

**STATISTICAL ANALYSES TO VALIDATE THE
WHO/ISH RISK PREDICTION CHARTS FOR
SRI LANKA**

Uthuru Beddage Thulani

(168845M)

Degree of Master of Science in Business Statistics

Department of Mathematics

University of Moratuwa

Sri Lanka

September 2020

**STATISTICAL ANALYSES TO VALIDATE THE
WHO/ISH RISK PREDICTION CHARTS FOR
SRI LANKA**

Uthuru Beddage Thulani

(168845M)

Dissertation submitted in partial fulfillment of the requirements for the degree
Master of Science in Business Statistics

Department of Mathematics

University of Moratuwa

Sri Lanka

September 2020

Declaration, copyright statement and the statement of the supervisor

“I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:

Date:

The supervisor/s declaration:

The above candidate has carried out research for the Masters Dissertation under our supervision.

Name of the supervisor:

Signature of the supervisor:

Date:

Name of the supervisor:

Signature of the supervisor:

Date:

Abstract

The WHO/ISH (WHO/ International Society of Hypertension) risk prediction charts have been used widely by South East Asian Countries. The WHO/ISH risk prediction charts provide approximate estimates of cardiovascular risk in people who do not have established coronary heart disease, stroke or other atherosclerotic diseases. Based on the 10-year risk of fatal or non-fatal major cardiovascular events according to age, gender, smoking status, systolic blood pressure, presence or absence of diabetes and total serum cholesterol level. However, it has not been validated for the Sri Lankan population. Thus this study was initiated to validate the above mentioned WHO/ISH risk prediction chart for cardiovascular diseases using the database maintained at the Faculty of Medicine, University of Kelaniya for 10 years (2007 - 2017). The major risk factors for cardiovascular diseases are age, gender, higher blood sugar level and higher systolic blood pressure when considered individual effect on cardiovascular(CV) diseases from each risk factor. In both risk prediction methods (risk prediction with serum cholesterol readings and without serum cholesterol readings), the majority of the population had a <10% risk of a fatal or non-fatal cardiovascular event. Risk of cardiovascular diseases in the same population increased with age. Males had a significantly higher cardiovascular risk than females. The risk classification using total serum cholesterol was a better prediction chart than the one without it.

Keywords: WHO/ISH, cardiovascular disease, risk prediction charts, Sri Lanka, South East Asia Region.

Acknowledgements

My dissertation work of the MSc in Business Statistics could not have been accomplished without the support and cooperation of all those who encouraged us during our project to make it successful.

I would like to express my special and sincere gratitude to my supervisor. Prof. A.R. Wickremasinghe, Professor of Public Health and Head of the Department, Department of Public Health, Faculty of Medicine, University of Kelaniya for the patience guidance, encourage and supervision.

Moreover, my sincere gratitude to my internal supervisor, Senior Professor. T.S.G. Peiris, Professor in Applied Statistics and Former Head of the Department, Department of Mathematics, Faculty of Engineering University of Moratuwa and the Course Coordinator of M. Sc. / Post Graduate Diploma in Business Statistics, for his guidance and support throughout this study.

I would like to thank Prof. H.J. de Silva and Prof. K.T.A.A. Kasturiratne Faculty of Medicine, University of Kelaniya for allowed me to access the RHS data and for their support.

Finally, my sincere thanks to everybody who supported directly or indirectly for my work.

Table of Contents

Declaration, copyright statement and the statement of the supervisor	iii
Abstract	iv
Acknowledgements	v
List of Figures.....	x
List of Abbreviations	xiii
CHAPTER 1	1
INTRODUCTION	1
1.1 Background of Cardiovascular Disease (CVD)	1
1.2 Estimation of Risk	2
1.3 Present Procedure of Identification of CVDs	3
1.4 CVD Risk Prediction Charts by WHO/IHS	3
1.5 Present Situation on WHO/ISH.....	4
1.6 Research Problem.....	6
1.7 Objective of the Study	6
1.8 Outline of Dissertation	6
CHAPTER 2.....	8
LITERATURE REVIEW	8
2.1 Status of NCD and CVD: Global Overview.....	8
2.2 NCD and CVD Status in South East Asian Region	9
2.3 NCD Status in Sri Lanka	10
2.4 Risk Prediction Charts	11
2.5 Summary of Chapter 2.....	12

CHAPTER 3.....	14
MATERIALS AND METHODS	14
3.1 Methodology.....	14
3.2 Study Setting	14
3.3 Selection of Sample.....	14
3.4 Follow Up of Cohort	15
3.5 Risk Classification of Participants.....	16
3.5.1 Risk levels based on WHO/ISH risk prediction charts	16
3.5.2 Assess the cardiovascular risk by using WHO/ISH risk prediction charts.....	19
3.5.3 Important points to be considered when assess the risk	20
3.6 Some Useful Definitions Used	20
3.7 Statistical Analysis	20
3.8 Comparison of Two Means	21
3.9 Analysis of 2-way Frequency Tables	21
3.10 Odds ratio	22
3.11 Binary Logistic Regression Analysis	23
3.11.1 Binary logistic regression major assumptions.....	24
3.11.2 Odd Ratios in logistic regression.....	25
3.11.3 Variable selection methods in binary logistic model	25
3.11.4 Model selection procedure	25
3.11.5 Cox & Snell R ² and Nagelkerke R ²	26
3.11.6 Deviance Test	26
3.11.7 Hosmer and Lemeshow Test	26
3.12 Ethical Considerations.....	27

CHAPTER 4.....	28
IDENTIFICATION OF RISK CATEGORIES ON CVDs IN SRI LANKA BASED ON WHO/ISH CRITERIA.....	28
4.1 Profile of Participants	28
4.2 Distribution of Participants of Follow up Cohort in 2017.....	29
4.3 Cardiovascular events among participants during the follow up	29
4.4 Distribution of Participants Based on WHO/ISH criteria	30
4.5 Distribution of the Observed Statistics by Gender	31
4.6 Distribution of cardiovascular (CV) risk factors of the participants aged > 40 from RHS database from 2007 to 2017	33
4.7 Distribution of Cardiovascular Events	35
4.8 Comparison of risk factors with CV events among participants from 2007 to 2017	36
4.8.1 Impact of Gender	37
4.8.2 Impact of Age on having a CV events.....	38
4.8.3 Impact of fasting blood sugar level and CV events of participants.....	39
4.8.4 Impact of serum cholesterol level and CV events of participants	40
4.8.5 Impact of systolic blood pressure level and CV events of participants	40
4.8.6 Impact of Smoking Status on CV events.....	41
4.9 Logistic Regression Approach	41
4.9.1 Goodness of Fit of the Fitted Model (Main effects).....	43
4.9.2 Logistic Model with 2-way interactions	46
4.10 Summary of Chapter 4.....	48

CHAPTER 5	49
VALIDATION OF THE WHO/ISH RISK PREDICTION CHARTS.....	49
5.1 Risk Prediction with Gender, Diabetes Status, Systolic Blood Pressure, Age, Smoking Status and Serum Cholesterol Level	49
5.2 Risk Prediction Chart with all Risk Factors	50
5.3 Risk Prediction with Gender, Diabetes Status, Systolic Blood Pressure, age, and Smoking Status (Without Serum Cholesterol Level).....	51
5.4 Risk Prediction without Serum Cholesterol Readings	53
5.5 Comparison of two risk predictions	54
Parenthesis indicates the row percentages.....	54
Parenthesis indicates the column percentages.....	55
CHAPTER 6.....	56
CONCLUSIONS AND RECOMENDATIONS	56
6.1 Conclusions	56
6.2 Recommendations	57
References	58
APPENDIX 1	61
Questionnaire.....	61

List of Figures

Figure 1. 1: Ragama Medical Officer of Health (MOH) area	5
Figure 2. 1: Risk of Premature Deaths due to NCDs in Sri Lanka.....	10
Figure 3. 1: WHO/ISH risk prediction chart for South East Asia Region B. 10-year risk of a fatal or non-fatal cardiovascular event by gender, age, systolic blood pressure, total blood cholesterol, smoking status and presence or absence of diabetes mellitus	17
Figure 3. 2: WHO/ISH risk prediction chart for South East Asia Region B. 10-year risk of a fatal or non-fatal cardiovascular event by gender, age, systolic blood pressure, smoking status and presence or absence of diabetes mellitus.....	18
Figure 4. 1: Follow up of the cohort from 2007 to 2017	29
Figure 4. 2: Cardiovascular events among individuals from 2007 to 2017.....	30
Figure 4. 3: Distribution of non-fatal CV events.....	34

List of tables

Table 2. 1: Proportional all-cause mortality in Sri Lanka.....	11
Table 3. 1: Two-way Frequency Table	21
Table 3. 2: Calculation of the odds ratio	22
Table 4. 1: Basic Statistics of the Initial Profile of Participants at baseline in 200728	
Table 4. 2: List of variables used for the analysis based on the WHO/ISH risk prediction charts	31
Table 4. 3: Distribution of Each Variables within Categories by Gender	32
Table 4. 4: Distribution of Cardiovascular (CV) events collected at RHS study in 2017 (Sri Lankan population).....	33
Table 4. 5: Profile of participants at baseline among persons who (i) had a CV event during 10 years (ii) had not a CV event during 10 years (iii) total followed up in 2017	35
Table 4. 6: Cutoff values of the variables for bivariate analysis	37
Table 4. 7: Influence of Sex on CV events	37
Table 4. 8: Association between age and CV events	38
Table 4. 9: Comparison of age with CV events	39
Table 4. 10: Influence of FBS level on CV events	39
Table 4. 11: Influence of serum cholesterol level on CV events.....	40
Table 4. 12: Influence of SBP level on CV events	40
Table 4. 13: Influence of Smoking Status on CV events.....	41
Table 4. 14: Categorical variables coding in logistic regression	42
Table 4. 15: Classification table of the model	43
Table 4. 16: Model summary for the main effects.....	43
Table 4. 17: Hosmer and Lemeshow test statistics	44

Table 4. 18: Final results of the Logistic Regression model (Forward LR Method)	44
Table 4.19: Final results with two way interaction terms (Forward LR method)	46
Table 5. 1: Distribution of participants by risk and gender.....	49
Table 5. 2: Validation of Risk Prediction of Cardiovascular Events Using Diabetes Status, Systolic Blood Pressure, Age, Smoking Status and Serum Cholesterol Level Based on WHO/ISH Chart for SEAR B.....	50
Table 5. 3: Distribution of participants by gender and risk ¹	51
Table 5. 4: Distribution of participants by gender and combined risk groups.....	52
Table 5.5: Validation of risk prediction with diabetes status, systolic blood pressure, age, smoking status with gender and cardiovascular events	53
Table 5. 6: Frequencies and the corresponding raw percentage under each category	54
Table 5. 7: Frequencies and the corresponding column percentage under each category	55

List of Abbreviations

ATP – Adult Treatment Panel

BMI – Body Mass Index

CABG – Coronary Artery Bypass Graft

CHD – Congenital Heart Disease

CV – Cardiovascular

CVD – Cardiovascular Disease

GN – Grama Niladhari

IMCJ – International Medical Centre of Japan

ISH –International Society of Hypertension

MI – Myocardial Infarction

MOH – Medical Officer of Health

NCD – Non-Communicable Disease

NCEP – National Cholesterol Education Program

OR – Odds Ratio

PCI – Percutaneous Coronary Intervention

PROCAM - Prospective Cardiovascular Munster

RHS – Ragama Health Study

SBP – Systolic Blood Pressure

SCORE - Systematic COronary Risk Evaluation

SEAR B – South East Asia Region B

WHO – World Health Organization