UNIVERSITY OF GHANA

SURVIVAL ANALYSIS OF PATIENTS' LENGTH OF HOSPITAL STAY: A CASE STUDY AT THE LEGON HOSPITAL, UNIVERSITY OF GHANA, ACCRA.

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL IN STATISTICS DEGREE

JULY, 2019

DECLARATION

DECLARATION BY CANDIDATE

I David Angkyiire humbly declare that apart from references made to other person's works published, which are duly acknowledged, this work is my own fashioned and designed, and this work have not been submitted for the award of any degree at this institution and other universities anywhere.

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ABSTRACT

Patient's duration of stay at the hospital is one useful indicator many employ to assess the performance and efficiency of healthcare provided by hospitals and healthcare units. Also, patients' LOS and inpatient mortality are two interconnected health issues with complex outcomes, and studying the relationship between the two is not an easy task. This study therefore employed non-parametric and semi-parametric statistics in modeling patients' survival time to death using secondary data from the Legon Hospital, university of Ghana, Accra. In the data analysis, we modeled patients' survival time to death by applying the Kaplan Meier survival model and Logrank test for equality of survival curves. Factors that are significant by the Logrank test are subjected to Cox PH regression analysis to determine their associative effect to relative hazards of patients' survival time to death at the hospital, within the study period. A summary of the results revealed that out of a sample of 532 patients used for the study, 394 events of interests (deaths) occurred within the study period with a mean duration of hospital stay as 6.8 days with prevalence and incidence rates of 74.06% and 10.88%, respectively. The Logrank test and Cox PH analysis revealed that age, cause of death and type of disease are valid predictors of patients' survival time to death, whereas regression analysis by cause of death reported that infectious diseases, cancers, respiratory disorders, diseases of blood and blood forming organs, and genitourinary diseases are significant predictors of the relative hazards of patients' survival time to death at the Legon Hospital, University of Ghana, Accra.

DEDICATION

This piece of work is duly dedicated to DeLife and DeVine and to the Angkyiire's family.

ACKNOWLEDGEMENTS

I would like to express my in-depth gratitude to God the Father for His love, protection and guidance through it all. My next in-depth praise goes to my supervisor Dr. F.O Mettle for his excellent patience, coaching and empowerment throughout this research. He took me out of my mess in this whole research and taught me how to be humble and hardworking. The same gratitude goes to my co-supervisor Dr. Asiedu Louis who started this work with me and on their shoulders I stand tall today.

I extend my profound gratitude to all my lecturers for their kind support and selfless training offered to me. I reserved special thanks for my friend and brother Mr. Kuuboore Marcellinus and wife Mrs. Derbie Justina for all their support and maximum cooperation.

In the best of moods I sincerely acknowledged Honourable Ali Merga Iddrisu, Dormaa West member of parliament, and his brother a friend indeed Mr. Khalid Iddrisu for all their support to me and family through it all. My special appreciation goes to my friend and brother Prince Osei Affi, for the selfless support from coursework to research and to all my colleagues. I am equally grateful to my brothers Mr. Kuunibe K. Joseph and Mr. Turban Peter Clever for their huge support given to me.

My heartbeat thanks goes to my family the Angkyiire's and most especially my wife Sr. Preciouz Ethel Bukari for all their sacrifices and support that aided me to complete this study.

Finally, I thank all and sundry for their assistance and most particularly those who might have been left out unaware, but contributed significantly to the success of this research. To all I say, God richly bless you.

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LIST OF ABBREVIATIONS

ABBREVIATIONS	MEANING
ALOS	Average length of stay
ANOVA	Analysis of variance
AIS	Abbreviated injury score
WHO	World Health Organization
ICD	International Classification of Diseases
DRG	Drug Related Groups
LOS	Length of stay
DOTDS	Diseases of the digestive system
DOTCS	Diseases of the respiratory system
DOTRS	Diseases of blood and blood forming organs
DOTGS	Diseases of the genitourinary system
DOTNS	Diseases of the nervous system
ENAMD	Endocrine, Nutritional and metabolic disorders
DOBABFO	Diseases of blood and blood forming organs
IDs	Infectious diseases
IPACOCOEC	Injury, poisoning and certain other consequences of external causes
CANCERS	Cancers
LMICS	Low and middle income countries

COPD	Chronic obstructive pulmonary disease
US	United states
CI	Confidence interval
CNS	Central nervous system
DRGS	Drug-related groups
CVD	Cardiovascular diseases
ICU	Intensive care unit
BID	Brought in dead
SPSS	Statistical package for social sciences
PH	Proportional hazards
HAI	Hospital acquired infections

CHAPTER ONE

1.0 Introduction

To start with, the breakdown of this chapter is based on the background of the study, the problem statement, and objectives of the study, the methodology, justification and outline of the thesis.

1.1 Background of the study

In healthcare, management of hospitals and healthcare units required a great amount of funding and resources, the very reason why the Government of every nation including private, national and international organizations is under the obligation to provide the citizens with quality healthcare. There is therefore an urgent expectation from the management of hospitals and healthcare units to deliver on point despite the inadequate resources given to them. This requires strict supervision and monitoring of what goes in-and-out of the hospitals and healthcare units. Hence in terms of hospital performance assessment and evaluation, one of the major indices approved by research in measuring the performance and efficiency of hospitals and healthcare units is patient's length of stay (LOS) at the hospital.

Patient LOS refers to the period of time between the patient's date of admission and date of discharged. It is the number of days spent by an inpatient at the hospital before being discharged (Amrita & Badgal 2015). Thus, patients' period of hospital stay is one of the most useful health indicators for measuring health resource utilization and cost, healthcare efficiency (Murata et al., 2016), accessibility and quality of healthcare (Lee et al., 2018). In literature, patients' hospital LOS is said to be influenced by several factors such as age, sex, marital status, day and time of patient admission, patients' physical and functional status, level of education, type and severity of sickness, multiple diseases, and hospital acquired

infections and so many other factors. For example, Hamill, Villwock, Sykes, Chamoun & Beahm (2018) revealed that age and Friday hospital admissions were substantially related to longer length of hospital days. Khosravizadeh et al., (2016) reported that patients' length of hospital stay was significantly associated with age, marital status, employment, records of previous admission, patient condition at the point of discharge, method of payment and type of treatment. In a study to determine factors influencing patients' average length of stay (ALOS) in a tertiary teaching hospital in North India, Amrita & Badgal, (2015) reported that patients' ALOS association with nutritional status, insurance status, and educational status was statistically significant. In a similar study, it was reported that female sex, insurance type, and Friday hospital admissions (that is afternoon and evening) were significantly associated with prolonged hospital LOS (Vavalle et al., 2012).

In a cross-sectional study, Agboado, Peters & Donkin (2012) reported that hospital LOS among chronic obstructive pulmonary disease (COPD) patients was significantly associated with age, socioeconomic deprivation, specialty of admission, and complications. Similarly, Ravangard et al., (2011) in a study disclosed that patient admission on Thursdays, admission by residents, the number of performed diagnostic tests, and spouse job were significantly related to patients' LOS. To add to that, Liu, Phillips & Codde (n.d.) investigated the variation in patients' length of hospital stay and possible factors that influence the LOS in a health department in Australia. The study indicated that age, source of referral, doctor specialty, payment classification, and ethnic group were significantly associated with patients' LOS at the hospital.

In many countries around the world, more particularly low and middle income countries (LMICs), hospital administrators, managers, heads of units and persons responsible for the care and management of patients are challenged with some level of managerial and political pressure to keep patients' LOS in an average state (McDermott & Stock, 2007). Thus

reducing patients' LOS without compromising treatment quality and efficiency is the greatest desire of most hospitals and healthcare units. Meanwhile, many countries including Ghana do not have guideline policy on patients' LOS at the hospital. The effect of which is the great variation in patients' LOS reported in literature across different localities, regions and states. Majority of the reports disclosed that patients' mean period of stay ranges from 5 to 7 hospital admission days. For example, An & Wang, (2017) reported an average length of stay (ALOS) of 6.02 days among patients admitted to a United States base hospital with immune thrombocytopenic purpura. In a study conducted by Nguyen et al., (2016) the mean duration of hospitalization was reported as 7 days.

McEwan, Larsen Thorsted, Wolden, Jacobsen & Evans, (2015) study of hypoglycemic patients in England, revealed that the mean LOS was 5.46 and 5.04 days for type 1 and 2 diabetes, respectively. Culakova, Poniewierski, Crawford, Dale, & Lyman, (2014) in a study to examine the mean length of hospitalization among patients with comorbidities and infectious diseases revealed that patients' ALOS at the hospital was 6 days in 2004 and 7 days in 2012. Wright et al., (2003) in a study to examine related factors to patients' LOS at the hospital among patients with heart failure reported that the ALOS was 6 days. Also, Reed, Blough, Meyer & Jarvik, (2001) in a multivariate analysis examined inpatients mean LOS among patients with stroke-related diseases and reported that the ALOS was 6.02 days. Black & Pearson, (2002) in a study to determine the ALOS among patients in general healthcare reported that, the ALOS was 11.7 days in 1980 and this decreased to 6.8 days by the year 2000, among patients living in England.

Similarly, Mushlin, Black, Connolly, Buonaccorso, & Eberly, (1991) in a prospective cohort study to investigate essential length of hospitalization among patients with COPD and to compare this LOS with that of the drug related group (DRG) system reported that the ALOS was between 6 and 7 days, which were by far below the ALOS proposed by the DRG system.

On the other hand, inpatient mortality (death rate) and LOS are two important indicators many used in assessing the performance and efficiency of hospitals and healthcare units (Falciglia, Freyberg, Almenoff, D'Alessio & Render, 2009). Thus, every hospital and healthcare unit greatest desire is to improve the healthcare statistics by ensuring that the number of patients dying at the facility or unit is cut down. Meanwhile, mortality and length of hospital stay have very complex and interwoven relationship with several health outcomes and with complex variation in patients' health outcomes and LOS. In literature, several research works with many from the United States have dealt into the relationship between inpatient mortality and patients' length of hospitalization.

For instance, Falciglia, Freyberg, Almenoff, D'Alessio & Render (2009) in a logistic regression analysis investigated the effect of hyperglycemia on inpatient deaths and LOS among severely ill patients receiving treatment in three acute units (medical, surgical and cardiac) of a hospital in the US. The results of their analyses revealed that hyperglycemia was a significant contributor of higher mortality as compared to normoglycemic. Brodovicz et al., (2012) evaluated the impact of hypoglycemia on inpatient mortality and length of hospital stay among patients received into a hospital for insulin care and reported that many patients died out of hypoglycemia as compared to those without hypoglycemia and many of these deaths out of hypoglycemia were severe cases.

Patients' length of hospital stay, defined by the total time spent in hospitalization (Amrita & Badgal, 2015) is a useful tool in survival analysis as it defines the time to an event. Survival analysis among other things detailed the occurrence of an event of interest relative to given time interval. One very important aspect of health management of hospital resources and improved efficiency of healthcare is to understand the complex relationship between patient length of hospital stay and in-hospital mortality (Lefaivre et al., 2009). Going through existing literature, less research is done on this using survival analysis, and few are sampled

to shape this work piece. For instance, Loef et al., (2005) conducted a study to examine in-hospital mortality and long-term survival rates of patients with renal postoperative function decline. Results of a Cox proportional hazards model analyses revealed that patients who were hospitalized and discharged alive and followed-up for longer period of time recorded a substantial number of in-hospital patient mortality with renal postoperative function decline as compared to those without renal function decline. In all, patients with postoperative renal function decline in cardiac surgery contributed positively to increase in-hospital mortality and worst state of long-term survival.

In a Cox proportional hazards multivariate analysis, Combes et al., (2003) evaluated the aftermath and health-related quality of life among patients receiving mechanical ventilation for fourteen days and more in an intensive care unit (ICU) and reported that having a preadmission immunocompromised status, and having a length of mechanical ventilation greater than 35 days were statistically significant predictors of patient mortality after being discharged from the ICU. In the literature search and those sampled for this work piece, all the analyses presented employed lifetime data of patients with majority from cohort studies. However, this research work is intended to model patients' survival time to death using mortality data from the Legon Hospital, University of Ghana, Accra.

1.2 Problem statement

Management of hospitals and healthcare units face various degrees of challenges every single day, either as a result of patient death or high healthcare cost or patient longer stay at the hospital. Length of hospital stay and patient mortality are two interconnected health outcomes with complex relationship, and studying the relationship between the two is not an easy task. Patients' LOS whether shorter or longer has some adverse consequences. Shorter LOS is said to influence frequent hospital visits and readmissions (Ansari, Yan, Zou, Worth & Barbaro, 2018) and consequent death(Aujesky, Stone, Kim, Crick & Fine, 2008), whereas,

prolong length of hospital stay is characterized by increase healthcare utilization and costs (Murata et al., 2016), increase hospital emergency admissions, lower hospital capacity and accessibility of care (Lee et al., 2018), and above all, increase the likelihood of hospital acquired infections (nosocomial diseases) (Glance, Stone, Mukamel, & Dick, 2011a). Several research works have been done on patient length of stay in literature using patients' lifetime data with majority from cohort studies but that which concerns patient length of hospital stay and all mortality data is yet to be intercepted.

Hence, this research work seeks to identify potential factors associated with patients' survival time to death and LOS at the hospital using mortality data from the Legon Hospital. This will serve as a guide to management and other workers in their care and management of patients at the hospital. It will also prompt management to intensity healthcare education to their members.

1.3 Objectives of the study

1.3.1 General objective

To model patients' survival time to death within a period of 7 hospital admission days and to determine possible factors influencing patients' LOS at the Legon Hospital.

1.3.2 Specific objectives

i. To determine the prevalence and incidence rate of patients' survival time to death within the study period.
ii. To compare and analyse patients' survival curves by sex, age, cause of death and disease.
iii. To assess the individual and joint impact of the various predictor variables on the relative hazard of patients' survival time to death at the Legon hospital.

1.4 Methodology

The study data which is a secondary data was obtained from the data unit of the Legon Hospital, University of Ghana, Accra. The data contained the demographic and diagnostic information of patients who died at the facility from 2016-2018. All patients who died at the facility with a known cause were eligible for the study. In the case where a patient died as a result of multiple infections, the principal or leading cause of death was considered. Out of 756 patients who died within the study period, 532 patients were eligible for the study, using purposive sampling technique. That is patients who died without known cause of death (cause of death pending postmortem or brought in dead [BID]) were eliminated in the study. Sampled data was then subjected to descriptive analyses and onward classification of the demographic variables into various categories which include age, sex, and cause of death. The age variable was categorized into two groups (younger age and older age) following the world health organization classification on age standardization on mortality. The move was engineered by the skewness of the data as more deaths occurred above middle age. The sex variable is classified into male and female.

Also, causes of death were classified into ten categories according to the International

Classification of Diseases - version 11 (ICD-11) published on June 18, 2018 and is currently available for member states and other stakeholders to use. The disease categories captured by this study data include the following:

- Disease of the digestive system (DOTDS)
- Disease of the circulatory system (DOTCS)
- Disease of the respiratory (DOTRS)
- Disease of the nervous system (DOTNS)
- Disease of blood and blood forming organs (DOBABFO)

- Endocrine, Nutritional and Metabolic disorders (ENAMD)
- Infectious diseases (IDs)
- Injury, Poisoning and certain other consequences of external causes (IPACOCOEC)
- Neoplasms/Cancers (CANCERS)

In organizing the data for research analysis, patients who died at the hospital within the study period are followed up for a period of one week (seven hospital admission days), where patients who died beyond seven hospital admission days are treated as right-censored data in the data analysis. Patients' LOS is treated as a continuous variable in the range of 1- 95 days.

Microsoft excel is the main tool used in organizing data into various classes and categories.

In analyzing the data, non-parametric, semi-parametric and parametric statistical tools are used as in most survival analysis using the STATA statistical package version 14 and SPSS version 21. These statistical tools are ANOVA (analysis of variance), Kaplan Meier survival model, Logrank test statistic and Cox proportional hazards (PH) regression model. The ANOVA is used to assess the mean levels of the independent variables used for the study and to determine the significance level of each. Preliminary analysis of survival data in STATA version 14 reveals the prevalence and incidence rate of patients' survival time within the study period. Kaplan Meier survival analysis as a non-parametric statistic provides survival curves for the various categorical variables and supported by the Logrank test of equality of survival curves, which allows comparison of survival curves of the various categories within each class or variable.

Individual and joint analysis of the independent variables and categorical variable in the case of cause of death is provided by the Cox PH regression model as a semi-parametric model.

1.5 Justification of the study

In Ghana and beyond, health workers are known with their monthly, quarterly, semi-yearly and yearly reports for the assessment of various units, hospitals, districts, regions and the nation as a whole, which include patients' length of hospital stay and mortality. Most at times, rewards are given to deserving and hardworking persons as an appreciation. In the developed nations particularly the United States, there exist in literature that, patients' length of stay is used to adjust the wages and incentives of health workers in some facilities.

Therefore a research on patients' survival time to death and possible factors which influence LOS will spell out the survival times to death and the relationship between the causes of death and patient mortality will amount other things guide health workers and healthcare providers and policy makers to take inform decision to improve the quality and efficiency of healthcare services, more particularly the Legon Hospital.

1.6 Organization of the study

This aspect contains an outline of the entire study. Thus, chapter 1 is made up of the below sub-headings:

- Background of the study
- Problem statement
- Objectives of the study
- Methodology and
- Justification of the study

Chapter 2 presents highlights on review of existing literature presented by various researchers whose findings are relevant and related to the study. Chapter 3 contains a methodological

review on the statistical tools that are relevant to the analyses of the study data. Chapter 4 presents the results of the data analysis and the discussion of the results and chapter 5 gives a summary in conclusion and recommendations for future research. The references and appendices end the entire report.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

To begin with, this section contains reviews of existing works done by other researchers regarding the concept of LOS, factors influencing LOS, patients' average length of stay, impact of LOS on inpatients mortality, and survival analysis on patients' duration of hospital stay. Thus, detail work on this chapter shall focus on the following headings:

- Factors influencing inpatient length of hospital stay
- Patients' average length of stay
- Length of stay and inpatient mortality
- Survival analysis on patients' length of stay

2.1 Factors influencing patients' length of hospital stay

Patient's LOS refers to the duration of time between the patient's date of admission and date of discharged the hospital. It is the number of days spent by an inpatient at the hospital before being discharged (Amrita & Badgal, 2015). Patient's period of hospital days is one of the most useful indicators for measuring health resource utilization and cost, (Murata et al., 2016) healthcare efficiency and healthcare accessibility (Lee et al., 2018). In literature, patients' hospital LOS is said to be motivated by several factors such as age, sex, marital status, patient's time of admission and day, patients' physical and functional status, level of education, type and severity of sickness, multiple diseases, and hospital acquired infections and so many other factors. For example, Hamill, Villwock, Sykes, Chamoun & Beahm, (2018) studied the percussion of socioeconomic indicators on patients' LOS at the hospital and healthcare costs and revealed that age and Friday hospital admissions were substantially related to longer length of hospital days. Lee et al., (2018) in a similar study to explore

perioperative factors associated with prolonged length of hospital stay among patients in a surgical unit revealed that age, admissions after 5 pm, referral to occupational therapy, patients' functional status, and the number of HAIs were statistically significant factors associated with prolonged LOS. Khosravizadeh et al., (2016) in a study to examine determinants of patients' length of hospitalization in some teaching hospitals in Qazvin providence reported that patients' LOS was significantly related to age, marital status, employment, records of past admittance, health status of patient at time of release, mode of disbursement and treatment category.

Amrita & Badgal, (2015) in a similar study to figure out indicators of patients' ALOS in a tertiary teaching hospital in North India reported that patients' ALOS association with nutritional status, insurance status, and educational status was statistically significant. Vavalle et al.,(2012) studied determinants of hospital LOS among patients with myocardial infarction and reported that female sex, insurance type, and Friday hospital admissions (that is afternoon and evening) were significantly associated with prolonged hospital LOS. In a study to assess the association of hospital LOS and patient healthcare using patients received into an indigenous hospital for COPD at Blackpool, England, Agboado, Peters & Donkin (2012) reported that hospital LOS among COPD patients was significantly associated with age, socioeconomic deprivation, specialty of admission, and complications. Similarly, Ravangard et al., (2011) in a study to investigate patients' LOS and its association with clinical and non-clinical factors in Women Hospital in Tehran, Iran used patients medical record charts reviewed from Oncology, Surgical and Obstetric units in 2008. Their analyses indicated that patient admission on Thursdays, admission by residents, the number of performed diagnostic tests, and spouse job were significantly related to patients' LOS at The women Hospital.

To add to that, Liu, Phillips & Codde (n.d.) investigated the variation in patients' length of hospital stay and possible factors that influence the LOS in a health department in Australia.

The study indicated that age, source of referral, doctor specialty, payment classification, and ethnic group were significantly associated with patients' LOS at the hospital. McDermott & Stock(2007) in a study evaluated the relationship between a set of operational variables and hospital performance in terms of patients' average length of hospital stay. The results of their analyses revealed that a direct relationship existed between patients' average length of hospital stay and location, hospital capacity, and teaching status, but no such relationship existed between capital expenditure, workers salary, and staffing levels.

Furthermore, Davis et al., (2000) studied inpatient healthcare outcomes by the hospitalist system of care to that of internist's healthcare outcomes in a rural community hospital with the same diagnosis-related groups (DRGs) in terms of patients' LOS, cost of treatment and resource utilization. The results of the study revealed that age, sex, race, insurance status, illness severity, and specific medical comorbidities were significantly associated with patients' length of hospital stay. Lee & Codde, (2000) conducted a study to compare and analyze the determinants of inpatient length of stay between the rural and the metropolitan public hospital in Western Australia, using patient discharged data for period of 1998 and 1999. The results of the study indicated that rural aboriginal patients had prolonged length of hospital stay than non-aboriginal patients. Also, patients admitted to a rural hospital was said to have lesser chances of early discharge as compared to their colleagues in metropolitan hospitals. However, the results indicated that metropolitan hospital faces greater chances of hospital acquired infections (HAIs) which tend to increase the average length of hospital stay in those hospitals.

Ansari, Yan, Zou, Worth & Barbaro, (2018) in a study to determine the relationship between patient length of hospital stay and hospital readmission rate using patients medical records between 2007 and 2014 reported that patient LOS was significantly associated with multiple diagnoses on admission ($P<0.001$), insurance type and readmission ($P<0.001$). It was also

revealed that having government insurance (P<0.01) was significantly associated with prolonged length of hospital stay**.** Saxena, Prasad, Prasad, Verma & Saxena,(2016) conducted a prospective study to determine factors predicting length of hospital stay among acute stroke patients admitted in a tertiary care hospital. Patients' data was obtained from medical records and used for the study. A report of their results revealed that location of stroke lesion, low Glasgow Coma Scale score and hospital acquired infections were significantly related to prolonged LOS more than seven days.

Whellan et al., (2011) examined predictors of hospital LOS for heart failure used a sample of 70,094 patients. The results of the analyses revealed that patients with multiple infections and higher severity of disease on admission were significantly associated with prolonged length of hospital stay.

Formiga et al., (2008) conducted an investigation to study admission indicators that possibly forecast prolong LOS at the hospital among elderly patients received for severe pain of heart failure. Formiga et al., (2008) disclosed that female gender with odd ratio of 1.645 at 95% CI, 1.047-2.584 and poorer functional status with odd ratio of 1.699 at 95% CI, 1.135-2.542 were substantially predictors of prolonged LOS.

Furthermore, Vavalle et al.,(2012) studied factors that influence hospital LOS among sick persons who suffered myocardial infarction and reported that, delay to cardiac catheterization more than 2 days, heart disorder and shock at the point of inmate were significantly related to prolonged hospital LOS.

Toptas et al., (2018) in a reflective examination to figure out and categorize determinants of prolonged LOS in an ICU, indicated that cardiovascular diseases (CVD), cerebrovascular diseases, central nervous system (CNS) disorders and multiple diseases were statistically significant with increased length of hospitalization at the ICU. Hamill et al., (2018) studied

the impact of socioeconomic factors affecting patients' LOS and healthcare costs and revealed that chest radiography, echocardiography, congestive heart failure, respiratory disorders and cancers were significantly associated with longer hospital days. Following the reports by earlier researchers in the literature, it stands out that, all data analyses are based on lifetime data of patients admitted at the hospital and majority are from cohort studies. However, this research is aimed to determine factors associated with patients' LOS at the hospital using mortality data from the Legon Hospital, University of Ghana, Accra.

2.2 Average Length of Hospital Stay

In many countries around the world, more particularly low and middle income countries (LMICs), hospital administrators, managers, heads of units and persons responsible for the care and management of patients are challenged with some level of managerial and political pressure to keep patients' LOS in an average state (McDermott & Stock, 2007). Thus reducing patients' LOS without compromising treatment quality and efficiency is the greatest desire of most hospitals and healthcare units. Meanwhile, many countries do not have any policy in place guiding patients' LOS at the hospital. Hence, a lot of variations exist in literature about the ALOS at the hospital. For instance Borghans, Heijink, Kool, Lagoe, & Westert, (2008) investigated the idea of benchmarking and reducing patients' LOS among hospitals in the Netherlands. The study covered 69 hospitals under the national medical registration of the Dutch. The results of analysis reported a decrease in the average length of hospital stay among hospitals in the Dutch from 14 days in the year 1980 to 7 days in 2006, and that majority of these hospitals had attained an average length of stay (ALOS) of 7 hospital admission days by the year 2000. It was again reported that the ALOS could fall to 6 days if all 98 hospitals of the Dutch were involved in the study.

An & Wang, (2017) in a study to assess LOS, healthcare cost, and in-hospital mortality among adult inpatients with immune thrombocytopenic purpura (ITP) in the United States from 2006 to 2012, reported that the ALOS 6.02 days. This was said to be 28% higher than the overall national discharged population ALOS of 4.7 days. Nguyen et al., (2016) in a reflective study of sick persons 20 and more years older attending healthcare in the United States in 2011, revealed that, the ALOS at the hospital was 7 days. In another retrospective cohort study of hypoglycemic patients aged 18 years and older with type 1 & 2 diabetes in England, McEwan, Larsen Thorsted, Wolden, Jacobsen & Evans, (2015) reported that the mean LOS at the hospital was 5.46 days for with among persons with level 1 diabetes and 5.04 among those with level 2 diabetes.

Culakova, Poniewierski, Crawford, Dale, & Lyman,(2014) in a search to examine the contribution of comorbidities and infectious complications on inpatient LOS and in-hospital mortality amidst a sample of 135,309 patients hospitalized with cancer in the US from 2004 to 2012. The results of their analyses in a multivariate logistic regression revealed that patients' average length of hospital stay increased from 6 days in 2004 to 7 days in 2012 and patients with leukemia, lymphoma and central nervous system (CNS) disorders recorded the longest average length of stay (21.4,10.5, and 10.2 days) respectively. Hall, Levant, & DeFrances, (2013) in a United States based health report on National Hospital discharged survey, 2000-2010, reported that the average length of hospital stay by inpatient mortality was 7.9 days as compared to 4.8 days for all patients admitted at the hospital, similar to the report by An & Wang, (2017).

Similarly, Wright et al., (2003) in a study to determine factors associated with patients' LOS at the hospital among patients with heart failure reported that the ALOS was 6 days. Also, Reed, Blough, Meyer & Jarvik, (2001) in a multivariate analysis examined inpatients mean length of hospital stay among patients with stroke-related diseases [Subarachnoid hemorrhage

(SAH), Intracerebral hemorrhage (ICH), Ischemic cerebral infarction (ICI) and TIA] hospitalized in community hospitals. The results of the analysis informed that the ALOS among patients were 11.5, 7.5, 5.9 and 3.4 days for SAH, ICH, ICI and TIA, respectively.

Black & Pearson, (2002) in a study to determine the ALOS among patients in general healthcare reported that, the ALOS was 11.7 days in 1980 and this decreased to 6.8 days by the year 2000, among patients living in England. Cavan, Hamilton, Everett & Kerr, (2001) in a study investigated the ALOS among patients with diabetes mellitus under the care of diabetes nurse advisor from January, 1997 to December, 1998. Results of the analysis revealed that ALOS at the hospital was 6.8 days and which fell by 4.0% after the study. It was again reported that ALOS was 11 days in medical ward against 8 days in the surgical ward in the year 1997 and these figures fell in 1998 to 8 and 5 days in the medical and surgical ward, respectively.

Mushlin, Black, Connolly, Buonaccorso, & Eberly, (1991) in a cohort study investigated the essential length of hospital stay among patients with chronic pulmonary disease and also, compared this LOS with that of the DRG system. The results of the analysis revealed that the medically accepted average length of hospital stay was between 6 and 7 days which were far below the ALOS proposed by the DRG system.

As reported earlier in this chapter, majority of the research works in literature used lifetime data of patients admitted at the hospital and most by cohort studies. However, this piece of work is aimed at modeling patients' survival time to death using all mortality data within a period of 7 hospital admission days as benchmark for ALOS at the hospital as reported by many in researchers in the literature.

2.3 Inpatient mortality and LOS

Inpatient mortality (death rate) and LOS are two important indicators many used in assessing the performance and efficiency of hospitals and healthcare units. Thus, every hospital and healthcare unit greatest desire is to improve the healthcare statistics by ensuring that the number of patients dying at the facility or unit is cut down. Meanwhile, mortality and length of hospital stay have very complex and interwoven relationship with several health outcomes and with complex variation inpatients healthcare and LOS. In literature, several research works with many from the United States had focused on examining the correlation between in-hospital mortality and inpatients LOS.

For instance, Falciglia, Freyberg, Almenoff, D'Alessio, & Render, (2009) in a two-level logistic regression study, examined the effect of hyperglycemia on in-hospital mortality and LOS among severely ill persons received into three intensive care units (medical, surgical and cardiac) in a US based hospital. The analyses informed that hyperglycemia was a significant contributor of higher patient mortality compared to normoglycemic patients, "adjusted odds of mortality at 95% CI for mean glucose levels of 111-145, 146-199, 200-300, and greater than 300 mg/dl were 1.31(1.26-1.36), 1.82(1.74-1.90), 2.13(2.03-2.25), and 2.85(2.58-3.14), respectively". Brodovicz et al., (2012) in a multivariate logistic regression analyses, evaluated the impact of hypoglycemia on inpatient mortality and length of hospital stay among patients admitted to a hospital for insulin treatment between 2005 and 2007 in the United States. The results of their analyses indicated that, out of 107,312 patients admitted, 21,561 (20%) had hypoglycemia and 7,539 (7.0%) were severe cases. They further reported that 6.5% of hypoglycemic patients died against 3.8% without hypoglycemia and 7.6% of the deaths of hypoglycemic patients were severe cases. To sum it all, the results indicated that hypoglycemia was significantly associated with inpatient mortality and length of hospital stay.

Similarly, Kwok et al., (2012) in another logistic regression analyses, investigated the relationship between pre-stroke disability, in-hospital deaths and prolonged LOS among patients, aside their ages, sexes, kind of stroke and severity of the disease associated with prestroke disability. The results of the analyses uncovered that inpatient mortality was 20.8% and increased mRs of pre-stroke disability was significantly related to increased mortality "(mRs = 1,2,3,4,and 5 against mRs = 0: OR: 1.28; 95% CI, 1.09-1.50; OR: 1.50; 95% CI, 1.29-1.75; OR: 1.85; 95% CI, 1.6-2.13; OR: 2.56; 95% CI, 2.15-3.04; and OR: 4.48; 95% CI, 3.47-5.80, respectively)''.

Lim et al., (2012) in a logistic regression analyses to determine the prevalence of malnutrition and its impact on patients' LOS and mortality rate in a tertiary teaching hospital in Singapore, utilized a sample of 818 adult patients. The results of their analyses revealed that out of the overall patients with nutritional deficiency, 29% had increased length of hospital stay (6.9 ± 7.3 days against 4.6 ± 5.6 days, $P<0.001$) than those who were properly-nourished ($P<0.014$). Mortality rates per their analyses revealed that mal-nourished patients faced greater mortality at all levels than those properly nourished (34% against 4.1%, $P<0.001$ in 1 year), (42.6% against 6.7%, $P<0.001$ in 2 years), and (48.5% versus 9.9%, $P<0.001$ in 3 years), respectively. In all, malnutrition was a statistically significant predictor of patient mortality rate (HR: 4.4; 95% CI, 3.3-6.0, $P<0.001$).

Also, Lingsma et al., (2018) in a study analyzed administrative data of patients discharged between 2007-2012 from 26 hospitals in six different countries (USA, UK, Netherland, Belgium, Australia and Italy) under the global comparators project to determine the correlation between patient mortality, length of hospital stay, and readmission. Their analyses by ordinal logistic regression revealed that inpatient mortality and length of hospital stay were significantly correlated at both hospital and patient level. It was further reported by Lingsma et al., (2018) that, patients in the upper quartile (75^{th} percentile) length of hospital

stay were associated with higher odds of mortality (OR: 1.45; 95% CI, 1.43-1.47) as compared to patients in the lower quartile (25th percentile) length of stay and that, hospitals with high standardized mortality had prolonged length of stay.

Glance, Stone, Mukamel, & Dick, (2011) employed logistic regression and generalized linear regression model to explore the economic burden and clinical impact of hospital acquired infections (HAIs) among trauma patients using a nationally representative data. The results of which revealed that hospital acquired infections was significantly associated with prolonged length of hospital stay and increased mortality rate. Culakova, Poniewierski, Crawford, Dale, & Lyman,(2014) conducted an investigation to examine the contribution of comorbidities and infectious complications on inpatient LOS and rate of deaths among 135,309 persons hospitalized with cancer in 239 medical centers in the United States between 2004 and 2012. The results of their analyses in a multivariate logistic regression revealed that, inpatient mortality was 10,261 (7.6%) and respiratory disorder recorded the highest rate of mortality (11.2%), CNS (9.3%) and leukemia (9.3%).

Furthermore, Aujesky, Stone, Kim, Crick,& Fine, (2008) conducted an investigation to assess the possible association between length of hospital stay and outpatient mortality rate. A sample of 15,531 patients discharged with a principal diagnosis of pulmonary embolism (PE) from 186 acute care hospitals in Pennsylvania, from January, 2000 through to November, 2002 was used for the study. The study reported that outpatient mortality was substantially greater among patients with an average length of stay of 4 days and below (OR: 1.55; 95% CI, 1.21-2.00) as compared to those with an average length of stay greater than 4 days. In conclusion, the results revealed that patients with shorter length of stay were significantly related to greater outpatient mortality than those with longer length of stay. The association of shorter LOS with higher patient mortality as reported by other researchers formed the base

of this study using mortality data and which is different from lifetime data and cohort studies as employed by other research works.

2.4 Survival analysis and LOS

Patients' LOS, defined by the total time spent in hospitalization (Amrita & Badgal, 2015) is a useful tool in survival analysis as it defines the time to an event. Survival analysis among other things detailed the occurrence of an event of interest relative to given time interval. One very important aspect of health management of hospital resources and improved efficiency of healthcare is to understand the complex relationship between patient LOS and in-hospital mortality (Lefaivre et al., 2009). Going through existing literature, less research is done on this using survival analysis, and few are sampled to shape this work piece. For instance, Loef et al., (2005) conducted a study to examine in-hospital mortality and long-term survival rates of patients with renal postoperative function decline. A sample of 843 patients who received cardiac surgery with cardiopulmonary bypass in 1991 was used for the study. Results of a Cox proportional hazards model analyses revealed that patients who were hospitalized and discharged alive and followed- up for longer period of time recorded a substantial number of in-hospital patient mortality with renal postoperative function decline as compared to those without renal function decline (HR: 1.83; 95% CI, 1.38-3.20). In all, patients with postoperative renal function decline in cardiac surgery contributed positively to increase in-hospital mortality and worst state of long-term survival.

Using Cox proportional hazards multivariate analysis, Combes et al., (2003) evaluated the aftermath and health-related quality of life among patients receiving mechanical ventilation for fourteen days and more in an ICU of a university hospital. A cohort of 347 consecutive patients aged 65 years and older who received the treatment was used for the analyses. The

results of which shown that having a preadmission immunocompromised status, and having a length of mechanical ventilation greater than 35 days were statistically significant predictors of patient mortality after being discharged from the ICU. In all, acute mechanical ventilation was identified with impaired health-related quality of life as compared to mild mechanical ventilation. In another prospective cohort study of 271 patients admitted to a hospital between January, 1998 to May, 1998 in the United States, Kyne, Hamel, Polavaram, & Kelly, (2002) investigated whether there exists differences in patient length of hospital stay, healthcare cost and survival rates of patients with nosocomial complication by clostridium difficile-related diarrhea compared with those without the infection. The results of the analyses in a Cox proportional hazards regression indicated that nosocomial infection due to clostridium difficile-related diarrhea was not statistically significant predictor of inpatient mortality.

In a survival analysis to determine the death rates of persons received into and intensive care unit of the hospital in Barcelona, Spain, with acute exacerbation of chronic obstructive pulmonary disease (COPD), Gudmundsson et al., (2006) employed "Kaplan Meier survival analysis and Cox regression model" to explore patient mortality and associated risk factors among persons with COPD. 416 consecutive patients were monitored for two years under "St. George's Respiratory Questionnaire". Results of the analyses revealed that patient mortality rate was 29.3% (122) and diabetic patients had the highest mortality rate (HR: 2.25; 95% CI, 1.28-3.95). Some equally associated risk factors revealed by the study were age, low forced expiratory volume in one second, and lower health status.

Similarly, Lefaivre et al., (2009) in a Cox PH model, evaluated the impact of delay to surgery (from the time of patients' admission to surgery) on inpatient death, major and minor complications and incidence of pressure sores among elderly patients aged 65 years and older with a fracture of the hip. A sample of 690 patients received into the "Vancouver General Hospital between 1998 and 2001" with a fracture of the hip was used for the study. Results of

their analyses indicated that “delay to surgery (P=0.0255), comorbidity (P<0.0001), age (P<0.0001) and type of fracture (P<0.0004) were all significant contributors to prolonged time to discharge” according to the Cox PH model. The results further indicated that delay to surgery (P=0.0255) was not significantly associated with deaths of patients at the hospital, notwithstanding, a delay of greater than 24 hours was said to be a valid indicator “of a minor medical complication (OR: 1.53; 95% CI, 1.05-2.22)”. Conversely, a delay of more than 48 hours was substantially related to a severe “risk of a major medical complication (OR: 2.21; 95% CI, 1.01-4.34), a minor medical complication (OR: 2.27; 95% CI, 1.38-3.72), and pressure sores (OR: 2.29; 95% CI, 1.19-4.40)”. In all, elderly patients with hip fracture needed early surgery to minimize the time to acute-care hospital discharge and to lessen the possible risk of complication.

Furthermore, Davidson et al., (2011) in an investigative study evaluated the prolonged survival rates of older persons with trauma received by five levels designated trauma units between 1995 and 2008 under the “Washington State Trauma Registry linked to death certificate data”, in the US. Davidson et al., (2011) employed “Kaplan Meier and Cox proportional hazards models to” determine the total mortality and the possible risk of death for trauma patients hospitalized at the various designated trauma units. The results of their analyses revealed that total number of deaths after “3 years of injury was 16% (95% CI, 15.8%-16.2%)” relative to the study group expected total number of deaths of 5.9% (95% CI, 5.9%-5.9%). The results also indicated a valid response in in-hospital mortality within the study length of 14 years “from 8% (n=362) to 4.9% (n=600), whereas long-term cumulative mortality rates substantially increased from 4.7% (95% CI, 4.1%-5.4%) to 7.4% (95% CI, 6.8%-8.1%)”. Davidson et al., (2011) further revealed those older patients as well as “those who were discharged to a skilled nursing facility experienced the greatest risk of death”. With HR of deaths among patients discharged to “a skilled nursing facility” according age

groupings given as follows "1.41 (95% CI, 0.72-2.76) for patients aged 18-30 years, 1.92(95% CI, 1.36-2.73) for those aged 31-45 years, 2.02 (95% CI, 1.39-2.93) among patients aged 46-55 years, 1.93 (95% CI, 1.40-2.64) in those patients aged 56-65 years, 1.49 (95% CI, 1.14-1.94) for those aged 66-75 years, 1.54 (95% CI, 1.27-1.87) for those patients aged 76-80 years old, and 1.38 (95% CI, 1.13-1.26) for those patients above 80 years" old.

In a retrospective cohort study of 1,352 consecutive elderly patients above 65 years admitted to a Level one trauma unit between 2005 and 2008, Ayoung-Chee et al.,(2014) investigated the long-term outcomes of ground-level falls (GLFs) among trauma patients hospitalized and discharged. Skilled nursing facilities (SNFs) were assigned to monitor patients' health outcomes in a follow-up to December, 2010. Kaplan-Meier and Cox proportional hazards analyses were employed to assess patients post discharge mortality. The outcome of their analyses shown that 48% of the patients had an Injury Severity Score (ISS) greater than 15, and out of which 12% died while on admission. They also revealed that 51% of the patients who survived hospitalization were discharged to a SNF, 33% to home without care, and 5% were discharged to rehabilitation units. The study again revealed that 44.6% of the patients assigned to various units were readmitted within 1-year period of injury, with a 1-year mortality of 33% for the general population and 24% for those who were discharged alive. It was again indicated that after adjusting hazard ratios, patients discharged to a SNF had three-times greater risk of 1-year mortality (HR: 2.82; 95% CI, 1.86-4.28) compared with those discharged to home without care. They also captured in their results that the mortality rate of patients discharged to a SNF at the end of the follow-up period was 48% and 61% of the deaths were patients residing at the SNF. The report concluded that GLFs among elderly patients resulted in severe injury, increased readmission rate and increased level of in-hospital mortality after discharge.

Shafi et al., (2012) in a similar search investigated whether survival rates of trauma patients who were treated and discharged remain stable afterward. Survival rates of persons with trauma received into a Level one trauma unit for the period of 2006 to 2008 in the US were assessed at "30,90,180 days, and 1 and 2 years from injury among two categories of trauma patients (Major and Minor based on Abbreviated Injury Scale [AIS] score)". The "Kaplan-Meier, Log-rank test and Cox proportional hazards models" were employed in their analyses. Results of the analyses disclosed that the survival rate for persons with severe injuries (AIS score ≥ 3 injuries) was 92% at 30 days post trauma which decreased "to 84% in 3 years period ($P>0.05$ compared with the general population), and for minor trauma patients (AIS score ≤ 2 injuries)", the survival rate was said to same as the entire group. "Age and injury severity were" said to be the only statistically significant predictors of prolonged mortality given survival to discharge. The Log-rank test analyses revealed that risk of death among persons with severe injuries score (AIS score ≥ 3 injuries) maintained a significantly greater survival rate up to 6 months after injury than the general population. To sum up, the report indicated that the survival rate for trauma patients with major injuries was substantially lower than the survival rate for patients with minor injuries and the general population for several months after discharge.

As reported in the literature, most survival analysis involved cohort studies or patients' lifetime data, where some patients survived and other died within the study period. In a similar survival analysis, this study is aimed at modeling patients' survival time to death and possible factors influencing patients' LOS using Kaplan Meier survival model, Log-rank test and Cox PH regression model with mortality data from the Legon Hospital, University of Ghana, Accra.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This section contains detailed discussion of the methodology and statistical packages used for the study. It contains four aspects as stated below.

Description of the data and study variables

Data collection and sampling technique

Data analysis and

Survival analysis.

3.1 Description of the data and the Study Variables

The study utilizes an administrative data of patient mortality from January, 2016 to August, 2018 from the Legon Hospital, University of Ghana, Accra. The data which was obtained from the data unit of the hospital through due process contained variables such as patient's LOS, age, sex and cause of death. Patients' LOS is treated as an outcome variable with age, sex, and cause of death as predictor variables.

In organizing and preparing data, patients who died at the hospital within the study period were followed up for a period of one week (seven hospital admission days), where patients who died beyond seven hospital admission days are treated as right-censored data in the data analysis.

3.2 Data Collection and Sampling Technique

The study data which is a secondary data contained two demographic variables (patient's age and sex), where sex is treated as binary variable (male or female), with the male sex assigned a value of one (Male = 1) and the female a value of two (Female = 2) in the sex column of the data. Patient's age was included in the data as a continuous variable, and also, as a categorical variable with two categories as the younger age group and the older with age range of 64

years or less and 65 years or more, respectively. This move was as a result of the data being left-skewed, where more of the deaths occurred above middle age, within the range of 1-119 years. In the data, the younger age group was assigned a value of one (≤ 64 years = 1) and the older age group was given a value of two (≥65 years = 2).

In a similar vein, causes of death were classified into ten categories according to the international classification of diseases – version 11 (ICD -11), which was released on June 18, 2018 and is currently available for member states and other stakeholders to use ("WHO International Classification of Diseases, 11th Revision (ICD-11)," 2019). The diseases that affect the wellbeing of humans are so numerous and interrelated in a complex manner that without a meaningful organization and classification, there will be no meaningful understanding and data analysis. Hence, the classification gave a better understanding of the diseases than assessing them individually. The disease categories captured by the study data according to the international classification of diseases – version 11 (ICD -11) and used for this study include:

Disease of the digestive system (DOTDS)

Disease of the circulatory system (DOTCS)

Disease of the respiratory (DOTRS)

Disease of the nervous system (DOTNS)

Disease of the blood and blood forming organs (DOTBABFO)

Endocrine, Nutritional and Metabolic disorders (ENAMD)

Infectious diseases (IDs)

Injury, Poisoning and certain other consequences of external causes (IPACOCOEC)

Neoplasms/Cancers (CANCERS)

For sake of data analysis, the disease categories were assigned values from one up to ten in the order listed above. That is DOTDS = 1, DOTCS = 2, DOTRS = 3, DOTGS = 4, DOTNS

= 5, DOTBABFO = 6, ENAMD = 7, IDs = 8, IPACOCOEC = 9, and CANCERS = 10. Again, the diseases were also classified as communicable diseases or non-communicable diseases (NCD). The communicable category of diseases were given a value of one and the non-communicable a value of two, and patients' length of hospital stay was treated as a continuous variable which ranges from 1 day to 95 days. In a nutshell, the study data can be briefly explained by table 3.1.

Table 3.1: A summary of the study variables used for the data analysis

Variable	Status
Length of stay (LOS)	Continuous
Event	Censored = 0 and Uncensored = 1
Age categories	$\leq 64 = 1$ and $\geq 65 = 2$
Sex	Male = 1 and Female = 2
Cause	DOTDS = 1, DOTCS = 2, DOTRS = 3, DOTGS = 4, DOTNS = 5, DOTBABFO = 6, ENAMD = 7, IDs = 8, IPACOCOEC = 9, and CANCERS = 10
Disease	Communicable = 1 and Non-communicable = 2

3.2.1 Inclusion Criteria

All patients who died at the facility with properly documented death records (age, sex, date of admission, date of death, and cause of death) were eligible for the study. In a situation where a patient died out of multiple infections or diseases, the principal or leading cause of death is considered the favourite

3.2.2 Exclusion Criteria

All patients who died without a known cause of death (cause of death pending post-mortem [PM] or brought in dead [BID]) or without proper documentation were excluded from the study.

The sampling technique employed by this study was purposive sampling, with the concept of establishing the relationship between patient mortality, LOS and cause of death. Hence, patients who died without a known cause could not fit into the study purpose and, therefore were excluded in the study.

Out of 756 patients who died within the study period, 532 patients met all the inclusion criteria for the study. This was after a careful study of the data revealed 224 patients with cause of death being brought in dead (BID) or waiting for post-mortem or unknown cause. That is, 148 patients were BID and the remaining died out of unknown causes). In all, 532 eligible patients were sampled for the study and data analysis.

3.3 Data analysis

This aspect describes the theoretical analyses of the statistical models and tests used for the study. It marks the beginning of the path to establish concrete facts about the study objectives stated in chapter one. The clarity in the collection, description and organization of the study data presented above is to facilitate an in-depth analysis of the study data. Non-parametric and semi-parametric statistics (Kaplan Meier survival model, the Log-rank test and Cox PH model) were employed for the data analysis. This was after basic descriptive analyses confirmed the assertion that survival data are usually skewed with long tail distributions which do not follow normal distributions. Data analyses are performed using Microsoft excel, SPSS statistical package version 21 and STATA statistical package version 14.

To begin with, we performed descriptive analyses using Microsoft excel to study the distribution status of the data, that is, a histogram on patients' LOS and that of cause of death. After investigating the nature of the data, the data was exported into the SPSS and STATA for further analyses to be carried out.

Secondly, to study the average length of hospital stay (ALOS), we performed comparative analysis of means by the SPSS statistical package version 21 based on the categorical levels of the independent variables. This allows us to study the average length of hospital stay by each categorical variable within the study period. Also, we performed analysis of variance (ANOVA) to compare the mean level of factors (Independent variables) and to determine the significance of each independent variable involved in the study. That is, ANOVA on age, sex and disease and that of age, sex and cause of death. The separate analysis is because causes of death are the same as the diseases and combining them in data analysis is statistically incorrect.

Furthermore, we performed descriptive analysis of survival data using the STATA statistical package to determine the number of deaths occurring within the study period and also, to assess the prevalence and incidence rate of the deaths occurring within the study period.

To determine the survival and hazard functions by sexes, age groups, causes of death and diseases, we employed the Kaplan Meier survival model to carry out the analyses. Sex, age and diseases are treated as binary variables that are males and females, younger age group and older age group and communicable (CD) and non-communicable (NCD), respectively. Survival analysis by cause of death was according to the ten classes of diseases given by ICD-11.

Furthermore, we performed comparative analysis of survival curves using the Logrank test of equality of survival curves to assimilate the differences in survival curves reported by the Kaplan Meier survival model. The Logrank test provides statistical significance or otherwise

for the differences in the survival curves of various groups. We again performed Cox PH regression analysis on the independent variables which are found significant according to the Logrank test. That is Cox PH regression analysis by age, disease and cause of death and also, the Cox PH analysis on the ten classes of diseases under the cause of death. We again employed the Cox PH regression analysis to determine the joint effect of age and disease and that of age and cause of death associated with patients' survival time and length of stay at the Legon Hospital, University of Ghana, Accra.

3.4 Survival Analysis

Survival analysis is simply just another name for time to event analysis. Survival analysis is commonly used in biomedical sciences with the major interest of observing the time to an event such as death, birth, pregnancy or contraceptive use and many others. In agricultural science, survival analysis is used to observe the time to birth or death of an animal or treatment response. Also, survival analysis is not left out in the social sciences, where time to event analysis is observed in events such as job loses or changes, time to marriage, divorce and so on. Similarly, survival analysis is used in the engineering sciences for modeling the life span of machines and other electronic gadgets.

Hence, survival analysis is the analysis of a set of data that is time-bound until an event of interest often referred to as death or failure occurs. Survival data usually have a follow-up time with well-defined starting point as a reference to the occurrence of an event of interest. The time factor could be measured in years, months, weeks or days.

3.5 Assumptions of survival analysis

Key assumptions guiding the accurate use of survival models include:

(i) The event status of survival analysis should clearly be defined by two mutually exclusive and distinctive states.

(ii) Censorship time should be clearly and precisely defined and measured.

(iii) Survival times are non-negative.

(iv) Survival function between two successive and distinct observations is a constant.

(v) When selecting a sample for survival analysis, circular trends should be avoided.

In survival analysis, it is worth noting that censored data can be right or left censored. But for this study, all censored data are right censored. Right censoring in survival analysis refers to censored data obtained when the event of interest called death or failure failed to occur in the life of a subject within the follow-up time during observation or where the event of interest occurs in the life of a subject beyond the study scheduled time. Also, when a subject under study for some reason drops out of the study or is lost to follow-up before the end of the study time, such a subject is considered as censored data. In survival analysis and for this study, censored data are denoted with a zero (0) and uncensored data with one (1). This is because little is known about the event of interest with regard to censored data and hence the zero, whereas uncensored data is known to contain the event of interest and hence the success value of one.

For this study, censored data was determined by the number of days a patient spent at the hospital during admission. A patient's LOS beyond seven (7) hospital admission days was considered as censored data, the reason being that, patients were followed up for a period of seven hospital admission days to support the literature review that patients who die at the hospital met their death at the early days of their hospital admission.

3.5.1 Kaplan Meier Survival Model

The Kaplan Meier survival model as a non-parametric statistical model is used to estimate the survival curve of a time dependent event without following the assumption of any underlying probability distribution. The survival curve is a plot of $S(t)$ against t, which usually come in the form of a stepwise reduction plot, which begins with a maximum value and decrease monotonically to a minimum value or zero. It measures the probability of surviving within a time space.

3.5.1.1 The assumptions of the Kaplan Meier survival model

The following model assumptions must be certified before putting the Kaplan Meier survival model to use:

(i) The Kaplan Meier survival model assumes that the survival times are non-negative.

(ii) The model also assumes that the survival function between successive distinct observations is a constant.

(iii) The model again assumes that censored data is right censored.

Advantages of the Kaplan Meier survival model

(i) As a non-parametric model, it does not require any mathematical assumption for its hazard function or proportional hazard as it deals with only the empirical probability of surviving over a given period of time.

(ii) It holds the view that the survival function between successive distinct observations is constant.

(iii) It handles successfully, censored data, more particularly right censored.

(iv) It also allows the comparison of survival functions among groups.

Limitations of the Kaplan Meier survival model

(i) It does not account for variations among covariates.

(ii) Its stepwise nature qualifies it better for handling categorical predictors and hence not good for continuous variables.

The Kaplan Meier survival model is based on the primary concept that the probability of surviving to time t is a product of all the 't' observed survival rates for each period; that is the cumulative proportional rate of the surviving time t. Let T denote a continuous non-negative random variable for a given survival time t, with probability density function (pdf) $f(t)$ and cumulative distribution function (cdf) $F(t) = \Pr(T \le t)$. Then the probability of surviving to time t is given by:

$$S(t) = \Pr(T > t) \tag{3.1}$$

$$S(t) = \prod_{j:t_j<t} \left(\frac{n_j - d_j}{n_j} \right) \tag{3.2}$$

$$S(t) = \prod_{j:t_j<t} \left(1 - \frac{d_j}{n_j} \right) \tag{3.3}$$

where j = 1,2,3,…, t_j denotes the time of an event, d_j the number of deaths at time t_j, and n_j denotes the number of subjects known to have survived up to time t_j.

The Kaplan Meier survival curve provides a useful ground to predict the survival probability at any given time, t. The curve usually remained constant between successive distinct observations, and drops instantaneously at each point of death to a new level. An inverse of the survival curve gives the cumulative hazard curve.

3.5.1.2 The Median survival time

The median survival time is estimated as the smallest survival time for which the survival function is less than or equal to 0.5 (50%). For uncensored data, it is estimated as the middle

observation of the ranked survival times, $t_{(1)}, t_{(2)}, ..., t_{(k)}$. When the number of observations, k , is odd, the median survival time is given by

$M = t_{\left(\frac{k+1}{2}\right)}$ and $M = \frac{1}{2}[t_{(\frac{k}{2})} + t_{(\frac{k}{2}+1)}]$, when k is even.

3.5.1.3 Confidence Interval estimation by the Kaplan Meier survival model

Just like other statistical models, the Kaplan Meier survival model also regarded confident interval estimation as vital as it indicates the level of reliability and accuracy of the estimates at a given point in time. Assuming normal distribution of the Kaplan Meier survival function, $S(t)$, the 95% confidence interval at time, t , is given by

$$S(t) - 1.96SE[S(t)] \text{ to } S(t) + 1.96SE[S(t)] \quad (3.4)$$

However, confidence interval estimation according to the Kaplan Meier survival model varies from one school of thought to another. Common among them are the Greenwood's method, the Peto's method, and the Transformation method. For this study, the first shall be discussed for its clarity and easy application.

According to the Greenwood's method of confidence interval estimation, the standard error of the survival function, $S(t)$, for any given time, t , $t \le t \le t_{k+1}$ is estimated as

$$SE(t) \approx S(t)\sqrt{\sum_{j=1}^{k} \frac{d_j}{n_j(n_j - d_j)}} \quad (3.5)$$

where j = 1,2,3,…, d_j denotes the number of deaths at the jth time, n_j represents the total number of patients at risk of death at the jth time, and $S(t)$ is the survival function.

Thus

$$\sum_{j=1}^{k} \frac{d_j}{n_j(n_j - d_j)} = \left(\frac{1}{n_2} + \frac{1}{n_1}\right) + \left(\frac{1}{n_3} + \frac{1}{n_2}\right) + ... + \left(\frac{1}{n_{k+1}} + \frac{1}{n_k}\right)$$

$$= \frac{1}{n_{k+1}} - \frac{1}{n}$$

$$= \frac{n - n_{k+1}}{n.n_{k+1}}$$

$$\sum_{j=1}^{k} \frac{d_j}{n_j\left(n_j - d_j\right)} = \left(\frac{1}{n_2} + \frac{1}{n_1}\right) + \left(\frac{1}{n_3} + \frac{1}{n_2}\right) + \ldots + \left(\frac{1}{n_{k+1}} + \frac{1}{n_k}\right) \tag{3.6}$$

$$\sum_{j=1}^{k} \frac{d_j}{n_j\left(n_j - d_j\right)} = \frac{n - n_{k+1}}{n.n_{k+1}}$$

Also, $S\left(t\right) = \frac{n_{k+1}}{n}$ (3.7)

Hence, $Var[S\left(t\right)] = S^{2}\left(t\right)\sum_{j=1}^{k} \frac{d_j}{n_j\left(n_j - d_j\right)}$ (3.8)

$$= S^{2}(t).\frac{n - n_{k+1}}{n.n_{k+1}}$$

$$= \frac{S^{2}(t)}{n}.\frac{n - n_{k+1}}{n_{k+1}}$$

$$= \frac{S^{2}(t)}{n}\left(\frac{n}{n_{k+1}} - 1\right)$$

$$= \frac{S^{2}(t)}{n}\left(\frac{1}{S(t)} - 1\right)$$

$$= \frac{S^{2}(t)}{n}\left(\frac{1 - S(t)}{S(t)}\right)$$

Therefore, $Var[S(t)] = \frac{S(t)}{n}[1 - S(t)]$ (3.9)

Since the confidence interval given in equation (3.4) is used for normal distribution, we shall follow the steps below to return our values to their normal scale as a non-parametric distribution.

Firstly, we shall take antilog of the limit values

Secondly, we negate the result

And to end it all we take second antilog of the values.

In all, the approximate $(1-\alpha)$ confidence interval of $S(t)$ for t, $t_k \le t < t_{k+1}$ is given by

$$S(t)^{\exp\left\{-\frac{1.96}{\ln S(t)}\sqrt{\sum_{j=1}^{k}\frac{d_j}{n_j(n_j-d_j)}}\right\}} \text{ to } S(t)^{\exp\left\{+\frac{1.96}{\ln S(t)}\sqrt{\sum_{j=1}^{k}\frac{d_j}{n_j(n_j-d_j)}}\right\}} \quad (3.10)$$

3.5.2 Hazard Function

The Kaplan Meier hazard model as a non-parametric statistic is used to estimate the hazard curve of a time dependent event without following the assumption of any underlying probability distribution. The curve is a plot of $[1-S(t)]$ against t, which usually comes in the form of a stepwise increasing plot, which begins with a minimum value and increase monotonically to a maximum value or one. It measures the probability of dying at least to time t.

The survival function, $S(t)$ and the hazard function, $h(t)$ can be related to the probability of success and failure of an event, and hence the reason why the simultaneous use of the two in survival analysis. The hazard model equation is given by

$$h(t) = \frac{f(t)}{S(t)} \quad (3.11)$$

For a small change in survival time, t the instantaneous probability of dying at time t, is given by

$$h(t) = \lim_{\Delta t \to 0} \frac{\Pr(t \le T \le t + \Delta t / T > t)}{\Delta t}$$

$$h(t) = \lim_{\Delta t \to 0} \frac{\Pr(t \le T \le t + \Delta t)}{\Delta t.\Pr(T > t)} \quad (3.12)$$

$$h(t) = \lim_{\Delta t \to 0} \frac{S(t) - S(t+\Delta t)}{\Delta t.S(t)}$$

$$h(t)=\frac{1}{S(t)}\lim_{\Delta t\to 0}\frac{S(t)-S(t+\Delta t)}{\Delta t}$$

$$h(t)=-\frac{1}{S(t)}\lim_{\Delta t\to 0}\frac{S(t+\Delta t)-S(t)}{\Delta t} \tag{3.13}$$

$$h(t)=-\frac{1}{S(t)}S^{1}(t)$$

$$h(t)=-\frac{d}{dt}[\ln S(t)] \tag{3.14}$$

$$S(t)=Exp\left\{-\int_{0}^{t} f(z)dz\right\}$$

$$S(t)=Exp\{-H(t)\} \tag{3.15}$$

Where $H(t)$ is the cumulative hazard rate at time, t and given by.

$$\hat{H}=-\ln\hat{S}(t) \tag{3.16}$$

3.5.3 Logrank test

The Log-rank test is used as a supportive test to the Kaplan Meier survival model to check the possible difference in the survival times of two or more events. This test provides statistical significance or otherwise to any existing difference in survival curves by the Kaplan Meier survival plots, by means of the Logrank Chi square test statistic.

The Logrank test as an extension of the Kaplan Meier survival model observes the same assumption as the Kaplan Meier survival model. These include:

(i) The Log-rank test assumes that the survival times are non-negative.

(ii) The model also assumes that the survival function between two successive distinct observations is a constant.

(iii) The model again assumes that censored data is right censored.

The Log-rank Chi square statistic is given by:

$$\chi^2_{Logrank} = \frac{(O_1 - E_1)^2}{E_1} + \frac{(O_2 - E_2)^2}{E_2} + \ldots + \frac{(O_k - E_k)^2}{E_k} \quad (3.17)$$

For $O_1 = \sum o_{1t}, O_2 = \sum o_{2t}, \ldots, O_k = \sum o_{kt}$ and $E_1 = \sum E_{1t}, E_2 = \sum E_{2t}, \ldots, E_k = \sum E_{kt}$ (3.18)

The generalized model for the Logrank Chi square statistic is given by:

$$\chi^2_{Logrank} = \sum_j^k \left[\frac{(O_j - E_j)}{E_j} \right], \quad j = 1,2,\ldots,k \quad (3.19)$$

The Logrank chi square statistic is then compared with the chi square distribution value at $(k-1)$ degree of freedom from statistical tables.

3.5.4 Cox PH regression analysis

The Cox PH model often referred to as the Cox regression model is employed to assess the individual contribution effect of the covariates as to whether the effect decreases or increases the hazard rate and by what proportionate amount within the study period. The Cox PH model is used to support the Logrank test. Thus the Logrank test is used to diagnose the existence of any significant difference in the survival times of various groups or categories, but does not allows each categorical variable the chance to explain itself, so as to differentiate the contribution effect of each variable. This is where the Cox PH model is very supportive.

The Cox PH model obeys the following assumptions for an accurate use.

(i) The hazard ratio between successive distinct observations is constant over time.

(ii) The model also holds the belief that the survival times between distinct individuals in a sample are independent.

(iii) The Cox PH model again assumes a linear multiplicative relationship between the predictor variables and baseline hazard.

The model equation is defined by

$$\lambda(t) = \lambda_0(t) Exp\{\theta\omega\} \tag{3.20}$$

where $\lambda(t)$ is the expected hazard at time t, $\lambda_0(t)$ is the baseline hazard, or the hazard when all the coefficients of the covariates turn to zero in multivariate cases and $Exp\{\theta\omega\}$ represents the relative risk associated with each covariate, ω.

For a univariate case, the Cox proportional hazards model is given by

$$\lambda(t) = \lambda_0(t) \exp\{\theta_1\omega_1\} \tag{3.21}$$

where θ_1 is the coefficient of the predictor variable, ω_1. Dividing both sides of equation (3.25) by the baseline hazard $\lambda_0(t)$ gives

$$\frac{\lambda(t)}{\lambda_0(t)} = \exp\{\theta_1\omega_1\}$$

Now, taking log on both sides yields

$$\ln\left\{\frac{\lambda(t)}{\lambda_0(t)}\right\} = \theta_1\omega_1 \tag{3.22}$$

Where a change in the expected log of the hazard ratio explains a unit change in the predictor variable ω_1, and θ_1.

In the multivariate case with k predictors, the Cox PH model is given by

$$\lambda_k(t) = \lambda_0(t) \exp\{\theta_1\omega_1 + \theta_2\omega_2 + \ldots + \theta_k\omega_k\} \tag{3.23}$$

Where $\theta_1, \theta_2, \ldots, \theta_k$ are the coefficients of the predictor variables, $\omega_1, \omega_2, \ldots, \omega_k$.

Equation (3.18) can be reduced as the generalized model for dealing with multivariate predictors as shown below.

$$\lambda_k(t) = \lambda_0(t)\exp\left\{\sum_{j=1}^{k}\theta_j\omega_j\right\} \tag{3.24}$$

Now, dividing both sides of equation (3.19) by the baseline hazard, $\lambda_0(t)$, gives

$$\frac{\lambda(t)}{\lambda_0(t)} = \exp\left\{\sum_{j=1}^{k}\theta_j\omega_j\right\}$$

(3.29)

Taking log on both sides will result in

$$\ln\left\{\frac{\lambda(t)}{\lambda_0(t)}\right\} = \sum_{j=1}^{k}\theta_j\omega_j \tag{3.25}$$

Where $\ln\left\{\frac{\lambda(t)}{\lambda_0(t)}\right\} = \theta_1\omega_1 + \theta_2\omega_2 + \ldots + \theta_k\omega_k$ (3.26)

In statistical analyses involving the Cox proportional hazards model, greater interest lies in the relationship between the predictor variables and the outcome of measurement. By this relation, the estimated coefficients, $\theta_j, (j = 1, 2, ..., k)$ of the Cox proportional hazards regression model reads that, a coefficient say, θ_j, represents a change in the expected Log of the hazard ratio explains a unit change in the predictor variable, ω_j, holding all other predictor variables constant.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.0 Introduction

This chapter presents the actual data analyses and discussion of the results, and the step by step procedures laid down to address the study objectives as discussed in the theoretical analyses presented in chapter three. It contains details of the analyses and results obtained from the various statistical models and test procedures discussed earlier by the previous chapter. This includes descriptive analysis of the nature and status of the study data by SPSS, analysis of variance (ANOVA) to determine the significance levels of the independent variables (age, sex, cause of death and diseases), descriptive statistics on survival data in STATA, Kaplan Meier survival models, Logrank Chi square test and Cox proportional hazards regression analysis using the STATA software package version 14.

4.1 Descriptive analysis

This section of the chapter presents descriptive analysis of the study data and analysis of variance to determine the significant levels of the independent variables and descriptive analysis of survival data.

4.1.1 Descriptive analysis of the study data

This aspect contains the descriptive analysis of the study data. Figure 4.1 presents Q-Q plots of LOS which shows that the study data is right skewed and figure 4.2 shows a histogram on patients' LOS at the hospital.

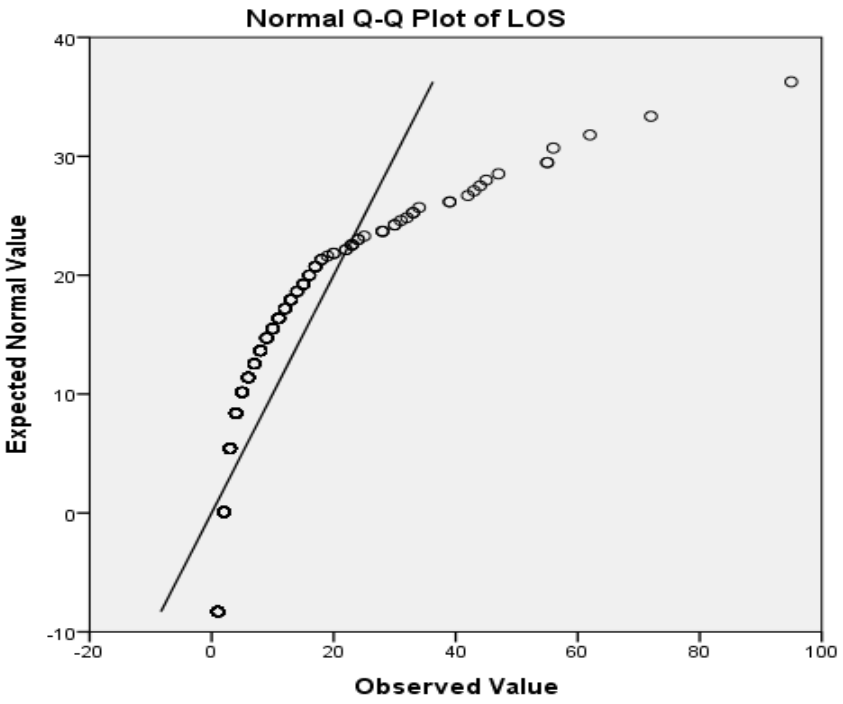

Figure 4.1: Q-Q plots of patients LOS

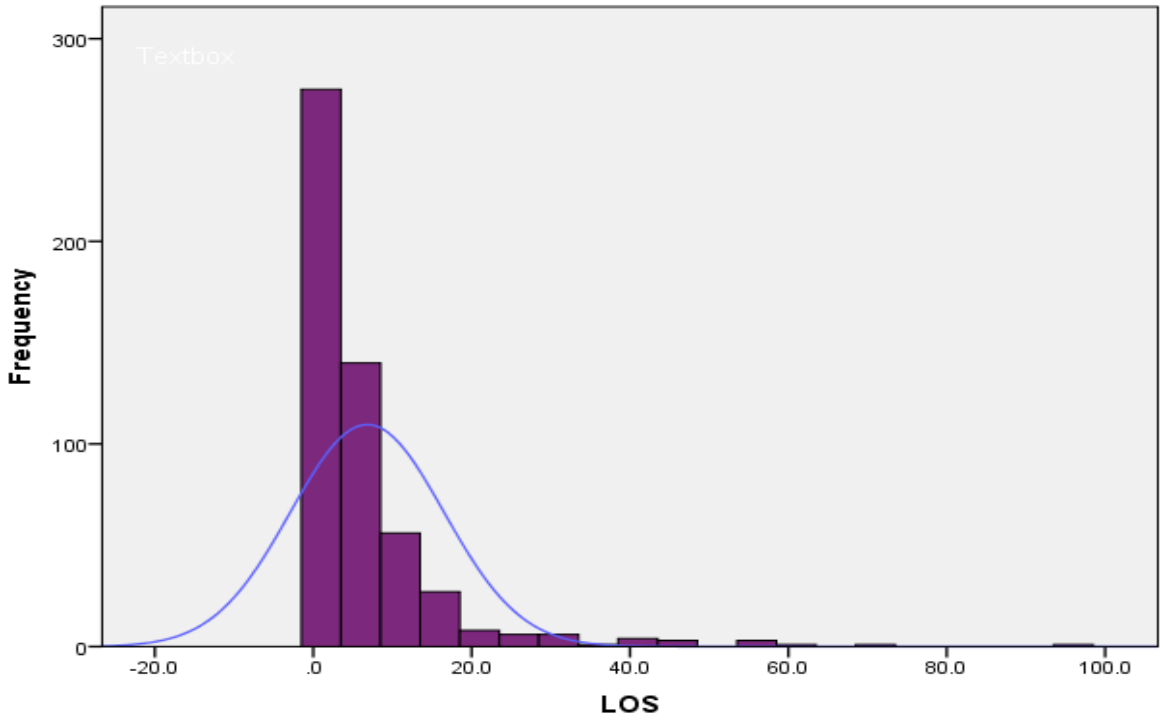

Figure 4.2 : Histogram of Patients LOS

4.1.2 Descriptive analysis by Age, Sex, Cause of death and Diseases

Table 4.2 presents results of comparative analysis on each of the independent variables by the level of categories. It contains the number of observations for each categorical level, percentage, average LOS, standard deviation, minimum and maximum LOS and level of skewness at each level for each independent variable. For the age variable, the results indicated that the older age group has a longer mean LOS and a higher variation in LOS as compared to the younger age group and for the sex groups, the female sex showed a longer average LOS with less variation in their LOS as compared to the male sex. Also, among the ten classification of diseases which formed the cause of death, we observed that patients who died of Cancers have the longest average LOS of 11.585 days, followed by patients who died of Infectious diseases with mean LOS of 9.139 days and the shortest mean LOS is recorded by patients who died out of Injury, Poisoning and certain other Consequences of External Causes (IPACOCOEC) with a mean LOS of 2.438 days.

Furthermore, assessing the variation in patients LOS at the hospital, the results revealed that patients with cancers has the greatest variation of 13.6473 as compared to patients who died out of IPACOCOEC with the least variation score of 1.9311. For the disease classification, we realized that patients who died of Communicable diseases (CD) have longer mean LOS at the hospital with less variation in their LOS days as compared to those who died as a results of Non-communicable diseases (NCD) with shorter mean LOS and higher variation in LOS at the hospital. The results also showed level of skewness greater than three by many categorical levels.

Table 4.2: Comparative analysis of means by Age, Sex, Cause of Death and Disease

Variable	Total obsr	Percentage	Mean	Std. Deviation	Min	Max	Skewness
AGE							
$\leq 64 yrs$	279	52.4	6.36	9.0162	1	62	3.420
$\geq 65 yrs$	253	47.6	7.28	10.3655	1	95	4.590
SEX							
Male	311	58.5	6.572	9.732	1	95	4.854
Female	221	41.5	7.136	9.627	1	56	3.097
CAUSE							
DOTDS	19	3.6	8.158	11.48	1	45	2.348
DOTCS	108	20.3	6.16	8.9584	1	62	3.704
DOTRS	123	23.1	5.951	7.1493	1	55	3.977
DOTGS	10	1.9	5.400	4.5995	1	15	1.126
DOTNS	96	18.0	5.844	10.454	1	95	6.962
DOBABFO	10	1.9	7.700	12.347	2	42	2.895
ENAMD	16	3.0	2.438	1.931	1	8	2.140
IDs	72	13.5	9.139	10.718	1	72	3.594
IPACOCOEC	25	4.7	2.600	2.179	1	11	2.662
CANCERS	53	10.0	11.585	13.647	1	56	1.847
DISEASE							
CD	105	19.7	7.581	9.458	1	72	3.420
NCD	427	80.3	6.616	9.739	1	95	4.590
Total	532	100.0	6.806		1	95	

4.1.3 Analysis of variance (ANOVA)

Although the our data do not follow a normal distribution, we performed analysis of variance due a large sample size of 532 observations by central limit theorem to determine the significance level of the independent variables involved in the study of patients' survival time

before death during hospital admission, using patients' LOS as a response variable. It compares the mean levels of factors including their interaction effect. Cause of death and the diseases are the same and the reason why they are separated in the analysis. Hence, table 4.3 and 4.4 present results of the analysis.

Table 4.3: Analysis of variance by Age, Sex and Disease

Source	SS	df	MS	F	Sig
Corrected	66.587	4	16.647	6.560	0.000
Age	27.191	1	27.191	10.715	0.001
SEX	6.718	1	6.718	2.647	0.105
DISEASE	33.038	1	33.038	13.019	0.000
SEX * DISEASE	7.454	1	7.454	2.937	0.087
Error	987.160	389	2.538		
Total	4540.000	394			
Corrected Total	1053.746	393			

From table 4.3, we realized that age and disease with probability values of 0.001 and less than 0.001, respectively, each less than 5% level of significance, are both significantly associated with patients' survival time to death with LOS as response variable, using mortality data at the Legon Hospital. However, the results indicated that sex as well as the interaction between sex and disease is not significantly related to patients' survival time before death at the hospital with significance probabilities of 0.105 and 0.087, respectively with each P-value greater than 5% level of significance.

Similarly, table 4.4 presents the analysis of variance by age, sex and cause of death.

Table 4.4: Analysis of variance by Age, Sex and Cause of Death

Source	SS	df	MS	F	Sig.
Corrected Model	102.239	20	5.112	2.004	0.007
Age	26.414	1	26.414	10.355	0.001
SEX	1.237	1	1.237	.485	0.487
CAUSE	50.690	9	5.632	2.208	0.021
SEX * CAUSE	24.505	9	2.723	1.067	0.386
Error	951.507	373	2.551		
Total	4540.000	394			
Corrected Total	1053.746	393			

The result revealed that age and cause of death with significant probabilities of 0.001 and 0.021, respectively, each less than 0.05 implying that, at 5% level of significance, both are significantly related to patients' survival time to death with LOS as the response variable within the specified time. Again, sex as well as the interaction between sex and cause of death is not significantly associated with patients' survival time to death with probabilities of 0.487 and 0.386, respectively each greater than 5% level of significance.

4.1.4 Descriptive analysis of survival data

Table 4.5 presents a summary of descriptive analysis of survival data. The results revealed that out of 532 patients observed during the study, 394 of these patients died within the study period of 7 hospital admission days. The results revealed a total number of hospital admission

days as 3,621 and an estimated average length of hospital stay of 6.80639 days. The minimum length of stay is reported as one day and maximum length stay is 95 days. The results further revealed a prevalence rate of 74.06% and an incidence rate of 10.88% of deaths occurring within the timeframe.

Table 4.5: Descriptive analysis of survival data

Category	TOTAL	MEAN	MIN	MEDIAN	MAX
Number of patients	532				
Time at risk	3621	6.80639	1	3	95
Failures (Events)	394	0.7406	0	1	1
Incidence rate		0.1088			

From the results presented by table 4.5, the average is 6.80639 with a prevalence and incidence rate of 0.7406 and 0.1088, respectively. Hence, analysis shows that the prevalence rate of death within the study period is 74.06% and this death rate per day referred to as the incidence rate is 10.88% within the study period at the Legon Hospital.

4.2 Survival analysis

In this section of the chapter, we employed the Kaplan Meier survival model as stated in the methodology in chapter three to provide lifetime survival tables, survival and hazard functions by the independent variables involved in the study of patients' survival times at the hospital. The section provides lifetime survival tables and curves on sex, age, cause of death and disease categories.

4.2.1 Survival functions by Sex

Table A1 of the appendix provides survival data for the male and female sex groups which revealed that the female sex group has a higher survival time than the male group. That is, the

female has a minimum LOS of 1 day and maximum being 56 days, with a minimum survival probability of 0.2670 and greatest survival probability of 0.8869 relative to the male group with minimum and maximum LOS of 1 day and 95 days, respectively, against a minimum survival probability of 0.2540 and a maximum survival probability of 0.8778.

Figure 4.3 provides the Kaplan Meier survival curves by sex. It shows a plot of LOS against survival probabilities for the male and female sexes.

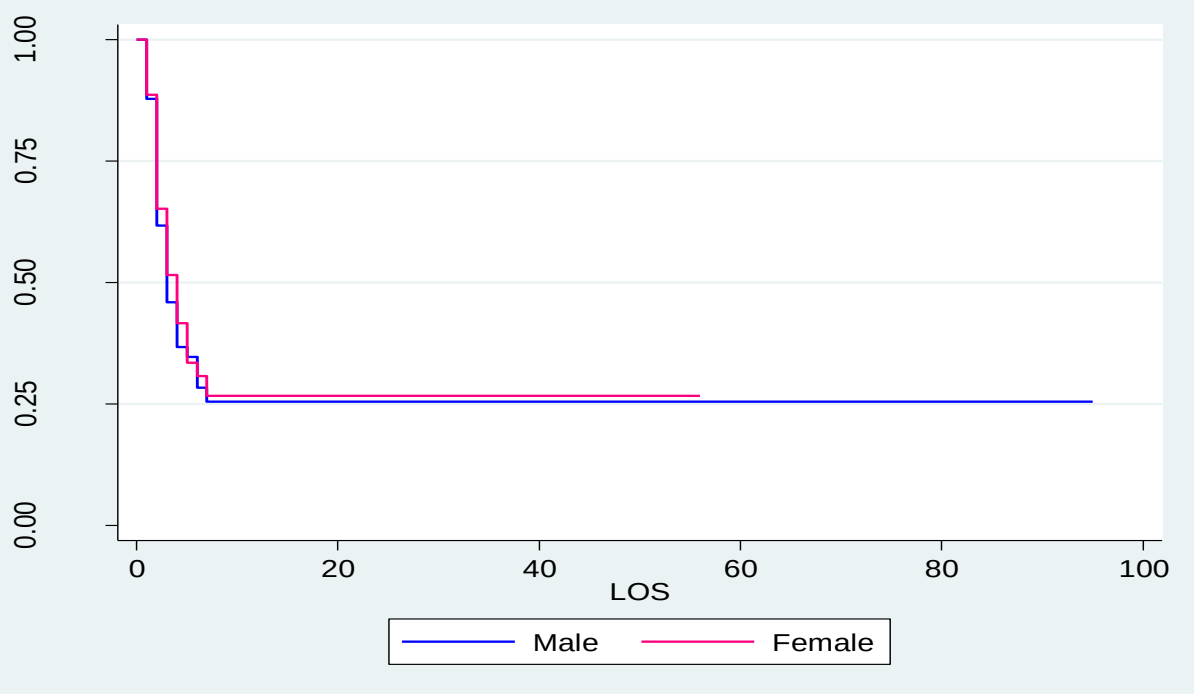

Figure 4.3: Kaplan Meier survival functions by Sex

Figure 4.4 presents the Kaplan Meier hazard functions by sex. It shows a plot of LOS against the hazard rates for the male and female sexes.

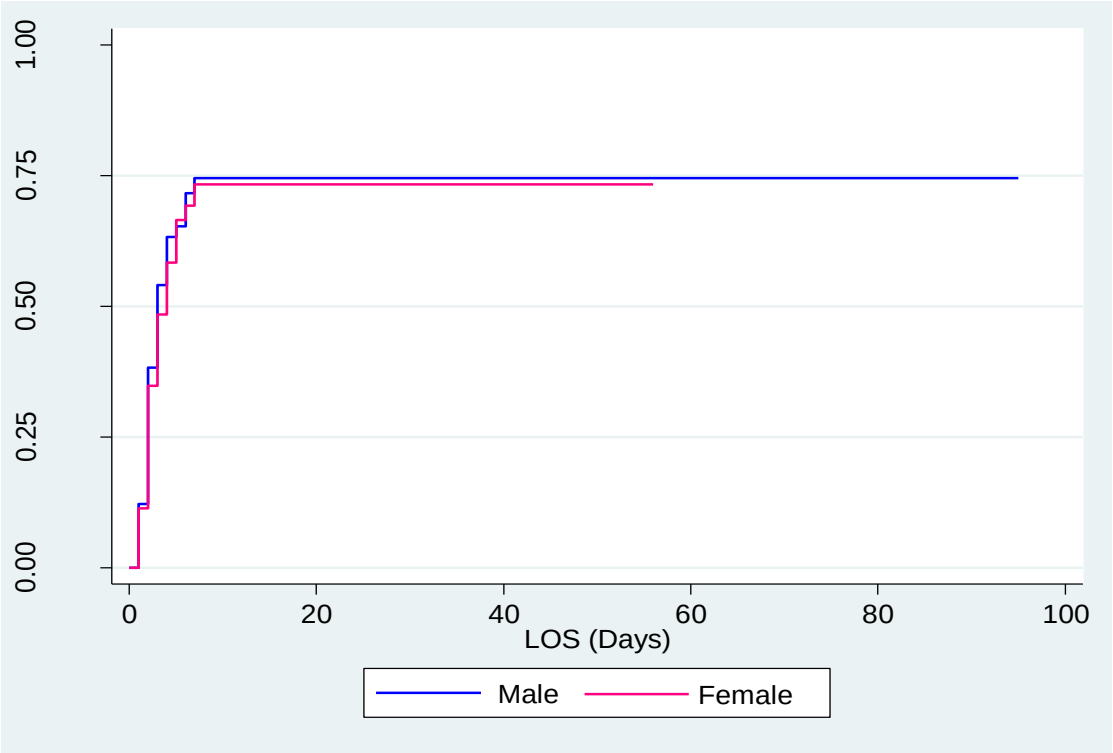

Figure 4.4: Kaplan Meier hazard function by Sex

Figures 4.3 and 4.4 show the survival and hazard functions of the male and female sexes as a stepwise function. The two figures explained the survival rates of the sex groups and both revealed that, the last male survived up to 95 days before the event of death whereas the last female died after surviving up to 56 days. In both cases, the stepwise function is seen at the early part of the curves, indicating that most deaths occurred at the early days of hospital admission at the Legon Hospital between 2016 and 2018. However, as stated in the methodology of the previous chapter, the results is only an estimate and must passed further test before any perceived difference in the survival times can be substantiated.

4.2.2 Survival Function by Age

Table A2 in the appendix provides survival data by age categories. Where age group 1 ($\leq$64 years) reveals a minimum LOS of 1 day and a minimum survival probability of 0.2401

against a maximum LOS of 62 days and a maximum survival probability of 0.8602, whereas age group 2 (≥65 years) reveals a minimum LOS of 1day and survival probability of 0.2806 and a maximum LOS of 95 days and a survival probability of 0.9051. Per the results, the older age group showed a longer survival time during hospital admission than the younger age group at the Legon Hospital. The results above are displayed by figures 4.5 and 4.6, where the older age group with the greater survival probability of 0.9051 is seen leading the younger age group with a maximum survival probability of 0.8602 in the survival functions in figure 4.5. Figure 4.6 shows the hazard functions for the age groups, where the younger age group with the greater hazard rate (lesser survival probability) is leading the older age group for the hazard functions in figure 4.6.

Figure 4.5 displays the Kaplan Meier survival curves for the age groups. It shows a plot of LOS against survival probabilities for the younger and older age groups.

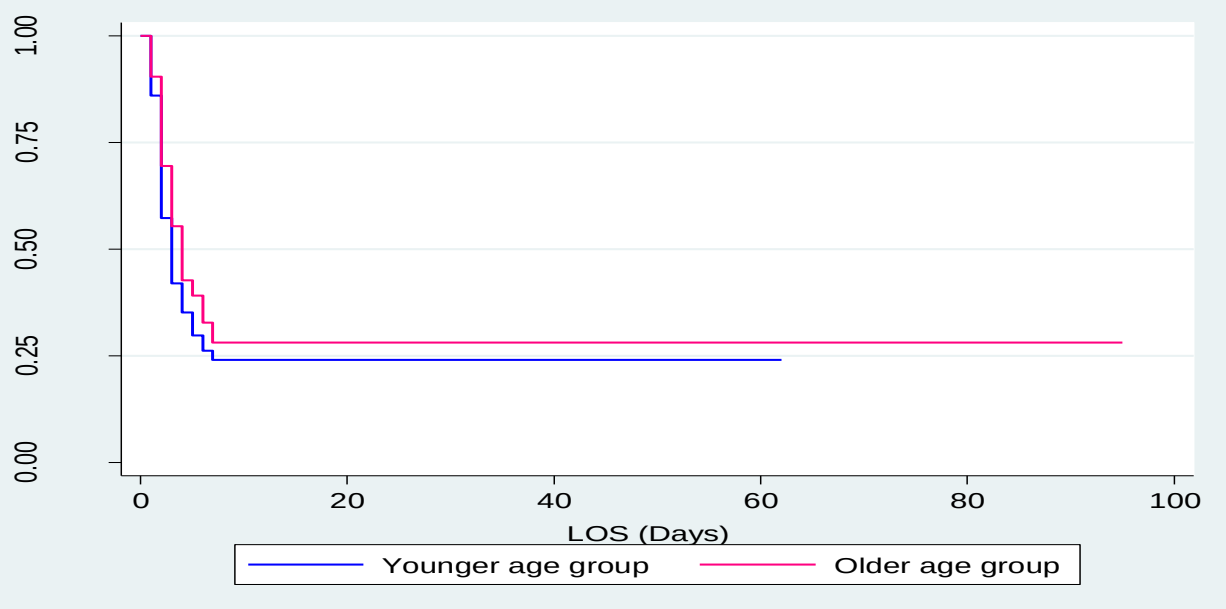

Figure 4.5: Kaplan Meier survival functions by Age

Figure 4.6 presents Kaplan Meier hazard functions by Age groups. It shows a plot of LOS against hazard probabilities for the younger and older age groups.

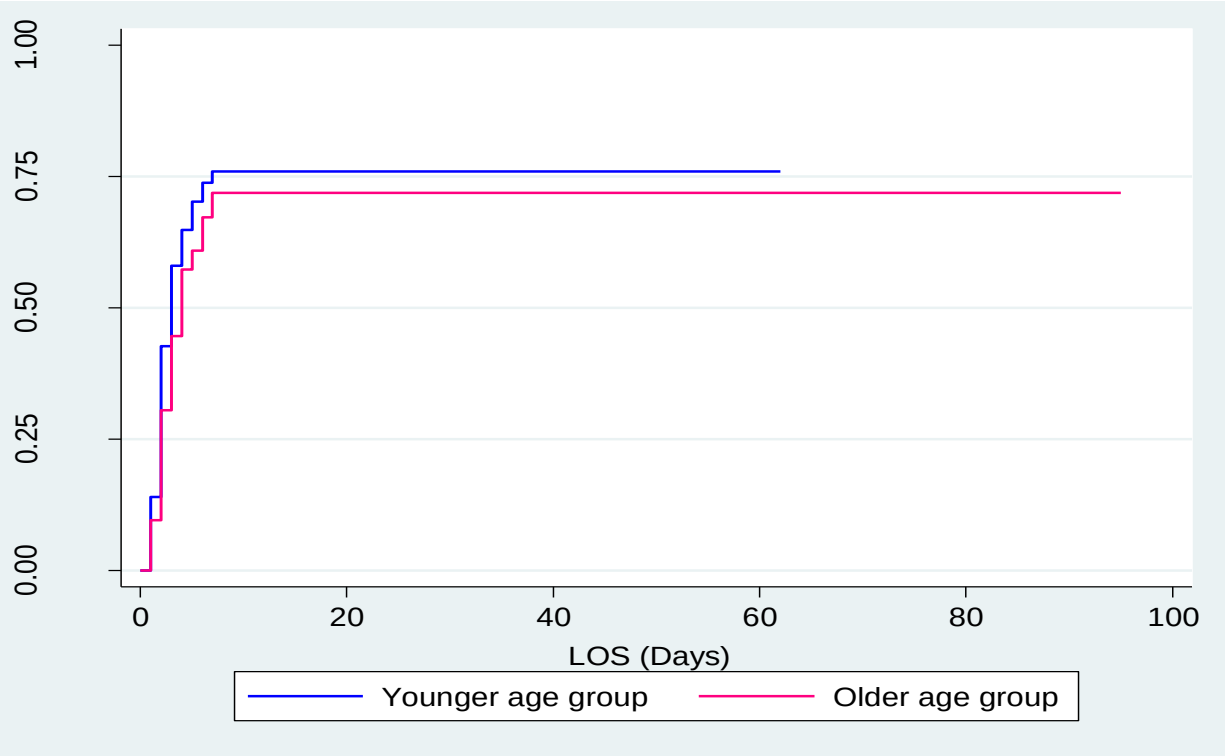

Figure 4.6: Kaplan Meier hazard functions by Age

Figures 4.5 and 4.6 both revealed that, the last older patient survived up to 95 days before the event of death during admission whereas the last younger patient died after surviving up to 62 days. The two figures clearly showed that, the stepwise function occurred at the early part of the curves, indicating that most deaths occurred at the early days of hospital admission at the hospital. However, as stated earlier in the methodology and in previous discussion in this chapter, the results is only an estimate and must passed further tests before any perceived difference in the survival curves can be substantiated.

4.2.3 Survival Function by Cause of Death

Table 4.6 presents a summary of survival data provided by cause of death in table A3 of the appendix based on the ten classification of diseases under the cause of death according to the

International Classification of Diseases-version 11 (ICD-11). It shows the minimum and maximum length of hospital stay and survival probabilities for each class of disease.

Table 4.6: Summary results of survival data by cause of death as in Table A3 of the appendix

Number	Cause of death	Length of stay		Survival probabilities	
		Min	Max	Min	Max
1	Diseases of the digestive system (DOTDS)	1	45	0.2632	0.9474
2	Diseases of the circulatory system (DOTCS)	1	62	0.2130	0.8426
3	Diseases of the respiratory system (DOTRS)	1	55	0.2439	0.8862
4	Diseases of the genitourinary system (DOTGS)	1	15	0.3000	0.8000
5	Diseases of the nervous system (DOTNS)	1	95	0.1771	0.9167
6	Diseases of blood and blood forming organs (DOBABFO)	2	42	0.3000	0.4000
7	Endocrine, nutritional and metabolic disorders (ENAMD)	1	8	0.0625	0.6875
8	Infectious diseases (IDs)	1	72	0.4444	0.9583
9	Injury, poisoning and certain other consequences of external causes (IPACOCOEC)	1	11	0.0400	0.6800
10	Neoplasms (CANCERS)	1	56	0.4340	0.9057

A ranking of the maximum survival probabilities from the greatest to the least as reported by the summary results in table 4.6 is given by 0.9583, 0.9474, 0.9167, 0.9057, 0.8862, 0.8426, 0.8000, 0.6875, 0.6800, and 0.4000 and the corresponding causes of death are IDs, DOTDS, DOTNS, CANCERS, DOTRS, DOTCS, DOTGS, ENAMD, IPACOCOEC, and

DOTBABFO, respectively. Also, a ranking of their minimum survival probabilities in ascending order is given by 0.0400, 0.0625, 0.1771, 0.2130, 0.2439, 0.2632, 0.3000, 0.3000, 0.4340, and 0.4444 with the corresponding causes of death as IPACOCOEC, ENAMD,DOTNS, DOTCS, DOTRS, DOBABFO, DOTGS, CANCERS, and IDs. The ranking of the causes of death shows how the diseases are presented in figure 4.7 and figure 4.8 of the survival and hazard functions. The ranking of the maximum and minimum survival probabilities are not inversely the same and this indicates some level of interaction among their curves as showed by figures 4.7 and 4.8.

Figure 4.7 shows the survival curves by causes of death. A plot of LOS against the survival probabilities of causes of death.

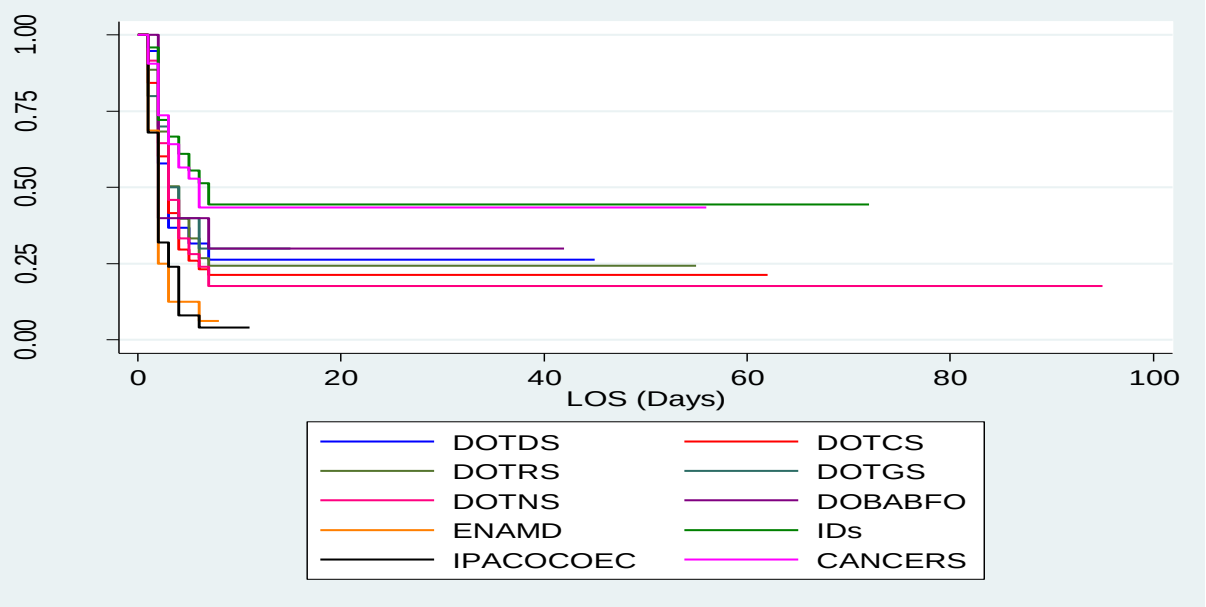

Figure 4.7: Kaplan Meier estimate of survival curves by Cause of Death

As stated earlier from the summary results by the ranking, infectious diseases had the greatest survival probability which appears at the top of the survival functions and diseases of blood and blood forming organs recorded the lowest survival rate with its survival function leading from the bottom. The hazard functions by causes of death are presented in figure 4.8.

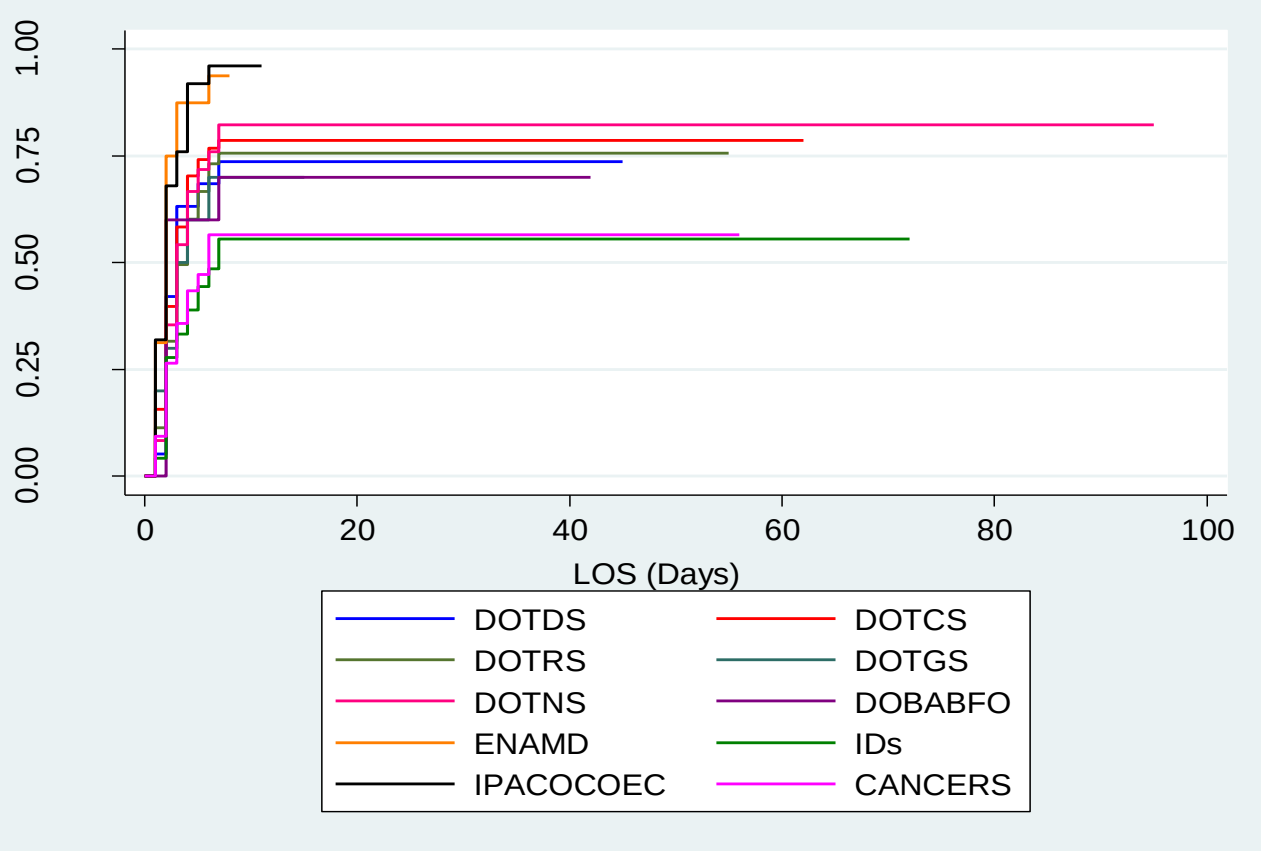

Figure 4.8: Kaplan Meier estimate of hazard functions by Cause of Death.

Following the discussion from the survival function in figure 4.8, it can be clearly seen that diseases of blood and blood forming organs which recorded the lowest survival rate now takes the lead in the hazard function with infectious diseases having the lowest hazard rate and its hazard function leading from the bottom.

4.2.4 Survival Function by Disease

Furthermore, survival data for the diseases provided by Table A4 of the appendix, indicates that communicable diseases have a minimum and maximum length of stay of 1 day and 72 days with minimum and maximum survival probabilities of 0.3238 and 0.9524, respectively, whereas NCD revealed a minimum and maximum length of stay of 1 and 95 days, and survival probabilities of 0.2436 and 0.8642. The following results is displayed in figure 4.9 and 4.10, where communicable diseases with greater survival probability of 0.9524 is seen with its survival curve leading the NCD with a lower survival probability of 0.8642 as

showed in figure 4.9. Figure 4.10 shows the hazard functions for the disease groupings, where NCD with the least minimum survival probability of 0.2436 lead the communicable diseases with minimum survival probability of 0.3238 in their hazard functions. As reported earlier, the survival and hazard functions explain the same concept but are inversely related.

Figure 4.9 presents the Kaplan Meier survival curves by disease type. It shows a plot of LOS against the survival probabilities for CD and NCD.

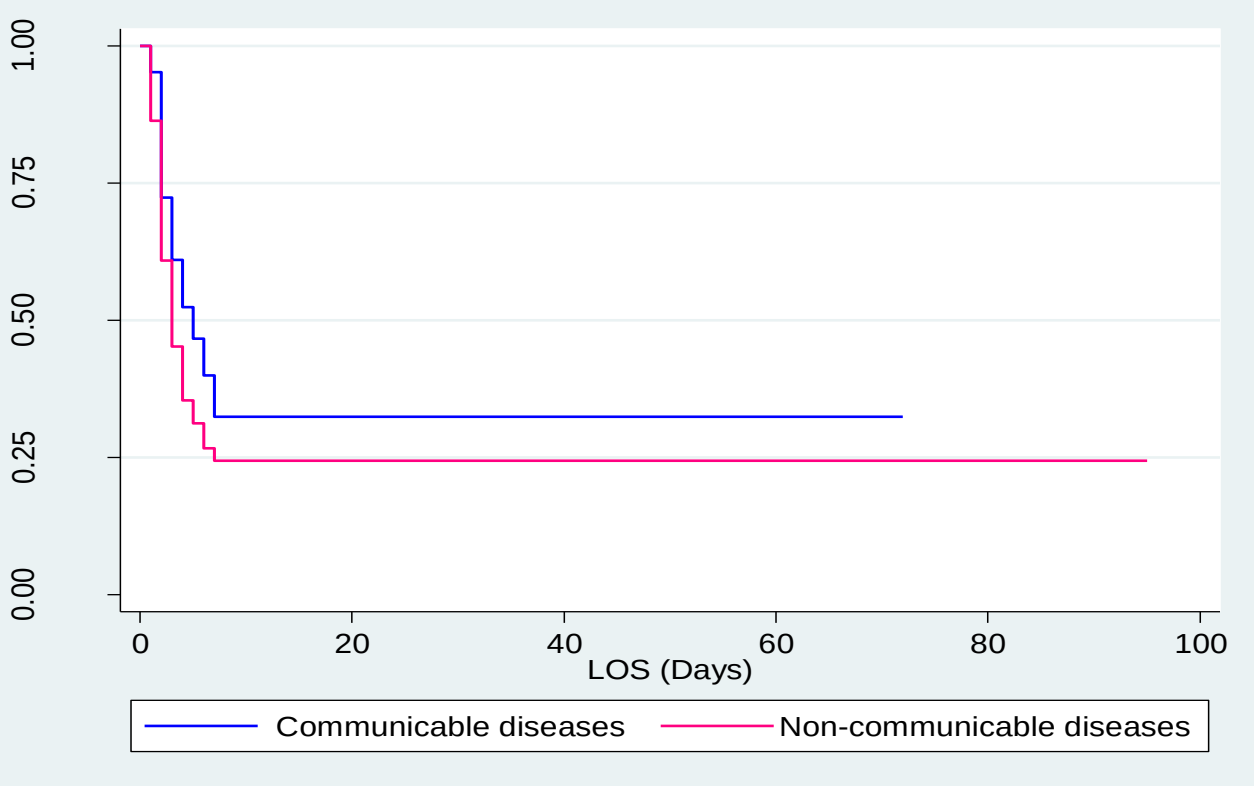

Figure 4.9: Kaplan Meier estimate of survival curves by Diseases

Figure 4.10 presents the Kaplan Meier hazard functions by disease type. It shows a plot of LOS against the hazard probabilities for communicable and NCD.

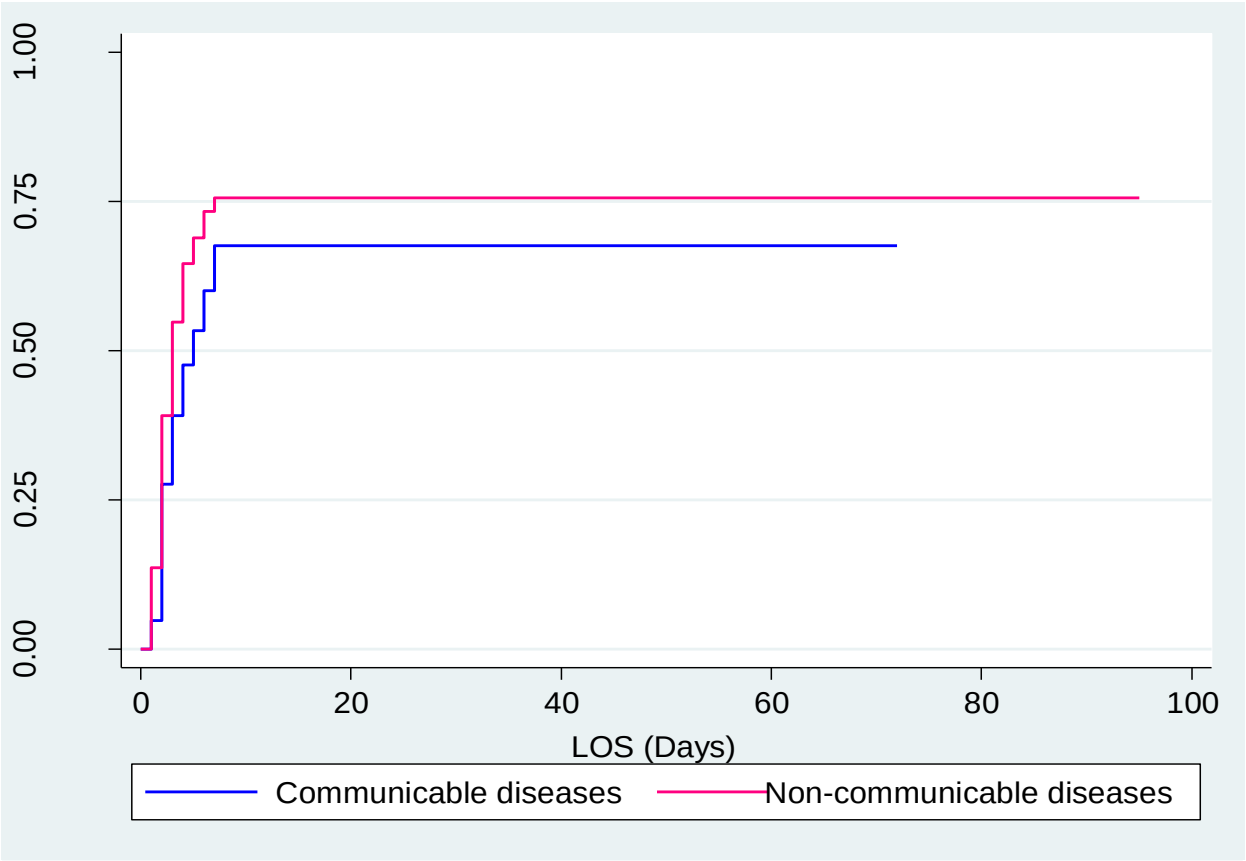

Figure 4.10: Kaplan Meier hazard functions by type of Disease

Figures 4.9 and 4.10 showed the inverse relationship between the survival and hazard functions by the type of diseases. Both indicated that the last patient with communicable disease died after surviving up to 72 days after admission at the hospital as compared to a survival of 95 days by the last patient with NCD. Also, both functions showed more deaths at the early days of hospital admissions as showed by the failure rates in the stepwise functions at the early part of patients' LOS as reported earlier.

4.3 Analysis of survival functions by Sex, Age, Cause of death and Disease

As stated earlier in this chapter and also in chapter three of the methodology, differences in the survival functions as provided by the Kaplan Meier survival model are mere estimates and can never be conclusive until further test is performed to seek statistical significance.

Hence, we employed the Logrank Chi-square test of statistical significance to authenticate the significance of the differences in survival curves by sex, age, cause of death and type of disease provided by the Kaplan Meier survival model.

4.3.1 Logrank test for equality of survival curves by Sex

Table 4.7 presents the Logrank test analysis of equality of survival functions by sex. It presents the total number of deaths observed against the number expected by each sex group with the Logrank Chi square statistic and probability value. Thus, the Log-rank test provides statistical significance for differences in the survival curves of two or more subjects based on a claim that the survival curves are the same.

Table 4.7: Results of Logrank test of equality of survival curves by Sex

Sex	Event observed	Event expected	Chi-square value	P-value
Male	232	226.63	0.3800	0.5389
Female	162	167.37		
Total	394	394.00		

The Logrank test of equality of survival curves by sexes according to the results displayed by table 4.7 indicated that, out of 394 events of interest (total deaths) observed within the study period, 232 are observed from the male sex group against 226.63 expected as compared to 162 events observed against 167.37 expected from the female sex group. A Chi square statistic value of 0.3800 at 1 degree of freedom with a probability value of 0.5389 is recorded in the results. The probability value of 0.5389 greater than 0.05 implies that there is no significant difference between the survival curves of the male and female sex groups. Hence,

the Kaplan Meier estimates of survival curves showed by figure 4.3, where the female sex showed higher survival time than the male is an estimate.

4.3.2 Log-rank test for equality of survival curves by Age Groups

Table 4.8 presents the Logrank test analysis of equality of survival functions by age groups. It presents the total number of deaths observed against the number expected by each group and the Logrank Chi square statistic and corresponding probability value.

Table 4.8: Results of Logrank test of equality of survival curves by Age groups

Age	Event observed	Event expected	Chi-square	P-value
$\leq 64 yrs$	212	193.63	4.3300	0.0374
$\geq 65 yrs$	182	200.37		
Total	394	394.00		

The results indicated that out of 394 deaths observed within the study period, 212 are observed from the younger age group against 193.63 expected as compared to 182 observed against 200.37 expected from the older age group. A Chi-square statistic value of 4.3300 with 1 degree of freedom and a probability value of 0.0374 are recorded in the results. There is significant difference between the survival curves of the age groups, since the probability value of 0.0374 is less than 0.05. Hence, the Kaplan Meier estimate of survival curves provided by figure 4.5 is significant and thus, showed that the older age group has a higher survival time to death than the younger age group at the hospital.

4.3.3 Logrank test of equality of survival curves by Cause of Death

The Logrank test of equality of survival functions by causes of death according to the International Classification of Diseases version 11 (ICD-11) is presented in table 4.9. The ten diseases according to ICD-11 are abbreviated here as explained in the methodology. Table 4.9 detailed the total number of observed deaths and the expected by each class of diseases and the overall chi square statistic and probability value.

Table 4.9: Results of Logrank test of equality of survival curves by Causes of Death

Cause of death	Event observed	Event expected	Chi-square	P-value
DOTDS	14	13.69	52.8000	0.0000
DOTCS	85	73.42		
DOTRS	93	92.90		
DOTGS	7	7.47		
DOTNS	79	69.87		
DOBABFO	7	7.25		
ENAMD	15	6.99		
IDs	40	64.95		
IPACOCOEC	24	11.49		
CANCERS	30	45.95		
TOTAL	394	394.00		

The results detailed the observed number of deaths against the expected for each class of diseases, beginning with diseases of the digestive system (DOTDS) with 14 observed deaths against 13.69 expected and ending with CANCERS with 30 observed deaths against 45.95 expected. The results also showed a Log-rank Chi-square statistic value of 52.8000 with 9 degree of freedom and a P-value less than 0.001. The probability value of less than 0.001 as compared to 0.05 reveals substantive differences in the survival curves by the ten classes of cause of death showed in figure 4.7 by the Kaplan Meier survival analysis. The results

showed that patients who died of infectious diseases stayed for longer days before death than those that died out of diseases of the blood and blood forming organs with the lowest survival time to death within the study period at the Legon Hospital.

4.3.4 Logrank test of equality of survival curves by Type of Disease

The Log-rank test of equal of survival functions by type of diseases is presented by table 4.10. It contains the total observed deaths and the number expected by each disease type and the chi square statistic with its corresponding probability value.

Table 4.10: Results of Log-rank test of equality of survival curves by type of Diseases

Disease	Event observed	Event expected	Chi-square	P-value
CD	71	89.62	6.3200	0.0119
NCD	323	304.38		
Total	394	394.00		

The results by table 4.10 indicated that communicable diseases had 71 deaths observed against 89.62 deaths expected as compared to NCD with 323 deaths observed against 304.38 expected out of a total of 394 deaths observed within the study period. Also, the results revealed a Chi square statistic value of 6.3200 with 1 degree of freedom and a probability value of 0.0119. Per the probability value of 0.0119 less than 0.05, there is significant difference in the survival curves of CD and NCD as indicated by the Kaplan Meier survival analysis in figure 4.9. Hence, the survival curves revealed that, patients who died of CD have higher survival time unto death than those who died of NCD.

4.4 Cox PH regression analysis

This section of the chapter contains Cox PH regression analysis by age, disease, and cause of death as well as the pair of age against disease and age against cause of death. As stated by the ANOVA in tables 4.2 and 4.3, the three variables cannot be combined because cause of death and disease are barely the same. In this analysis, we intend to assess the impact of each independent variable that showed significant difference in their survival curves according to the Logrank test analysis and by which are significant for the Cox PH regression analysis.

4.4.1 Cox PH regression analysis by Age, Disease and Cause of Death

Table 4.11 presents Cox PH regression analysis by age, disease and cause of death. It shows for each variable the regression coefficient, standard error, value of the test statistic (z), P-value, hazard ratio, Likelihood Ratio Chi square statistic and the P-value of the Chi square statistic.

Table 4.11: Cox PH regression on Age, Disease and Cause of Death

Variable	Coeff.	Std. Err.	Z	P>|z	H.Ratio	LR Chi2	P>Chi2
Age	-0.0055	0.0021	-2.5800	0.0100	0.9945	6.56	0.0104
DISEASE	0.2931	0.1313	2.2300	0.0260	1.3406	5.330	0.0213
CAUSE	-0.0401	0.0182	-2.2000	0.0280	0.9607	4.94	0.0263

The results indicated a negative regression coefficient of -0.0055 for age and -0.0401 for cause of death and a positive regression coefficient of 0.2931 for the disease. These coefficients generated the hazard ratios of 0.9945 for age and 0.9607 for cause of death which are less than one and a hazard ratio of 1.3406 for disease which is greater than one. It can be inferred from the results that, older age decreases the relative hazard by an average of 0.0055

(0.55%) as compared to the younger age. Also, diseases with higher survival rates decrease the relative hazard of patients' survival time to death by an of average of 0.2931 (29.31%).

4.4.2 Cox PH regression analysis on the ten classes of Cause of Death

The ten classes of diseases according to the international classification diseases- version 11 were assigned categorical values from 1 to 10. Hence, to assess the individual impact of each ten class of diseases under the ICD-11 for cause of death, we performed Cox proportional hazards regression analysis to assess the effect of each disease as indicated by table 4.12. The results include the regression coefficient (β), standard error (SE), Wald statistic, degree of freedom (df), significance level for Wald statistic, hazard ratio [Exp(β)] and confidence interval for the hazard ratio.

Table 4.12: Cox PH analysis on the ten classes of Cause of Death

Covariate	β	SE	Wald	df	Sig.	Exp(β)	95.0% CI for Exp(β)	
CAUSE			39.533	9	0.000			
DOTCS	0.458	0.324	1.996	1	0.158	1.580	0.838	2.981
DOTRS	0.583	0.213	7.521	1	0.006	1.792	1.181	2.719
DOTGS	0.435	0.210	4.275	1	0.039	1.544	1.023	2.331
DOTNS	0.365	0.420	0.758	1	0.384	1.441	0.633	3.281
DOBABFO	0.559	0.215	6.774	1	0.009	1.749	1.148	2.665
ENAMD	0.398	0.420	0.897	1	0.344	1.488	0.654	3.390
IDs	1.216	0.318	14.654	1	0.000	3.375	1.811	6.292
IPACOCOEC	-0.059	0.242	0.061	1	0.806	0.942	0.587	1.513
CANCERS	1.189	0.275	18.616	1	0.000	3.282	1.913	5.632

Following the results displayed by table 4.12, IDs, CANCERS, DOTRS, DOTGS and DOBABFO, are found to be significant predictors of patients' survival time to death with each significance probability less than 0.05 compared to diseases of the digestive system (DOTDS). The diseases involved with their regression coefficients and hazard ratios are IDs (β = 1.216, H.R = 3.375; 95% CI, 1.811 – 6.292, P = 0.000), CANCERS (β = 1.189, H.R = 3.282; 95% CI, 1.913 – 5.632, P =0.000), DOTRS (β = 0.583, H.R = 1.792; 95% CI, 1.181 – 2.719, P = 0.006), DOBABFO (β = 0.559, H.R = 1.749; 95% CI, 1.148 – 2.665, P = 0.009) and DOTGS (β = 0.435, H.R = 1.544; 95% CI, 1.023 – 2.331, P = 0.039). This implies that IDs, CANCERS, DOTRS, DOBABFO and DOTGS each patients' relative hazard by an average of 1.216, 1.189, 0.583, 0.559 and 0.435, respectively, as compared to DOTDS as the reference point.

4.4.3 Cox PH regression analysis by Age and Disease

To assess the joint impact and marginal effect of age, disease and cause of death, we again performed Cox proportional hazards regression analysis by age and disease as well as age and cause of death. Hence, table 4.13 presents Cox proportional hazards regression analysis by age and disease, which is similar to that presented in table 4.11.

Table 4.13: Cox PH regression by Age and Disease

Variable	Coeff.	Std. Err.	Z	P>|z|	H.Ratio	LR Chi2	P>Chi2
Age	-0.0055	0.0022	-2.5500	0.0110	0.9945	11.74	0.0028
Disease	0.2899	0.1312	2.2100	0.0270	1.3362	11.74	0.0028

The resulted presented by table 4.13 is the same as reported earlier with regression coefficients of -0.0055 for age and 0.2899 for disease with a marginal decrease in the effect of disease on the relative hazard of patients' survival time before death by 0.32%.

4.4.4 Cox Proportional PH analysis by Age and Cause of Death

Table 4.14 presents the Cox PH regression analysis by age and cause of death, similar to what is presented by table 4.13.

Table 4.14: Cox PH regression by Age and Cause of Death

Variable	Coeff.	Std. Err.	Z	P>|z|	H.Ratio	LR Chi2	P>Chi2
Age	-0.0055	0.0021	-2.5600	0.0110	0.9945	11.39	0.0034
CAUSE	-0.0396	0.0182	-2.1700	0.0300	0.9612	11.39	0.0034

The joint effect of age and cause in the regression analysis revealed a regression coefficient of -0.0055 for age and -0.0396 for cause. This decreases the effect of cause of death on the relative hazard of patients' survival time to death by 0.05% with a negligible effect on age.

4.5 Discussion of Results from the Analyses

The discussion of results is viewed in the following aspects of the data analysis, the descriptive analysis of the study data, analysis of variance, Kaplan Meier survival modeling, the Log-rank Chi-square test of equality of survival curves, and the Cox proportional hazards regression analysis.

The general aim of the study is to model patients' survival time to death and to determine possible factors associated with patients' length of hospital stay at the Legon Hospital. The results revealed an average length of stay of 6.806 days similar to Black & Pearson, (2002) who reported an ALOS of 6.8 days, Wright et al., (2003) & Aujesky, Stone, Kim, Crick & Fine, (2008) with ALOS of 6 days and Culakova, Poniewierski, Crawford, Dale & Lyman, (2014) with ALOS of 7 days.

In modeling patients' survival time to death, the Kaplan Meier survival analysis by sex, age, cause of death and disease revealed that, the instantaneous failure rate that formed the stepwise functions among the survival curves occurred at the early part of patients' LOS at the hospital within study period. This is reflected in the high prevalence rate of 74.06% and incidence rate of 10.88% and the median LOS of 3 days as reported by the analysis.

From the results of the analysis of variance by tables 4.3 and 4.4, the Logrank test for differences in survival curves and the Cox PH regression analysis, we found out that age, cause of death and type of disease are significant predictors of patients' survival time to death at the Legon Hospital.

Meanwhile, the Logrank test analysis as well as the analysis of variance all indicated that sex is not a significant predictor of patients' survival time before death at the hospital. The result thus contradicts the findings of Vavalle et al., (2012) in the literature, who reported that, the female sex is significantly associated with patients' LOS at the hospital.

To determine the individual and joint effect of the predictor variables by Cox PH regression analysis by age, cause of death and type of disease, we found out that older age as well as causes of death with high survival rates decreases the relative hazard of patients' survival time to death by an average of 0.55% and 4.01% respectively, whereas NCD increases patients' relative hazard by an average of 29.31% relative to CD. Hence, the analysis revealed that older patients survived longer during hospital admission than the younger patients at the Legon Hospital. This finding supports the works of a good number of researchers in literature including Formiga et al., (2008), Hamill, Villwock, Sykes, Chamoun & Beahm, (2018), Khosravizadeh et al., (2016) and Agboado, Peters, & Donkin, (2012). However, this contradicts the findings of Davidson et al., (2011) in the literature who saw the older age group with higher risk of death.

Furthermore, results of the analyses indicated that, patients with NCD faced greater hazard and shorter length of hospital stay before death as compared to CD. Averagely, causes of death such as infectious diseases, CANCERS, diseases of the respiratory system, diseases of blood and blood forming organs and diseases of the genitourinary system among the ten classes of diseases showed greater hazard on patients' survival time to death at the Legon Hospital. This result also supports the findings of many researchers in literature including Loef et al., (2005), Lefaivre et al., (2009), Davidson et al., (2011), Shafi et al., (2012) and Ayoung-Chee et al., (2014).

Finally, older age is associated with higher patients' survival time and longer LOS than the younger age, and patients who died of non-communicable diseases have shorter LOS and higher mortality as compared to patients who died out of communicable diseases according to the mortality data from the Legon Hospital. The overall analyses also revealed that shorter LOS is associated with high inpatient mortality at the early stage of hospital admission within the study space at the hospital.

In conclusion, age, cause of death, and type of disease are significantly associated with patients' survival time to death according to mortality data from the Legon Hospital, University of Ghana, Accra.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter contains briefly the summary of results, conclusions made from the findings gathered from the results and recommendations based on the decisions made from the findings. It gives brief account of the work done and suggested ways of improving future research.

5.1 Summary of Results

The study entirely proved significant in modeling patients' survival time to death within the study period of 7 hospital admission days and determining significant factors influencing patients' LOS at the hospital. The statistical models used are analysis of variance (ANOVA), Kaplan Meier survival model, Logrank Chi-square test, and Cox PH regression model. The ANOVA was used to generally assess the significance level of the independent variables, the results of which revealed that age, cause of death and type of disease were found to be significantly related to patients' survival time before death. However, sex was found to be insignificant. The Kaplan Meier survival model was used to provide survival curves for the independent variables which are age, sex, cause of death and diseases. The Logrank Chi-square test for equality of survival curves shows that age, cause of death and disease revealed significant differences in their survival curves. Hence, age, cause of death and type of disease are significant factors associated with patients' survival time to death at the hospital.

The Cox PH regression model was used to determine the individual and joint effect of age, cause of death and type of disease on the relative hazard of patients' survival time to death at the hospital. The results thus revealed that, older age decreases the relative hazard by an

average of 0.55%, as well as cause of death with an average rate of 4.01%. however, disease revealed an average increase in the relative hazard by 29.31%.

Also, infectious diseases, cancers, diseases of the respiratory system, diseases of blood and blood forming organs and diseases of the genitourinary system are significantly associated with greater hazards to patients' survival time to death.

In a nutshell, the analyses revealed that shorter LOS is associated with high mortality with prevalence rate of 74.06% and incidence rate of 10.88% within the study period at the hospital according to the study data. It also emerged that older patients lived longer days before death than younger patients and patients with NCD showed a shorter LOS and higher mortality as compared to communicable diseases.

5.2 Conclusion

In a sum, the decisions gathered from the results of the study are that; the Kaplan Meier survival curves revealed that majority of the deaths occurred at the early days of hospital admission, with a prevalence rate of 74.06% and an incidence rate of 10.88% according to mortality data within the study space at the Legon Hospital. The survival analysis and the Logrank test also reported substantial differences in the survival curves by age, cause of death and type of disease. The results indicated that older patients have longer days of hospital admission before the event of death relative to the younger age group, whereas patients with NCD showed shorter days on admission before death as compared to CD.

The Cox PH regression analysis revealed that age, cause of death and type of disease are significant predictors of patients' survival time to death, and that diseases such as infectious

diseases, cancers, diseases of the respiratory system, diseases of blood and blood forming organs, and diseases of the genitourinary system are significantly associated with increase hazard to patients' survival time to death at the Legon Hospital, University of Ghana, Accra.

5.3 Recommendations

This section of the chapter gives suggested ways to address the findings gathered, remedy the challenges identified and to improve future research. From the decisions made out of the findings based on the results presented, this study recommends the following:

- Management of Legon Hospital and other healthcare providers should pay rapid attention on patients' admission, particularly at the early state to address the high prevalence and incidence rate of mortality among patients surviving to death.
- Management of Legon Hospital and other healthcare providers should educate patients on seeking early healthcare whenever they are sick. High inpatients mortality at early days of hospital admission raised a concern that patients surviving to death could be attending hospital at the worst state of their health.
- The government of Ghana, Ghana health services and other organizations should mount more public education through the media and other fora to educate people on the wide spread of NCD.

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Appendices

Table A1: survival day by sex

Interval		Total	Deaths	Lost	Survival	SE	95% Conf. Int.	
Male								
1	2	311	38	0	0.8778	0.0186	0.8360	0.9095
2	3	273	81	0	0.6174	0.0276	0.5609	0.6688
3	4	192	49	0	0.4598	0.0283	0.4036	0.5141
4	5	143	29	0	0.3666	0.0273	0.3132	0.4199
5	6	114	6	0	0.3473	0.0270	0.2948	0.4002
6	7	108	20	0	0.2830	0.0255	0.2340	0.3337
7	8	88	9	0	0.2540	0.0247	0.2071	0.3035
8	9	79	0	12	0.2540	0.0247	0.2071	0.3035
9	10	67	0	8	0.2540	0.0247	0.2071	0.3035
10	11	59	0	4	0.2540	0.0247	0.2071	0.3035
11	12	55	0	12	0.2540	0.0247	0.2071	0.3035
12	13	43	0	3	0.2540	0.0247	0.2071	0.3035
13	14	40	0	7	0.2540	0.0247	0.2071	0.3035
14	15	33	0	2	0.2540	0.0247	0.2071	0.3035
15	16	31	0	4	0.2540	0.0247	0.2071	0.3035
16	17	27	0	4	0.2540	0.0247	0.2071	0.3035
17	18	23	0	4	0.2540	0.0247	0.2071	0.3035
18	19	19	0	1	0.2540	0.0247	0.2071	0.3035
19	20	18	0	1	0.2540	0.0247	0.2071	0.3035
20	21	17	0	1	0.2540	0.0247	0.2071	0.3035
22	23	16	0	1	0.2540	0.0247	0.2071	0.3035
23	24	15	0	2	0.2540	0.0247	0.2071	0.3035
24	25	13	0	1	0.2540	0.0247	0.2071	0.3035
28	29	12	0	3	0.2540	0.0247	0.2071	0.3035
30	31	9	0	1	0.2540	0.0247	0.2071	0.3035
31	32	8	0	1	0.2540	0.0247	0.2071	0.3035
33	34	7	0	1	0.2540	0.0247	0.2071	0.3035
34	35	6	0	1	0.2540	0.0247	0.2071	0.3035
44	45	5	0	1	0.2540	0.0247	0.2071	0.3035
47	48	4	0	1	0.2540	0.0247	0.2071	0.3035
62	63	3	0	1	0.2540	0.0247	0.2071	0.3035
72	73	2	0	1	0.2540	0.0247	0.2071	0.3035
95	96	1	0	1	0.2540	0.0247	0.2071	0.3035
Female								
1	2	221	25	0	0.8869	0.0213	0.8372	0.9221
2	3	196	52	0	0.6516	0.0321	0.5848	0.7103
3	4	144	30	0	0.5158	0.0336	0.4481	0.5794
4	5	114	22	0	0.4163	0.0332	0.3509	0.4803
5	6	92	18	0	0.3348	0.0317	0.2735	0.3972
6	7	74	6	0	0.3077	0.0310	0.2481	0.3691
7	8	68	9	0	0.2670	0.0298	0.2105	0.3265

8	9	59	0	9	0.2670	0.0298	0.2105	0.3265
9	10	50	0	6	0.2670	0.0298	0.2105	0.3265
10	11	44	0	6	0.2670	0.0298	0.2105	0.3265
11	12	38	0	2	0.2670	0.0298	0.2105	0.3265
12	13	36	0	4	0.2670	0.0298	0.2105	0.3265
13	14	32	0	4	0.2670	0.0298	0.2105	0.3265
14	15	28	0	2	0.2670	0.0298	0.2105	0.3265
15	16	26	0	4	0.2670	0.0298	0.2105	0.3265
16	17	22	0	2	0.2670	0.0298	0.2105	0.3265
17	18	20	0	2	0.2670	0.0298	0.2105	0.3265
18	19	18	0	2	0.2670	0.0298	0.2105	0.3265
20	21	16	0	1	0.2670	0.0298	0.2105	0.3265
22	23	15	0	1	0.2670	0.0298	0.2105	0.3265
23	24	14	0	1	0.2670	0.0298	0.2105	0.3265
24	25	13	0	1	0.2670	0.0298	0.2105	0.3265
25	26	12	0	1	0.2670	0.0298	0.2105	0.3265
30	31	11	0	1	0.2670	0.0298	0.2105	0.3265
32	33	10	0	1	0.2670	0.0298	0.2105	0.3265
33	34	9	0	1	0.2670	0.0298	0.2105	0.3265
39	40	8	0	2	0.2670	0.0298	0.2105	0.3265
42	43	6	0	1	0.2670	0.0298	0.2105	0.3265
43	44	5	0	1	0.2670	0.0298	0.2105	0.3265
45	46	4	0	1	0.2670	0.0298	0.2105	0.3265
55	56	3	0	2	0.2670	0.0298	0.2105	0.3265
56	57	1	0	1	0.2670	0.0298	0.2105	0.3265

Table A2: survival data by age groups

Interval		Total	Deaths	Lost	Survival	Error	[95% Conf. Int.]	
Younger age								
1	2	279	39	0	0.8602	0.0208	0.8137	0.8959
2	3	240	80	0	0.5735	0.0296	0.5132	0.6291
3	4	160	43	0	0.4194	0.0295	0.3611	0.4765
4	5	117	19	0	0.3513	0.0286	0.2957	0.4072
5	6	98	15	0	0.2975	0.0274	0.2449	0.3518
6	7	83	10	0	0.2616	0.0263	0.2116	0.3143
7	8	73	6	0	0.2401	0.0256	0.1918	0.2916
8	9	67	0	9	0.2401	0.0256	0.1918	0.2916
9	10	58	0	8	0.2401	0.0256	0.1918	0.2916

10	11	50	0	5	0.2401	0.0256	0.1918	0.2916
11	12	45	0	4	0.2401	0.0256	0.1918	0.2916
12	13	41	0	4	0.2401	0.0256	0.1918	0.2916
13	14	37	0	7	0.2401	0.0256	0.1918	0.2916
14	15	30	0	1	0.2401	0.0256	0.1918	0.2916
15	16	29	0	4	0.2401	0.0256	0.1918	0.2916
16	17	25	0	1	0.2401	0.0256	0.1918	0.2916
17	18	24	0	4	0.2401	0.0256	0.1918	0.2916
18	19	20	0	2	0.2401	0.0256	0.1918	0.2916
19	20	18	0	1	0.2401	0.0256	0.1918	0.2916
20	21	17	0	2	0.2401	0.0256	0.1918	0.2916
22	23	15	0	1	0.2401	0.0256	0.1918	0.2916
23	24	14	0	1	0.2401	0.0256	0.1918	0.2916
24	25	13	0	1	0.2401	0.0256	0.1918	0.2916
28	29	12	0	1	0.2401	0.0256	0.1918	0.2916
30	31	11	0	1	0.2401	0.0256	0.1918	0.2916
31	32	10	0	1	0.2401	0.0256	0.1918	0.2916
33	34	9	0	1	0.2401	0.0256	0.1918	0.2916
34	35	8	0	1	0.2401	0.0256	0.1918	0.2916
39	40	7	0	1	0.2401	0.0256	0.1918	0.2916
42	43	6	0	1	0.2401	0.0256	0.1918	0.2916
43	44	5	0	1	0.2401	0.0256	0.1918	0.2916
44	45	4	0	1	0.2401	0.0256	0.1918	0.2916
55	56	3	0	1	0.2401	0.0256	0.1918	0.2916
56	57	2	0	1	0.2401	0.0256	0.1918	0.2916
62	63	1	0	1	0.2401	0.0256	0.1918	0.2916
Older age								
1	2	253	24	0	0.9051	0.0184	0.8618	0.9354
2	3	229	53	0	0.6957	0.0289	0.6349	0.7483
3	4	176	36	0	0.5534	0.0313	0.4899	0.6121
4	5	140	32	0	0.4269	0.0311	0.3654	0.4868
5	6	108	9	0	0.3913	0.0307	0.3311	0.4509
6	7	99	16	0	0.3281	0.0295	0.2710	0.3862
7	8	83	12	0	0.2806	0.0282	0.2267	0.3369

8	9	71	0	12	0.2806	0.0282	0.2267	0.3369
9	10	59	0	6	0.2806	0.0282	0.2267	0.3369
10	11	53	0	5	0.2806	0.0282	0.2267	0.3369
11	12	48	0	10	0.2806	0.0282	0.2267	0.3369
12	13	38	0	3	0.2806	0.0282	0.2267	0.3369
13	14	35	0	4	0.2806	0.0282	0.2267	0.3369
14	15	31	0	3	0.2806	0.0282	0.2267	0.3369
15	16	28	0	4	0.2806	0.0282	0.2267	0.3369
16	17	24	0	5	0.2806	0.0282	0.2267	0.3369
17	18	19	0	2	0.2806	0.0282	0.2267	0.3369
18	19	17	0	1	0.2806	0.0282	0.2267	0.3369
22	23	16	0	1	0.2806	0.0282	0.2267	0.3369
23	24	15	0	2	0.2806	0.0282	0.2267	0.3369
24	25	13	0	1	0.2806	0.0282	0.2267	0.3369
25	26	12	0	1	0.2806	0.0282	0.2267	0.3369
28	29	11	0	2	0.2806	0.0282	0.2267	0.3369
30	31	9	0	1	0.2806	0.0282	0.2267	0.3369
32	33	8	0	1	0.2806	0.0282	0.2267	0.3369
33	34	7	0	1	0.2806	0.0282	0.2267	0.3369
39	40	6	0	1	0.2806	0.0282	0.2267	0.3369
45	46	5	0	1	0.2806	0.0282	0.2267	0.3369
47	48	4	0	1	0.2806	0.0282	0.2267	0.3369
55	56	3	0	1	0.2806	0.0282	0.2267	0.3369
72	73	2	0	1	0.2806	0.0282	0.2267	0.3369
95	96	1	0	1	0.2806	0.0282	0.2267	0.3369

Table A3: Survival data by cause of death

Interval		Total	Deaths	Lost	Survival	SE	95% Conf. Int.	
DOTDS								
1	2	19	1	0	0.9474	0.0512	0.6812	0.9924
2	3	18	7	0	0.5789	0.1133	0.3321	0.7626
3	4	11	4	0	0.3684	0.1107	0.1652	0.5748
5	6	7	1	0	0.3158	0.1066	0.1291	0.5225
7	8	6	1	0	0.2632	0.1010	0.0958	0.4677
8	9	5	0	1	0.2632	0.1010	0.0958	0.4677
15	16	4	0	1	0.2632	0.1010	0.0958	0.4677
20	21	3	0	1	0.2632	0.1010	0.0958	0.4677
28	29	2	0	1	0.2632	0.1010	0.0958	0.4677
45	46	1	0	1	0.2632	0.1010	0.0958	0.4677
DOTCS								

1	2	108	17	0	0.8426	0.0350	0.7591	0.8991
2	3	91	26	0	0.6019	0.0471	0.5032	0.6870
3	4	65	20	0	0.4167	0.0474	0.3231	0.5074
4	5	45	13	0	0.2963	0.0439	0.2134	0.3837
5	6	32	4	0	0.2593	0.0422	0.1810	0.3444
6	7	28	3	0	0.2315	0.0406	0.1571	0.3144
7	8	25	2	0	0.2130	0.0394	0.1415	0.2942
8	9	23	0	4	0.2130	0.0394	0.1415	0.2942
9	10	19	0	2	0.2130	0.0394	0.1415	0.2942
11	12	17	0	1	0.2130	0.0394	0.1415	0.2942
12	13	16	0	2	0.2130	0.0394	0.1415	0.2942
15	16	14	0	2	0.2130	0.0394	0.1415	0.2942
16	17	12	0	1	0.2130	0.0394	0.1415	0.2942
17	18	11	0	2	0.2130	0.0394	0.1415	0.2942
18	19	9	0	1	0.2130	0.0394	0.1415	0.2942
19	20	8	0	1	0.2130	0.0394	0.1415	0.2942
20	21	7	0	1	0.2130	0.0394	0.1415	0.2942
23	24	6	0	1	0.2130	0.0394	0.1415	0.2942
24	25	5	0	1	0.2130	0.0394	0.1415	0.2942
25	26	4	0	1	0.2130	0.0394	0.1415	0.2942
30	31	3	0	1	0.2130	0.0394	0.1415	0.2942
47	48	2	0	1	0.2130	0.0394	0.1415	0.2942
62	63	1	0	1	0.2130	0.0394	0.1415	0.2942

DOTRS

1	2	123	14	0	0.8862	0.0286	0.8154	0.9310
2	3	109	25	0	0.6829	0.0420	0.5928	0.7572
3	4	84	22	0	0.5041	0.0451	0.4128	0.5884
4	5	62	13	0	0.3984	0.0441	0.3118	0.4834
5	6	49	8	0	0.3333	0.0425	0.2518	0.4168
6	7	41	8	0	0.2683	0.0400	0.1935	0.3486
7	8	33	3	0	0.2439	0.0387	0.1722	0.3225
8	9	30	0	6	0.2439	0.0387	0.1722	0.3225
9	10	24	0	2	0.2439	0.0387	0.1722	0.3225
10	11	22	0	4	0.2439	0.0387	0.1722	0.3225
11	12	18	0	2	0.2439	0.0387	0.1722	0.3225
12	13	16	0	3	0.2439	0.0387	0.1722	0.3225
13	14	13	0	3	0.2439	0.0387	0.1722	0.3225
15	16	10	0	2	0.2439	0.0387	0.1722	0.3225
16	17	8	0	2	0.2439	0.0387	0.1722	0.3225
17	18	6	0	2	0.2439	0.0387	0.1722	0.3225
18	19	4	0	1	0.2439	0.0387	0.1722	0.3225
30	31	3	0	1	0.2439	0.0387	0.1722	0.3225
39	40	2	0	1	0.2439	0.0387	0.1722	0.3225
55	56	1	0	1	0.2439	0.0387	0.1722	0.3225

DOTGS

1	2	10	2	0	0.8000	0.1265	0.4087	0.9459
2	3	8	1	0	0.7000	0.1449	0.3287	0.8919

3	4	7	2	0	0.5000	0.1581	0.1836	0.7532
4	5	5	1	0	0.4000	0.1549	0.1227	0.6702
6	7	4	1	0	0.3000	0.1449	0.0711	0.5779
9	10	3	0	1	0.3000	0.1449	0.0711	0.5779
10	11	2	0	1	0.3000	0.1449	0.0711	0.5779
15	16	1	0	1	0.3000	0.1449	0.0711	0.5779

DOTNS

1	2	96	8	0	0.9167	0.0282	0.8403	0.9574
2	3	88	26	0	0.6458	0.0488	0.5414	0.7323
3	4	62	18	0	0.4583	0.0509	0.3567	0.5541
4	5	44	12	0	0.3333	0.0481	0.2414	0.4278
5	6	32	5	0	0.2813	0.0459	0.1955	0.3731
6	7	27	4	0	0.2396	0.0436	0.1598	0.3284
7	8	23	6	0	0.1771	0.0390	0.1085	0.2594
8	9	17	0	2	0.1771	0.0390	0.1085	0.2594
9	10	15	0	4	0.1771	0.0390	0.1085	0.2594
10	11	11	0	1	0.1771	0.0390	0.1085	0.2594
11	12	10	0	2	0.1771	0.0390	0.1085	0.2594
12	13	8	0	1	0.1771	0.0390	0.1085	0.2594
13	14	7	0	3	0.1771	0.0390	0.1085	0.2594
17	18	4	0	1	0.1771	0.0390	0.1085	0.2594
28	29	3	0	1	0.1771	0.0390	0.1085	0.2594
33	34	2	0	1	0.1771	0.0390	0.1085	0.2594
95	96	1	0	1	0.1771	0.0390	0.1085	0.2594

ENAMD

2	3	10	6	0	0.4000	0.1549	0.1227	0.6702
7	8	4	1	0	0.3000	0.1449	0.0711	0.5779
8	9	3	0	2	0.3000	0.1449	0.0711	0.5779
42	43	1	0	1	0.3000	0.1449	0.0711	0.5779

DOBABFO

1	2	16	5	0	0.6875	0.1159	0.4046	0.8563
2	3	11	7	0	0.2500	0.1083	0.0775	0.4716
3	4	4	2	0	0.1250	0.0827	0.0207	0.3280
6	7	2	1	0	0.0625	0.0605	0.0041	0.2470
8	9	1	0	1	0.0625	0.0605	0.0041	0.2470

IDs

1	2	72	3	0	0.9583	0.0235	0.8764	0.9864
2	3	69	17	0	0.7222	0.0528	0.6033	0.8110
3	4	52	4	0	0.6667	0.0556	0.5452	0.7626
4	5	48	4	0	0.6111	0.0575	0.4887	0.7127
5	6	44	4	0	0.5556	0.0586	0.4337	0.6613
6	7	40	3	0	0.5139	0.0589	0.3934	0.6218
7	8	37	5	0	0.4444	0.0586	0.3279	0.5545
8	9	32	0	4	0.4444	0.0586	0.3279	0.5545
9	10	28	0	4	0.4444	0.0586	0.3279	0.5545
10	11	24	0	1	0.4444	0.0586	0.3279	0.5545
11	12	23	0	7	0.4444	0.0586	0.3279	0.5545

13	14	16	0	4	0.4444	0.0586	0.3279	0.5545
14	15	12	0	2	0.4444	0.0586	0.3279	0.5545
15	16	10	0	1	0.4444	0.0586	0.3279	0.5545
16	17	9	0	2	0.4444	0.0586	0.3279	0.5545
17	18	7	0	1	0.4444	0.0586	0.3279	0.5545
22	23	6	0	1	0.4444	0.0586	0.3279	0.5545
24	25	5	0	1	0.4444	0.0586	0.3279	0.5545
28	29	4	0	1	0.4444	0.0586	0.3279	0.5545
31	32	3	0	1	0.4444	0.0586	0.3279	0.5545
44	45	2	0	1	0.4444	0.0586	0.3279	0.5545
72	73	1	0	1	0.4444	0.0586	0.3279	0.5545

IPACOCOEC

1	2	25	8	0	0.6800	0.0933	0.4609	0.8253
2	3	17	9	0	0.3200	0.0933	0.1524	0.5015
3	4	8	2	0	0.2400	0.0854	0.0976	0.4167
4	5	6	4	0	0.0800	0.0543	0.0139	0.2249
6	7	2	1	0	0.0400	0.0392	0.0029	0.1699
11	12	1	0	1	0.0400	0.0392	0.0029	0.1699

CANCERS

1	2	53	5	0	0.9057	0.0402	0.7881	0.9596
2	3	48	9	0	0.7358	0.0606	0.5951	0.8342
3	4	39	5	0	0.6415	0.0659	0.4973	0.7542
4	5	34	4	0	0.5660	0.0681	0.4227	0.6865
5	6	30	2	0	0.5283	0.0686	0.3865	0.6516
6	7	28	5	0	0.4340	0.0681	0.2992	0.5612
8	9	23	0	1	0.4340	0.0681	0.2992	0.5612
9	10	22	0	1	0.4340	0.0681	0.2992	0.5612
10	11	21	0	3	0.4340	0.0681	0.2992	0.5612
11	12	18	0	1	0.4340	0.0681	0.2992	0.5612
12	13	17	0	1	0.4340	0.0681	0.2992	0.5612
13	14	16	0	1	0.4340	0.0681	0.2992	0.5612
14	15	15	0	2	0.4340	0.0681	0.2992	0.5612
15	16	13	0	1	0.4340	0.0681	0.2992	0.5612
16	17	12	0	1	0.4340	0.0681	0.2992	0.5612
18	19	11	0	1	0.4340	0.0681	0.2992	0.5612
22	23	10	0	1	0.4340	0.0681	0.2992	0.5612
23	24	9	0	2	0.4340	0.0681	0.2992	0.5612
32	33	7	0	1	0.4340	0.0681	0.2992	0.5612
33	34	6	0	1	0.4340	0.0681	0.2992	0.5612
34	35	5	0	1	0.4340	0.0681	0.2992	0.5612

39	40	4	0	1	0.4340	0.0681	0.2992	0.5612
43	44	3	0	1	0.4340	0.0681	0.2992	0.5612
55	56	2	0	1	0.4340	0.0681	0.2992	0.5612

Table A4: survival data by type of diseases

Interval		Total	Deaths	Lost	Survival	SE	95% Conf. Int.	
CD								
1	2	105	5	0	0.9524	0.0208	0.8894	0.9799
2	3	100	24	0	0.7238	0.0436	0.6276	0.7991
3	4	76	12	0	0.6095	0.0476	0.5094	0.6953
4	5	64	9	0	0.5238	0.0487	0.4243	0.6140
5	6	55	6	0	0.4667	0.0487	0.3691	0.5583
6	7	49	7	0	0.4000	0.0478	0.3063	0.4919
7	8	42	8	0	0.3238	0.0457	0.2367	0.4138
8	9	34	0	6	0.3238	0.0457	0.2367	0.4138
9	10	28	0	5	0.3238	0.0457	0.2367	0.4138
10	11	23	0	1	0.3238	0.0457	0.2367	0.4138
11	12	22	0	7	0.3238	0.0457	0.2367	0.4138
13	14	15	0	3	0.3238	0.0457	0.2367	0.4138
14	15	12	0	2	0.3238	0.0457	0.2367	0.4138
15	16	10	0	1	0.3238	0.0457	0.2367	0.4138
16	17	9	0	2	0.3238	0.0457	0.2367	0.4138
17	18	7	0	1	0.3238	0.0457	0.2367	0.4138
24	25	6	0	1	0.3238	0.0457	0.2367	0.4138
28	29	5	0	1	0.3238	0.0457	0.2367	0.4138
31	32	4	0	1	0.3238	0.0457	0.2367	0.4138
33	34	3	0	1	0.3238	0.0457	0.2367	0.4138
44	45	2	0	1	0.3238	0.0457	0.2367	0.4138
NCD								
1	2	427	58	0	0.8642	0.0166	0.8279	0.8933
2	3	369	109	0	0.6089	0.0236	0.5609	0.6534
3	4	260	67	0	0.4520	0.0241	0.4043	0.4985
4	5	193	42	0	0.3536	0.0231	0.3085	0.3990
5	6	151	18	0	0.3115	0.0224	0.2681	0.3557
6	7	133	19	0	0.2670	0.0214	0.2259	0.3096
7	8	114	10	0	0.2436	0.0208	0.2040	0.2851
8	9	104	0	15	0.2436	0.0208	0.2040	0.2851
9	10	89	0	9	0.2436	0.0208	0.2040	0.2851
10	11	80	0	9	0.2436	0.0208	0.2040	0.2851
11	12	71	0	7	0.2436	0.0208	0.2040	0.2851
12	13	64	0	7	0.2436	0.0208	0.2040	0.2851
13	14	57	0	8	0.2436	0.0208	0.2040	0.2851
14	15	49	0	2	0.2436	0.0208	0.2040	0.2851
15	16	47	0	7	0.2436	0.0208	0.2040	0.2851
16	17	40	0	4	0.2436	0.0208	0.2040	0.2851
17	18	36	0	5	0.2436	0.0208	0.2040	0.2851

18	19	31	0	3	0.2436	0.0208	0.2040	0.2851
19	20	28	0	1	0.2436	0.0208	0.2040	0.2851
20	21	27	0	2	0.2436	0.0208	0.2040	0.2851
22	23	25	0	2	0.2436	0.0208	0.2040	0.2851
23	24	23	0	3	0.2436	0.0208	0.2040	0.2851
24	25	20	0	1	0.2436	0.0208	0.2040	0.2851
25	26	19	0	1	0.2436	0.0208	0.2040	0.2851
28	29	18	0	2	0.2436	0.0208	0.2040	0.2851
30	31	16	0	2	0.2436	0.0208	0.2040	0.2851
32	33	14	0	1	0.2436	0.0208	0.2040	0.2851
33	34	13	0	1	0.2436	0.0208	0.2040	0.2851
34	35	12	0	1	0.2436	0.0208	0.2040	0.2851
39	40	11	0	2	0.2436	0.0208	0.2040	0.2851
42	43	9	0	1	0.2436	0.0208	0.2040	0.2851
43	44	8	0	1	0.2436	0.0208	0.2040	0.2851
45	46	7	0	1	0.2436	0.0208	0.2040	0.2851
47	48	6	0	1	0.2436	0.0208	0.2040	0.2851
55	56	5	0	2	0.2436	0.0208	0.2040	0.2851
56	57	3	0	1	0.2436	0.0208	0.2040	0.2851
62	63	2	0	1	0.2436	0.0208	0.2040	0.2851