Influence of the Factors Associated with Suicides:
A Case Study for the Kelaniya Police Division in Sri Lanka

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Abstract— Suicide is a major public health problem worldwide and moreover it is considered as a social problem. In Sri Lanka, suicides have been a major social and economic burden for the previous three decades. Hence, developing a statistical analysis on suicides is a fruitful study for the country. This case study aims at identifying factors that mainly associated with suicides in the selected area covered by twelve police stations under Kelaniya Police Division. Secondary data were collected from those police stations from 2013 to 2017. Addiction to narcotic drugs, chronic disease, economic problems, loss, love affairs, mental disorder and family disputes were considered as explanatory variables. The significantly associated explanatory variables were identified using a univariate analysis and included in the multivariate analysis to perform multinomial logistic regression.Attained results implies that, civil status, age and gender were identified as influenced factors for both chronic disease and mental disorder. Economic problems are influenced by age and gender. Civil status has an impact on loss. Moreover, Education level, civil status, gender and age were identified as having impacts on love affairs.Due to encountered classification problems and high number of coefficients of the factors were insignificant in themodel, above dependent variables were re-categorized based on the influence for suicide which lead to fit a binary logistic regression model. Based on the results, civil status, education level and occupation and age were identified as influenced factors for suicides from the final model with the accuracy of 72.6% correctly classified.

*Keywords— **Suicide, Multinomial logistic regression, Binary logistic regression***

I. INTRODUCTION

The World Health Organization says one person commits suicide every 40 seconds in the world. Suicide is a major public health problem worldwide. Every suicidal death is a tragedy bringing the life of the person to a sudden end; consequently, it has an unbearable effect on families, individuals and friends. The significant number of deaths and hospitalizations place a heavy burden on health systems and the socio economic impact is often huge.

More than 800,000 people lose their life to suicide every year, corresponding to an annual global age standardized suicide rate of 11.4 per 100,000 populations with 15 for males and 8 for females. (World Health Organization, 2014)Over 800,000 suicide deaths are reported every year, 75% of these origination from the lower and middle-income countries predominantly within Asia.

Suicide is related to numerous potential factors in adults, including smoking, drinking alcohol, sleeping, depression, stress, self-rated health, subjective body image and socio-demographic background (Taylor *et al.*, 2007).These factors may reveal different patterns based on gender, and social roles should differ by gender. These differences between men and women may result in different indicators of mental health status, including suicidal ideation, suicide attempts and suicide rate.

Both genders, those who were married, had higher educational attainment or were non-smokers experienced low stress and had good self-rated health showed lower suicidal ideation. Significant factors were age for men and subjective body image and sleep time for women. In men, those aged 45–54 years showed the highest suicidal ideation rate. The effects of stressand depression on suicidal ideation were higher in men than in women.(Chin, Lee and So, 2011)

Asian countries' suicide rate is higher than western countries. Factors leading to suicides and para suicides in developed countries would clearly differ from, those countries such as Sri Lanka and conclusions reached from western studies may not be relevant to our country.

In Sri Lanka nearly 3,000 people died in 2015 due to suicide with a death rate of 14.7 per 100,000 populations (*Sri Lanka Police Department*, 2015). Sri Lanka was listed as the country having the 4th highest suicide rate. (World Health Organization, 2014). The conflict ridden history of the country has meant that suicide has been a major

burden of the previous three decades, nevertheless the measures and interventions implemented by the governing body has shown to positively impact suicide mortality rates, particularly legislations on pesticides.

The rate of suicides has risen sharply over the past two decades in the country. The rate of the island has surpassed the rates of some western countries like Britain and U.S.A. and has approached the higher rates prevalent in several other European countries.(Dissanayake and De Silva, 1974).Prevalence of suicidal ideation in Sri Lanka is lower than reported from the West and yet suicide rates are higher. Further work must explore according to cultural and religious factors.(Samaraweera *et al.*, 2010)

This study explores the dynamics of suicidal behavior in Sri Lanka and the interplaying factors that contribute to the persistent national burden. It investigates the education and employment systems as well as assessing successfulness of interventions and policies implemented by the governing body.

Although a number of descriptive medical studies have been published in our country which were concentrate on the method (mode) of suicide and demographic features of the victims, no attempt has been made to understand the reasons (factors) for suicides. Hence, it is important to identify the factors for suicides to emphasize the social and economic aspect of a country. Developing statistically significant statistical models for predictions on suicides is a fruitful study for a country since it effects directly to the social and economic aspect of a country.

II. METHODOLOGY

Considering the significant impact of predictor variables on categorical response variable, Multinomial Logistic Regression and Binomial Logistic Regressionapproaches were used to model the reason for suicides.

A.Data Collection

Since there was a lack of information in Annual reports of Registrar General and Crime statistics of Sri Lanka Police Department (i.e. Only summary information) in such data on the main causative factors on suicide, details of the direct suicides of scoped area was collected as the secondary data which originally entered in manual reports for suicides in all twelve police stations (Peliyagoda, Wattala, Ja-Ela, Kandana, Kelaniya, Kadawatha, Kiribathgoda, Biyagama, Sapugaskanda, Ragama, Meegahawatta and Welisara) by visiting them personally. From the available records, 394 records used to develop the study. Age, Gender, Civil Status, Race, Religion, Educational level, Occupation, Mode & Reason for suicide of each individual were collected as secondary

data using manual source data. Reason has defined as the outcome variable.

B.Pearson Chi-Square Test of Independence

The Chi-Square test of independence is used to determine if there is a significant relationship between two categorical variables. The frequency of each category for one categorical variable is compared across the categories of the second categorical variable. The conclusion is based on the hypotheses:

H_0: There is no association between the two categorical variables. ($\pi_{ij}=\pi_{i+}\pi_{+j}$)

H_1: There is an association between the two categorical variables. ($\pi_{ij}\neq\pi_{i+}\pi_{+j}$)

Where π_{ij} denoted the expected probability associated with the cell (i, j), π_{i+} and π_{+j} as the expected marginal probabilities of the row and column variables and the test statistic of Chi-Square test is illustrated as below.

$$= \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(n_{ij}-\mu)}{\mu_{ij}} \tag{1}$$

Where n_{ij} denote the observed frequency of cell (i, j), μ_{ij} denote the fitted frequency of cell (i, j), n_{i+} and n_{+j} as the marginal frequency of the row and column variables. Different between observed and fitted frequency is called residual.

C.Multicollinearity

Multicollinearity means there is a relation between two or more than two predictor variables. This relation makes overlapping between variables. Multicollinearity can cause serious problem in estimation and prediction by increasing the variance of least squares of the regression coefficients and tending to produce least squares estimates that are too large in absolute value.

1)Variation Inflation Factor (VIF)

VIF is diagnostic tool, which measure the multicollinerity among predictor variables. Extent of variation compared to the minimum variation (no linear relationship among Xj and other predictors) of estimated coefficient is called VIF. Therefore, VIF indicates the degree of degrading the precision of an estimated model coefficient of the particular predictor variable and the equation is:

$$VIF_j = \frac{\cdot}{1-\cdot} \tag{2}$$

D.Binary Logistic Regression

Binary logistic regression model is the most popular model for binary data. It is generally used to study the relationship between a binary response variable and a group of predictors (can be either continuous or categorical). The response can take the values 1 or 0 and it is impractical to model probabilities with linear regression techniques, because the linear regression

model allows the dependent variable to take values greater than 1 orless than 0. The logistic regression model is a type of Generalized Linear Models extends the linear regression model by linking the range of real numbers to 0-1 range and relevant equations are illustrated as below.

$$Y_i \sim Bin(n_i, \pi_i)$$

$$(Y_i, \pi_i) = \binom{n_i}{y_i} \pi_i{}^{y_i}(1 - \pi_i)^{n_i \cdot} \qquad (3)$$

$$(Y_i, \pi_i) = \binom{n_i}{y_i}(1 - \pi_i)\exp(y_i \log(\frac{\pi_i}{1-\pi}) \qquad (4)$$

Binomial distribution of   is in the form of exponential family.

$$f(Y_i, \pi_i) = a(y_i)b(\pi_i)\exp(Y_i Q(\pi \qquad (5)$$

$$Q(\pi_i) = \log(\frac{\pi_i}{1-\pi_i}) \qquad (6)$$

$Q(\pi_i)$isthe natural parameter of the distribution. Here X is the design matrix with dimensions (N, K+1) with elements X_{ik} for K number of independent variables. GML using the canonical link transformation is,

$$\log(\frac{\pi_i}{1-\pi_i}) = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_k X_{ik} \qquad (7)$$

E.Multinomial Logistic Regression

Multinomial logistic regression is a simple extension of binary logistic regression that allows for more than two categories of dependent or outcomes variable.

For the multinomial logistic regression model, we equate the linear component to the log of the odds of a jth observation compared to the jth observation. That is, we will consider the jth category to be the omitted or baseline category, where logits of the first j-1 categories are constructed with the baseline category in the denominator as illustrated in the equation 8.

$$\log\frac{\pi_{ij}}{\pi_{ij}} = \log\frac{\pi_{ij}}{1-\sum_{j=1}^{J-1}\pi_{ij}} = \sum_{K=0}^{K} x_{ik}l \qquad (8)$$

III. RESULTS

A. *Preliminary Analysis*

Figure 1shows the proportions of suicides of the selected twelve Police Stations. Most of the Police Stations cover very urban places in Gampaha District. Wattala Police Station has recorded the highest suicide rate (12.94%) for the last five years, which covers a very spread urbanization area with various type of ethnicities are lived.
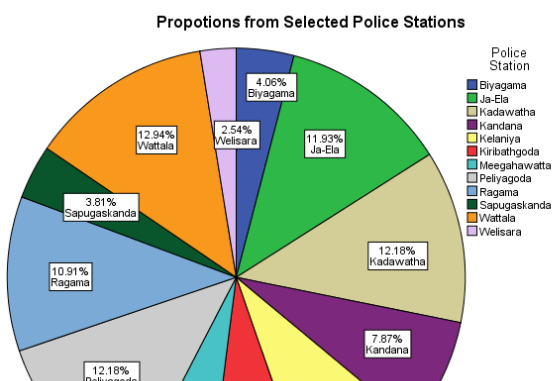

Figure 1.Pie Chart of Selected Police Stations

According to the Table 1, the sample includes 47.0% Sinhala Buddhists and 69.0% of Sinhalese in the study.

Table 1. Cross tabulation of Ethnicity and Religion

Race	Religion %				Total
	Buddhist	Catholic	Hindu	Islam	%
Sinhala	47.0	22.1			69.0
Tamil		1.3	16.2	0.3	17.8
Muslim				13.2	13.2
Total	47.0	23.4	16.2	13.5	100.0

It is noticeable that the majority rate of the people who had committed to suicide in this area for the last five years were Sinhalese. Comparatively, Tamils and Muslims had low rates for the suicides for the last five years.

B. *Univariate Analysis*

Chi square test of independence was used to find the association between Reason to suicide versus different eight predictor variables.Among the eight of predictor variables, Age, Gender, Civil Status, Education Level and Mode are statistically significantly associated with Reason at 5% level of significance.

Table 2. Summary of the Association Tests

No.	Variable	Test Value	DF	P-Value	Significance
1	Age	109.21	18	0.000	Significant
2	Gender	22.12	6	0.001	Significant
3	Civil Status	75.12	6	0.000	Significant
4	Race	20.11	12	0.065	Not Significant
5	Religion	27.86	18	0.064	Not Significant
6	Education Level	82.91	30	0.000	Significant
7	Occupation	54.99	42	0.086	Not Significant
8	Mode	36.55	24	0.048	Significant

C. *Multivariate Analysis*

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Multinomial and Binary logistic regression approaches were carried out.

1)Multinomial logistic regression (MLR) model 1

All eight predictors were used to develop the MLR model1. Forward selection method was used for selecting the "best" variables to the model.

Table 3. MLR Model 1 Step Summary

Action	Effect(s)	-2 Log Likelihood	Chi-Square[a]	df	Sig.
Entered	Intercept	1404.273	.		
Entered	CivilStatus	1326.220	78.053	6	.000
Entered	Age_cat	1261.515	64.705	18	.000
Entered	Gender	1238.114	23.401	6	.001
Entered	Education_level	1183.665	54.449	30	.004
Entered	Occupation_cat	1118.139	65.525	42	.012

According to Table 3, five variables have only added to the MLR model 1 among eight predictors because of only those variables were statistically significant at 5% level of significance. Further,all selected predictor variables for MLR model 1 except 'Occupation' was statistically significant according to the to the Pearson Chi Square Association Test at 5% level of significance.

Table 4. MLR Model 1 Goodness of fit

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	2070.123	1698	.000
Deviance	1055.044	1698	1.000

Table 4 exhibits that, the Pearson Chi Square and the Deviance (Likelihood ratio Chi Square) significance values are 0.000 (which is less than 0.05) and 1.000 (which is greater than 0.05) respectively. Since the Pearson Chi Square significance value less than 0.05 it is not statistically significant and implies that the null hypothesis of model adequately fits the data is rejected. Then, there is not enough evidence to say that the data are consistent with the model assumptions at 5% level of significance.

Table 5. MLR Model 1 Pseudo R Square

Pseudo R-Square	
Cox and Snell	.516
Nagelkerke	.528
McFadden	.192

Cox and Snell R Square and Nagelkerke R Square values are used to calculated the explained variation which are referred to as pseudo R square values. According to both these values, the explained variation in the dependent variable based on the model ranges from 51.6% to 52.8% respectively.

According to the built classification table whichshows the practical results of using the MLR model 1, cells on the diagonal are correct predictions. Cells off the diagonal are incorrect predictions. Of the cases used to create the model 1, overall 42.9% of the cases are classified correctly.

When checking multicollinearity Tolerance value of all dummy variables are greater than 0.2 and VIF values for all dummy variables are between 1.0 and 4.0. (VIF range should be in between 1.0 – 2.5). That implies that there is presence of moderate multicollinearity among predictor variables. Multicollinearity was checked again by removing 'Occupation' variable. (which was not significant according to the Pearson Chi Square Association Test and had 3.078 VIF value for dummy variable Occu_student).Now, Tolerance value of all dummy variables are greater than 0.3 and VIF values for all dummy variables are between 1.0 and 3.0, suspects that there is still presence of mild multicollinearity among predictor variables. But no variable with all its level exceed the VIF value 2.5 implying that presence of mild multicollinearity is not a fatal effect.

2)MLR model 2

By Removing 'Occupation' variable which presences the multicollinearity and removing the variables already removed by MLR model 1, four predictor variables were used to develop the MLR model 2 and similar procedure was carried out. All entered four predictor variables have added to the MLR model 2 because of those variables were statistically significant at 5% level of significance.

In this model, the Pearson Chi Square and the Deviance (Likelihood ratio Chi Square) significance values are 0.863 and 1.000 (which are greater than 0.05) respectively. It implies that the null hypothesis of model adequately fits the data is not rejected. Then, there is enough evidence to say that the data are consistent with the model at 5% level of significance.

According to Cox and Snell R Square and Nagelkerke R Square values, the explained variation in the dependent variable based on the model ranges from 42.9% to 43.9% respectively.Of the cases used to create the MLR model 2,

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overall 40.9% of the cases are classified correctly.When compared to the both classification values of MLR Model 1 and MLR model 2, overall 42.9% and overall 40.9%of the cases are classified correctly. Both classification percentages are less than 50%. This creates lower classification accuracy in the models.Furthermore, according to the MLR Model 2 parameter estimates, most of factor levels' Wald Statistic significant values are greater than 0.05. That implies that coefficients of the factors are zero and not statistically significant. When compared to the 'Addiction to narcotic drugs' category levels Wald statistic significant values of all category levels of all variables are greater than 0.05. Therefore, less number of factors are in the model and most of the factor levels are rejected.To overcome above problems, response variable 'Reason' has re-categorized as 'Influence' in to two category levels considering the influence from the family/society as follows which leads to a binary logistic regression analysis.

Table 6. Recode description of the Response Variable: 'Reason'

Reason	Influence
Addiction to narcotic drugs	Affected by family/society
Family Disputes	
Economic Problems	
Chronic Disease	Not affected by family/society
Loss	
Love Affairs	
Mental Disorder	

3)Binary logistic regression (BLR) model 1

Chi square test of independence was used to find the association between Influence versus different eight predictor variables.Among the eight of predictor variables, Age, Civil Status, Education Level and Occupation are statistically significantly associated with Influence at 5% level of significance.

All eight predictors were used to develop the BLR model 1. Backward selection method was used for selecting the more suitable variables to the model.

The current model has become significant at the fourth step of backward stepwise method. Omnibus Test of Model Coefficients based on Chi-Square test implies that the overall model is predictive of Influence for Suicides. The model chi-square value which is the difference between the null model and the current model (step four) value was 100.016. The null hypothesis is rejected since the p-value is less than0.05. Hence it can be concluded

that the final model predicts the likelihood of being Influence at the 5% level of significance.

Cox & Snell R Square and Nagelkerke R Square values, ranges from 22.4% to 29.9% respectively.Hosmer and Lemeshow test use to represent that data fit the model satisfactorily. As the results shown in the Table 7, P value is 0.386 for the fourth step which is greater than 0.05 implies that according to the Hosmer and Lemeshow goodness of fit test suggests the model is a good fit to data at 5%level of significance.

Table 7. BLR Model 1 Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	7.979	8	.435
2	4.936	8	.764
3	6.990	8	.538
4	8.499	8	.386

When closely observed the process of this analysis, the model at fourth step, prediction power is estimated at 71.3%. Therefore, it was found that the model correctly predicted 71.3% of the validation data. That means developed BLR model 1 accurately predicts the Influence for Suicides than the prediction in null model.

When checking multicollinearity, Tolerance value of all dummy variables are greater than 0.2 and VIF values for all dummy variables are between 1.0 and 4.0. That implies that there is presence of moderate multicollinearity among predictor variables. Therefore, again multicollinearity was checked by removing 'Gender' variable. (which was not significant according to the Pearson Chi Square Association Test, but was in the BLR model 1). VIF values for all dummy variables are still between 1.0 and 4.0, implies that still suspecting presence of multicollinearity among predictor variables. But no variable with all its level exceed the VIF value 2.5 and all VIF values are not greater than 10.

4) BLR model 2
By Removing 'Gender' variable which was not significant by the association test and subjected to the multicollinearity and removing the variables already removed by BLR model 1, four predictor variables (Age, Civil Status, Education Level and Occupation) were used to develop the BLR model 2. Backward selection method was used for selecting the more suitable variables to the model.

The current model has become significant at the first step of backward method. The model chi-square value which is the difference between the null model and the current model value was 96.022. The null hypothesis is rejected

since the p-value is less than 0.05. Hence it can be concluded that the final model predicts the likelihood of being Influence at the 5% level of significance.

Cox & Snell R Square and Nagelkerke R Square values ranges from 21.6% to 28.9% respectively.Hosmer and Lemeshow test (P value is 0.796 which is greater than 0.05) suggests the model is a good fit to data at 5%level of significance.The model's prediction power is estimated at 72.6%. That means developed BLR model 2 also accurately predicts the Influence for Suicides than the prediction in null model.

5) Model Validation
In this section 25% of original data were used to validate the developed model (BLR model 2).The model's prediction power is estimated at 83%. Therefore, it was found that the model correctly predicted 83% of the validation data. That means developed BLR model 2 accurately predicts the Influence for Suicides than the prediction in baseline model.

Equation of thefitted BLR Model 2 reference to the 'Not affected by family/society'(Y_2), For Affected by family/society (Y_1) is illustrated in equation 9.

$$Y_{1|2} = \log(\pi_1/\pi_2) = -2.631*[\text{Age cat=1}] -0.985*[\text{Age cat=3}]$$
$$+2.221*[\text{Civil Status=1}]$$
$$+1.231*[\text{Education level cat=1}]$$
$$+1.324*[\text{Occupation cat=2}]$$
$$+1.157*[\text{Occupation cat=3}] \quad (9)$$

Table 8. Variable Description

Variable	Description
Age cat=1	12-19 years
Age cat=3	31-50 years
Civil Status=1	Married
Education level cat=1	School not attended
Occupation cat=2	Student
Occupation cat=3	Pensioner

IV. DISCUSSION AND CONCLUSION

The aim of the study was to identify the influence of factors associated with suicides and which factors provide a significant contribution among them to make an impact on the suicides incidences in Kelaniya Police Division in Sri Lanka by a case study.

Police stations which cover very spread urbanization areas with various type of ethnicities are lived, have recorded highest suicide rates for the last five years. It is noticeable that the maximum rate who had committed to suicide in these areas were Sinhalese. Comparatively, Tamils and Muslims had low rates for the suicides for the last five years. When consider the modes used to commit suicide drinking pesticides, hanging, jumping to the water, jumping to the moving train and setting fire to oneself are the recorded ways to commit suicide. Among them hanging was the most popular mode. Since the selected geographical area consist of several water resources such as Kelani river, Aththanagalu river and Ja-Ela canal considerable suicides has recorded by jumping to the water. Moreover, jumping to the moving train and drinking pesticides have recorded due to railway transportation and agricultural farming background of the selected area.

According to the maximum occurrencethere were majority victims in the age category 31-50. Males from the Gender category, married victims from the Civil status category. By considering rates, Sinhalese from the Race category and Buddhists from the Religion category have the highest rates. Moreover, individuals who have educated to the G.C.E. Ordinary level from Education level category, Labors from Occupation category have recorded the maximum occurrence for Suicides.

There are number of social economic and cultural factors that increase the risk of suicides (Samaraweera *et al.*, 2010)Pearson chi-square tests were conducted simultaneously to establish associations between the reason and indicated factors such as age, gender, civil status, race, religion, education level, occupation and mode to determine the significance for suicide. Among the eight of predictor variables, there are associations between age, gender, civil status, education level, mode and reason to commit suicide. In that case, encountered some issues such as zero or non-observation in categories of predictor variables such as education level and occupation. To overcome this problem, merged some levels of those categorical variables together since Chi Square test of independence is not reliable while occurring zeroes in cells.

A multinomial logistic regression was carried out in each of them with dependent variable reason which has seven categories such as addiction to narcotic drugs, chronic disease, economic problems, loss, love affairs and mental disorder and family disputes. The maximum likelihood approach has used to estimate parameters. In that case, cause of multicollinearity checked, which leads to invent non-convergence and complete separation issues. By detecting correlation between independent variables, occupation variable was eliminated from the fitted Multimonial logistic regression (MLR) model 1 since, it leads to correlation between variables as well as was not significant according to the Pearson Chi Square association test. MLR model 2 was selected as the best model for multinomial logistic regression model since no multicollinearity presence among predictor variables and

considering statistics for Pearson Chi Square of goodness of fit.

When compared to the 'Addiction to narcotic drugs' category levels Wald statistic significant values of all category levels of all variables are greater than 0.05. It implies that remaining factors not significantly associated with the response variable even though it was identified as significant factor through the literature (Knipe *et al.*, 2018)

Due to encountered classification problems and high number of coefficients of the factors were insignificant in the fitted MLR model 2, dependent variable was re-categorized concerning the influence for suicide as affected by family or society and not affected by family or society for a suicide which lead to fit a binary logistic regression model.

Pearson chi-square tests were again conducted simultaneously to establish associations between the influence for suicide and indicated factors to determine the significance. Among the eight of predictor variables, age, civil status, education level and occupation were identified as statistically significant variables at 5% level of significance. Then fitted binary logistic regression (BLR) model 1 and checked inter correlation among predictor variables. By detecting inter correlation between predictor variables gender variable was eliminated from the fitted BLR model 1 which was not significant according to the Pearson Chi Square association test and subjected to the multicollinearity. According to the current study, BLR model 2 was selected as the best model among all models considered in the study considering statistics such as Pseudo R square, Pearson Chi Square of goodness of fit, and classification accuracy(error).

Based on the results, civil status, education level and occupation and age were identified as influenced factors for suicides from the final model which exhibits 72.6% accuracy.

The age categories 12-19 yrs. & 31-50 have been identified as risk age categories for suicides. In conclusion, the attention should be given to children who are in secondary education stage and closer to teen ages as well as individuals who are in middle age stage. The individuals who are married, are more likely to be suffering from suicidal ideation and finally commit to suicide when compared to individuals who are single. The individuals who never attended to a school more likely to commit suicide compared to the rest. Moreover, students and pensioners have identified as risk groups of individuals who are more likely to commit suicide. As an

overall conclusion of the race and religion, no significant effect has been done to the suicide.Since the data not available for whole country, collected for the study was based on onlythe secondary data which originally entered in manual reports for suicides in all twelvepolice stations under Kelaniya Police Division, suicide population for the whole countrymight not be well represented.If the study could be done for all police divisions covering the whole country withadditional sociological and biological factors, it would provide much precise results onthe study.

Finally, obtained results imply that, more attention should be given to the both education and employment systems of the country, which will result in building a high civilized person in order to reduce and prevent the suicides.

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