRT but portal imaging is performed for the first two days of treatment and weekly portal imaging is followed for 3D-CRT pelvic region treatment. Offline correction

protocol has not been implemented and online correction is carried out if the detected deviation is more than or equal to 0.5 cm in any direction in two orthogonal portal images for 3D-CRT in pelvic region patients. A considerable amount of displacements (78%) were within the tolerance level (<0.5 cm), while nearly one-fourth of all displacements of pelvic cancer patients were out of range.

A comprehensive report published by the Royal College of Radiologists is used for calculating systemic and random errors in this study shown in Table 1. Comparison of systemic error and random error findings in similar studies are tabulated in Table 8 and 9. It shows that results in the present study are well-matched with the previous literature.

Several mathematical models have been published for generating CTV-PTV margins. Assuming equal effect on dose distribution from systemic and random error, International Commission on Radiation Units has published the margin generating formula as $\sqrt{\Sigma^2 + \sigma^2}$, where Σ is the population systemic error and σ is the population random error (Landberg et al., 1999). Incorporation of differential effects on dose distribution over systemic and random errors and using probability matrices and dose-volume histogram respectively, van Herk et al., 2000 and Stroom et al., 1999 have suggested formulae as $2.5\Sigma + 0.7\sigma$ and $2\Sigma + 0.7\sigma$. The calculated margin in the present study is well aligned with the calculated margin in similar studies performed recently by Loganathan et al., 2014 Nigam, Kumar and Balan, 2016 and Noghreiyen et al., 2019 (Table 10).

Table 8: Summary of systematic error reported in four similar studies performed in pelvic radiotherapy and the present study (all values are in cm).

Study	Systematic error			
	R-L	A-P	S-I (Ant.)	S-I (Lat.)
Loganathan et al., 2014	0.2568	0.2698	0.3284	
Nigam et al., 2016	0.3100	0.2700	0.3700	
Swarna K , 2017	0.2404	0.1966	0.5832	
Noghreiyen et al., 2019	0.2364	0.2742	0.4993	0.3859
Present study	0.2416	0.2550	0.2270	0.2203

Table 9: Summary of random error reported in four similar studies performed in pelvic radiotherapy and the present study (all values are in cm).

Study	Random error			
	R-L	A-P	S-I (Ant.)	S-I (Lat.)
Loganathan et al., 2014	0.1628	0.2339	0.1603	
Nigam et al., 2016	0.2500	0.2300	0.2500	
Swarna K , 2017	0.2135	0.1946	0.6191	
Noghreiyen et al., 2019	0.1511	0.1593	0.2747	0.2321
Present study	0.4045	0.3666	0.3134	0.3370

Table 10: Summary of margin calculated in 3 similar studies performed in pelvic radiotherapy and the present study (all values are in cm) according to the recipes published by ICRU 62, Stoom, and Vanherk. [Study 1- Loganathan et al., 2014, study 2- Nigam et al., 2016, and study 3- Noghreiyen et al., 2019].

Recipe	Dir.	Study			
		1	2	3	Present
ICRU	R-L	0.3040	0.4200	0.2805	0.4711
	A-P	0.3570	0.3500	0.3171	0.3870
	S-I (Ant.)	0.3650	0.4400	0.5699	0.4465
	S-I (Lat.)			0.4503	0.4026
Stroom	R-L	0.6270	0.7900	0.5785	0.7663
	A-P	0.7030	0.7000	0.6599	0.6733
	S-I (Ant.)	0.7690	0.9100	1.1909	0.7665
	S-I (Lat.)			0.9342	0.6764
Vanherk	R-L	0.7560	0.9400	0.6967	0.8871
	A-P	0.8380	0.8300	0.7669	0.7868
	S-I (Ant.)	0.9330	1.0900	1.4406	0.8940
	S-I (Lat.)			1.1271	0.7866

The maximum value of the margin generated by mentioned recipes in any direction are highlighted in table 10 and a comparison of these values of similar studies performed recently is shown in Figure

3. It shows that generated margins in the present study are in the range of margins found in the literature.

By applying estimated margins related to the present study, 0.9 cm margin to the CTV ensured that 90% of patients will receive a dose of at least 95% of the prescribed dose according to the assumptions made by van Herk (van Herk et al., 2000). 0.8 cm expansion of the margin to CTV has ensured that 99% CTV is covered by 95% of prescribed dose accordingly (Stroom et al., 1999). According to the ICRU recommendation, 0.5 cm is enough for ensuring the coverage of CTV by prescribed dose assuming systemic and random error effect has equally contributed to margin determination.

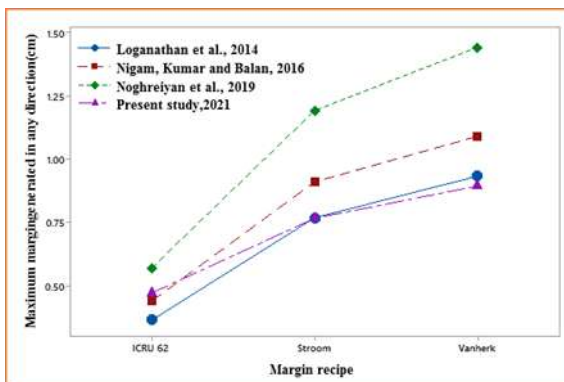


Figure 3: Comparison of maximum margin generated by ICRU 62, Stroom and Vanherk recipes in any direction in three similar studies and present study.

The number of limitations minimizes the ideality of calculated margin values. Internal structural changes cannot be detected on the electronic portal imaging study as the evaluation was based on a visual comparison of the bony anatomy of the portal image reference to the DRR created by TPS. Rotation errors were not evaluated in this study as there is no available facility to re-correct these errors. Error evaluation is only based on two orthogonal portal images. Above mentioned errors were not accounted for in calculating the CTV-PTV margins in the current study. The immobilization technique was the same for all patients and correlation between different techniques was not possible. Calculated

random errors were larger than systemic errors which show that additional attention must be required to reduce random errors during the patient positioning procedure. Inability to involve with the patient positioning procedure was identified as a shortcoming of the current retrospective study.

5. CONCLUSION

Setup errors may vary from institute to institute due to the influence of implemented protocols directly on the systematic and random errors. Determined setup errors of the present study are well matched with the published setup error data corresponding to the pelvic radiotherapy practices. The calculated random errors in the present study were larger than systemic error, which indicates that patient positioning procedures must be carefully handled to minimize day-to-day setup variations.

78.17% of the deviations are within the tolerance limit. The margin which is less than 0.5 cm in all directions produced according to ICRU recommendation is selected as a safety margin among calculated CTV-PTV margin according to three formulae for all patients treated with 3DCRT in the pelvic region.

A deliberate attempt must be taken to evaluate the factors that can potentially impact upon margin to ensure the coverage of target before adopting any published margin recipes. However, the portal imaging study is suggested as a useful tool for monitoring the clinical practice and audit changes introduced by new equipment, technology, and practice.

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A LITERATURE REVIEW ON FACTORS AFFECTING THE ACADEMIC PERFORMANCE OF UNDERGRADUATE NURSING STUDENTS IN A SRI LANKAN UNIVERSITY CONTEXT

KLKTD Sandharenu¹ and AGK Neranja²

Department of Nursing & Midwifery, Faculty of Allied Health Sciences, General Sir John Kotelawala Defence University, Sri Lanka¹,

Department of Pharmacy, Faculty of Allied Health Sciences, General Sir John Kotelawala Defence University, Sri Lanka²,

ABSTRACT

This article explores various cutting-edge strategies Sri Lanka might use to modernize its nursing curriculum in order to tackle contemporary issues. Employers search the world over for nursing experts who have the skills necessary to meet the modern requirements of the world healthcare system. It is now vital to enhance nursing education in order to extend its focus, deliver more remarkable patient care, and increase the retention and persistence of the students. Nursing students in Sri Lankan institutions place a premium on academic achievement. Meanwhile, many factors that impact nursing students' academic success have been studied, yet many issues still exist. The current study employed a review technique to examine the literature on undergraduate nursing students' academic performance in a Sri Lankan university context, as well as numerous factors influencing nursing students' performance. The relevant literature for the article was gathered from the Cumulative Index of Nursing and Allied Health Literature (CINAHL), PubMed, and Google Scholar. The search was restricted to the English language. The paper illustrates how both internal and external factors have an impact on academic performance and outlines measures to enhance the grades of nursing students. Internal factors include student-related factors, while external factors include teacher-related, institutional-related, and home-related factors. The student-related factors were investigated by allowing the students themselves to understand the factors and implement actions to improve their academic performance. Teachers play a major role in enhancing performance. This could be done by allowing them to identify problems encountered by students that impact their performance. The relevant educational institutions can promote different workshops and activities to enhance the thinking skills of students, as well as help teachers, understand the influences of their student's preferred learning methods that will enhance their performances. Parents can identify the matters that pertain to the studies of their children and enhance their performance by giving them support. The study has the benefit of identifying the factors affecting performance and giving suggestions for producing intelligent and skilled nursing graduates for the nation.

KEYWORDS: *Internal, External, Academic, Performance, Nursing Education*

Corresponding Author: KLKTD Sandharenu., Email: tharanisanda@kdu.ac.lk

1. INTRODUCTION

The goal of education is to empower students through social transformation and to provide them with access to information (Noro et al., 2015). Due to the impact of global economic and sociopolitical variables, it is subject to regular changes (Li, 2016; Rodrigues et al., 2016). Education in the field of health care is no exception; in fact, it is a crucial component of higher education that needs to be updated to reflect contemporary world trends.

Formal nursing education started in 1939 and was influenced by the British nursing tradition. It opened the door for the apprenticeship concept to be incorporated into Sri Lankan hospital-based nursing education. But this approach was also the main driver behind splitting apart nursing schools to provide more specialized training. As a result, under the direction of the Ministry of Health, 11 nursing schools in Sri Lanka currently offer a 3-year general nursing education program, with more than 1000 nurses graduating from these programs each year. In addition to midwifery and clinical specialties like Mental Health Nursing, Sri Lanka's Ministry of Health (MOH) provides a broad range of post-registration education and training for nurses.

It is now evolving to have more nurses who are qualified with a bachelor's degree due to the lack of policies that address training infrastructure, accreditation procedures, curriculum development, modification, or faculty shortages (MOH, 2017). A four-year pre-registration degree program leading to a BSc in nursing was developed by the University Grants Commission of Sri Lanka after comprehensive assessments of the proposals made by innovative nursing leaders and authorities at five state universities in nursing (Jayasekara and Amarasekara, 2015). On-site and online nursing degree programs are offered in English (UGC, 2017).

Only a small percentage of Sri Lankan nurses (approximately 1%) have degrees beyond a bachelor's (De Silva & Rolls 2010). Most nurses with graduate degrees work for universities or have left the

country. Government, donor organizations, and private (personal) sources of finance for higher education outside of Sri Lanka are scarce (Jayasekera & Amarasekera 2015). However, less emphasis is placed on research, evidence-based practice, therapeutic communication skills, exposure to cutting-edge technology, and computer literacy in Sri Lanka's current nursing curriculum. A few private universities have recently started awarding applicants who have finished the BSc degree with a Master's degree in nursing. Nursing education in Sri Lanka has reached a significant milestone, with nursing PhD holders contributing their knowledge to the improvement of nursing education in both local and global contexts.

In Sri Lanka, there aren't enough nurses to care for all the patients. If nursing education is improved and updated in Sri Lanka, these modifications will inspire more people to pursue careers in nursing. Additionally, Sri Lankan nurses can expand their services both domestically and abroad if they have access to internationally recognized nursing education and training. Therefore, some of the key initiatives that can be adopted in Sri Lanka include raising English proficiency, improving therapeutic communication skills, and establishing a holistic approach to nursing education and patient care. Furthermore, it is suggested that methods for multiple intelligences, learning styles, emotional intelligence, and enhancing counseling skills are essential interventions.

Educational institutions are worthless without students. Any educational institution relies heavily on its students. Universities' most valuable asset is their students. It has a significant impact on the quality of education, and human wealth as well as on personality development and performance, all of which ultimately contribute to the improvement of human living standards (Feenberg, 2012). The performance of students is crucial in creating high-quality graduates who will serve as outstanding leaders and highly skilled personnel for the country, and thus is strongly tied to a country's social and

economic progress. Students must put forth the

maximum effort in their studies to get excellent marks and to prepare themselves for prospects in their careers. Therefore, nursing programs throughout the globe utilize a range of metrics to assess nursing students' academic achievement. One dominant method is assessing the grade point average (GPA). Academic performance refers to the capacity to learn and recall things, as well as the ability to communicate the acquired knowledge verbally or in writing. According to Annie, Howard & Mildred (1996, p.2-5) "Academic performance is defined as the outcome of education; the extent to which a student, teacher, or institution has achieved their educational goals". It is a key feature in education because the way of student learns and how they approach their learning situations is unique to every individual student (Abewardhana et al., 2019). Academic achievement is a criterion for evaluating and comparing students (Almigbal, 2015). It is a significant criterion utilized by academic institutions to assess the quality of education. According to Minnesota (2007), "the academic achievement of graduate students determines higher education success.

Especially, nursing students have lower self-consciousness and psychological resilience than working people because of their minimal social interactions, making them more sensitive to psychological issues (Bask & Salmela Aro, 2013). Therefore, academic achievement has been shown to positively predict life satisfaction in university nursing students (Xiao, Tang, & Shim, 2009). Furthermore, academic achievement is the critical criterion used to assess the success of a student's university life. Therefore, there have been several efforts to increase nursing students' academic achievement, and there has been a substantial amount of study on student academic performance and the different factors that impact it.

A student's academic success is influenced by a variety of factors. Students learning capabilities are mostly affected by their thinking skills if they do not learn what they need to study. If teachers do not know how to get a student's attention, the student will

struggle to pay attention to the material. The student becomes sluggish because he or she is studying a subject that they or believe is unrelated to their course; nonetheless, they or continue to study it.? However, the goal of the BSc nursing program is to develop professional and trained nurses who can use their knowledge and abilities in the field. Therefore, nurse educators must look for ways to improve our current techniques and practices to help students succeed. To accomplish this, it is necessary to get a deeper understanding of the elements that determine nursing students' academic achievement. This will aid in academic achievement and, as a result, have an impact on outcomes such as retention, attrition, and graduation rates. As a result, a limited narrative literature review was conducted to identify factors impacting nursing undergraduates' academic performance. The usefulness of this research aids in the implementation of remedial procedures that will assist students in enhancing their academic performance. Therefore, the main goal of this literature review was to investigate the factors that influence the academic performance of nursing undergraduates in a university setting, to aid in the advancement of both students and teachers.

2. METHODOLOGY

The Cumulative Index of Nursing and Allied Health Literature (CINAHL), PubMed, and Google Scholar were used to find the pertinent literature for this article. Since it was impossible to locate relevant publications in Tamil or Sinhala, the search was limited to English-language resources published until 2020 and related to the subject of the present study.

The studies that explored the factors affecting the academic performance that focused on nursing students were included and the keywords used to identify the relevant sources were: "nursing education", "nursing students", "adjustability", "study habits", "motivation", "self-efficacy", "stress and coping", "learning styles", "resilience", "English language skills", "family support", "academic support" and "institutional support". Boolean operators (AND, OR, and NOT) were used to combine the search on the above key terms. The duplicated studies were excluded.

Title and abstract reading were done first in the search and study selection procedure, followed by the comprehensive reading of the chosen paper. The literature references listed in the chosen studies were looked up both backward and forwards.

3. RESULTS

50 articles were found in the initial search. After the first screening, 10 articles were removed due to duplication, and 9 were found to be unrelated. The six papers were not accessible when the review was conducted in terms of the availability of the full articles. Finally, 6 other papers were deleted, and 25 were studied after the study of the articles. The retrieved literature related to the factors that may affect nursing students' academic performance was categorized into four sections. The first section defines and describes student-related factors in the literature within the nursing education context. The second section explains and provides examples of the teacher-related factors that influence the academic development of nursing students. The institutional-related factors are described and illustrated in the third section. The final section defines and provides a description of the aspects of the home that affect students' academic achievement.

Student- related Factors or Personal Conditions

Students' efforts, age, and self-motivation, as well as learning preferences, entrance qualifications, and prior school experience, were all identified as student-related factors. Furthermore, student-related factors such as adjustment, attitude, desire for high grades, study habits, attention, priorities, and motivation have been identified as having a considerable influence on the academic achievement of student nurses (Kusurkar et al., 2012).

Adjustability

Starting university is a significant life step for many students. Students undergo a significant transition period at the time they start university life. It may be challenging to adjust to many changes at once, requiring support. Most of the students raised the fact

that they are confronted with numerous challenges due to adjusting to a new social situation.

Also, it may be incredibly stressful. Pre-existing mental health issues may be exacerbated for certain adolescents throughout this adjustment. These issues may remain or even worsen throughout their academic careers, affecting academic achievement (Auerbach et al., 2016; Mortier et al., 2015; Zivin et al., 2009). Others, on the other hand, may have psychopathology as a result of the stress of university life and adjusting to a new social situation (Eisenberg et al., 2007). Therefore, it is identified that adjustability is an important support need especially for newly recruited undergraduate students, to maintain student retention and persistence.

Many students are adjusting to university life while simultaneously adjusting to their journey into adulthood. Therefore, the first few months at university are said to be particularly difficult and stressful due to significant psychological adaptations (Conley et al., 2014). Moreover, a poor adjustment may be led to a decrease in their academic performance, an increase in fatigue, and a decrease their well-being. Furthermore, this severe issue is addressed a little in the university and this can negatively affect student outcomes and retention (Shields, 2011).

Study Habits

The most significant predictor variable for academic achievement appears to be study habits (Aluja et al., 2004; Boehler et al., 2001). Study habits are the capacity of students to manage their time for studies (Ozsoy et al., 2009). Further, study habits are students' techniques of studying, whether systematic, efficient, or inefficient (Ayodele & Adebisi, 2013). This means that effective study habits contribute to academic success, while inefficient study habits lead to failure. Several studies conducted throughout the world have found that there is a link between study habits and academic success (Bashir and Mattoo, 2012; Kurshid, Tanveer, and nas Quasmi, 2012). According to a study conducted by Marquez (2009), a student who performs well in his chosen career has good study habits. It is also said that students should

apply these methods throughout their academic careers, and this inherent quality adds to the great academic achievement of nursing students. Alos et al. (2011) agreed with this, noting that a student who succeeds in his or her chosen profession has good study habits.

Study habits were also noted by Mashayehki et al. (2014) as a factor determining students' academic development. Dimkpa et al. (2013) investigated the causes of low academic performance among student nurses at Nigeria's Bayelsa State School of Nursing, and the findings concluded that students with good study habits assist others in grasping difficult topics, completing projects, and internalizing material in group studies. Moreover, another recent descriptive study conducted at a Philippine institution discovered that study habits have a substantial impact on student nurses' academic success. This demonstrates that academic achievement is largely determined by students' study habits. As a result, to improve education, students' study habits must be improved.

Motivation and Self-efficacy

Academic burnout is prevalent among students in many disciplines of study, ranging from 10.3 percent to 76.8 percent (Mikaeili et al., 2013). This is affected by stress (Fares et al., 2016), student-teacher relationships (Abolghasemi, 2010), social support (Seo et al., 2015), emotional intelligence (Kang, 2015), endurance (Dyrbye et al., 2010), personal characteristics (Otero-López et al., 2015), motivation (Cazan, 2015), self-efficacy (Rahmati, 2015) and academic atmosphere (Brazeau et al., 2010). Among these factors, motivation and self-efficacy are the most important characteristics that appear to be useful in reducing the degree of academic burnout among students (Cazan, 2015; Rahmati, 2015).

Bandura (1999) defined self-efficacy as the “individual’s perceived capability to perform in a way that creates regulation over events affecting his/her life” (p.?). It is described as how the person regulates his or her behaviour when interacting with the environment (Bandura, 1997). This controls human function through cognitive, motivational,

emotional, and decisive processes (Bandura & Locke, 2003). According to social cognitive theory, experiences, observational learning, social persuasion, and emotional arousal can lead to self-efficacy which helps individuals overcome obstacles and perform well in academics with confidence (Bandura, 1997). Another study carried out by Bernacki et al., (2015) revealed that self-efficacy thoughts are a motivating output, and when a person can deal with his or her issues, his or her self-efficacy rises, and he or she becomes more driven to attain academic achievement (Bernacki et al., 2015). Moreover, Richardson et al. (2012) highlight that self-efficacy is a strong predictor of academic performance and the results are in line with earlier reports on meta-analyses of the relationship between self-efficacy and academic performance (Multon, Brown, & Lent, 1991; Robbins et al., 2004).

When it comes to motivation in the classroom, there are three types: internal, external, and no motivation. Internal motivation is the evaluation of students to study self-preferences and experience mastery of learning, whereas external motivation is the teacher's reinforcement, score, and other conditional rewards that are respected for students in the event of performance advancement. When a person is unable to express his or her desire to participate in a certain activity, it is stated that they lack motivation (Akomolafe et al., 2013; Reeve, 2014). Moreover, Green et al. (2012) depicted that learners' performance and academic progress may be improved by participating in class and performing assignments, and therefore, educational motivation was found to have favourable effects on learning, class engagement, and assignment completion in the class.

Stress and Coping

Student life is a thrilling and hard time in one's life. During this time, all students must improve their mental health and self-confidence to succeed in academic life. Therefore, the psychological state of students has a significant role in their academic achievement. Psychological support is important to improve their emotional well-being and academic

performance during the undergraduate period. The prevalence of mental health issues such as depression and anxiety has increased among undergraduate students and these problems have been shown to have a negative influence on both emotional well-being and academic performance. Many aspects of the undergraduate experience, such as the transition from high school to university life, heavy workload, peer pressure, etc., contribute to mental health issues among the students. Stress is identified as a physiological and psychological response to a stressor that is perceived as difficult to adequately cope with by an individual (Lewis & Shaw, 2007). It has been reported that the prevalence of stress is common among nursing students (Chan et al., 2009) and it is acknowledged as one of the most essential and persisting issues in nursing education. The prevalence of stress is relatively high among BSc nursing undergraduates in Sri Lanka. Several studies have demonstrated that more than half of the nursing student population has reported mild to severe symptoms of stress (Ilankoon & Warnakulasooriya, 2014). It may be due to the effects of many stressors along with the transition from school life to university life, including the different mediums of conducting lectures, the unique university culture with discipline, interacting with the unaccustomed clinical environment, and different assessment methods. This stress can lead to a decrease in their academic performance, increase fatigue, and decrease their well-being as well (Bradshaw et al., 2018; Gibbons, 2010; Kernan et al., 2008; McCarthy et al., 2018). Previous researchers have found that excessive stress can affect the academic performance of students (Hughes, 2005; Beddoe et al., 2004) and their psychomotor skills. (Bell, 1991). Thus, the education of student nurses during their undergraduate period may be compromised due to this stressful learning environment. In Sri Lankan universities, it has been noticed that there is clear evidence of poor academic performance and the fail rate is high in first-year nursing undergraduates compared to the other academic years. This is due to the stress they experience at various moments throughout their nursing education, particularly clinical training. Moreover, this severe issue is addressed little in the university, and this can negatively affect student

outcomes and retention (Shields, 2011).

The biggest source of stress for students is a heavy workload. Fazean Idris (2021) highlighted that in terms of mental health, students reported more stress (64.9%), despite having more time for self-study and tighter ties with family. They were also more anxious owing to deadlines, unanticipated interruptions, and larger workloads. Several studies have also demonstrated that the workload must be affordable to the students, and that an excessive workload can lead to stress. A study conducted by Pitkethly and Prosser (2001) also highlighted this heavy workload as a weakness among first-year students. Moreover, Batanneh (2013) reported that the demand of the academic pressure associated with limited social and personal time can lead students to possess a unique type of stressor.

Perception and the response to stress are highly individualized from person to person as well as from time to time in the same person. Therefore, specific and essential strategies should be practiced to cope with those responses to different stressors in order to handle stress or anticipate stress. Coping strategies are the specific tools, both behavioural and psychological mechanisms used to control, reduce or tolerate stressful events. Coping strategies are categorized mainly into two parts: problem-focused coping strategies and emotion-focused coping strategies. Problem-focused strategies are efforts to do something active to alleviate stressful situations, and emotion-focused strategies involve efforts to manage the emotional consequences of stressful events (Shelley Taylor, 1998). In emotion-focused coping, people try to accept sympathy from others, seek social support and deny the existence of stress while in problem-focused coping people take direct actions to solve problems as well as change or modify the source of stress. Researchers have proven that people use both strategies to cope with stressful events (Folkman & Lazarus, 1980).

Resilience

Resilience is described as the process, capacity, or result of effective adaptation in the face of adversity

or threat (Martin et al., 2009). The person can bounce back or recover from a stressful situation (Smith et al., 2008). In the student context, it is the capacity to successfully overcome potential environmental challenges created by early characteristics, situations, and experiences in an academic setting (Martin et al., 2013). This has been examined in numerous studies and several researchers have looked at the link between resilience and academic achievement in nursing students (Beauvais et al., 2014; Montas et al., 2021). For example, Beauvais et al. (2014) found that while there was no link between resilience and academic success in undergraduate nursing students, there was a link between resilience and academic performance in graduate nursing students. Hirano et al. (2010) developed the Bidimensional Resilience Scale (BRS) which was used to clarify which components of resilience are related to academic performance. Furthermore, Beauvais et al. (2014) discovered a link between resilience and academic achievement among undergraduate nursing students in New England. Therefore, students must retain a high level of intrinsic motivation and performance despite the presence of stressful events and situations that lead to poor academic performance and, eventually, dropping out (Martin et al., 2009).

Learning

Preferences and Learning styles

Learning preferences are a complicated notion that describes how students see, process, store, and recall what they are attempting to learn (James & Gardner, 1995). In a learning environment, students differ in many ways because, among other things, they have formed their learning preferences. The first-year nursing student population, in particular, challenges established teaching and learning approaches, such as developing new, culturally sensitive teaching methods (Carty et al., 1998) and their preference for self-directed learning (Walker et al., 2007). Educators and teachers, according to Miller (2001), have a responsibility to understand the diversity of students' learning preferences. Understanding that students have learning preferences might impact how course content is approached. For example, it

motivates teachers to employ a range of teaching techniques, resources, and media to accommodate individual variances (Lujan and DiCarlo, 2006).

Understanding these techniques also makes it easier to engage learners and assist their learning processes (Howard-Jones, 2009). Therefore, this will enhance the university student's academic performance which is effectively quantified using grade point average (GPA), which also analyses their academic goals and educational quality. Moreover, our perception of our ability to influence academic results, also known as perceived academic control (PAC), has an impact on academic achievement. In a Canadian psychology course, students with outstanding academic control had higher three-year GPAs and dropped out of fewer courses (Perry et al., 2005). Therefore, knowing nursing students' learning preferences and how they relate to academic achievement might help inspire curriculum revisions, more appropriate teaching styles, and evaluation methods.

Learning styles pertain to how people like to acquire information and develop conclusions (Savvas, El-Kot, & Sadler-Smith, 2001). Learning styles are one of the crucial elements in academic achievement (Özyurt et al., 2014). It is essential to understand students' learning styles to improve educational efficacy (Mupinga et al., 2006). Nursing educators' failure to pay attention to students' learning styles might result in academic failure. The association between learning style and academic success has been studied in several research. Some of these research findings revealed a strong link between these two factors. For example, Bangcola (2016) revealed that the most common learning style among students was kinesthetic learning style. On the other hand, Alipour et al. (2013) expressed auditory style can also be linked to the teachers' teaching methods. Therefore, instructors should consider the learning styles of nursing students while selecting their teaching approaches to devise effective intervention strategies.

English Language Skills

English language competency has emerged as the key facilitator of globalization and modernization as

society advances in an age where technology governs every area of life (Fischer et al., 2019). There is a rising need for second language acquisition due to increased cultural diversity and frequent interactions between individuals from various cultures. Given that English plays a significant role in empowering people on a global scale, there is an increasing need to increase English language skills, particularly among non-native English speakers (Rameez, 2019). Many non-native English speakers, especially nursing students, are prevented from growing and improving because of their lack of language proficiency, which also causes anxiety, fear, and tension (Khawaja et al., 2017).

In the sphere of education, English is used as a language of instruction by Sri Lankan nursing schools as well as universities. The majority of published academic research and significant references utilized by nursing students and academics in universities around the country are in English. In universities, especially the newly recruited undergraduate students face many challenges due to poor English language skills. At the university, there is new exam patterns like Objective Structured Practical Examinations (OSPE), lectures, Continuous Assessment Tests (CAT) exams, Multiple 8 Choice Questions (MCQs), writing paper, viva, and other practice exams which are conducted in the English language. As a result of these concerns, they are highly stressed, leading them to drop out of the course. Many students would need to devote more time and effort to learning English.

It is said that the language of instruction is critical in aiding course content acquisition and teaching the topic (Ibrahim, Shafaatu, & Yabo, 2017). Previous research has found a strong link between English language competency and academic achievement (Wilson and Komba, 2012; Aina et al., 2013; Kumar, 2014). A study carried out by Neumann (1985) revealed that the English language difficulty faced by students from non-English speaking backgrounds at university is complex and requires significant attention. Moreover, this may be led to a decrease in their academic performance, increase fatigue and decrease their well-being. Furthermore, this severe

issue is addressed a little in the university and this can negatively affect student outcome and retention (Shields, 2011).

According to several studies that have been carried out in the Philippines, it was found that English language ability affects nursing students' academic performance (Oducado & Penuela, 2014; Vidal, Labeeb, Wu, & Alhajraf, 2017). Language barriers affect their learning capacity and, which may have an impact on their academic achievement. According to Abriam-Yago et al. (1999) students with lesser English language acculturation (literacy competence) perform worse in all first-year topics in an undergraduate nursing program. Furthermore, Salamonson et al. (2008) discovered that language challenges affect learning capacity and hence academic performance. Further, it concludes that students with poorer English language competence perform worse in all first-year nursing subjects. In addition, several studies have depicted that nursing students who speak English as a Second Language (ESL) may have more difficulty learning and performing well academically (Glew, Hillege, Salamonson, Dixon, Good, & Lombardo, 2015; Salamonson, Everett, Koch, Andrew, & Davidson, 2008).

Additionally, while English instruction should be offered throughout all academic years, nursing students in many Sri Lankan colleges only receive a few weeks of it during their orientation program. An investigation of nursing education in Taiwan (Ryan et al., 1998) revealed that students' communication, presentation, and research and assignment writing abilities, as well as their level of confidence, were all significantly influenced by their inability to speak or write in English. Because of their poor English communication skills, the study also discovered that these students participated in seminar discussions to a relatively low degree. They were especially hesitant to converse in English in front of native speakers. For many nursing students, being unable to communicate in English became a distressing experience (Ryan et al., 1998).

Therefore, a lack of English proficiency may be a

barrier to students' academic achievement as well as their ability to acquire the nursing knowledge and skills necessary to generate internationally competitive nursing graduates.

Teacher-related Factors

According to multiple prior studies, instructors have the greatest effect on nursing students' academic progress. To increase the growth of students' learning experiences, Ganyaupfu (2013) emphasizes the need for teachers to provide a learner-friendly environment. He also says that lecturers' subject knowledge, class preparation, lesson presentation, and effective communication all contribute to students' academic performance. In addition, Mays (1946) stressed the necessity of having qualified instructors in the area of education, claiming that the capacity of the teacher to educate determines the success of any program. As a result, education implementation, selection, preparation, and monitoring will be impacted. Furthermore, according to Dayad (2000), competent instructors are always on the lookout for methods and instructional resources that will make learning more meaningful. A previous study carried out by Shaheen et al. (2020) stated that the availability of lecturers for educational discussions, educational counselling, and English language and IT (Information Technology) information enhancement support play a significant role in university students.

Richardson et al. (2001) revealed that if a teacher lacks knowledge or is uninterested in teaching, students may not be able to get a thorough understanding of their subject matter. Furthermore, when a lecturer lacks expertise in the course material, students become frustrated, and when their expectations are not met, their academic performance declines (Mbugua et al. 2012). Moreover, Alos et al. (2011) revealed that teaching techniques, student-teacher interactions, and communication difficulties are all challenges to nursing students' academic achievement. As a result, Rane (2010) recommends that teachers should enhance their teaching skills to increase student academic achievement.

Furthermore, Bangbade (2004) discovered that the characteristics of lecturers, such as academic knowledge, communication skills, emotional stability, strong human interactions, and enthusiasm for the job, had a significant influence on students' academic progress. This concludes that a variety of teaching attributes such as subject expertise, effective communication, and lesson preparation have a great impact on the academic performance of nursing students.

Institutional Related Factors

Institutional support assists students with excellent academic achievement and a comfortable lifestyle, particularly in the institutional environment and process (Shaheen et al., 2020). Institutional-related factors have been shown to have a major impact on the academic achievement of student nurses. A supportive team of workers, adequate facilities, affordable charges or course fees, the accessibility and perceived quality of learning resources such as the library, computers, and laboratories, as well as the university's academic regulations, are among these components that help students for good academic and day-to-day life management (Shaheen et al., 2020). Furthermore, various studies have revealed that unqualified and poorly educated instructors, limited facilities, and outdated instructional materials are also among the factors that affect the academic success of students. Many of the other researchers also found that culturally insensitive staff, an unwelcoming environment, and racism in the university were reasons for leaving the university (Walker, Roz, 2000). Bailey et al. (1998) and Prebble et al. (2004) also highlighted that the institutional environment was the third significant factor in retention and satisfaction at the university.

In addition, several previous studies (Prebble et al., 2004; Heverly, 1999) revealed that early and required contact activities with students, enrolment procedures, course scheduling, general administrative procedures, and suitability of timetabling affect the students' satisfaction and persistence in the university and students who complain that information is not readily accessible,

the staff is not supportive, or that policies are not fair are likely to feel alienated from the institution. A similar study by Rikinson and Rutherford (1996) also discovered that useful and better information might have enabled them to enrol in more appropriate courses at the university.

The findings of Listphoria's (2011) study show that physical learning environments, such as insufficient heating and air conditioning, affect students' learning and academic accomplishments, regardless of the teacher's expertise and effectiveness. The findings are in line with the study conducted by Mokgaetsi (2009), which stated that students' attention deteriorates, they feel tired or drowsy, and their cognition, intellectual function, and creativity are all damaged if the environment is excessively hot. Furthermore, the university library should offer comfortable seats, and a broad collection of books, computers, and other learning aids that aid students in succeeding (Jafta, 2013). Therefore, educators and administrators should create an environment that allows students to study more effectively (Tanvi, 2011).

Home-related Factors

Family support is also considered a vital component in students' lives. Since most undergraduates are unemployed, the financial support, love, and care provided by family members is the first and most crucial aspect any student requires (Zavatkay, 2015). Many researchers attempted to find the combination of family and peer support that influenced college outcomes.

Zavatkay (2015) highlighted that since most undergraduates are unemployed, the financial support, love, and care provided by family members is the first and most crucial aspect any student requires. Many researchers attempted to find the combination of family and peer support with college outcomes (Jayarathna, 2015). This finding is in accordance with the findings of some studies, which revealed that social support from family and friends positively correlates with academic engagement (Magolda et al., 1993).

According to research conducted by Bonci (2008), home support is crucial to students' academic performance. Additionally, Evans et al. (2013) and Lourenco et al. (2013) expressed that a lack of parental support leads to a decrease in student academic performance. Moreover, Farooq et al. (2011) stated that family stress, parental educational background, family income, and relationship issues, such as a lack of support and assistance from friends and family members, can have a negative impact on a student's academic performance, causing emotional issues, a lack of attention in class, and a lack of confidence in whatever the student does.

Graetz (1995) performed research on the socioeconomic status of students' parents and found that socioeconomic background had a significant influence on academic achievement. It has been the primary source of educational disparity among students as well as their academic achievement. Considine and Zappala (2002) also agreed with Graetz's viewpoints and they claimed in their study on the impact of social and economic disadvantage on school children's academic performance that parents or guardians who have social, educational, and economic advantage improve the degree of their child's future achievement.

Nnamani et al., (2014) conducted another study on the socioeconomic status of a student's parents, which found that a student's socioeconomic background had a considerable impact on his or her academic potential. They believed that students' academic performance was influenced by social and economic disadvantages. Furthermore, students' socioeconomic issues influence the quality of their mental and physical health, which has an impact on their academic performance. According to Farooq et al. (2011), students with financial challenges, have poor academic performance because they cannot afford to purchase essential resources and their basic needs are not satisfied.

4. DISCUSSION

This review contributes to a better understanding of the factors that affect the academic performance of

nursing students. The findings of the review revealed four related factors that affect the academic performance of nursing students: a) student-related factors, b) teacher-related factors, c) institutional-related factors, and d) home-related factors. The reviewed literature illustrated the background of nursing education in Sri Lanka and provided a comprehensive definition of academic performance within the nursing students' context. The reviewed articles showed the importance of academic progress among nursing students because they have lower self-consciousness and psychological resilience than working people because of their minimal social interactions, making them more sensitive to psychological issues. Therefore, academic achievement has been shown to positively predict life satisfaction among university nursing students (Xiao, Tang, & Shim, 2009). Therefore, there have been several efforts to increase nursing students' academic achievement.

The reviewed articles supported the findings of the student-related factors like adjustability, study habits, motivation, English language skills, stress and coping mechanisms, learning styles, etc., and teacher-related factors like lecturers' subject matter competence, class preparation, lesson presentation, enthusiasm, effective communication, etc., were found to affect the academic achievement of nursing students. In addition, institutional-related factors like a supportive team of workers, adequate facilities, affordable charges or course fees, the accessibility and perceived quality of learning resources such as the library, computers, and laboratories, as well as the university's academic regulations, etc., also affect the academic performance of nursing students. Further, the findings of the review revealed that social support from family and friends positively correlates with the academic engagement of students. Additionally, it clarifies how these variables could affect nursing students' learning strategies and academic results.

5. CONCLUSION

The provision of holistic nursing care depends heavily on nursing education, which is influenced by

the content of educational programs, the delivery of teaching, and the expertise of the lecturers (Zamanzadeh et al., 2015). Therefore, the goal of this review was to investigate the effects of diverse student concerns on academic performance. This review concluded that external factors such as teacher-related, home-related, and institutional-related factors, as well as internal factors such as personal circumstances, including study habits, impact nursing students' academic performance. Therefore, university administrators and academics have a responsibility to prepare and conduct an intervention program to aid nursing students in improving their academic performance. According to Pinehas et al. (2017), the assessment will encompass students' time management abilities, study skills, stress management skills, nursing field expectations from the student, and the student's family duties. This will assist educators in identifying challenges that students may have that may affect their performance and providing additional support to students so that they may develop good study habits and finish their studies on time.

In addition, mastering the English language is essential for exploring new ideas and receiving internationally standardized healthcare services (Squires & Jacobs, 2016). However, interventions to raise nursing students' level of language proficiency are lacking in Sri Lankan nursing education. Lack of English language ability had a detrimental effect on communication, research, and assignment writing skills. Therefore, improving nursing students' English language proficiency would benefit the nursing profession and healthcare as a whole. It will boost nursing students' psychological health and self-esteem. Moreover, the nursing curriculum in Sri Lanka has to be updated to focus on enhancing IT knowledge and abilities among nursing students. Making IT one of the required core disciplines for nursing students will help achieve this (Huston, 2013). As a result, students will have access to knowledge from around the world, will be able to advance evidence-based practice, and will be able to develop their research skills.

6. RECOMMENDATIONS

The following suggestions might help to improve the positive aspects of this review, including that students who are struggling with a lack of interest or time management challenges should receive counseling. For students who are experiencing problems with the English language, special language lessons might be conducted. Further, students should be provided with positive feedback as a reward for better efforts, and teaching techniques should be more participatory and clinically focused. Also, it is recommended that support services provided by universities be updated and improved in light of the current state of the nation, and it is advised to pinpoint the causes of the poor academic performance of nursing undergraduates, implement the necessary remedial measures and direct students in need of extra assistance or the right personnel or services.

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TRENDS AND DETERMINANTS OF TIRE EXPORT INCOME IN SRI LANKA: AN ECONOMETRIC ANALYSIS

R.P.B Madushani¹, M.D.J.W Wijesinghe¹ and I.P.Weerasinghe²,

Department of Economics and Statistics, Faculty of Social sciences and Languages, Sabaragamuwa University of Sri Lanka¹

Camsco Loadstar (pvt) Ltd., Midigama²

ABSTRACT

The tire industry in Sri Lanka shows excellent potential for the development of the economy with a substantial contribution to export income. Therefore, the main objective of this study is to examine the determinants and impact of tire export income in Sri Lanka. Secondary data was obtained from Central Bank in Sri Lanka and United Nations Statistical Office covering the period from 1989 to 2018. Unit root test, simple and multiple regression Co integration analysis, Error Correction Model, and Granger Causality tests were used for analysis. The study found a long-run causality between GDP, Global market price for rubber, Exchange Rate, and Inflation with tire export income. The causality test suggested a causality running from export income to GDP. However, there is no causality running between GDP and export income. According to regression results, GDP, inflation, and exchange rate significantly determined the tire export income in Sri Lanka. Further, inflation and exchange rates were negative, and the GDP was positively influenced by the tire export income. While Domestic and Global Market prices for rubber did not show a significant influence on the tire export income. Government should maintain favourable macroeconomic policies, especially monetary policies which enhance the stability of the economy.

KEYWORDS: *Tire Export Income, GDP, Causality, Cointegration*

Corresponding author: M.D.J.W Wijesinghe, Email: jayaniwijesinghe@yahoo.com

1. INTRODUCTION

In terms of foreign exchange earnings and exertion on the rubber-based product business in Sri Lanka, the tire industry plays a vital part in the Sri Lankan economy. Throughout the last 70 years, the tire sector has been a substantial contributor to Sri Lanka's export value as a partner of rubber-based products. Rubber Products account for around 7% of overall yearly export revenues, with the tire industry accounting for more than 60% of that figure. (Export Development Board, 2017). Furthermore, current statistics suggest that the tire industry's contribution to the Sri Lankan economy has been steadily expanding in recent years. (Export Development Board, 2017). Sri Lanka exports several types of tires and among them, Solid tires are the most significant tires on the market, followed by pneumatic and semi-pneumatic tires. Until now, Sri Lanka has developed into a hub for solid tire manufacture, and the country is the world's largest solid tire exporter, accounting for 20% of the market share (Samarasinghe and Karunarathne, 2015).

The tire industry, as one of the key contributors to foreign earnings, is influenced by a variety of internal and external factors. Over the last 30 years, the money earned from tire export in Sri Lanka has been highly volatile due to swings in the exchange rate and market price of rubber. Rubber pricing, as a significant determinant factor of tire cost, is critical in determining tire export income. Further when looking at the Sri Lankan tire market, tire export income shows some changes due to fluctuations in rubber prices locally and globally from 1989 to 2018. According to data, the greatest tire export income record in 2013 was 402\$ mn due to low rubber prices in the domestic market when compared to rubber prices over the previous four years. It records 396 million dollars in tire export income in 2018, compared to the lowest rubber in the local market over the previous 12 years. (World Bank, 2018). In addition, the most widely accepted notion is that higher exchange rate fluctuations create uncertainty, raising the riskiness of trading activity and eventually depressing trade (Todani and Munyama, 2005).

Changes in domestic inflation also influence price swings in the tire sector. Because it is a crucial element in determining input costs as well as the exchange rate. The largest inflation rate in the last 30 years was recorded in 2008, and as a result, the price of rubber in the domestic market climbed up to 2.47 \$, recording the highest price for rubber in the domestic market. In the same year, tire export income fell to 140 million dollars, the lowest level since 2003. According to data, it had the highest export revenues in 2015 and 2016 in relation to the Sri Lankan economy's low inflation rate during the same year (International monetary fund, 2017).

In this regard, the present study was carried out on determinants of tire export and its impact on the economy. Furthermore, the research was targeted at assessing the level of influence of those determinants and finding their impact of them on tire export earnings in Sri Lanka. In addition, it is hard to find studies directly related to tire export income and its determinants. Therefore, the findings of this study and their policy implications will provide a comprehensive picture to policymakers in the economy as well as experts in export and rubber and tire sectors and give an opportunity to rethink policies and macroeconomic management in the economy.

2. LITERATURE REVIEW

The literature review mainly based on the rubber export and its determinants. Abolagba et al. (2010) found a positive significant correlation between natural rubber production and rubber export in a study on factors influencing rubber export in Nigeria utilizing time series data from 1970 to 2005 and semi-log data. However, there was a considerable inverse link between domestic rubber consumption and rubber export in Nigeria. When it comes to interest rates, the researchers identified a considerable positive association between interest rates and rubber export. The findings of Amoro and Shen (2012) using OLS regression agreed with those of Abolagba. Rubber export in Cote D'Ivoire has a considerable influence and a positive association with domestic rubber output, according to secondary data from 1970 to 2005. The findings also revealed a negative link between local rubber consumption and rubber export. The same is true for the currency rate. It

has a substantial impact on rubber export but has a negative association. This suggests that the depreciation of domestic currencies resulted in an increase in rubber exports. In terms of interest rates, they identified a considerable positive association between interest rates and the quantity of rubber exported. Similarly, Boansi (2014) used annual time series data from 1986 to 2011 to study the factors of Ghana's rubber export performance. The OLS regression findings also demonstrated that rubber export was strongly and positively connected to natural rubber production. Meanwhile, the study discovered a negative association between domestic consumption of rubber and quantity export of rubber, indicating that when domestic consumption is high, the quantity of export is low. Kannan (2013), on the other hand, discovered that the relationship between natural rubber production and export is insignificant in predicting the quantity of natural rubber exported in India. He analyzes the relevant data using secondary data from 1991 to 2010 and the OLS approach. The same can be said about Mousavi and Leelavathi (2013), who used time series data from 1980 to 2010 to study the causal links between agricultural export quantity and real exchange rate in India. They also discovered that there is no substantial association between agricultural export quantity and real exchange rate. The OLS findings revealed that natural rubber production has a positive significance influence on natural rubber export, whereas domestic consumption and interest rates have a negative significance effect on natural rubber export. Meanwhile, between 1985 and 2015, the influence of currency rates on Malaysian natural rubber exports was statistically insignificant. (Laili et al,2017). Kautsar (2014) was also investigating the factors influencing the export price of natural rubber from Indonesia. The goals of this study are to present the current state of the Indonesian natural rubber export price and to examine the factors influencing the Indonesian natural rubber export price. In this study, panel data regression was used from 2002 to 2012. According to the findings of this study, world pricing, export tariffs, exchange rates, local consumption, export volume, and the global crisis all have a substantial impact on the export price of Indonesian natural rubber. According to the findings of a study conducted by Daulika et al (2020), international rubber prices, exchange rates, and domestic

consumption all have a considerable impact on the price of Indonesia's natural rubber exports. Fatahillah et al. (2022) found that the dollar exchange rate negatively and considerably affects rubber exports. Suri et al. (2021) also observed that the exchange rate has a significant and substantial influence on the export volume of natural rubber in North Sumatra.

In the case of inflation, according to Ball et al. (1988), inflation causes an increase in the cost of goods and services, which makes a country's products and services less desirable or competitive on the international market. In addition, Gylfason (1991) examined the influence of numerous macroeconomic variables on export, with a focus on inflation. He concurred that there is a negative correlation between high inflation and export performance. Rehman and Khan (2015) conducted a case study of Pakistan and identified the rise in food prices between 1992 and 2013 in Pakistan, which had a negative impact on the country's export of food items. Mallik and Chowdhury (2001) conducted a similar analysis with four developing South Asian nations and discovered a positive long-term association between inflation and economic growth, meaning that there is a positive association between inflation and export. In the context of rubber export, the study done by Fatahillah et al. (2022) showed that rubber output and inflation considerably and positively impacted rubber exports. In contrast, Suri et al. (2021) found that inflation does not affect the export volume of North Sumatra natural rubber.

3. METHODOLOGY

The data for this study were obtained from secondary sources using time series data for the study purpose. The study employed annual time series data covering the period 1989-2018. These secondary data were collected using both national and international sources such as central bank reports, World Bank reports, United Nations Statistical Office Economic Research Division and Federal Reserve Bank of St. Louis and International Monetary Fund.

To identify the factors affecting tire export earning in Sri Lanka, the multiple regression analysis was done, by using the following equations.

A dynamic equation can be derived as:

$$Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + \mu$$

Where,

Y - Tire Export Earning (US \$)

x_1 - Gross Domestic Product (US \$)

x_2 - Exchange Rate (US \$)

x_3 - Average Annual Domestic Market Price of rubber (US \$)

x_4 - Average Annual Global Market Price of rubber (US \$)

x_5 - Inflation Rate (%)

μ - error term

b_1 - b_5 Regression Coefficients

In addition, this study attempts to identify the short and long-run influence of these independent variables on the dependent variable. Therefore, using cointegration analysis and Error Correction Model (ECM) test long-run causality running from independent variables to dependent variables. Therefore, assess long-term causation flowing from independent factors to dependent variables using cointegration where Y - Tire Export Earning (US \$)

4. RESULT AND DISCUSSION

Sri Lanka produces an extensive variety of latex and dry rubber-based products. According to the data presented in Figure 1, tires account for 60% of export earnings.

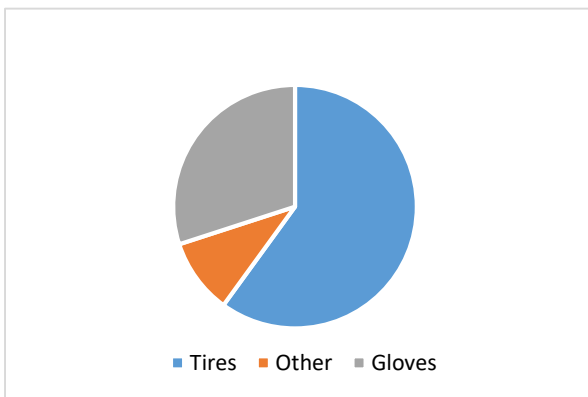


Figure1: Rubber-based export analysis and the Error Correction Model (ECM). Source: Export development board industry capability report (2017)

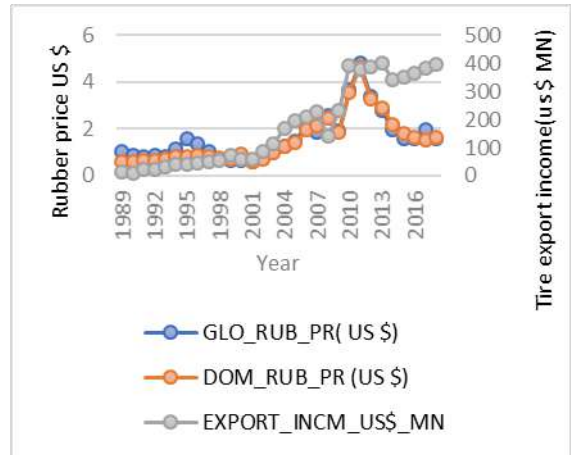


Figure 2: Fluctuations of tire export income and rubber price. Source: World Bank (2018)

This graph depicts the annual price fluctuations of rubber on the domestic and international markets from 1989 to 2018. Except for 1995 and 2017, all other years have identical data distribution patterns. It indicates that the price of rubber as a raw material for tire production swings similarly in the local and worldwide markets. In 1995, however, the worldwide market price for rubber significantly exceeded the domestic market price. Nonetheless, there is an upward tendency in the data up until 2011, after which the global and domestic rubber market prices decline. According to Okoruwa et al. (2003), a rise in the rubber price to match the global price will stimulate the maintenance and expansion of rubber farms. Consequently, it will have a good effect on the rubber-based product market.

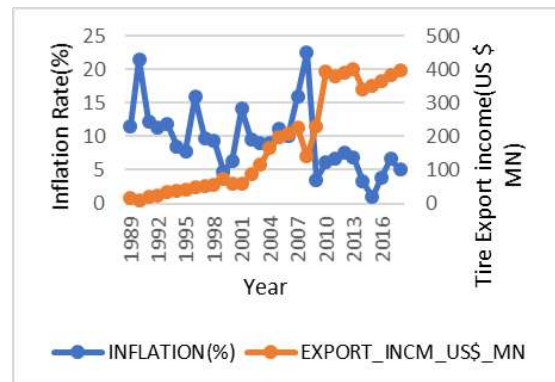


Figure 3: Changes in tire export income and inflation rate. Source: International Monetary Fund (2018)

According to the graph (Fig. 3) above, there was a substantial increase in tire export profits in 1995 due to the low price of rubber. Price increases on the domestic market in 1999 reduced tire export revenue. During the period from 2001 to 2007, both pricing and tire export revenue increased similarly. However, it ceases with the abrupt increase in rubber prices in the local and global markets.

According to Figure 3, the inflation rate soared in 2007 while tire export earnings dropped from \$226 million to 140 million in the same year. This is because a high inflation rate might affect input costs such as those for materials and labour. When the cost of production rises, the producer raises the price of a commodity to offset the increase. As a result of this action, foreigners must pay more for the commodities they were purchasing from our country. However, they dislike paying more than before. Therefore, they utilize a substitute for that commodity. Consequently, export earnings decline with inflation. In 2009, however, the rate of inflation quickly declined to 3.6%. It had the lowest inflation rate through 2014. This decrease positively impacts economic activity. As a result, tire export earnings grew by \$231 million in 2008 due to falling inflation. The studies Daulika et al., 2020; Fatahillah et al. 2022 and Suri et al. 2021 highlighted similar results.

The researcher built two separate equations based on the result of the analysis.

4.1 Model for Impact of Tire export income

The study used export income as their dependent variable and GDP as their independent variable. But according to the theoretical concept we export will influence on GDP. Therefore, the researcher test the causality of these variables to find out the impact of tire export income. According to result there can see impact from export to GDP. According to this impact researcher built following equation.

Equation,

$$DLOGDP = 0.085 + 3.51E-10 EXP_INCM$$
 0.2097(standardized coefficient)

According to result there is a positive impact from

export to GDP. The researcher used the standardized coefficient to interpret the impact from export income to GDP. Standardized beta coefficient compares the strength of effect of each independent variable to the dependent variable. According to that if tire export income increases by one standard deviation, on average, the GDP increases by 0.2 standard deviation unit. The R² value of this normal regression model shows 4.3% of variation of tire export income is explained by the GDP in the regression model.

4.2 Model for Determinants of Tire Export Income

Another main objective of is to identify the determinants of tire export income in Sri Lanka. Here the dependent variable is tire export income and the researcher used five independent variables. Such as Global market price for rubber, Domestic market price for rubber, Gross Domestic Price, Exchange Rate, and Inflation. Therefore, multiple regression analysis was conducted so as to test the relationship among variables (independent) on the tire export income in Sri Lanka. To identify the factors affecting Tire export income in Sri Lanka, the Ordinary Least Squares (OLS) technique was done, by using the following equations.

Equation,

$$DLOEXP_INCM = 13882769 + 5.29E+08 DLOGDP + 16105408 DLOGLOBAL_RUB_PR - 10442015 DLODOM_RUB_PR - 7.70E+08 DLOEX_RATE - 6507248 INFLATION$$

Table 4. 1 Standardized beta coefficient

Variable	coefficient	Standardized coefficient	Elasticity at means
DLOGDP	5.29E+08	0.8847	3.5941
LOGLOBAL_RUB_PR	16105408	0.2334	0.0275
DLODOM_RUB_PR	-10442015	-0.0590	0.0216
LOEX_RATE	-7.70E+08	-0.8251	3.0405
INFLATION	-6507248.	-0.7913	-4.6275

Source: Secondary data (1989-2018)

According to table 4.1, if GDP increase by one standard deviation, on average, the tire export income increases by 0.9 standard deviation unit by showing the positive significant relationship between Export income and GDP.

When Global rubber price increase by one standard deviation, on average, the tire export income increases by 0.2 standard deviation unit by showing the positive relationship between Export income and global market rubber price. But the relationship is not significant. Even though Global rubber price relate positively Domestic market rubber price shows negative relationship with tire export income. It is true because when raw material price increase it cause to reduce our export income. Hence when Global rubber price increase by one standard deviation, on average, the tire export income decreases by 0.06 standard deviation unit.

If exchange rate increase by one standard deviation, on average, the tire export income decreases by 0.8 standard deviation unit by showing the negative significant relationship between Export income and exchange rate. When inflation increase by one standard deviation, on average, the tire export income decreases by 0.8 standard deviation unit by showing the negative significant relationship between Export income and inflation. Daulika et al., 2020; Fatahillah et al., 2022 and Suri et al., 2021 also found a similar result.

The R² value of this normal regression model shows 48% of variation of tire export income is explained by the independent variables such as GDP Global and Domestic market price for rubber, Exchange rate and inflation in a regression model. P value of f statistic is less than 5%, and it is 0.6%. Means that it is highly all independent variables jointly can influence on dependent variable. GDP and exchange rate has the standardized coefficient with the largest absolute value. This measure suggests that GDP and exchange rate are the most important independent variables in the regression model. Inflation also shows considerable influence on the dependent variable when compares with other independent variables.

Before we proceed for tire exports of Sri Lanka and its determinants (by using Vector Error Correction Model), to check whether the variables are stationary or not, the researcher’s employed the ADF test. A summary of the results is given below (Table 4.2).

Table 4. 2: ADF Unit root test

Variable	Level/First difference	Probability		
		Intercept	Trend & Int	None
LOEXP_INCM	Level	0.5473	0.5512	0.9952
	First difference	0.0000		
LOGDP	Level	0.9169	0.0790	1.0000
	First difference	0.0044		
LOGLOBAL_RUB_PR	Level	0.5966	0.7472	0.2707
	First difference	0.0018		
LODOM_RUB_PRICE	Level	0.5995	0.8399	0.2869
	First difference	0.002		
EXCHANGE_RATE	Level	0.3878	0.8156	1.0000
	First difference	0.0003		
INFLATION	Level	0.0156		

Source: Secondary data (1989-2018)

As shown in Table 4.2 stationary test verified that the log variables such as export income, GDP, Global market rubber price , domestic market rubber price and exchange rate stationary after first differenced but inflation stationary at level.

4.3 Cointegrated Model

The result of the cointegrated model is as follows.

4.3.1 Johansen test of cointegration

In the Johansen test of cointegration, the number one condition is variable must be nonstationary at level and but stationary after converting in to first difference. In this research although inflation stationary at level all other variables stationary after converting in to first difference. Before running the Johansen test researcher checked the optimum lag selection using lowest AIC value According to that

choose lag 2 as best. Johansen test of cointegration has two test. One is “Trace Statistics” and another one is “Maximum Eigen value”. Here two Hypotheses were built as given below.

Null hypothesis H0: There is no cointegration among variables

Alternative hypothesis H1: There is cointegration among variables.

4.3.2 Trace statistics

If trace statistics are higher than the critical value, the researcher can reject the null hypothesis that there is no cointegration. The trace test indicates 3 cointegrating equations at the 0.05 level. Therefore, there are 3 error correction models.

4.3.3 Maximum Eigenvalue

If maximum eigenvalue is more than critical value can reject null hypothesis. Max-eigenvalue test indicates 2 cointegrating equations at the 0.05 level. Both results indicate two different values. Among them selected two cointegration equation as best to run the model. Because it is match with the output of both tests. All these results indicate long run associate of all variables.

4.3.4 Vector Error Correction Model (VECM)

When all variables are cointegrated researcher can run VECM. But if variables are not cointegrated researcher should run VAR model. In this research researcher run VECM because our variables are cointegrated in long run. In fact, in here target is to use the first model which used export income as dependent variable.

The estimate equation of error correction model is given below.

In here,

C1: coefficient of error correction model

C2: Constant of the Model

4.3.5 Long run influence

The quid line is C (1) should be significant and all coefficient of these error correction terms should be negative. The value of error correction term is -1.21. It is called as speed of adjustment towards the equilibrium or speed of adjustment any disequilibrium towards long run equilibrium state. In this model speed of adjustment is 121%. Meaning that is adjusting very fast towards long run equilibrium. Therefore, there is a long run causality from five independent variables. Meaning that GDP, Global and domestic market price for rubber, Exchange Rate and Inflation have influence on the dependent variable of tire export income at long run. In the other words there is long run causality running from independent variables to dependent variables.

Table 4. 3 Equation of error correction model

Dependent Variable: D(LOEXP_INCM)				
Method: Least Squares				
Sample (adjusted): 1992 2018				
Included observations: 27 after adjustments				
D(LOEXP_INCM) = C(1)*(LOEXP_INCM(-1) - 0.651846095858				
*LOGLOBAL_RUB_PR(-1) - 0.20114112828*LODOM_RUB_PR(-1) +				
1.69099871177*LOEX_RATE(-1) + 0.0710696638046*INFLATION(-1) -				
11.5211746094) + C(2)*(LOGDP(-1) - 0.649804021569				
*LOGLOBAL_RUB_PR(-1) - 0.793231429658*LODOM_RUB_PR(-1) +				
2.27603804441*LOEX_RATE(-1) - 0.027450009597*INFLATION(-1) -				
13.580920052) + C(3)*D(LOEXP_INCM(-1)) + C(4)*D(LOEXP_INCM(-				
-2)) + C(5)*D(LOGDP(-1)) + C(6)*D(LOGDP(-2)) + C(7)				
*D(LOGLOBAL_RUB_PR(-1)) + C(8)*D(LOGLOBAL_RUB_PR(-2)) +				
C(9)*D(LODOM_RUB_PR(-1)) + C(10)*D(LODOM_RUB_PR(-2)) +				
C(11)*D(LOEX_RATE(-1)) + C(12)*D(LOEX_RATE(-2)) + C(13)				
*D(INFLATION(-1)) + C(14)*D(INFLATION(-2)) + C(15)				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.212887	0.530289	-2.287221	0.0411
C(2)	-0.638892	0.209678	-3.047016	0.0101
C(3)	0.135988	0.315277	0.431330	0.6739
C(4)	0.480929	0.362179	1.327876	0.2089
C(5)	3.031568	1.738850	1.743433	0.1068
C(6)	4.098242	1.942973	2.109264	0.0566
C(7)	-0.383209	0.472773	-0.810556	0.4334
C(8)	-0.670867	0.393915	-1.703075	0.1143
C(9)	0.316907	0.387070	0.818733	0.4289
C(10)	0.335291	0.417116	0.803831	0.4371

C(11)	-1.832545	1.819432	-1.007207	0.3337
C(12)	0.139201	1.765833	0.078830	0.9385
C(13)	0.022470	0.023344	0.962542	0.3548
C(14)	0.010870	0.014832	0.732842	0.4777
C(15)	-0.627410	0.339778	-1.846528	0.0896
R-squared	0.577716	Mean dependent var		0.110194
Adjusted R-squared	0.085050	S.D. dependent var		0.214259
S.E. of regression	0.204945	Akaike info criterion		0.031972
Sum squared resid	0.504028	Schwarz criterion		0.687938
Log likelihood	15.43162	Hannan-Quinn criter.		0.182095
F-statistic	1.172633	Durbin-Watson stat		2.022639
Prob (F-statistic)	0.395250			

Source: Secondary data (1989-2018)

4.3.4 Short run influence

According to result final decision is GDP jointly can influence on tire export income, but Global and Domestic market rubber price, Exchange Rate and Inflation cannot influence jointly on tire export income in the short run (Table 4.4)

Table 4. 4 Walt test result (Source: Secondary data (1989-2018))

Variable	Null hypothesis	P value	Decision
EXP_INCM (1) EXP_INCM (2)	C(3)=C(4) =0	0.41	There is no short-run causality running from the lag value of tire export income to tire export income.
DLOGDP(1) DLOGDP(2)	C(5)=C(6) =0	0.04	There is short-run causality running from the lag value of tire GDP to Tire export income.
LOGGLOBAL_RUB_PR (1) LOGGLOBAL_RUB_PR (2)	C(7)=C(8) =0	0.22	There is no short-run causality running from the lag value of Global Rubber price to tire export income.
DLODOM_RUB_PR(1) DLODOM_RUB_PR(2)	C(9)=C(10))=0	0.59	There is no short-run causality running from the lag value of Domestic . Rubber price to tire export income

LOEX_RA TE(1) LOEX_RA TE(2)	C(11)=C(12) =0	0.59	There is no short-run causality running from the lag value of the Exchange Rate to tire export income.
INFLATIO N(1) INFLATIO N(2)	C(13)=C(14) =0	0.61	There is no short-run causality running from the lag value of inflation to tire export income.

Source: Secondary data (1989-2018)

5. CONCLUSION AND RECOMMENDATION

This study employed econometric approaches to determine the impact and determinants of tire export income in Sri Lanka using the Ordinary Least Square method. In this study, researchers looked at five independent variables that have an impact on tire export income in Sri Lanka. Such as GDP, global market rubber price, domestic market rubber price, exchange rate, and inflation. The data for this study were gathered from secondary sources as time series data from 1989 to 2018. The researcher's two aims in this study are to investigate the impact and factors of tire export income in Sri Lanka. As a result, the researchers developed two distinct models to identify the impact and determinants. The variables GDP, inflation rate, and currency rate were identified as the most relevant factors influencing tire export income in Sri Lanka in this model. At a 5% level of significance and a 95% level of confidence, those variables are significantly influenced positively or negatively. The findings found that, while the variable GDP had a favorable influence on tire export income in Sri Lanka, variables such as inflation and currency rate had a negative effect. However, fluctuations in the global and domestic market rubber prices have no bearing on tire export earnings.

According to the standardized coefficient values, GDP and exchange rate have the greatest impact on the tire export income.

When looking at the exchange rate from 1989 to 2018, the value of the rupee depreciates year by year in relation to the dollar. As a result, our export income

is reduced. As a result, the exchange rate has a negative impact on tire export revenue. When we evaluate the inflation rate, we can see that inflation raises the price of our commodity. Then, it diminishes demand from foreign countries, resulting in lower export demand. As a result, the inflation rate has a negative impact on tire export income. However, when GDP is considered, it raises the question of whether exports impact GDP or GDP influences export income. The Granger causality test method was used to determine the direction of the link between export and GDP. The researcher demonstrated causation from export to GDP in this test. As a result of demonstrating these linkages, run a simple regression model to demonstrate the influence of tire export income in Sri Lanka.

The cointegrated model was performed using all dependent and independent variables to investigate the long run relationship between dependent and independent variables. The regression analysis results also demonstrated a 121 percent pace of adjustment towards long run equilibrium. It means that it rapidly adjusts from any state of disequilibrium to long-run equilibrium. Following the establishment of the linkages between variables, the Walt test was used to assess the influence of the short run coefficient of lag values of variables. In the short run, the result demonstrated an impact from lag vales of GDP on Sri Lanka's tire export income.

Based on the findings, the study recommends the followings.

As a developing country, Sri Lanka must establish a long-term strategy to improve the quality of its exportable goods through the adoption of improved technology, because export income is a primary determinant of the country's sustainable GDP.

Rather than selling raw rubber, the government should focus on exporting standardized produced goods that help it compete with other countries.

The government should implement trade policies that eliminate trade barriers when exporting manufactured goods.

Tire export earnings have shown an increasing trend in recent years with reductions in the inflation rate in the Sri Lankan economy; therefore, it is necessary to maintain a favourable inflation rate by implementing new techniques.

According to the study, the government should boost export promotion measures to preserve a trade surplus and a favourable climate. Adequate security and infrastructure should be given to entice international investors to invest in the rubber-based product sector of the economy.

The government should maintain favourable macroeconomic policies, particularly monetary ones that improve economic stability.

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STRENGTHENING PASSWORDS AGAINST PEEPING ATTACKS

Induwara Jayalath¹, Thilini Delpachithra¹, Hansika Muthunayake¹, Tharindu Wijethilake¹ and Chamath Keppetiyagama¹

University of Colombo School of Computing, Sri Lanka¹

ABSTRACT

Despite a multitude of vulnerabilities of textual passwords, they are more likely to remain widespread since no scheme has become able to come close to providing all desired benefits. Among those vulnerabilities, peeping attacks are recognized as a real threat but, yet remain much unexplored. Most often, applications and systems use textual passwords for authentication, without considering the threat of peeping attacks. Our study provides the first numerical evidence of strength reduction to represent the impact of the attack. We introduce a novel authentication scheme that is conceptually different but purely text-based, as an endeavour towards strengthening textual passwords against the impact of peeping attacks. An experimental approach was used to collect data, simulating a peeping attack. Researchers intended were to provide an idea to the community, at the level of which the strength of a password can be reduced. This vulnerability is something crucial, yet haven't focused enough. Having such an understanding is desirable, as it can provide an image on the impact that these attacks can have on strength of textual passwords.

KEYWORDS: *Password security, Entropy, Peeping attacks, Authentication*

1. INTRODUCTION

Digitization acts as one of the core pillars of humans in the modern world as it helps people in their day-to-day lives. People use applications and information systems that contain much sensitive information daily (Zaman et al., 2017). These applications use authentication methods to secure personal data from unauthorized access. Textual passwords are a popular authentication method (Shah et al., 2015). Even though textual passwords are vulnerable to many threats and have been discussed widely, there is no trend to eliminate text-based passwords any sooner (Bošnjak and Brumen, 2019). Password strength meters (PSMs) help users to create stronger passwords.

The biggest issue, though, is whether password security can be guaranteed by password strength checks as strength measurement methods now in use have numerous shortcomings.

Most commonly used meters do not provide any publicly available explanation of their threat models or the logic behind their strength assignment techniques (de Carné de Carnavalet and Mannan, 2014). Most interesting fact is these strength meters gives different values for the same password (de Carné de Carnavalet and Mannan, 2014).

In this paper, we will highlight that the most effective password given by the strength checker can also be vulnerable. If the user enters the password in a crowded or public environment, such as a train or a bus, an observer can grasp some information about the password. Based on this information, the observer can infer the password. This is the peeping attack. Anecdotal evidence reveals these attacks occur more often than we might think (Bošnjak and Brumen, 2019). There are some already proposed solutions for this security threat. However as mentioned by Bosnjak et al. these solutions still have problems in usability and deployability. Even though textual passwords have many security issues, they are still in use as the major authentication method of most applications since 1960, which makes it challenging to replace new technology (Yang et al., 2020).

The focus of this study is to propose a solution to the strength reduction of passwords due to peeping attacks. So, we will propose a novel approach to reduce the threat caused by the peeping attack on textual passwords. We will use Shannon entropy-based calculations to measure the strength of the passwords. With a series of experiments, we will calculate the strength reduction of the passwords due to the peeping attack. Then, we will introduce our solution to the text-based authentication mechanism and redo the experiments to measure the strength reduction of the passwords. By comparing the entropy-based values, we will evaluate the effectiveness of our solution. Finally, we will also check the usability aspects of the solution.

2. LITERATURE REVIEW

According to NIST Digital Identity Guidelines, digital identity is the unique representation of digital services and can be claimed with digital authentication (Fenton et al., 2017). Passwords are the simplest and most widely used authentication method and their reliability of it depends on the strength of the password (Ma et al., 2010).

Password strength is a measurement of the effectiveness of a password against guessing or other attacks such as brute force, dictionary attacks, etc. (Panda et al., 2020). The current threat models of existing strength meters only have measures to mitigate or decrease the risk associated with brute-forcing and dictionary attacks (de Carné de Carnavalet and Mannan, 2014).

Attacks on Textual Passwords

The study of Hsien Cheng Chou et al. has shown the attackers can use methods such as social engineering, phishing and shoulder surfing to collect information on passwords and they have proposed a method to create strong passwords against dictionary attacks by considering the keyboard patterns. Wang Yao et al. has introduced a method to enter passwords using eye movements accurately using the front camera of mobile phones (Wang et al., 2018).

But this is difficult to use on laptops or desktops. A study by Shukia et al. introduces a new type of side-channel attack on the smartphone Personal Identification Number (PIN) entry process, that relies on the Spatio-temporal hand dynamics (Shukia et al., 2014). They have collected a corpus of 200 PIN entry videos that capture a part of the user's hand while entering the PIN and the backside of the smartphone. They have used a Tracking Learning Detection framework to track the positions. Based on their observations, they have concluded that the attack can decode up to 94% of the PINs. They believe the attack can be extended to passwords as well.

A paper by Panda et al. shows using of acoustic signals to recover 4–6-digit PIN from the emanations generated from the keystrokes with a chance of 60% (Panda et al., 2020). Their attack model is specifically made for modern PINs such as Automated Teller Machine keypads. Based on the results they provide a defence mechanism as well.

The study of Chou et al. has identified special keyboard patterns as AP-pattern (Adjacent and Parallel key). They have proved it has increased the effectiveness of dictionary brute force attack when incorporating these identified patterns (Chou et al., 2012).

The GazeRevealer is a side-channel attack technique (mobile app) which records the victim's eye patterns when tapping the keys on the screen using front camera. By analyzing those videos, GazeRevealer infers the keystrokes. The study has showed their approach achieved 77.43% accuracy for a single key number and 83.33% accuracy for the entire 6-digit password.

Peeping Attacks

Among techniques for cracking or acquiring passwords, peeping attacks remain a real threat. As a solution for peeping attacks, most of the studies introduce graphical/ picture-based authentication methods (Renaud and De Angeli, 2009), (Takada, 2008), (Zaman Nizamani et al., 2017), (Hameed et

al., 2017), (Bošnjak and Brumen, 2019). The research conducted by FoongHo et al., has proposed a method of concealing password information to prevent shoulder surfing attacks using graphical passwords (Ho et al., 2014).

Zaman et al. has introduced a new approach with two steps to protect the textual password from peeping attacks and increase the security. The first step is the registration phase which will collect the password, encrypt, and store. The second step is password transformation, which transforms the character to different characters. Each time when the user enters the password it will show a mapping of the characters (decimals numbers). Therefore, the user will type the decimal numbers instead of real characters which will mislead the peepers (Zaman et al., 2017). The study conducted by Cain et al. has shown that the nonadjacent, diagonal knight moves have reduced a significant level of threat in Over Shoulder Attacks (OSA), especially in swipe passwords (Cain et al., 2016).

The study conducted by Leon Bošnjak et al. with 274 participants for on-site shoulder surfing experiments provides empirical evidence that graphical passwords are easier to observe (Bošnjak and Brumen, 2019). This was one of the closest studies from our literature that explores the field of Shoulder Surfing attacks. As the final output, they provide vulnerability metrics and most importantly they verify their method on four conceptually different authentication methods. Considering three similarity metrics, password characteristics, distance metrics, guessing order and thirteen factors under them the vulnerability metrics have been developed. Their experiment of simulating the observation attack consists of two types of attackers (active and passive) and four types of authentication methods.

3. METHODOLOGY

We adopted the experimental research design and in-person interviews to collect the data for the research. A laboratory setup was created to simulate the password-entering process. An experimental approach was considered since examining a real peeping attack is not possible. Researchers followed

design science approach with empirical analysis for the research.

Preliminaries of experiment design

1) *Entropy Calculation*: Many studies have used entropy as a measurement of password strength (Yang et al., 2020), (de Carné de Carnavalet and Mannan, 2014), (Golla and Dürmuth, 2018). It shows that passwords with lower entropies are weak and higher entropies are strong (Ma et al., 2010). We use Shannon entropy to calculate entropy (Shannon, 1948) before the experiment. This is the equation for a single-character password and it needs to be multiplied by the number of characters in the password according to the password.

$$E = - \sum_{i=1}^n P(x = i) \cdot \log_2 P(x = i)$$

E = Entropy of the password

n = Number of characters in the character pool

P(X) = Probability of the character

2) *Proxemic Interactions*: People naturally correlate physical distance to social distance. (Laga et al., 2016), (Hans et al., 2015). Social space was turned out to be the most suitable area to perform the experiment without sensing that some stranger is watching us. Therefore, we consider social space for our experiment.

3) *Peripheral Vision*: This vision covers an area of more than approximately 200 degrees in diameter horizontally (Valero et al., 2018). For our experiment, we considered the area out of this far peripheral vision of the user to avoid the user from getting any sense of the attacker.

4) *Lighting Condition*: In our experiment setup, we simulated the same lighting condition equals to 500 lux as same as working environments which was measured by a mobile application called Light Meter in apple app store (SUMMERS, 1989).

5) *Data Source*: We chose “RockYou”, a corpus of 14 million unique passwords which was available on

Kaggle (Mutalik et al., 2021). This corpus contains passwords, leaked from multiple popular applications like ‘Facebook’, ‘myspace’ and ‘Friendster’ etc (Weir et al., 2010).

6) *Participants*: The experiment has two roles for the participants; attackers and victims. External participants were considered as attackers and one of the experimenters were considered a victim. We employed 30 participants voluntarily, within the age from 18 to 25, which is considered as the highest computer literate group in Sri Lanka (Department of Census and Statistics - Sri Lanka, 2020). These participants are familiar with using passwords and authentication in general. As the sampling method, we use the judgemental sampling method, in the non-probabilistic sampling category (Taherdoost, 2018).

Pre-processing of data

We filtered out set of passwords from the corpus considered as strong. The selection process was conducted in two phases.

1) *Calculating the entropy*: First, we selected passwords that have a length greater than eight characters which is considered as the minimum length of a strong password (Fenton et al., 2017). Then we calculated the entropy of those selected set of passwords using the aforementioned Shannon’s equation assuming all possible keys are equally probable to be used in the passwords. The considered character pool includes 26 lowercase letters, 26 uppercase letters, 10 digits and 32 symbols.

We selected the passwords with entropy greater than 128 since it is considered as the lower limit of the strongest category (Matematik and Winsløw, 2020). Considering the practical usage of passwords in our experiment, the highest entropy was considered as 150.755 and there were 18079 passwords which had this entropy. Then we cleaned the list by removing junk data such as email addresses, some HTML links and passwords which do not contain alphanumeric characters and symbols. Finally, it provided the output with 141 passwords which had the highest entropy.

2) *Filtering through password strength meters (PSMs)*: Since the experimenters are encouraged to

deliberately choose passwords of sufficient length and complexity (Bošnjak and Brumen, 2020), we filtered the passwords using PSMs as well. According to the usage and recommendations of previous research, we used three popular third-party PSMs (Yang et al., 2020). We chose *All Things Secured*, *The Password Meter*, and *MyILogin* (Julkunen and Molander, 2016). These meters consider different factors like the length of the password, LUDS, dictionaries, etc. to check the strength of the passwords. Based on the readings of all three PSMs separately, 110 passwords were labeled as strong. That set of passwords was again filtered using random sampling and selecting 30 passwords as the final set for the experiment.

Experimental Setup

We adopted an experimental process in order to simulate a peeping attack in an office environment. The laboratory conditions were set up mimicking a real office environment. QWERTY US laptop keyboard was used to input the password, which is considered as standard keyboard mapping. It which is often referred to as the universal keyboard (Buzing, 2003, Kafae et al., 2022). First, we conducted the interviews using video recordings. Then it was executed as a live experiment as a comparison resource to evaluate the result with respect to the solution and then to check the cognitive impact of the human. A mobile phone camera with a resolution of 1080p was used to record the videos. The camera was placed in a position with a distance of 2.35m to the victim's position. 2.35m is the average distance considering the edges of social distance. Reflecting the average height of a Sri Lankan person, the stand which holds the camera was 5'3" of height (Bostock, 2019). The video recordings were taken from 9 locations around the victim with each having 2.35m of similar distance to the position of the victim. The locations were taken from the area that is not caught in the peripheral vision of the victim (140°) (Valero et al., 2018). Every two positions have a similar distance in between (Figure 1a). Figure 2 shows the experimental setup which we used to record the videos. We used a laptop as the device for entering the password, with a screen size of 13 inches. 13 inches is considered the standard screen size.

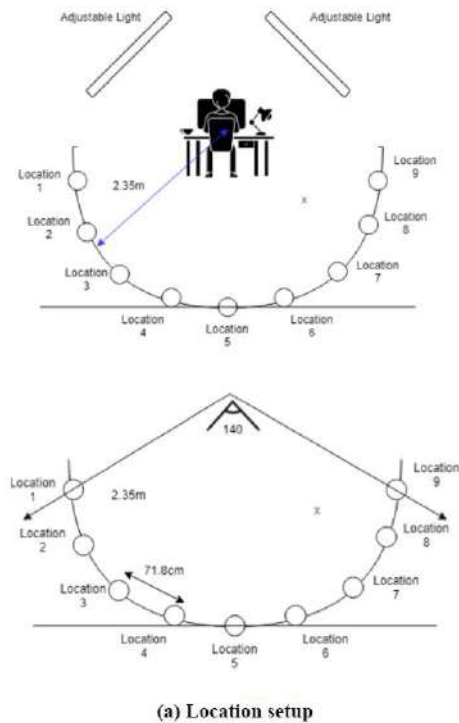


Figure 1: Experiment setup (bird eye view)



Figure 2: Experiment setup

Experimental Procedure

To simulate the attacker, we either can use a live human attacker or use online recruiters and ask them to observe video recordings of the victim entering the password. We performed our experiment in both ways. After preparing the experiment setup, we recorded the videos for the online experiment. One of the experimenters acted as the person who enters passwords (victim). She entered the passwords in a moderate speed imitating an average user. Videos for each password in the selected set were recorded from all nine positions. To avoid the person acting as the victim getting familiarized with the passwords, all passwords for a single location were recorded at one time and then moved to the next location. The videos were labeled according to the location and the password and then stored in Google drive. Once the video recording process was finished, we conducted a pilot study prior to the experiment with two participants. Based on the feedback from the pilot study some of the design decisions were changed.

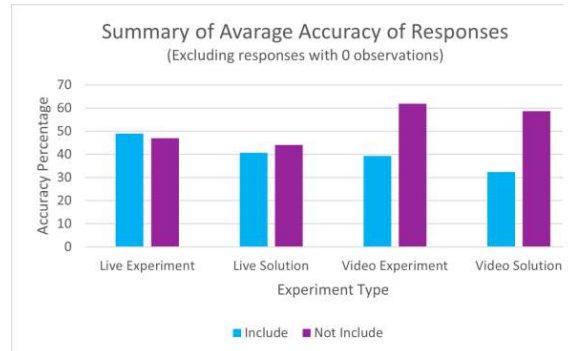
1) Online experiment using video recordings

The interviews were conducted on the zoom platform. Only one participant at one time was taken into the virtual meeting room. First, the participant was provided with some instructions of the experiment steps using a PowerPoint presentation. It included an image of the 9 positions, the keyboard layout used to enter the passwords, and a video clip that reflects the 9 positions. Participants were given the freedom to choose a preferred position. They were informed regarding the intention of the experiment and asked to put themselves into the role of an attacker who tries to capture the password. We informed them to note down or memorize all the facts they can obtain about the passwords. After they selected the location, we provided the Google drive link of the video and asked them to share the screen and play the video on their computer. This was for smoother playback and to avoid the quality drop and getting stuck due to weak connection issues. After watching the video, an open-ended interview was conducted with the participant in order to avoid misunderstandings. We

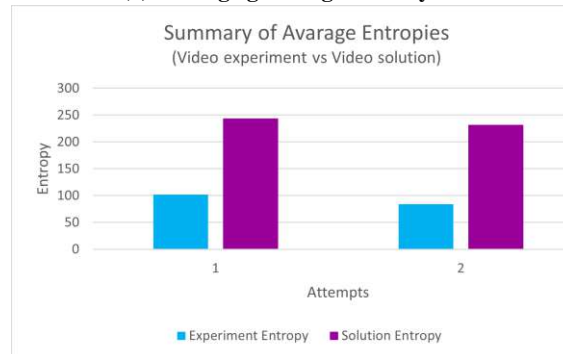
marked the keyboard areas according to their observations using an application.

Questions were based on following 4 categories.

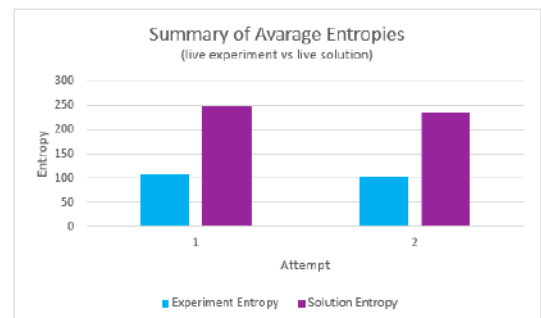
- Exactly included in the password
- Exactly not included in a password
- Approximately included in the password
- Approximately not included in the password



(a) Average guessing accuracy



(b) Average video observation entropy



(c) Average live observation entropy

Figure 3: Observation results

After getting the first feedback we gave them a second chance to watch the video and confirm their observations.

2) Onsite experiments

During the pilot study we noticed a huge difference between the quality of the visuals through the human eye and the camera lens. Therefore, in order to comparatively analyse live and video-based experiment responses, we conducted the same experiment on site.

The attackers were asked to observe the victims key-press events during the login process. Then a live interview was conducted to record what the attacker obtained. Same participants were taken to both online and live experiments, and we have strictly limited the collection and processing of personal data to the best of our abilities.

4 ANALYSIS

The first observation we got from the feedback of attackers was that location 5 was not taken and the majority had taken locations 3 & 7 (Figure 1b). Then we recorded their observations. If attackers that some characters are definitely or approximately not in the password, and if it is actually not in the password we omit them from the character pool, and if the attacker said some characters are definitely or approximately included in the password and actually that password includes these characters, we assume that all characters have the probability of 1. Other characters have an equal probability to reveal.

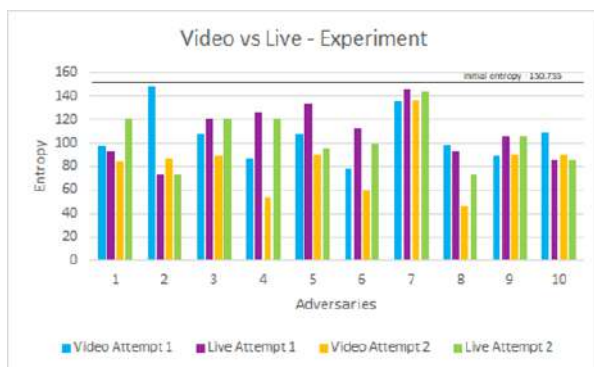


Figure 4: Video vs live entropy comparison summary (experiment)

Figure 3a shows the guessing accuracies of the adversaries. After this analysis, we identified, in the second attempt of video observation shows a progress on guessing the password (Figure 3b) and live

observations do not have considerable difference on that (Figure 3c). In our character pool, there are 94 characters. Each key in the keyboard owns two characters in the pool and if one key is revealed to the attacker, we have to assume that both characters in the pool are revealed. Based on these assumptions we calculate the entropy and compare them with the initial entropy values of the passwords. Figure 4 shows how the entropy values behaved in live and video-based experiments, with respect to the attempt.

Even though a drastic reduction of entropies were expected in live experiment after the login process was exposed to the attacker, it was identified most of the participants provided more accurate responses in the video experiment. Since we recruited 10 participants for the live experiment, the relevant 10 passwords from the video experiment were taken for the purpose of entropy comparison. As initially we assumed, a significant reduction of the entropies in the second attempt than in the first attempt can be observed reflecting they have provided more accurate responses in their second attempt. Compared to their initial entropies of original passwords, the entropies of both attempts have been reduced.

5. PROPOSED SOLUTION

Based on the results and observations obtained from the experiment, we designed a novel method of authentication. Most importantly, this form of authentication is not another graphical or totally different method from existing, widely used methods. Since we identified the usability and deployment issues in previously proposed solutions, we did not want to build a totally different method, replacing textual passwords which will require a lot of effort for a user to get used to. Hence, we built a solution based on textual passwords. This is a pure text-based solution and no additional tool or memorability is required. The actual changes for the

authentication process have been applied on the login screen. No changes have to be made in the password creation process; hence we can simply use the same password creation process when we implement this solution. Our primary intention here is to reduce the amount of strength reduction due to peeping attack. If we can reduce the number of correctly guessed characters, we can reduce the strength reduction. The usual elements we commonly see on a login form are username and password fields and submit button. The basic concept behind the proposed solution is the user has to insert the real password characters mingled with some random garbage characters. It will mislead the attacker making him think the garbage characters are also real characters in the password. The user is provided with the instructions by some indications in the input field such that he can see when to enter the real password characters and when to enter garbage characters. The input field borders and the label of the field will appear in green colour when the real password characters need to be entered. When the colour is changed into red and the label appears as Garbage, we need to enter some random characters.



Figure 5: Solution password entry field

The number of garbage characters to be entered at one time is randomly generated by the system. It is denoted as the count, and for the ease of the user, we indicated using a circle under the password field. When real characters are entered, the circle is getting filled, when garbage values are entered, it is getting empty. This number will be changed from one attempt to the next. For example, if the appeared count is 3, after entering 3 letters of the password the user has to enter 3 garbage values. For the first 3 characters, the field will be in green and then will turn into red, after entering 3 garbage values again the field will turn into green colour.

At the same time, the progress circle will fill its perimeter for real characters by one-third of the circle for one character and will remove filled parts for garbage characters one by one. This will continue until the password ends. The interface of two scenarios when the real characters and garbage characters are entered is presented using the Figures 5a and 5b. We use colors like red and green as indications to make it easier to find relevant actions.

6. EVALUATION

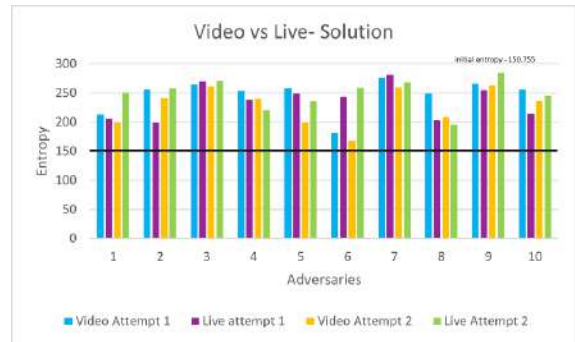


Figure 6: Video vs live entropy comparison summary (solution)

To evaluate the level of resistance to peeping attacks and the effectiveness of the proposed solution, we conducted the same experiment in a similar simulated environment, under the same conditions, as described in *Experimental Setup*. For the evaluation also, both live and video experiments were conducted. As the same participants took part, previous locations were taken as the attacker’s position. We shuffled the passwords in order to avoid any attempts of participants trying to respond by recalling their responses from the last interview. If they noted down what they observed during the first experiment, they could use that as well. Then we allowed participants to watch the video and observe the characters in 2 attempts. We were cautious not to provide information about the nature of the new authentication method. They were just asked to observe the password-entering process and provide a response based on what they observed. The interview with the attacker was conducted in the same way as the previous interviews. After the experiment is done with the solution it reveals that the password entropy

is higher than the initial entropy after experiment. Figure 6 illustrates the entropy increase of the password when using our solution in all the attempts of the adversaries in both video and live attempts. Table 1 displays the entropy differences relevant to the attempts.

To evaluate our solution’s usability aspect, we conducted a survey with the participation of same users of the experiment. We focused on the login times and the error rate with respect to the number of attempts. The error rate reflects the learnability of the scheme (Ashley A. Cain and Jeremiah D. Still, 2018). The participants were tasked to enter a given password using our proposed method. The password was chosen from our initial corpus. We measure the time starting with the participant clicking on the password field and ending with the participant clicking the login button. Participants were given practice trials as they were new to the scheme, they were asked to enter passwords in five attempts once they are ready.

Table 1: Entropy difference comparison

Description	Overall	Attempt 1	Attempt 2
Initial entropy	150.755	150.755	150.755
After video experiment	92.956	102.090	83.822
Entropy reduction with initial	57.799	48.665	66.933
After live experiment	106.335	103.847	108.822
Entropy reduction with initial	44.420	46.908	41.933
After video solution	237.572	243.593	231.551
Entropy increment with initial	86.817	92.838	80.796
Entropy increment with experiment	144.616	141.503	147.729
After live solution	242.372	235.895	248.849
Entropy increment with initial	91.617	85.140	98.094
Entropy increment with experiment	136.037	132.048	140.026

Usability Evaluation

We used 30 passwords and 30 participants and each one had 5 attempts on solution (Figure 7). The time taken for the normal textual passwords are lower which can be attributed to their familiarity with the scheme. It also showcases when attempts go on, the time taken becomes slightly lower. Figure 8 shows the percentages of wrong password inputs participants have submitted in each of their attempts. ‘Normal attempt’ of the graph shows the percentage of wrongly typed passwords. Other attempts show the percentage of wrong inputs when using our solution. Inputting garbage values does not take that much of time since user can press some random keys. After a set of garbage characters, user might have to

recall the next character of the real password.

It was observed that the input speed becomes slightly faster and the percentage of incorrect inputs in each attempt moves towards 0 when repeating, showing that the wrong attempts can be reduced when users have sufficient experience. We made available a small browser extension for chromium - based

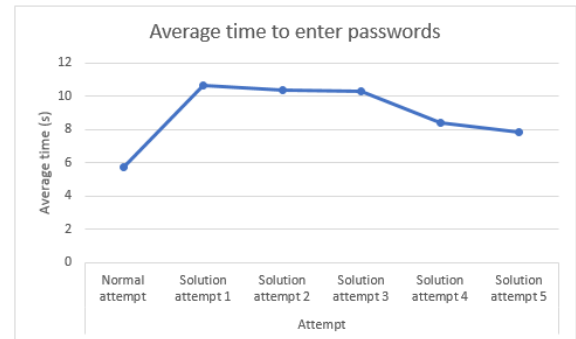


Figure 7: Time spent to enter passwords using the solution

browsers (Figure 9). When the user is in any login page, he or she could use the plugin to type the password. Once the password is typed, user can copy and paste it in the password field of the respective login form. Our solution, ‘PeepingOne’ is designed addressing some limitations of previously proposed authentication with respect to the deployability, usability and security.

Hence, users can use it once it is added to the browser without experiencing compatibility issues, storage issues and privacy issues. This will just be added to the browser and does not require any device storage. The size of the extension itself is 109KB. We do not store any of the passwords typed by the user in PeepingOne. It does not have access to the browser cache, therefore any sensitive information the user might have stored on the browser will not be exposed to it. It can be introduced as a surface running application while it does not require any cookie access or local storage access on the browser. Unlike most other applications, PeepingOne does not ask permission to access any privacy related features such as microphone, video camera, location etc. Another issue which was highlighted is the processing speed of the scheme. Most of the

alternative schemes were using graphical approaches which requires a lot of processing power and time (Zhao and Li, 2007). Those methods also consume a lot of storage space since they use thousands of graphical elements (Shah et al., 2015). From the developer’s perspective, the implementation of the software does not require much effort.

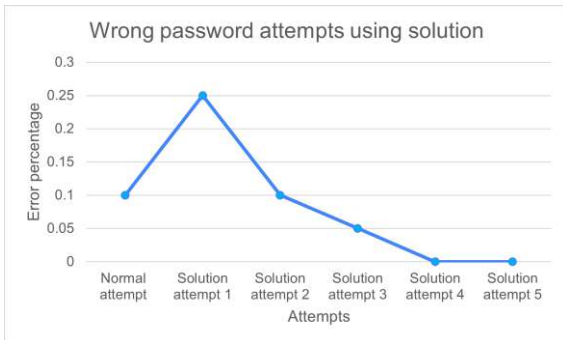


Figure 8: Percentage of wrong password input in each attempt

7. DISCUSSION

Throughout the study, our focus was on the strength reduction of textual passwords by shoulder surfing attacks. It was identified a significant amount of strength reduction in both live and video experiments. There were no significant differences observed between the results of the two types of experiment. Also, participants were more tended towards selecting location 3 and 7 (Figure 1b). This questions most of the design decisions of previous studies because; most of them chose a place directly behind the attacker. In our case, no one chose that particular place.

Another contribution is introducing a novel form of authentication which solves many drawbacks of previously proposed solutions. They addressed this threat of shoulder surfing by introducing a whole new method replacing textual passwords. Considering the easiness of learning, if it requires less time for users to get trained, it is a good sign that it provides a positive user experience. Graphical schemes usually need more complex interactions than simply entering a textual password. For example, the user might have to search for an image from a very large number of

images multiple times. (Still and Cain, 2020). However, studies can be found which have recognized graphical schemes are more vulnerable to peeping attacks (Bošnjak and Brumen, 2019).

Having a complex registration phase is another issue. (Zhao and Li, 2007), (Renaud and De Angeli, 2009). Users have to create their passwords using the new scheme. Our solution does not require any specific

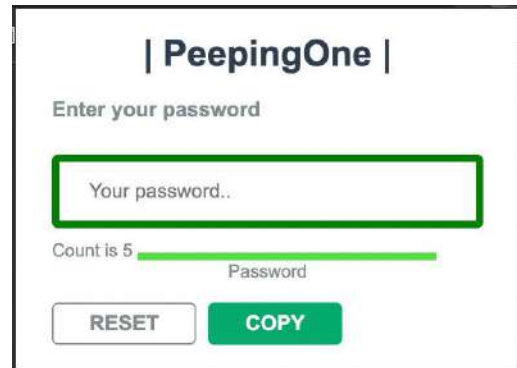


Figure 9: Browser extension

prior work before the login phase as the usual process of textual registration can be followed. The implementation and deployability were other major issues they had. As mentioned in their researches, significant limitations of those solutions are related to implementation efforts. Also, they need extra memory capacity to store their additional materials. Our solution is pure textual password solution that is easy to implement. Our solution is recommended for people who memorize their passwords since they can recall the real characters after a set of garbage characters. People most often tend to keep their passwords written down somewhere on their computers or physically in notepads, sticky notes etc. For those who copy and paste their passwords from somewhere, our solution would not be an ideal solution. Similarly, we do not recommend this for people who use auto filling password field since the garbage values need to be entered at some points in the middle of the actual password. However, unless you are using a trusted application from a trusted source to store passwords, copying, and pasting passwords you saved on the computers is not recommended. It has a different set of threats associated with it. When using this extension, it is

better not to use the same character repetitively in the password as garbage values as there is a potential security threat to identifying such characters by the attackers successfully.

8. CONCLUSION

It is clear that the password strength meters measure the strength of the password with different matrixes but do not consider the peeping attack. But it is a real threat to textual passwords. Based on the results of the study we state the answers to the following questions.

1) *To which extent password strength can be reduced due to peeping attacks?*

Our experimental setup was created unflavored for the attacker. But still the attackers have obtained some information on the password entered by the victim. Under these conditions, the result of the first analysis shows that there is a potential entropy reduction of 29.46% and 38.33% in both live and video attacks respectively.

2) *How to reduce the strength reduction of passwords after a peeping attack?*

We have introduced a novel form of authentication which does not replace textual passwords. Based on our evolution we have observed that it has an increase of 60.77% of entropy of the passwords in live attacks and 57.58% increment of entropy in video attacks. Most of the proposed solutions have problems with deployment and usability. But we have shown that our solution can easily deployed and user adaptation is very fast.

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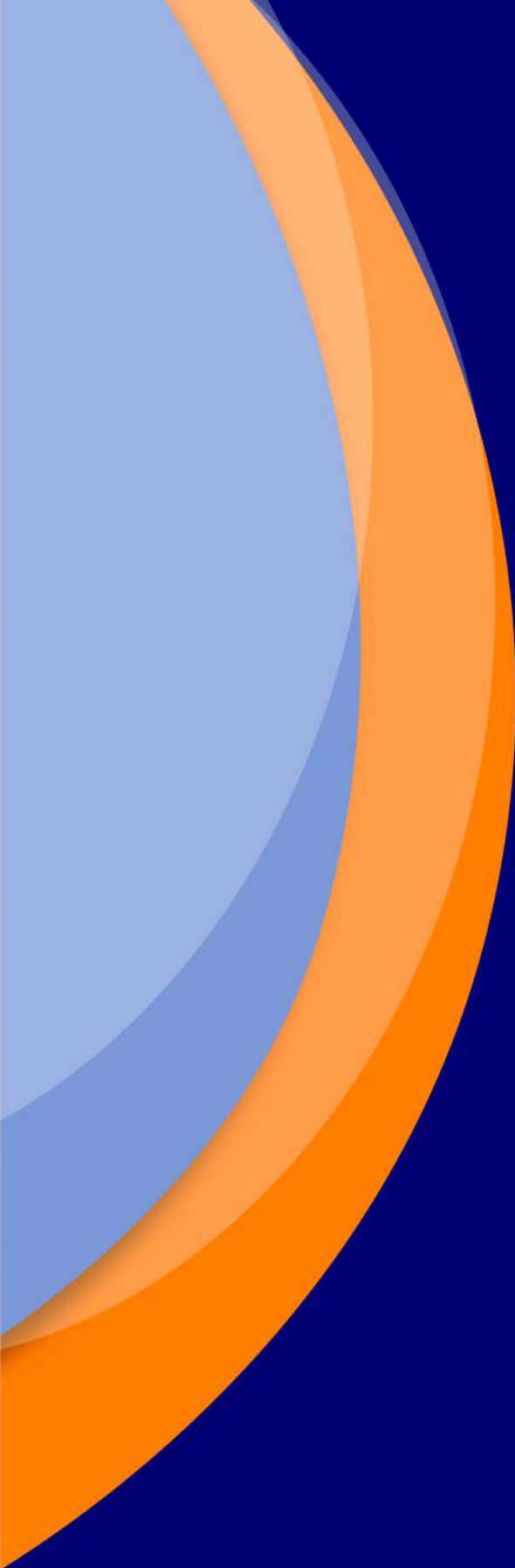
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